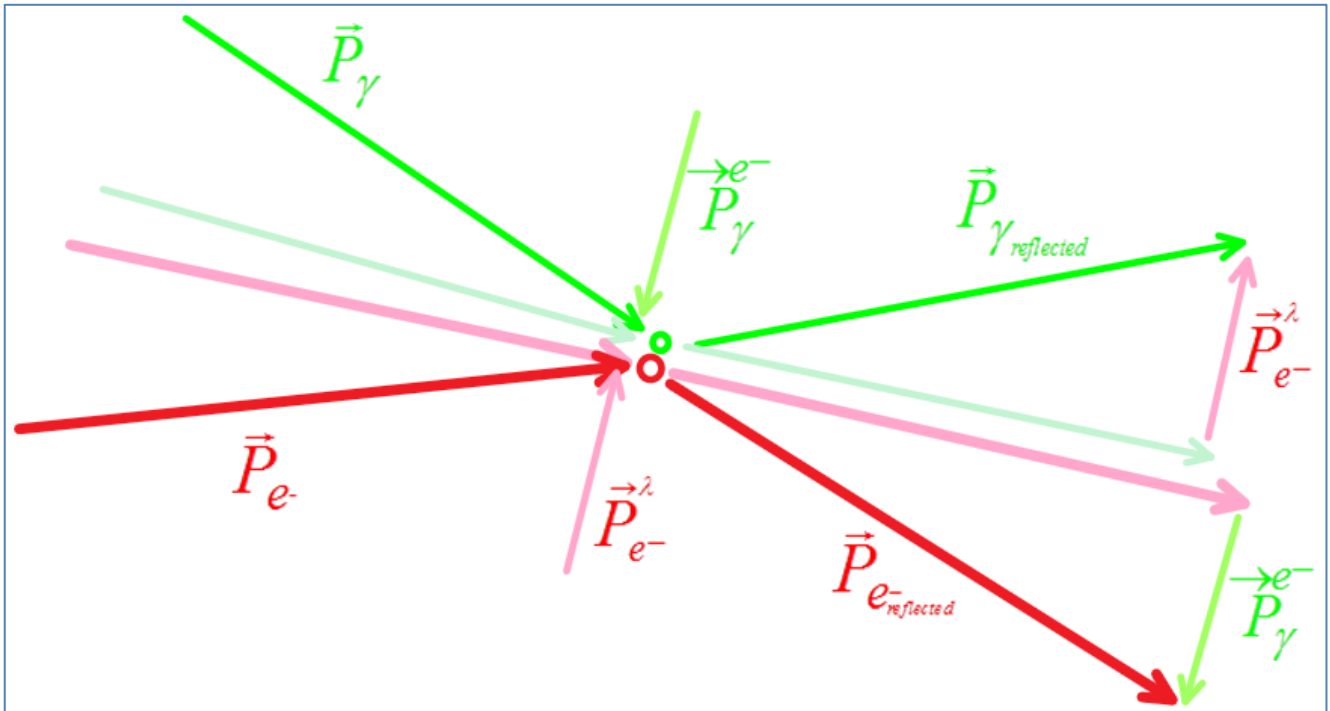


Q_{uantum} - G_{eometry} D_{ynamics}

an axiomatic approach to physics



Daniel L. Burnstein

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Quantum-Geometry Dynamics

An Axiomatic Approach to Physics

by

Daniel L. Burnstein

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“What matters is not to convince but to give something to think about.”

Bernard Werber

Foreword

“An important scientific innovation rarely makes its way by gradually winning over and converting its opponents: it rarely happens that Saul becomes Paul. What does happen is that its opponents gradually die out, and that the growing generation is familiarized with the ideas from the beginning: another instance of the fact that the future lies with the youth.”

Max Planck

In his article titled *The Good Reasons Scientists Are So Hostile to New Ideas*, Ethan Siegel¹ writes:

“Proposals that attempt to revolutionize one (or more) of our accepted theories have a large suite of hurdles to overcome. In particular, they must:

- reproduce all the successes of the prevailing theory,
- explain a phenomenon more successfully than the current theory can,
- and make novel predictions that can be tested that differ from the theory it’s attempting to supersede.”

Satisfying the above criteria requires that a new theory or proposal be sufficiently developed. It is unlikely that a new proposal or theory will be capable of meeting those criteria early on. Unlike established theories, new theories have not benefited from decades of contributions by generations of scientists. So, the consequences of ideas must be rigorously and thoroughly explored before shooting them down for not meeting the criteria.

That said, I agree with pretty much every point Siegel makes in his article that new ideas must meet those criteria, but one should avoid putting them to the test prematurely. Not only do I agree with the criteria he describes, but I think a theory should be held to the stricter set of criteria I describe later in this book.

There is a need however to clarify what Siegel meant by “reproduce all the successes of the prevailing theory”.

I will take it that he means that it should make it possible to derive predictions that are consistent with the confirmed predictions of established theories. That said, predictions maybe consistent observations yet derived from a different set of axioms which implies

¹ Ethan Siegel is an American theoretical astrophysicist and award-winning science writer who writes on mainstream science topics.

that those the observations are consistent with both the new and the accepted theories, the interpretations of the observations would differ.

He concludes:

“In the end, the Universe will always be the ultimate arbiter of what is real and what theories best describe our reality. But it’s up to us — the intelligent beings that conduct the enterprise of science — to rigorously uncover those truths. Unless we do it responsibly, we run the risk of fooling ourselves into believing what we want to be true. In science, integrity and intellectual honesty are the ideals to which we must aspire.”

This is the very definition of the scientific method. Ethan Siegel understands and explains it very well in this and other articles, so it is not for lack of understanding that he forgoes the scientific method in his article titled This is Why Space Needs to be Continuous in which he argues against the idea of space being discrete.

The validity of a theory (or premise) can only be determined by the scientific method described above which implies descriptions, explanations, predictions that have or can be tested experimentally. Theoretical arguments are important but are no substitute for experiments.

The validity of a theory cannot be determined from within the framework of a second theory when their axiom sets are mutually exclusive. There is a simple reason for that. Using a premise in an argument based on a theory that axiomatically excludes it will inevitably make it internally inconsistent and consequently render any theoretical argument and its conclusion inconsistent with both the theory (or premise) and the theory on which the argument is based. Sure, we can determine if an idea is consistent with a theory, but being found to be inconsistent with an accepted theory does not invalidate it.

For example, space continuum is an implicit axiom of the relativity theories. Space continuum and space discreteness are mutually exclusive. It follows that the relativity theories cannot be used to describe physics in discrete space or make consistent predictions about discrete space.

Siegel argues that space discreteness is also inconsistent with the relativity principle but that is a forgone conclusion considering that discreteness is axiomatically excluded.

Several strong theoretical arguments can be made against space discreteness. For example, if space were discrete rather than continuous, then gravitational waves would not exist, time would not be physical and the universe would be strictly deterministic (to

give only a few examples), all of which supported by overwhelming evidence. But Siegel's entire argument against space discreteness is based on an application of the principle of relativity, a postulate (another word for axiom) of special relativity. The principle of relativity precludes the possibility of measuring absolute velocity, distance, momentum, etc.,

From impossibility to make an absolute measurement, Siegel concludes that space cannot be discrete. His argument is that space discreteness implies the existence of a fundamental unit of distance (a smallest possible distance), yet measurements of this distance is dependent on the observer. Hence, two observers in constant motion relative to one another would not agree on its length, thus contradicting of the existence of a fundamental unit of distance. Hence space discreteness implies that the principle of relativity would be wrong and consequently so would be special relativity. But how could special relativity be wrong considering that its predictions have been shown to be consistent with observations to a very high degree of accuracy?

One must keep in mind that special relativity is a measurement theory which accurately predicts the relative measurements of physical properties. Special relativity (not necessarily nature) precludes absolute measurements. But special relativity cannot handle space discreteness or make any predictions about the physics of discrete space. Only a theory derived from a self-consistent axiom set which has space discreteness as one of its axioms can make predictions about physics in discrete space. It would not only be able to predict the absolute measurements of all physical properties (all observers would see make the same measurements), but also make accurate predictions of relative measurements as or more accurately than even special relativity.

It stands to reason that any such theory should possess explanatory powers comparable to those of the relativity theories and beyond that, should make unique testable predictions that can set it apart. These would be the necessary and sufficient criterions to validate the theory. But Siegel ignores the criterions of the scientific method and replace them with a single theoretically biased criterion: space discreteness must be consistent with the principle of relativity.

On its own, the idea of space discreteness has nothing to say about reality, it has zero descriptive, explanative, or predictive power. Only a theory that is based on a self-consistent axiom set that contains an axiom of space discreteness can be tested using the criterions we have set forth as necessary and sufficient. Only by comparing such a theory's descriptions, explanations and predictions to observations can it be validated or refuted. This brings me to quantum-geometry dynamics.

Quantum-geometry dynamics (QGD) is a theory derived from a consistent axiom set containing an axiom of space discreteness. In terms of state of development there is no comparison between what a single individual can accomplish in a decade versus generations of researchers over a century, but it already explains and describes what we already know, and makes testable predictions. So, let us hope that some physicists will do what Siegel suggests but failed to do in the case of space discreteness and rigorously subject QGD to the scientific method. The idea of space discreteness certainly deserves further exploration.

Though Planck's principle certainly applies to QGD, I believe there are people willing to step out of the framework of established theories and consider the approach I propose in this book. I hope you are one of them.

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I wish merely to point out the lack of firm foundation for assigning any physical reality to the conventional continuum concept. My own view is that ultimately physical laws should find their most natural expression in terms of essentially combinatorial principles, that is to say, in terms of finite processes such as counting or other basically simple manipulative procedures. Thus, in accordance with such a view, should emerge some form of discrete or combinatorial space-time.

Roger Penrose, On the Nature of Quantum-Geometry

Hilbert's 6th problem

In 1900, the famous mathematician David Hilbert introduced a list of 24 great problems in mathematics. The list of problems addressed a number of important issues in mathematics; many of which have remained to this day unresolved. Hilbert's 6th problem, which has become central to physics, reads as follow:

To treat in the same manner, by means of axioms, those physical sciences in which already today mathematics plays an important part; in the first rank are the theory of probabilities and mechanics.

We may legitimately wonder if true axiomatization of physics may be a finite and complete set of axioms from which all the governing laws of the Universe could be derived. Could a physics theory be an axiomatic system; that is, a theory that is founded on axioms from which all physics can be deduced from or reduced to.

An axiom, as most of you know, is a fundamental assumption or proposition about a domain. What this means is that it cannot be reduced, derived or deduced from any other propositions. In other words, an axiom cannot be mathematically proven.

Though, Gödel's incompleteness theorems demonstrates that not all propositions, theorems and corollaries can be deduced from the set of axioms associated with a specific domain, they do not preclude the existence of a complete and consistent set of axioms in physics.²

In physics, axioms are understood as representing fundamental properties or components of reality. My understanding of Hilbert's 6th problem is that a set of axioms about physical reality that is complete be created. That is, all observations, any and all phenomena could be deduced from the set of axioms. The set of axioms and laws, explanations and predictions deduced from it would form an axiomatic system or axiomatic theory which would axiomatize the whole of physics.

It seems evident that the purpose of physics is to identify the fundamental properties or components of reality and to use them to develop theories that can explain observations of physical phenomena. What is less evident is how to determine when the propositions chosen by physicists to be the basis of a theory are really axioms.

² See [Do Gödel's Incompleteness Theorems Exclude the Possibility of a Theory of Everything?](#)

While in mathematics one can arbitrarily chose any consistent set of axioms as a basis of an axiomatic system, the axioms in a physics theory must represent fundamental aspects of reality. This raises the essential question: What constitutes a fundamental aspect of reality?

As we will see in this book, quantum-geometry dynamics proposes that reality obeys a principle of strict causality. From the principle of strict causality, it follows that an aspect of reality is fundamental if it is absolutely invariable. That is, regardless of interactions it is subjected to, a fundamental aspect of reality remains unaffected.

Now that we established what we mean by a fundamental aspect of reality, two presuppositions need to be accepted in order to answer Hilbert's 6th problem. First, we must assume that the Universe is made of fundamental objects having properties which determine a consistent set of fundamental laws. Second, that it can be represented by a complete and consistent axiomatic system. That is, the Universe has a finite set of fundamental components which obey a finite set of fundamental laws. These two presuppositions are essential for the construction of any true axiomatic system.

In addition to the two presuppositions, there is also the question of the minimal axiom set necessary to form a complete and consistent axiomatic theory.

To determine that value, we need to remember that the number of constructs that can be built from a finite set of fundamental objects is always greater than the number of objects in the set.

If, for example, the number of objects in the fundamental set is equal to n , and the number of ways they can be assembled by applying laws of combination is equal to l then the number of objects that can be formed is equal to

$$l \propto n!^j$$

where j is the maximum number of objects which can be combined. From this, we can see that the closer we get to fundamental reality, the lower l becomes, the simpler reality becomes; with reality being at its simplest at the fundamental scale. What this implies is that any axiomatic theory of reality will have fewer fundamental components than constructs. It follows that a theory must allow for an exponentially greater number of composite structures than it has elementary particles.

In plain language, reality at the fundamental scale is simpler, not more complex.

So, what is the smallest possible set of axioms an axiomatic theory of fundamental physics can have?

Before answering this question, quantum-geometry dynamics first asks: What does all things in the Universe have in common? What does every single theory of physical reality ever conceived of have in common?

The answer: space and matter³. Space and matter are aspects of reality shared by everything, all phenomena, all events in the Universe. It follows that any axiomatic theory of physical reality must minimally account for space and matter. Quantum-geometry dynamics, which is the subject of this book, is derived from the following two axioms.

Space is made of discrete fundamental units, $preons^{(-)}$, and is dimensionalized by the intrinsic repulsion force acting between them.

Matter is made of fundamental strictly kinetic particles, $preons^{(+)}$, which form particles and structures as a result of the intrinsic attractive force acting between them.

Two Approaches to Physics

From an axiomatic standpoint, there are two approaches to theoretical physics. The first aims to extend, expand and deepen an existing theory, which is what the overwhelming majority of theorists do. This approach assumes that the theory is fundamentally correct, that is, its axioms are thought to correspond to fundamental aspects of reality.

The second approach is to create a new axiom set and derive a theory from it. Distinct axiom sets will lead to distinct theories which, even if they are mutually exclusive may still describe and explain phenomena in ways that are consistent with observations. There can be a multiplicity of such “correct” theories if the axioms are made to correspond to observed aspects of physical reality that are not fundamental but emerging. For instance, theories have been built where one axiom states that the fundamental component of matter is the atom. Such theories, though it may describe very well some phenomena at the molecular scale will fail in explaining a number of phenomena at smaller scales. In the strict sense, premises based on emergent aspect of reality are not axioms in the physical sense. They can better be understood as theorems. And as mathematical theorems in mathematics can explain the behavior of mathematical objects belonging to a certain class but cannot be generalized to others, physical theorems can explain the behavior of class of objects belonging to a certain scale, but these explanations cannot be extended to others scales or even to objects or other classes of objects in the same scale.

But axioms are not inherently wrong or right. By definition, since axioms are the starting point, they cannot be reduced or broken down. Hence, as such, we cannot directly prove whether they correspond to fundamental aspects of reality. However, if the models that emerge from an axiom set explain and describe reality and, most importantly, allows predictions that can be tested, then confirmation of the predictions become evidence supporting the axiom set.

³ Energy is omitted at this point as this property will be derived from the axiom set.

The Axiomatic Approach

It can scarcely be denied that the supreme goal of all theory is to make the irreducible basic elements as simple and as few as possible without having to surrender the adequate representation of a single datum of experience.

Albert Einstein

The dominant approach in science (and a hugely successful one for that matter) is the empirical approach. That is, the approach by which science accumulates data from which it extracts relationships and assumptions that better our understanding of the Universe.

The empirical approach is an essential part of what we might call deconstructive. By that I mean that we take pieces or segments of reality from which, through experiments and observations, we extract data from which we hope to deduce the governing laws of the Universe. But though the deconstructive approach works well with observable phenomena, it has so far failed to provide us with a complete and consistent understanding of fundamental reality.

Of course, when a theory is formulated that agrees with a data set, it must be tested against future data sets for which it makes predictions. And if the data disagrees with predictions, the theory may be adjusted so as to make it consistent with the data. Then the theory is tested against a new or expanded data set to see if it holds. If it does not, the trial-and-error process may be repeated so as to make the theory applicable to an increasingly wider domain of reality.

The amount of data accumulated from experiments and observations is astronomical, but we have yet to find the key to decipher it and unlock the fundamental laws governing the Universe.

Also, data is subject to countless interpretations and the number of mutually exclusive models and theories increases as a function of the quantity of accumulated data.

But, more to the point, what if fundamental reality is orders of magnitude smaller than the smallest observable scale we can probe? Should this be the case, an axiomatic approach may then be our only hope to gain insight into the workings of reality at the fundamental scale.

About the Source of Incompatibilities between Theories

Reality can be thought as an axiomatic system in which fundamental aspects correspond to axioms and non-fundamental aspects correspond to theorems.

The empirical method is essentially a method by which we try to deduce the axiom set of reality, the fundamental components, and forces, from theorems (non-fundamental interactions). There lies the problem. Even though reality is a complete and consistent system, the laws extracted from observations at different scales of reality, and which form the basis of physics theories do not together form a complete and consistent axiomatic system.

The predictions of current theories may agree with observations at the scale from which their premises were extracted, but they fail, often catastrophically, when it comes to making predictions at different scales of reality.

This may indicate that current theories are not axiomatic (they are not based on true physical axioms), which means the founding propositions of the theories do not correspond to fundamental aspects of reality. If they were, then the axioms from distinct theories could be merged into a consistent (but not necessarily complete) axiomatic set. There would be no incompatibilities.

Also, if theories were axiomatic systems in the way we described above, their axioms would be similar or complementary. Physical axioms can never be in contradiction.

This raises important questions about the empirical method and its potential to extract physical axioms from the theorems it deduces from observations. The fact that even theories which are derived from observations of phenomena at the microscopic scale have failed to produce *physical axioms* (if they had, they would explain interactions at larger scales as well) suggests that there is a distinction between the microscopic scale, which is relative to our scale, and the fundamental scale which may be any order of magnitude smaller.

There is nothing that allows us to infer that the microscopic scale which is assumed to be fundamental is truly fundamental scale or that what we observe at the microscopic scale is fundamental. It may very well be that everything we hold as fundamental, the particles, the forces, etc., are not.

Also, theories founded on theorems related to different scales rather than axioms cannot be unified. It follows that the grand unification of the reigning theories which has been the dream of generations of physicists is mathematically impossible. A theory of everything cannot result from the unification of the standard model and relativity, for instance, they are based on mutually exclusive axiom sets. Therefore, it is essential to rigorously derive any axiomatic theory from its axiom set and always avoid the temptation of contriving it into agreeing with other theories.

So even though, as we will see later, Newton's law of universal gravity, the laws of motion, the universality of free fall and the relation between matter and energy can all be derived from QGD's axiom set, deriving them was never the goal when the axiomatic set was chosen. These laws just followed naturally from QGD's axiom set.

However, an axiomatic approach as we have described poses two important obstacles.

The first is choosing a set of axioms where each axiom corresponds to a fundamental aspect of reality if fundamental reality is inaccessible and thus immeasurable.

The second obstacle is how to test the predictions of an axiomatically derived theory when the scale of fundamental reality makes it immeasurable.

In the following chapters, we will see that even in the likely scenario that fundamental reality is unobservable, if the axioms of our chosen set correspond to fundamental aspects of reality, then there must be inevitable and observable consequences at larger scales which will allow us to derive unique testable predictions. We will show that it is possible to choose a complete and consistent set of axioms, that is one from which interactions at all scales of reality can be reduced to. In other words, even if the fundamental scale of reality remains unobservable, an axiomatic theory would make precise predictions at scales that are.

Internal Consistency and Validity of a Theory

Any theory that is rigorously developed from a given consistent set of axioms will itself be internally consistent. That said, since any number of such axiom sets can be constructed, an equal number of theories can be derived that will be internally consistent. To be a valid axiomatic physics theory, it must answer positively to the following questions.

1. Do its axioms form an internally consistent set?
2. Is the theory rigorously derived from the axiom set?
3. Are all descriptions derived from the theory consistent with observations?
4. Can we derive explanations from the axiom set that are consistent with observations?
5. Can we derive from the axiom set unique and testable predictions?

And if an axiom set is consistent and complete, then:

6. Does the theory derived from the axiom set describe physical reality at all scales?

In the following chapters, we will see how quantum-geometry dynamics answers these questions.

QGD's Axiom Set

For several decades now, mathematicians and physicists have tried to reconcile quantum mechanics and general relativity, two of the most successful physics theories in history, but despite their best efforts such unification has remained beyond the limit of the scientific horizon.

The problem, we believe, stems from the fact that the axiom sets of quantum-mechanics and general relativity are mutually exclusive. It is a mathematical certainty that unification of axiom sets which contain mutually exclusive axioms is impossible, as is the unification of the theories derived from them. In other words, though it may be possible to unify quantum mechanics and general relativity, it cannot be done without abandoning some of the axioms of their respective axiom sets but abandoning any of the axioms amounts to giving up on one, if not both theories. However, it is impossible to give up on one without giving up on the other since both are necessary to describe reality at all scales. Hence the impasse physicists have struggled with. Unification of the two theories requires that their axiom sets be unified, which in turn requires that their axioms be complementary and not, as are those of QM and GR, exclusory. QM and GR cannot be reconciled without abandoning some of their fundamental assumptions.

We propose here an alternative approach. Intuiting that at its most fundamental, reality is also at its simplest, we construct the simplest possible axiom set that can describe a dynamic system; one where each axiom corresponds to a fundamental aspect of reality agreed upon by all theories of physics. That is, the existence of space and the existence of matter. We will show that from such a minimal set of axioms a theory can be developed that describes and explains all physical phenomena, thus agrees with the predictions of quantum-mechanics and general relativity. Most importantly, a theory that is in complete agreement with physical reality.

The idea is to create an absolute minimal dynamic system and explore how such a system will evolve from an initial state. The choices of the minimal components of a dynamic system and their properties will constitute axioms from which theorems will be derived that will predict how such a system will evolve. One should not assume that the axioms and theorems correspond to fundamental aspects to physical reality unless the dynamic system they describe evolves into one that is analogous to observable reality.

It is evident that such a system must exist in space, but space could be continuous or discrete, static, or dynamic. Here we chose space to be fundamentally discrete. We will call the fundamental discrete units or particles of space *preons*⁽⁻⁾.

Preons⁽⁻⁾ do not exist in space, they are space, yet each of them is distinct, that is, they each correspond to a distinct location. We will assume that *preons*⁽⁻⁾ are kept apart from each other by a repulsive force acting between them which we will call n-gravity. So between *preons*⁽⁻⁾ is not space but the n-gravity field. Therefore, *preons*⁽⁻⁾ exists in the n-gravity field. Also, it follows

that $preons^{(-)}$ must static since movement would require that they move in space, that is, that they exist in space and that would contradict the defining assumptions.

Next, we need matter and since matter must exist in space and our space is discrete, then it follows that the matter in the dynamic system we are creating must also be discrete or corpuscular. And since our system is minimal, we have only one fundamental unit of matter, one type of fundamental particle which we will call $preons^{(+)}$. If $preons^{(+)}$ are to interact to form more massive particles and structures, then they need to be kinetic and they need to be capable of binding with one another. $Preons^{(+)}$ will therefore be assumed to move by “leaping” from $preons^{(-)}$ to $preons^{(-)}$ and thus have momentum. The momentum of a $preon^{(+)}$ will be the fundamental unit of momentum and the displacement between two $preons^{(-)}$ the fundamental unit of displacement.

For $preons^{(+)}$ to bind into particles and structures, there must be an attractive force acting between them. We will call that force, p-gravity.

Since in our minimal system we have only one fundamental particle of matter, there are no other particles a $preon^{(+)}$ can decay into or be formed from. $Preons^{(+)}$ are eternal, hence their number is fixed and finite. The same goes for $preons^{(-)}$.

As for the initial state, we will define it as one in which $preons^{(+)}$ are free and homogeneously distributed in discrete space.

Other minimal systems can be constructed, and different initial states can be chosen for each, but the above is the only one we will explore here. I have called the study of the evolution of this minimal system *quantum-geometry dynamics*.

Minimal Axiom Set

From a minimal set of axioms, we can derive dynamics systems which behaviour find their counterparts in nature.

Axiom 1: We define quantum-geometrical space as that which emerges from the repulsive interactions between fundamental quanta of space we will call $preons^{(-)}$.

Axiom 2: We define quantum-geometrical matter as that which is formed by the binding of fundamental particles of matter through an attractive force acting between them. We will call the fundamental particles of matter $preons^{(+)}$

Axiom 3: The initial state of the quantum-geometrical universe is that in which $preons^{(+)}$ were uniformly distributed through quantum-geometrical space.

Axiom 4: *A quantum-geometrical particle is fundamental if it never decays or transmutes into other particles. Preons⁽⁻⁾ and preons⁽⁺⁾ are the only fundamental particles that exist in the quantum-geometrical universe.*

Principle of Strict Causality:

All successive states of a particle, structure or system are strictly and uniquely causally linked.

The principle of strict causality being based on properties of physical reality, it offers the possibility of understanding the evolution of the Universe as sequences of events that are causally connected. Strict causality effectively allows a description of the evolution of any system without having to resort to the relational concept we call time.

The principle of strict causality implies is that the Universe does not evolve with time, but changes from one state to the next because of concurrent causally related series of events.

Fundamentality and the Conservation Law

What is considered fundamental has often changed over the course of History so that often what at some time we have consider fundamental ultimately revealed itself to be non-fundamental. How we define "fundamental" has profound consequences on the way we interpret reality or create models. QGD uses the following definition:

An aspect of reality is fundamental if it is invariant.

Thus, if an object is fundamental its intrinsic properties are conserved throughout the existence of the Universe.

Strict causality excludes spontaneity which assumes that a particle or system can change for no other reason that over time there is a probability that it will. It implies that when a particle decays into other particles and no external interaction affected that change, then the change must be caused by internal interactions, which in turn imply structure, so that the particle is not elementary.

It also implies that if a particle is elementary, that is, has no structure, hence no internal interactions which can cause it to change, then it can never decay.

Quantum-Geometrical Space

Let me say at the outset that I am not happy with this state of affairs in physical theory. The mathematical continuum has always seemed to me to contain many features which are really very foreign to physics. [...] If one is to accept the physical reality of the continuum, then one must accept that there are as many points in a volume of diameter 10^{13} cm or 10^{33} cm or 10^{1000} cm as there are in the entire universe. Indeed, one must accept the existence of more points than there are rational numbers between any two points in space no matter how close together they may be. (And we have seen that quantum theory cannot really eliminate this problem, since it brings in its own complex continuum.)

Roger Penrose, On the Nature of Quantum-Geometry

The Nature of Space

I consider it quite possible that physics cannot be based on the field concept, i. e., on continuous structures. In that case nothing remains of my entire castle in the air, gravitation theory included, [and of] the rest of modern physics. - Einstein in a 1954 letter to Besso.

What Einstein might have been referring to is that special relativity and general relativity require that space be continuous. The axiom of continuity of space is implied by special relativity as well as most current physics theory.

Einstein understood that if the implied continuity axiom turned out not to correspond to the fundamental nature of space, his theory and all theories which are based on it would also fall apart. We disagree. Einstein's theories would still hold very well if space were discrete rather than continuous, and so would be the principle of relativity.

When considering that predictions of the relativity theories have been confirmed by countless experiments and observations, it is logical to assume that their underlying axioms must be correct, including that of space continuum which is an implicit axiom. And space continuum and space discreteness being mutually exclusive, if space were discrete, then it would follow that space continuum and theories founded on it would be wrong, correct?

But what if the space continuum is not fundamental? What if space only appears and behaves to be continuous at larger than the fundamental scale allowing physical theories such as the relativity theories to correctly describe systems at those scales. Then space continuum would not be an axiom in the sense we have described [here](#), but a theorem. That could explain why general relativity can correctly describe dynamic systems at large scales while failing for systems at the fundamental scale where space would be discrete. If this were the case, then understanding how the space continuum emerges from discrete space would open the door to fundamental theories that can describe dynamics systems in discrete space while still being compatible with theories such as general relativity.

Dominant theories successfully explain and predict phenomena at scales at which they are observed and from which observations theorems were derived. Space continuum is what is observed at non-fundamental scales.

Quantum-geometry dynamics postulates that space is fundamentally discrete. Specifically, that space is quantum-geometrical, that is: Quantum-geometrical space is formed by fundamental particles we call *preons*⁽⁻⁾ (symbol $p^{(-)}$) and is dimensionalized by the repulsive force acting between them. Thus, according to QGD, spatial dimensions are emergent properties of *preons*⁽⁻⁾, hence dimensionalized space is not fundamental.

The interaction between any two *preons*⁽⁻⁾ is the fundamental unit of the force acting between them which because it is repulsive, we will call n-gravity (symbol g^-).

It is important here to remind the reader that what exists between two *preons*⁽⁻⁾ is the n-gravity field of interactions. There is no space in the geometrical sense between them. The force of the field between any two *preons*⁽⁻⁾, anywhere in the Universe, is equal to one g^- .

Figure 1 is a two-dimensional representation of quantum-geometrical space. The green circle

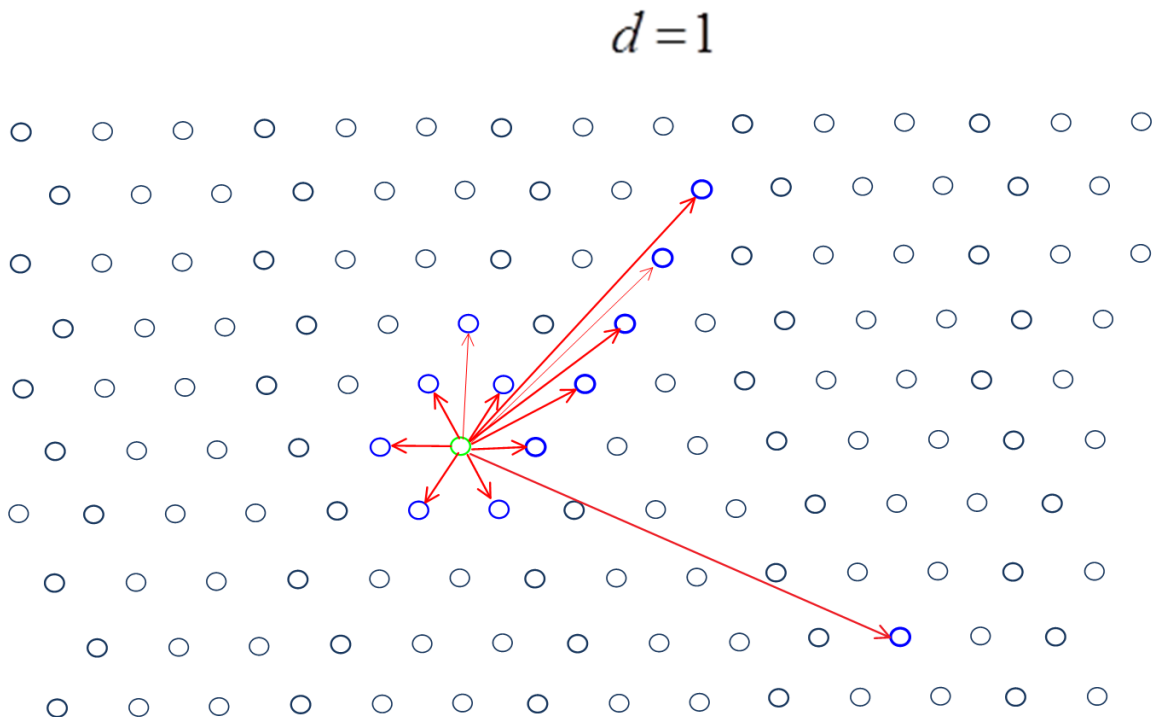


Figure 1

represents a *preon*⁽⁻⁾ arbitrarily chosen as origin and the blue circles represent *preons*⁽⁻⁾ which are all at one unit of distance from it. As we can see, distance in quantum-geometrical space at

the fundamental scale is hugely different from Euclidian distance (though we will show below that Euclidian geometry emerges from quantum-geometrical space at larger scales).

Quantum-geometric space is not merely mathematical or geometrical but physical. Because of that, to distinguish it from quantum-geometrical space, we will refer to space in the classical sense of the term as *Euclidian space*.

Quantum-geometric space is different from Euclidean space. A consequence of this is that the distance between any two $preons^{(-)}$ in quantum-geometric space is very different from the measure of the distance using Euclidian space; the distance between two points or $preons^{(-)}$ being equal to the number of leaps a $preon^{(+)}$ would need to make to move from one to the other.

To understand quantum-geometric space, one must put aside the notion of continuous infinite and infinitesimal space. Quantum-geometrical space emerges from the n-gravity interactions between $preons^{(-)}$. What that means is that $preons^{(-)}$ do not exist in space, they are space. Since $preons^{(-)}$ are fundamental and since QGD is founded on the principle of strict causality (this will be discussed in detail later), then the n-gravity field between $preons^{(-)}$ has always existed and as such may be understood as instantaneous. N-gravity does not propagate. It simply exists.

Figure 2 shows another example of how the distance between two $preons^{(-)}$ is calculated. So, although the Euclidian distance between the green $preon^{(-)}$ and any one of the blue $preons^{(-)}$ are nearly equal, the quantum-geometrical distances between the same varies greatly.

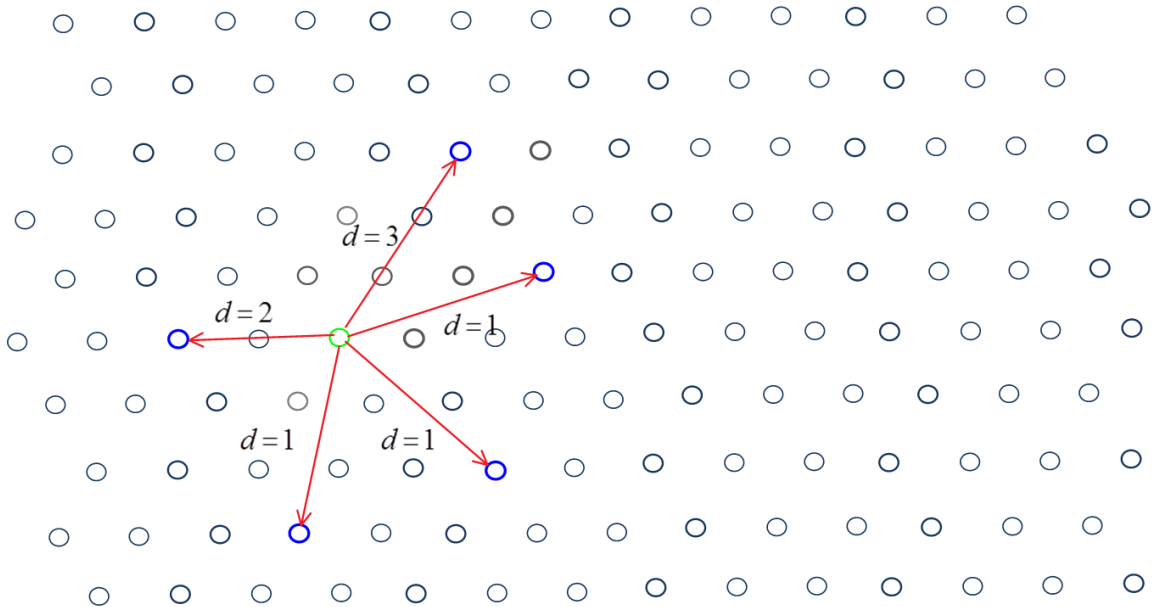


Figure 2

Since the quantum-geometrical distances do not correspond to the Euclidian distances, the theorems of Euclidean geometry do not hold at the fundamental scale. Trying to apply Pythagoras's theorem to the triangle which in the figure 3 below defined by the blue, the red and the orange lines, we see that $a^2 + b^2 \neq c^2$.

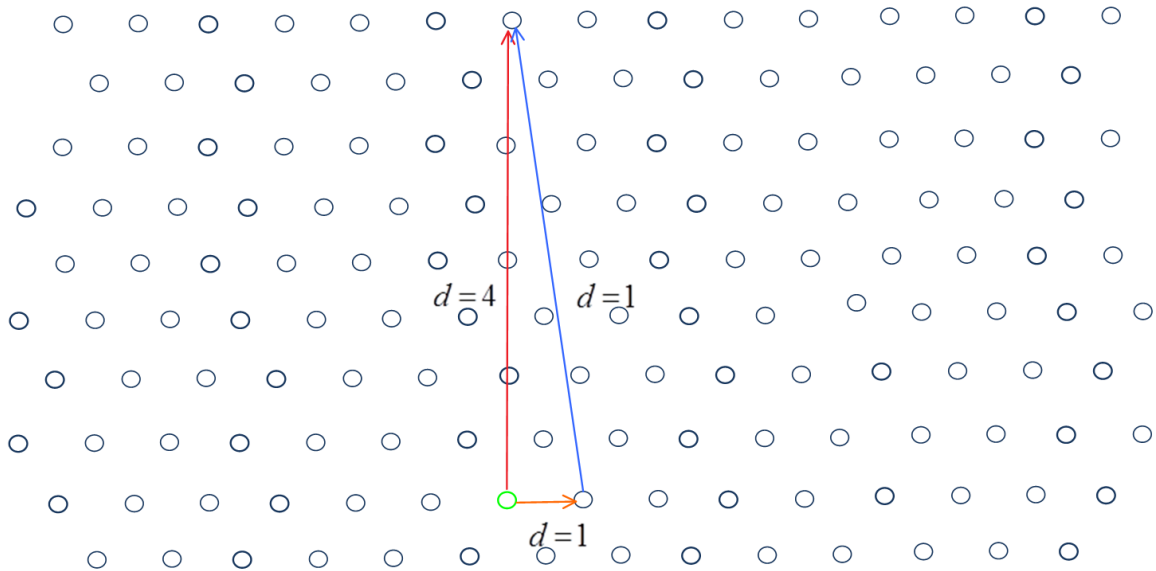


Figure 3

Also interesting in figure 3 is that if a is the orange side, b the red side and c the blue side (what would in Euclidian geometry be the hypotenuse), then $a + c < b$. That is, the shortest distance between two $preons^{(-)}$ is not necessarily the straight line.

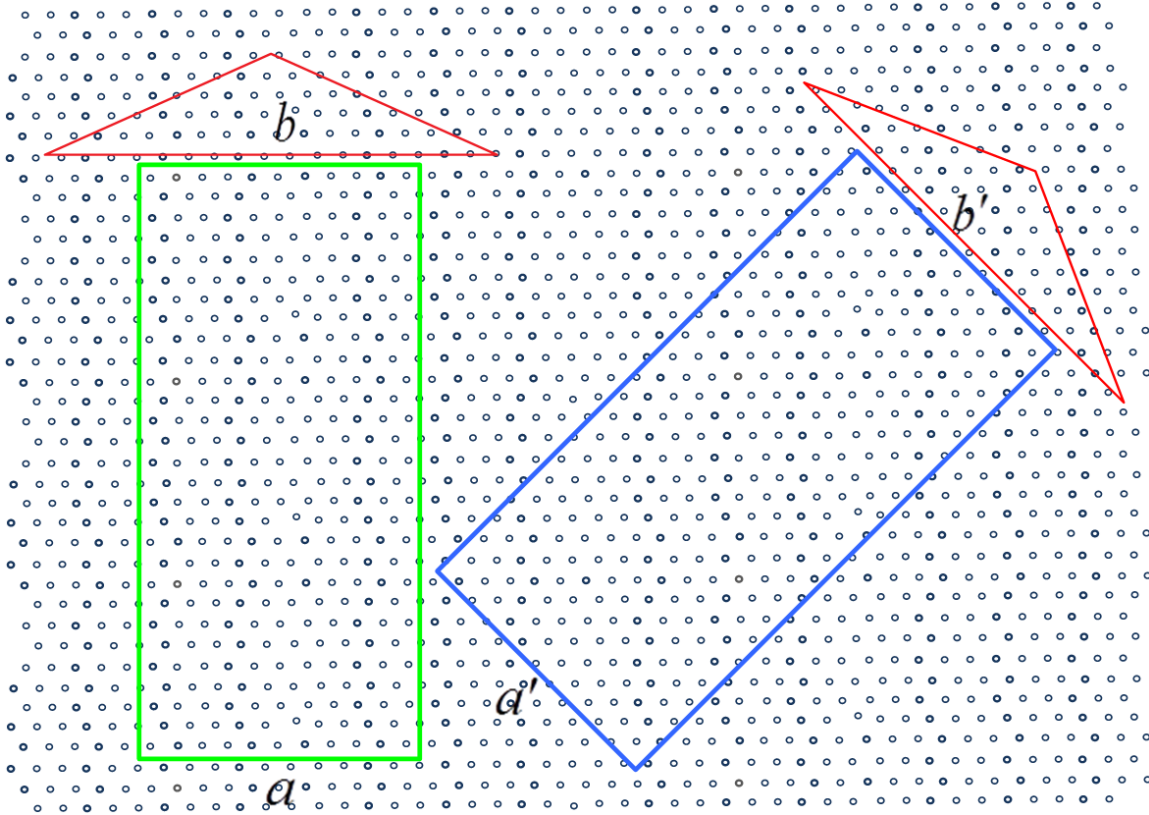


Figure 4

But we evidently live on a scale where Pythagoras's theorem holds, so how does Euclidian geometry emerge from quantum-geometrical space? Figure 4 shows the quantum-geometrical space two identical objects scan when moving in different directions.

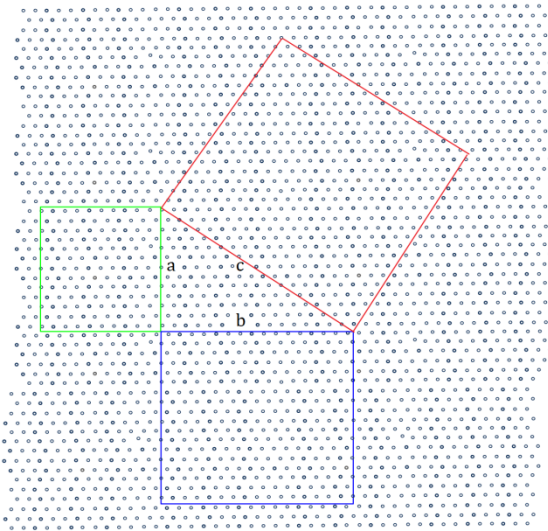
Here, if we consider that the area in the blue rectangles is made of all the $preons^{(-)}$ through which the object moves, we see that as we move to larger scales, the number $preons^{(-)}$ contained in the green rectangle approaches the number of $preons^{(-)}$ in the blue rectangle, so that if the distance from a to b or from a' to b' is defined by the number of $preons^{(-)}$ contained in the respective rectangles divided by the width of the path, we find that $a \rightarrow b \simeq a' \rightarrow b'$.

Theorem on the Emergence of Euclidian Space from Quantum-Geometrical Space

If d and d_{Eu} are respectively the quantum-geometrical distance and the Euclidean distance two $preons^{(-)}$, then $\lim_{d \rightarrow \infty} d - d_{Eu} = 0$.

The theorem implies that beyond a certain scale the Euclidian distance between two points becomes a good approximation of the quantum-geometrical distance, but that below that scale, the closer we move towards the fundamental scale, the greater the discrepancies between the Euclidian and quantum-geometrical measurements of distance. A direct consequence of the structure of space and the derived theorem is that Euclidean geometric figures are ideal objects that though they can be conceptualized in continuous space can only be approximated in quantum-geometrical space to the resolution corresponding to the fundamental unit of distance.

It is important to note that since there are no infinities in QGD, the infinite sign ∞ is the distance



between the two *preon*⁽⁻⁾ that are furthest apart in the universe, hence the difference between quantum-geometrical and Euclidean distances, though it can very large or insignificantly small, can never be infinite or equal to zero.

In figure 5, if n_1 , n_2 and n_3 are respectively the number of parallel trajectories that sweep the squares a , b and c , for $n_{1-3} > M$, then

$$\bar{a} \approx \frac{\sum_{i=1}^{n_1} d_i}{n_1}, \quad \bar{b} \approx \frac{\sum_{i=1}^{n_2} d_i}{n_2} \text{ and } \bar{c} \approx \frac{\sum_{i=1}^{n_3} d_i}{n_3} \text{ so that}$$

$\bar{a}^2 + \bar{b}^2 \approx \bar{c}^2$. Hence, given the quantum-geometrical length of the sides of any two of the

three squares above, Pythagoras's theorem can be used to calculate an approximation of a the length of the side of the third. Also, the greater the values of n_1 , n_2 and n_3 the closer the approximation will be to the actual unknown length. That is $\lim_{\substack{n_1 \rightarrow \infty \\ n_2 \rightarrow \infty \\ n_3 \rightarrow \infty}} (\bar{a}^2 + \bar{b}^2) = \bar{c}^2$.

Application of the Theorem of Emergent Space

Even though reality at the fundamental scale is discrete, the theorem of emergence of Euclidean space allows us to use of continuous mathematics to describe dynamic systems at larger scales. We must however keep in mind that however accurate they may be, calculations using continuous mathematics remain approximations of the behaviour of the discrete components that form dynamics systems taken as a group and that quantum-geometrical reality only admits integer values of physical properties.

Interactions between Preons⁽⁻⁾

We mentioned earlier that the interactions between two adjacent *preons*⁽⁻⁾ is repulsive and the fundamental unit of n-gravity. Two *preons*⁽⁻⁾ are adjacent if there is no other *preons*⁽⁻⁾ between them. So for two *preons*⁽⁻⁾, *a* and *b*, $G(a;b) = 1 g^-$ where $G(a;b)$ is the magnitude of the n-gravity interaction between them.

To obtain the magnitude of the n-gravitational interaction between any two *preons*⁽⁻⁾ *a* and *b*, we need to take into account the cumulative interactions between the *preons*⁽⁻⁾ that lie on the line of force connecting them. Thus, we need to count the number of interactions. Using the simple combinatory formula, we find that the magnitude of the n-gravitational interaction between any two *preons*⁽⁻⁾ is

$$G^-(a;b) = \frac{d^2 + d}{2} g^- \quad (1)$$

where *d* is the distance measure in number of *preons*⁽⁻⁾ between *a* and *b*.

We will show in a [later section](#) that the repulsive force between space and matter is consistent with the effect we attribute to dark energy.

Properties of Preons⁽⁻⁾

Preons⁽⁻⁾ do not exist in space, they are space. Since any motion would imply that they would themselves be in space, which would contradict the 1st axiom, it follows that *preons*⁽⁻⁾ must be static.

And since they are fundamental, *preons*⁽⁻⁾ do not decay into other particles, so the number of *preons*⁽⁻⁾ is finite and constant which implies that quantum-geometrical space is finite, and that the Universe is finite.

Emerging Space and the Notion of Dimensions

We think of spatial dimensions as if they were physical in the way matter and space are physical, but the concept of dimensions is a relational concept which allows us to describe the motion (even if that motion is nil) of an object or set of objects *a* relative to an object or set of objects *b* taken as a reference. Different systems of reference having directions and speeds relative to a given object or set of objects give different measurements of their positions, speed, mass and momentum and, according to dominant physics theories, there is no way to describe the motion of a reference system relative to space (or absolute motion), thus no way to know anything but relative measurements of properties are such as mass, energy, speed, momentum or position.

However, if QGD is correct in its description of space, then each fundamental unit of space is a distinct permanent position relative to all other discrete components of space (*preons*⁽⁻⁾ being static) so that quantum-geometrical space can be taken as an absolute reference system.

The dimensionality of quantum-geometrical space (physical space) is the maximum number of elements in a set of non-concurrent and mutually orthogonal lines that have a common a *preon*⁽⁻⁾. Space being an emergent property of *preons*⁽⁻⁾ and all *preons*⁽⁻⁾ having identical fundamental intrinsic properties, and all interacting to create space, then space must be isotropic.

Conservation of Space

That quantum-geometrical space is not infinitesimal also implies that geometric figures are not continuous either. For example, a circle in quantum-geometric space is a regular convex polygon whose form approaches that of the Euclidian circle as the number of *preons*⁽⁻⁾ defining its vertex increases. That is, the greater the diameter of the polygon, the more its shape approaches that of the Euclidean circle (a similar reasoning applies for spheres).

The circumference of a circle in quantum-geometric space is equal to the number of triangles with base equal to 1 leap which form the perimeter of the polygon. It can also more simply be defined as the number of *preons*⁽⁻⁾ corresponding to the polygon's vertices.

Since both the circumference of a polygon and its diameter have integer values, the ratio of the first over the second is a rational number. That is, if we define π as the ratio of the circumference of a circle over its diameter, then π is a rational function of the circumference and diameter of a regular polygon.

This implies that in quantum-geometric space the calculation of the circumference or area of a circle or the surface or volume of the sphere can only be approximated by the usual equations of Euclidian geometry.

The surface of a circle would be equal to the number of *preons*⁽⁻⁾ within the region enclosed by a circular path.

From the above we understand that π , the ratio of the circumference of a circle over its diameter, is not a constant as in Euclidean geometry, but a function. If $\pi(a)$ is the proportionality function between the apothem a of the polygon and its perimeter then, since the base of the triangles that form the perimeter is equal to 1, it follows that the size of the polygon increases the value of the apothem of the polygon approaches the value of its circumradius and $\pi(a)$ approaches the geometrical value of π . Note that the smallest possible circumradius is equal to 1 leap, which defines the smallest possible circle which has six vertexes. Since in this case $2\pi r = 6$ and $r = 1$ it follows that $\pi(1) = 3$ $\pi(1) = 3$.

$$\pi(a) = n / 2a$$

$$\lim_{a \rightarrow \infty} \pi(a) = \pi$$

where n is the number of sides of the polygon and ∞ is a very large number of the order of the quantum-geometrical diameter of a circle at our scale (QGD doesn't allow infinities).

So, within quantum-geometrical space, the geometrical π is a rational number that corresponds to the ratio of two extremely large integers. In fact, the size of the numerator and denominator are such that the decimal periodicity of their ratio is too large for any current computers to express.

Mathematical operations in quantum-geometry always are carried out from discrete units and can only result in discrete quantities.

In conclusion, the reader will understand that if space quantum-geometrical, then the mathematics used to describe it and the objects it contains must also be quantum-geometrical. Continuous mathematics, though it can provide approximations of discrete phenomena at larger than fundamental scales, becomes inadequate the closer we get to the fundamental scale.

The Concept of Time

Although time is a concept that has proven useful to study and predict the behaviour of physical systems (not to mention how, on the human level, it has become an essential concept to organize, synchronize and regulate our activities and interactions) it remains just that, a concept.

Time is a relational concept that allows us to compare events with periodic systems, in other words, clocks. But time has no more effect on reality than the clocks that are used to measure it. In fact, when you think of it, clocks do not really measure time. Clocks count the number of recurrences of a particular state of a periodic system. For instance, the number of times the pendulum of a clock goes back to a given initial position following a series of causality linked internal states. So, clocks do not measure time, they count recurrent states or events.

If clocks do not measure time, what does?

That answer is nothing can. There has never been nor will there ever be a measurement of time the simple reason that time is non-physical. Neither has there been nor ever will be a measurement of a physical effect of time on reality. Experiments have shown that rates of atomic clocks are affected by [velocity](#) and [gravity](#) but the [slowing down of clocks](#) is not a slowing of time, but a slowing down the mechanism of clocks itself measured by comparing them to the rate of a reference clock.

Another argument against the physicality of time is that as useful as the concept of time may be, it is not, as generally believed, essential to modeling reality. As we will see in the following sections, any physical systems can be described without ever referring to time. If time is unnecessary to describe reality, it follows that time is not physical. Taking time as non-physical also removes a number of problems that stems from considering time as a physical dimension.

For instance, we will show that properties such as mass, momentum, velocity, and energy are fundamentally intrinsic and that they can be described without the concept of time. Consequently, these properties will be shown to be observer independent. That is, measurements of those properties will give identical results regardless of the frame of reference provided that the measurements take into account the dynamics describing the observer and frame of reference.

And if time is not physical, then neither is time dilation. Time dilation and the implied assumption of space continuum are essential to explain the constancy of the speed of light in special relativity. But neither are necessary in QGC since the [constancy of the speed of light](#) follows naturally from the discreteness of space.

Finally, the unification of space (a representation of space to be precise) and time (which is a relational concept) is no more than a mathematical construct, granted a useful framework in which we can study the evolution of a system, if time is not physical, then physical space-time makes no sense.

However, as we have mentioned, the concept of time is useful, and we will use it here, but we will do so with the understanding that time is not a physical dimension through which reality evolves. It is a mathematical representation of evolution of dynamic systems.

The Quantum-Geometrical Nature of Matter

If space is discrete, then matter, which exists in quantum-geometrical space must also be discrete. Not only must it be discrete, but it must fit the discrete structure of quantum-geometrical space. That is, it should correspond to the amount of matter which can occupy the quantum of space that is the $preon^{(-)}$. We assigned the name $preon^{(+)}$, symbol $p^{(+)}$, to the fundamental particle of matter. QGD assumes that the $preon^{(+)}$ is the only fundamental particle of matter, hence all other particles are composed of $preons^{(+)}$.

$Preons^{(+)}$ are fundamental so, to keep in agreement with our definition of what constitutes a fundamental particle, they neither decay into other particles nor are composed of other particles, and as a consequence they are conserved throughout the entire existence of the universe. This implies that the amount of matter of the universe remains constant and finite throughout its existence.

Also, in the same way that the interactions between two $preons^{(-)}$ is the fundamental unit of n-gravity or g^{-} , the interactions between two $preons^{(+)}$ is the fundamental unit of p-gravity or g^{+} . Here however, while n-gravity is a repulsive force acting between $preons^{(-)}$ from which emerges quantum-geometrical space, p-gravity is an attractive force acting between $preons^{(+)}$ ⁴.

In addition to carrying the fundamental force of p-gravity, $preons^{(+)}$ are strictly kinetic particles and as such have momentum. The properties of fundamental particles must evidently also be fundamental, so the momentum of a $preon^{(+)}$ is fundamental, that is, it never changes. Also fundamental is the fundamental velocity of the $preon^{(+)}$ which as we will see must be deduced from its momentum using QGD's definition of velocity we will introduce later and shown to be equal to the speed of light.

Preon⁽⁺⁾ | Preon⁽⁺⁾ pairs

If $preon^{(-)}$ are the fundamental unit of space, then each one must hold exactly one fundamental unit of matter. If a $preon^{(-)}$ could hold n $preons^{(+)}$ then the fundamental unit of space with

⁴ We will show in the section about the formation of particles how p-gravity binds $preons^{(+)}$ into particles and structures.

be $\frac{preon^{(-)}}{n}$ or one n^{th} of a $preon^{(-)}$ which would be inconsistent with axiom 1. Therefore, there is the *exclusion principle* by which a $preon^{(-)}$ can only host a single $preon^{(+)}$.

The $preon^{(+)}$ is strictly kinetic and moves by leaping from $preon^{(-)}$ to $preon^{(-)}$. If it exists, it must occupy space and so transitorily must pair with $preons^{(-)}$ along its path. And since $preons^{(-)}$ and $preons^{(+)}$ are fundamental, that is, they and their intrinsic properties are conserved, $preon^{(-)} | preon^{(+)}$ pairs must interact with each other through both n-gravity and p-gravity.

Propagation

Propagation implies motion; the displacement of matter ($preons^{(+)}$) through quantum-geometric space. A $preon^{(+)}$ a will leap from the $preon^{(-)}$ it is paired with to the next adjacent $preon^{(-)}$ in direction of its momentum vector \vec{P}_a .

$$Two\ preons^{(-)}\ p_1^{(-)}\ and\ p_2^{(-)}\ are\ adjacent\ if\ G(p_1^{(-)}; p_2^{(-)}) = -1 .$$

The preonic leap is the fundamental unit of displacement and determines the fundamental speed of $preons^{(+)}$. We will show that the speed of light and its constancy are direct consequence of the structure of quantum-geometrical space and the speed of $preons^{(+)}$.

Interaction

Interactions through n-gravity and p-gravity do not require the displacement or exchange of matter. So unlike propagations, interactions are not mediated by quantum-geometric space ($preons^{(-)}$).

We already explained that quantum-geometric space emerges from the interactions between $preons^{(-)}$; the n-gravity field between them. N-gravity does not propagate through quantum-geometric space since it generates it. It follows that n-gravity is instantaneous.

P-gravity, the force acting between $preons^{(+)}$ is similarly instantaneous and, as we will see later, gravity must be the resultant effects of n-gravity and p-gravity.

Mass, Energy, Momentum of Particles and Structures

We will now derive the properties of mass, energy, momentum, and velocity from the axiom set of QGD.

Mass

The fundamental units of matter are $preons^{(+)}$. The mass of any particle or structure is an intrinsic property and corresponds to the number of $preons^{(+)}$ that compose it.

We will show that this simple and natural definition of mass is the only one required to describe any physical system.

Also, as an intrinsic property, mass is observer independent (see here for the way by which we can obtain the intrinsic mass of an object).

Energy

The fundamental unit of energy corresponds to the kinetic energy of the $preon^{(+)}$ which is equal to the magnitude of its momentum vector \vec{c} . That is $E = \left\| \vec{P}_{p^{(+)}} \right\| = \left\| \vec{c} \right\| = c$.

Note that we use the symbol c because, as we will show, the fundamental energy of a $preon^{(+)}$ is numerically equal its momentum and to its speed, the latter being equal to the speed of light.

From our definitions of mass and energy, we find that the energy E_a of an object a is equal product its mass m_a (the number of $preons^{(+)}$ it contains) by the fundamental energy of the $preon^{(+)}$. That is:

$$E_a = \sum_{i=1}^{m_a} \left\| \vec{c}_i \right\| = m_a c \quad (2)$$

For a single $preon^{(+)}$ we have $m_{p^{(+)}} = 1$ so $E_{p^{(+)}} = \left\| \vec{c}_i \right\| = c$.

Momentum

The momentum vector of a $preon^{(+)}$ is fundamental. It never changes magnitude, but when bound within a structure $preons^{(+)}$ follow bounded trajectories. That is, the directions of the component vectors change as they follow trajectories determined by the inner interactions acting between them.

The momentum of a body of a is the magnitude of its momentum vector $\vec{P}_a = \sum_{i=1}^{m_a} \vec{c}_i$, that is:

$$P_a = \left\| \vec{P}_a \right\| = \left\| \sum_{i=1}^{m_a} \vec{c}_i \right\| \quad (3).$$

But since $\max \left\| \sum_{i=1}^{m_a} \vec{c}_i \right\| = \sum_{i=1}^{m_a} \|\vec{c}_i\| = m_a c$ then $0 \leq \left\| \sum_{i=1}^{m_a} \vec{c}_i \right\| \leq m_a c$; the maximum momentum of an body is equal to its energy which occurs in structures when the trajectories of bound *preons*⁽⁺⁾ are parallel.

Velocity

The velocity of a particle or structure follows naturally from QGD's axiom set and corresponds to the ratio of its momentum vector over its mass. That is:

$$\vec{v}_a = \frac{\sum_{i=1}^{m_a} \vec{c}_i}{m_a} \quad (4) .$$

And since both momentum and mass are intrinsic, thus frame independent, so it must be of velocity. We'll call the speed as defined in equation (4) as the *intrinsic speed*.

Therefore, the conventional definition of velocity is not a measure of the intrinsic velocity, but really a measure of the distance travelled by an object in a given direction concurrently with the counting a chosen number of recurring states of a periodic system (the tics of a clock for example). As for the distance travelled, we understand that it is relative to the frame of reference against which the measurement is made. To distinguish is from QGD's intrinsic velocity, we will refer to the conventional velocity as the *relative metric velocity*.

From the [section on the nature of space](#) we understand that quantum-geometrical space is a fixed structure and as such provides an absolute frame of reference. Using quantum-geometrical space as a frame of reference, we define *metric velocity* as the quantum geometrical distance an object will travel as a function of time or $\overset{\mapsto}{v}_a = \frac{d}{t} \vec{u}$ where $\overset{\mapsto}{v}_a$ is the metric velocity, d is the quantum-geometrical distance measured in *preons*⁽⁻⁾ (or preonic leaps between the initial and final position), t is the counted number of recurrences of a chosen state of arbitrarily chosen periodic systems and \vec{u} is the unit vector.

The intrinsic velocity \vec{v} is distinct from the metric velocity $\overset{\mapsto}{v}$. The first is a physical property while the second is a correlation between two distinct counting mechanism which are the count of the number of units of distance and a concurrent count of the number of recurrences of a chosen state of a periodic system. The intrinsic velocity is a property of the particle or structure independent of space. Metric velocity is the measure of the consequential displacement resulting from the intrinsic velocity. That is, $\overset{\mapsto}{v}_a \propto \vec{v}_a$.

Now that we have defined metric velocity and shown its relation to intrinsic velocity, the most important question that comes to mind is: How do we measure the metric velocity of an object?

We only know how to measure the velocity of an object relative to a second object. The measurement of the velocity of an object relative to space itself appears to be an impossibility since there is no way that using conventional methods we can know if an object is moving relative to a fixed point in space, or at what speed and in what direction if it is.

As a physics theory, quantum-geometry dynamics must describe and explain the behaviour of dynamic systems and provide testable predictions. This implies measurements of metric velocity, mass, and momentum. It is true that measurements of the metric velocity as defined earlier is not theoretically possible but that is exactly the point. The obstacle to measurements of metric velocity is not technical or technological but theoretical. In the following sections we will derive the theoretical framework necessary for such measurements, then, in the section on applicability of QGD, we will describe how such measurements can be made.

The Velocity of Light and Preons⁽⁺⁾

Using QGD's definition of velocity we find that the intrinsic velocity of a photon γ is

$$\vec{v}_\gamma = \frac{\vec{P}_\gamma}{m_\gamma} = \frac{\sum_{i=1}^{m_\gamma} \vec{c}_i}{m_\gamma} = \frac{m_\gamma \vec{c}}{m_\gamma} = \vec{c} \text{ which is the velocity of the } preon^{(+)}. \text{ From this we see that the}$$

intrinsic velocity of light is constant, and its constancy is a direct consequence of the fundamental property that is the intrinsic velocity of *preons*⁽⁺⁾.

Also, since $v_\gamma \propto \vec{v}_\gamma$, then the constancy of the intrinsic velocity of photons implies the constancy of their metric velocity. However, the constancy of the metric velocity of light implies that the relative velocity of light is not constant.

Consequently, we can predict that given an apparatus that includes a light source and a light detector separated by a constant distance, the one-way measurement of the velocity of light will

vary depending on the metric velocity of the apparatus. That is, $\vec{c} = \vec{c} + \vec{v}_a$ where \vec{c} is a one way

measurement of the velocity of light, \vec{c} is the metric velocity of light and, \vec{v}_a is the metric velocity of the apparatus.

However, for \vec{c} , two-way measurements of the velocity of light using a similarly rigid apparatus,

$$\text{we have } \vec{c} = \frac{\vec{c} + \vec{v}_a + \vec{c} - \vec{v}_a}{2} = \vec{c}. \text{ Two-way measurements of the velocity of light are therefore}$$

equal its metric velocity. This and the relation between intrinsic velocity and metric velocity make it possible for QGD to describe dynamic systems in nature and derive testable predictions if one-way measurement of the velocity of light are shown to be possible. We will describe such an

experiment the chapter titled [Deriving Testable Predictions from QGD](#) after having introduced the prerequisite theoretical concepts.

Heat, Temperature and Entropy

From the concepts we have introduced so far, we will now derive the properties of *heat*, *temperature*, and *entropy*.

Given a system S having n unbound particles, the heat of the system is equal to $\sum_{i=1}^n P_i$, where

P_i is the magnitude of the momentum vector of the i^{th} particle and its temperature is $\frac{\sum_{i=1}^n P_i}{Vol_S}$

.where Vol_S is the volume of the system measured in $preons^{(-)}$, the fundamental and discrete particle which forms and dimensionalizes quantum-geometrical space. The total energy of the system being equal to $\sum_{i=1}^n m_i c$, it follows that if we define entropy in the classical sense, then the

entropy of S is $\sum_{i=1}^n m_i c - \sum_{i=1}^n P_i$.

Application to Exothermic Reactions within a System

The QGD definitions can be used to describe the changes in heat and temperature resulting from chemical or nuclear reactions. The particles involved are different, as are the reaction mechanisms, and the reactions occur at different scales, but both result in changes in the structure and number of bound particles.

Consider $S_1 \rightarrow S_2$ where S_1 is a dynamic system containing n_1 unbound particles (or structures) some of which reacting with each other, and S_2 the resulting system containing n_2 unbound

particles, if $n_2 > n_1$ then $\sum_{i=1}^{n_1} P_i < \sum_{i=1}^{n_2} P_i'$ and the change in heat of the system

$\Delta H = \sum_{i=1}^{n_2} P_i' - \sum_{i=1}^{n_1} P_i$ is positive.

For example, let say the system contains only a particle e^- and a particle e^+ which annihilate to

give n photons (γ), then $\Delta H = \sum_{i=1}^n m_{\gamma_i} c - (v_{e^-} m_{e^-} + v_{e^+} m_{e^+})$. Here, the difference in heat

depends on the speed of interacting electrons and is at the lowest when electrons achieve the speed of light; in which case $\Delta H = 0$. Note that from the QGD model, when electrons achieve c , internal motion stops, so that component $preons^{(+)}$ move in parallel trajectories.

Also, QGD predicts that electrons accelerated to c become indistinguishable from photons and become electrically neutral. The electrical charge of a particle is caused by internal motion of its

component $preon^{(+)}$ which interact with the preonic field (the free $preons^{(+)}$ populating quantum-geometrical space). Since all internal motion stop at speed c , the electron moving at that speed must lose their electric charge.

Also, worth nothing is that $\sum_{i=1}^n m_{\gamma_i} = m_{e^-} + m_{e^+}$ which implies that $E_{S_1} = E_{S_2}$, that is; mass and energy are conserved. This holds for all closed systems. So though it is believed that a nuclear reaction results in the conversion of mass into energy, according to QGD, it results in the freeing of bound particles which carry with them momentum, hence increase the heat of the system. Aside from the reaction mechanism, the only difference between exothermic chemical and nuclear reactions is in the type of particles that become free. For chemical reactions these particles are molecules, atoms and photons and for nuclear reactions, nuclei and other subatomic particles.

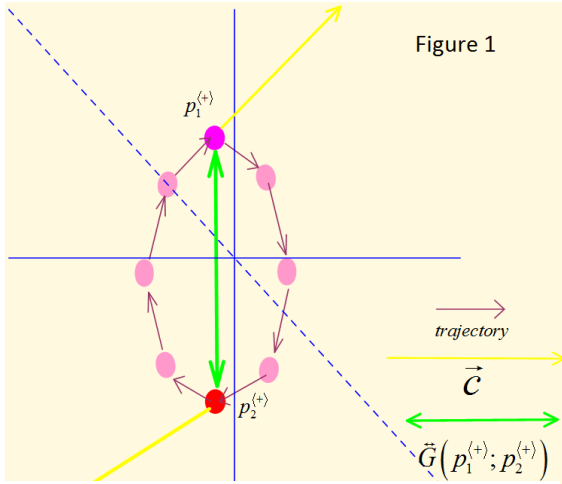
Physical Interpretation of the Equal Sign in Equations

$E_a = m_a c$, the equation relating energy and mass appears which is derived naturally from QGD's axiom set appears similar to Einstein's $E = mc^2$ (which itself reduces to $E = mc$ when the speed of light is taken as a unit). But there are essential distinctions between the two.

Einstein's equation is understood as an expressing the equivalence between mass and energy. That is, mass and energy are considered to be two forms of the same thing so mass can be converted to energy and vice versa. This interpretation implies that pure energy (photons) and pure mass can exist.

QGD's equation expresses a proportionality relation between distinct physical properties that cannot exist separately. All particles, including photons, are made of $preons^{(+)}$ and as we have seen their mass is simply the amount of matter they contain, that is, the number of $preons^{(+)}$ they are composed from. And since $preons^{(+)}$ have an intrinsic kinetic energy, it follows that the energy of a particle or structure is simply the number of $preons^{(+)}$ times their intrinsic energy or $E_a = m_a c$. The equal sign expresses the proportionality between an intrinsic property of matter and the energy associated with it. So according to QGD, it is a grave mistake to assume that the equal sign expresses physical equivalence.

QGD's $E_a = m_a c$ provides a different interpretation of nuclear reactions but one that is more consistent with observations. While the classical interpretation of Einstein's equation implies that nuclear reactions result in a certain amount of mass being transformed into energy, QGD model suggests is that during a nuclear reaction, mass is not transformed into energy, but rather, bound particles are freed from the structures they were bound into and carry with them their momentum. According to QGD, there is no conversion of mass into energy, but only the release of particles having momentum.



To illustrate this, let's consider the simple particle made of two bound *preons*⁽⁺⁾ as shown in the following figure 6.

Here the particle, which we'll denote *a* , is composed of two bound *preons*⁽⁺⁾, $p_1^{(+)}$ and $p_2^{(+)}$. The purple arrows represent their trajectories in quantum-geometrical space.

The energy of this particle is $E_a = \sum_{i=1}^{m_a} \|\vec{c}_i\| = m_a c = 2c$, and its momentum is $P_a = \left\| \sum_{i=1}^{m_a} \vec{c}_i \right\| = \|\vec{c}_1 + \vec{c}_2\| = 0$. This system has

zero momentum, hence cannot impart momentum to any other structure or particle.

But if as a result of a nuclear reaction the bound between the component *preons*⁽⁺⁾ of the particle was broken, the energy of this system would remain the same but the momentum of the system would be equal to the sum of the momentum of the now free *preons*⁽⁺⁾ . In this simple case, the momentum of the system would be equal to its energy $\left\| \vec{P}_{p_1^{(+)}, p_2^{(+)}} \right\| = \|\vec{c}_1\| + \|\vec{c}_2\| = 2c$. And the momentum that the system can impart is $2c$. The amount of mass and energy of this two *preons*⁽⁺⁾ system does not change because of a nuclear reaction. What changed is the momentum of the system which is interpreted the energy of the system and incorrectly attributed to a conversion of mass into energy. This will be discussed in detail in the appropriate sections of this book.

*

Another example in which it is the QGD interpretation of the equal sign is necessary is in special cases where the component *preons*⁽⁺⁾ of a particle or structure move on parallel trajectories.

In such case we find that that $P_a = \left\| \sum_{i=1}^{m_a} \vec{c}_i \right\| = \sum_{i=1}^{m_a} \|\vec{c}_i\| = E_a$. That is, for such special cases there

number of units of momentum found on the left is equal to the number of units of energy we have on the right. But though the number of units are equal, the units are units of different properties and we must always keep in mind that the units on the left are units of momentum while those on the right are units of energy. They may be numerically equal, but they represent two distinct properties.

Lastly, consider the properties of energy, momentum and speed of a single *preon*⁽⁺⁾.

$$E_{p(+)} = \sum_{i=1}^{m_{p(+)}} \|\vec{c}_i\| = \|\vec{c}\| = c \text{ units of energy}$$

$$P_{p(+)} = \left\| \sum_{i=1}^{m_{p(+)}} \vec{c}_i \right\| = \|\vec{c}\| = c \text{ units of momentum}$$

$$v_{p(+)} = \frac{\left\| \sum_{i=1}^{m_{p(+)}} \vec{c}_i \right\|}{m_{p(+)}} = \frac{c}{1} = c \text{ units of speed}$$

Here we have three distinct intrinsic properties which are quantitatively equal but qualitatively different. So though from the equation above we can derive $E_{p(+)} = P_{p(+)} = v_{p(+)} = c$ we have to remember that c is a fundamental quantity of several distinct fundamental properties.

The necessity of the distinction between mathematical and physical interpretations becomes evident since for most particles and structures $E_{p(+)} \neq P_{p(+)} \neq v_{p(+)}$.

The physical and mathematical interpretations of the relations between physical properties can differ significantly and ignoring such differences leads to incorrect assumptions about nature. For instance, in the section on optics, we will show that the quotient of a Euclidean division of the momentum of a photon over the mass of a particle corresponds to the absorbed part of the photon while the remainder of the operation is the reflected part. The physical interpretation of the mathematical must be derived from the theory's axioms.

Forces, Interactions and Laws of Motion

The dynamics of a particle or structure is entirely described by its momentum vector. The momentum vector can be affected by forces, which imply no exchange of particles. The momentum vector of a particle or structure can also be affected by interactions during which two or more particle of structures will exchange lower order particles or structures. These are non-gravitational interactions which result in momentum transfer or momentum exchanges.

We will show how all effects in nature result from one or a combination of these two types of interactions.

Gravitational Interactions and Momentum

Following QGD' axiom set, gravity is not a force but the combined effect of n-gravity and p-gravity. The gravity effect between two objects a and b is:

$\vec{G}(a;b) = \vec{G}^+(a;b) + \vec{G}^-(a;b)$ where $\vec{G}^+(a;b)$ is the p-gravity component of gravity and $\vec{G}^-(a;b)$ the n-gravity component.

To obtain $\vec{G}^-(a;b)$ we count the number of n-gravity interactions that exist between every $preon^{(+)}$ of a and every $preons^{(-)}$ of b and with all $preons^{(-)}$ in between. Using the simple combinatory formula, we find that the magnitude of the n-gravitational interaction is

$$\vec{G}^-(a;b) = m_a m_b \frac{d^2 + d}{2} \vec{g}^-$$

where d is the preonic distance between a and b given in $preons^{(-)}$ and \vec{g}^- the n-gravity unit vector.

$\vec{G}^+(a;b)$ is the number of p-gravity interactions between every $preon^{(+)}$ of a and every $preons^{(+)}$ b which is simply $\vec{G}^+(a;b) = m_a m_b \vec{g}^+$.

Now, from observation we know that $\|\vec{g}^+\| \gg \|\vec{g}^-\|$, that is $\|\vec{g}^+\| = k \|\vec{g}^-\|$ so that if we use $\vec{g}^- = -\hat{u}$ as base unit, where \hat{u} is the unit vector along the $[a, b]$ axis, we get:

$\vec{G}(a;b) = \left(m_a m_b k - m_a m_b \frac{d^2 + d}{2} \right) \hat{u}$ which we understand is attractive when $\vec{G}(a;b) > 0$ and

repulsive when $\vec{G}(a;b) < 0$ and neutral for $\vec{G}(a;b) = 0$.

Gravitational Dynamics

From our definition of momentum, we understand that a variation in gravitational interaction between two objects a and b translates into variations of their momentums. We have

$$\Delta \vec{P}_a = \Delta \vec{P}_b = \Delta \vec{G}(a;b) = \Delta \vec{G}^+(a;b) + \Delta \vec{G}^-(a;b).$$

Therefore, the gravitational accelerations of a and b are respectively $\Delta \vec{v}_a = \frac{\Delta \vec{G}(a;b)}{m_a}$ and $\Delta \vec{v}_b = \frac{\Delta \vec{G}(a;b)}{m_b}$.

Also, since $\Delta \vec{G}^+(a;b) = \vec{0}$ then

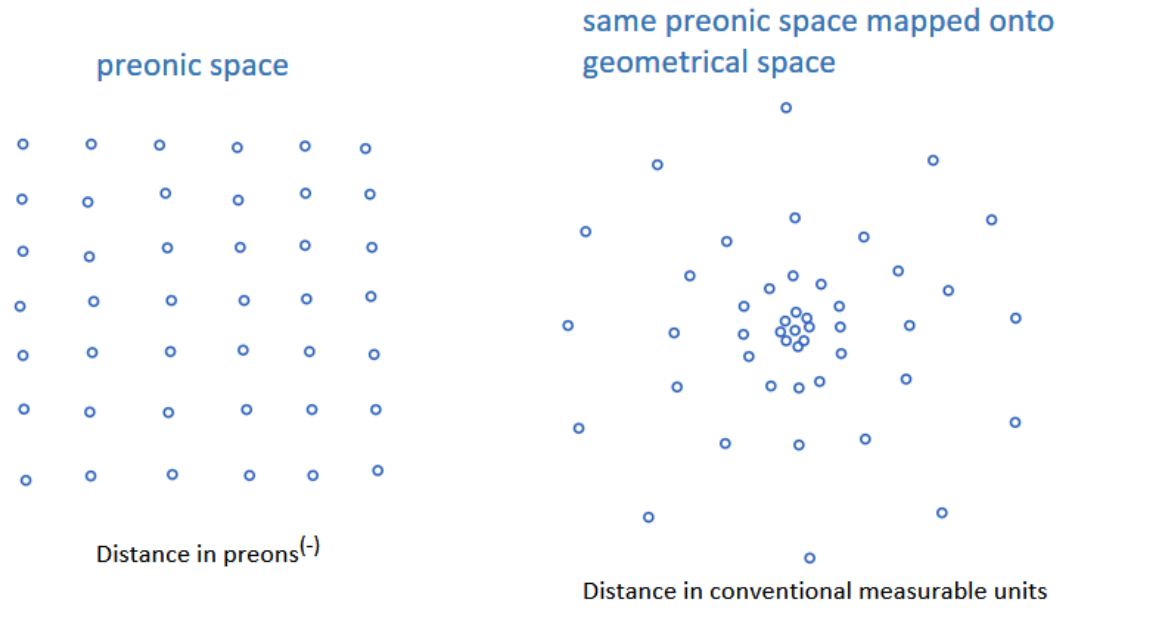
$$\Delta \vec{G}(a;b) = \Delta \vec{G}^-(a;b) \quad (1)$$

And

$$\Delta \vec{P}_a = \Delta \vec{P}_b = \Delta \vec{G}^-(a;b) \quad (2)$$

Derivation of Newton's Law of Gravity

To derive Newton's law of gravity from our minimal axiom set we must keep in mind that equation (1) describes gravity in preonic space while Newton's equation describes the effect of gravity in geometrical space (space as we observe it). Therefore, we must map preonic space, which is a regular grid, onto geometrical space.



Blue circles represent reference $preons^{(-)}$ of a region of preonic space with a massive object at its center.

This requires us to consider the preonic density. The concentration of matter in a body, which is a concentration of $preons^{(+)}$, decreases the n-gravity interaction with surrounding space and in accordance to equation (1) results in spatial density following the inverse square law.

Consequently, $d \propto dens_{preons^{(-)}} \propto \frac{1}{r^2}$ where d is the preonic distance and r is the geometrical distance from the center of a body. Substituting in equation (2) we get:

$$\Delta \vec{G}^{-}(a;b) \propto m_a m_b \frac{1}{r^2} \hat{u} \quad \mathbf{(3)}$$

which we recognize as Newton's law of gravity.

The reader may note from above that we may derive the geodesics of general relativity from the relation between preonic and geometrical space and have provided a mechanism for the curvature of space, which according to our model is a variation in preonic density resulting from the interaction between matter and preonic space.

One of the most interesting consequences of the above is that the first composite particles and structures would cause anisotropies in preonic space which in turn would have played a major role in the formation of increasingly more massive particles and material structures. Matter increases the preonic density, which in turn allow for higher geometrical density of matter. The ratio of p-gravity over n-gravity increases in a region containing matter, increases the preonic density, which concentrates matter, which increases preonic density. This cycle creates conditions favorable to the formation of increasingly more massive particles and structures.

The Fundamental Momentum and Gravity

That the momentum of the $preon^{(+)}$ is fundamental is a postulate of QGD. It is equal to $\|\vec{P}_{p^{(+)}}\| = \|\vec{c}\| = c$. In fact, of all properties of the $preon^{(+)}$, only its direction is variable. And the only thing that affects it is gravity.

The direction of a $preon^{(+)}$ is determined by the resultant of the gravitational interactions acting on it, which interactions are with free $preons^{(+)}$, particles or structures and if the $preon^{(+)}$ is bound, with the $preons^{(+)}$ that it is bound to.

A change in direction of a $preon^{(+)}$ is proportional to the change in the resultant of the forces acting on it. That is:

$\vec{P}_{p^{(+)}} = \vec{P}_{p^{(+)}} \vec{\mp}_{s_1 \rightarrow s_2} \Delta \vec{G}$ where $\Delta \vec{G}_{s_1 \rightarrow s_2} = \left(\sum_{j=1}^{m_a} \Delta \vec{G}(p_i^{(+)}; p_j^{(+)}) + \sum_{k=1}^n \Delta \vec{G}(p_i^{(+)}; a_k) \right)$ is the

resultant of the forces acting on the *preon*⁽⁺⁾ and $\vec{\mp}$ is the directional vector sum which we

define as
$$\vec{P}_{p^{(+)}} \vec{\mp}_{s_1 \rightarrow s_2} \Delta \vec{G} = \frac{\vec{P}_{p^{(+)}} + \Delta \vec{G}_{s_1 \rightarrow s_2}}{\left\| \vec{P}_{p^{(+)}} + \Delta \vec{G}_{s_1 \rightarrow s_2} \right\|} c = \vec{c}_{s_2}.$$

The directional vector sum describes the conservation of the momentum of the *preons*⁽⁺⁾. The result of the directional is the normalized vector sum of the momentum vector of the *preon*⁽⁺⁾ and the variations in gravity vector $\Delta \vec{G}$ between states s_1 and s_2 .

Newton's first law of motion is implied here since for $\Delta \vec{G} = 0$ we have $\vec{P}_{p^{(+)}} = \vec{P}_{p^{(+)}}$.

We will see how Newtonian gravity emerges from gravitational interactions at the fundamental scale.

Gravity between Particles and Structures

Astrophysical observations which we shall discuss later suggest that $k \gg 10^{100}$, so that at short distances, the number of n-gravitational interactions being very low, the magnitude of the n-gravity being over a hundred orders of magnitude weaker than p-gravity.

$$\vec{G}(a;b) = m_a m_b \left(k - \frac{d^2 + d}{2} \right)$$

The n-gravitational component of QGD equation for gravity is insignificant compared to the p-gravitational component. Gravity at short scales being over a hundred orders of magnitude stronger than at that at macroscopic scales, it is strong enough to bind *preons*⁽⁺⁾ into composite particles and composite particles into larger structures.

Bound *preons*⁽⁺⁾ form particles and structures which then behave as one body which dynamic

property is described by the momentum vector $\vec{P}_a = \sum_{i=1}^{m_a} \vec{c}_i$. That is $P_a = \left\| \vec{P}_a \right\| = \left\| \sum_{i=1}^{m_a} \vec{c}_i \right\|$. Because

of that, the dynamics of particles and structures can be described simply as the evolution of their momentum vector \vec{P}_a from state to state.

Particles and structures are in constant gravitational interactions with all particles and structures in the entire universe. The direction of the momentum vector of a particle or structure at any position is the resultant of its intrinsic momentum and extrinsic interactions. Hence, if the structure of a particle or structure and its interactions remain constant, so will its momentum vector. Changes in momentum are due to variations in the magnitude and direction of the gravitational interaction, hence due to variations in their positions.

For simplicity, we will start by describing the dynamics of a system consisting of two gravitationally interacting bodies.

Consider bodies a and b in state s_1 which interact gravitationally in accordance to the equation

$$\vec{G}_{s_1}(a;b) = m_a m_b \left(k - \frac{d^2 + d}{2} \right).$$

Change in the momentum vector of the bodies from s_1 to the next causally related state s_2 is $\Delta_{s_1 \rightarrow s_2} \vec{P}_a = \Delta_{s_1 \rightarrow s_2} \vec{G} = \vec{G}_{s_2}(a;b) - \vec{G}_{s_1}(a;b)$ so that

$$\vec{P}_{a,s+1} = \vec{P}_{a,s} + \Delta_{s+1} \vec{G}(a;b) \phi_a \quad \text{and} \quad \Delta_{s_1 \rightarrow s_2} \vec{P}_b = \Delta_{s_1 \rightarrow s_2} \vec{G} = \vec{G}_{s_2}(a;b) - \vec{G}_{s_1}(a;b) \quad \text{so that}$$

where s_2 is a successive state of our two body system.

Here $\phi_x = \left[\frac{c - v_x}{c} \right]$ preserves the fundamental limit of the momentum of a particle or structure

which we have shown cannot exceed its energy; that is: $\left\| \sum_{i=1}^{m_x} \vec{c}_i \right\| \leq \sum_{i=1}^{m_x} \|\vec{c}_i\|$. The bracket is the

ceiling function so that for $c < v_x$ we have $\left[\frac{c - v_x}{c} \right] = 1$ and $\Delta_{s_1 \rightarrow s_2} \vec{P}_x = \Delta_{s_1 \rightarrow s_2} \vec{G}(a;b)$ but for

$v_x = c$ we have $\left[\frac{c - v_x}{c} \right] = 0$ and $\Delta_{s_1 \rightarrow s_2} \vec{P}_x = 0$. And since the momentum of a particle or structure

cannot exceed its energy, its maximum speed is $\max v_x = \frac{\sum_{i=1}^{m_x} \|\vec{c}_i\|}{m_x} = \frac{m_x c}{m_x} = c$.

Note that for descriptions of dynamics system at speed below the speed of light, will simply

write $\vec{P}_{a,s+1} = \vec{P}_{a,s} + \Delta_{s+1} \vec{G}(a;b)$ and $\vec{P}_{b,s+1} = \vec{P}_{b,s} + \Delta_{s+1} \vec{G}(a;b)$ with the understanding that ϕ_x is implicit

and equal to 1.

Derivation of the Weak Equivalence Principle

At scales at which space is Euclidean, the weak equivalence principle or universality of free fall is easily derived from QGD's equation for gravity $G(a;b) = m_a m_b \left(k - \frac{d^2 + d}{2} \right)$ where m_a and m_b are respectively the masses of a and b and d the distance, all in natural fundamental units⁵.

According to QGD, the change in momentum due to gravity following the change in positions between two successive states s_1 and s_2 is equal to the gravity differential between the two positions $\Delta G(a;b)$. That is: $\left\| \frac{\Delta \vec{P}_a}{s_1 \rightarrow s_2} \right\| = \left\| \frac{\Delta \vec{G}(a;b)}{s_1 \rightarrow s_2} \right\|$.

QGD defines speed of a body as $v_a = \frac{\|\vec{P}_a\|}{m_a}$ and the acceleration of a body is $\Delta v_a = \frac{\|\Delta \vec{P}_a\|}{m_a}$. Since $\|\Delta \vec{P}_a\| = \Delta G(a;b)$, the acceleration of an object a due to the gravitational interacting between a and b is $\Delta v_a = \frac{\|\Delta \vec{P}_a\|}{m_a} = \frac{\|\Delta G(a;b)\|}{m_a}$

Since

$$\Delta G(a;b) = m_a m_b \left(k - \frac{d_1^2 + d_1}{2} \right) - m_a m_b \left(k - \frac{d_2^2 + d_2}{2} \right) = m_a m_b \left(\left(k - \frac{d_1^2 + d_1}{2} \right) - \left(k - \frac{d_2^2 + d_2}{2} \right) \right)$$

then

$$\Delta v_b = \frac{1}{m_a} m_a m_b \left(\left(k - \frac{d_1^2 + d_1}{2} \right) - \left(k - \frac{d_2^2 + d_2}{2} \right) \right) = m_b \left(\left(k - \frac{d_1^2 + d_1}{2} \right) - \left(k - \frac{d_2^2 + d_2}{2} \right) \right).$$

Therefore, gravitational acceleration of a body a relative a second body b is independent of the mass of the first and dependent on the mass of the second. Conversely, the gravitational acceleration of an object b relative to a is given by $\Delta v_b = m_a \left(\left(k - \frac{d_1^2 + d_1}{2} \right) - \left(k - \frac{d_2^2 + d_2}{2} \right) \right)$

⁵ The equivalence principle breaks down at non-Euclidean scales since

$$\left\| \vec{G}(a;b) \right\| = m_a m_b k - \sum_{\substack{i=1 \\ j=1}}^{m_b} \frac{d_{i,j}^2 + d_{i,j}}{2} \text{ where } d_{i,j} \text{ is the quantum-geometrical distance between } a_i \text{ and } b_j$$

b_j are respectively component *preons*⁽⁺⁾ of a and b and we may have $\Delta \vec{G}(a;b) \neq x m_a$.

is independent of m_b . So, regardless of their mass m_a , all bodies a will be accelerated relative to a given body b at the same rate.

We have shown that the weak equivalence principle is a direct consequence of QGD's equation for gravity which itself is derived from QGD's axiom set.

According to QGD, the momentum vector of object is an intrinsic property given by $\left\| \sum_{i=1}^{m_a} \vec{c}_i \right\|$ where

the mass, m_a , is the number of bounded $preons^{(+)}$ of a and each \vec{c}_i correspond to the

momentum vector of a bound $preon^{(+)}$. The speed of object is given by $\frac{\left\| \sum_{i=1}^{m_a} \vec{c}_i \right\|}{m_a}$.

Gravity affects the resultant trajectories of the component $preons^{(+)}$, which changes the momentum. The change in speed is a consequence of the change in momentum and not the reverse.

Given two object a and b both at the same distance from a massive structure, it is impossible to distinguish between them based on their respective acceleration, which makes acceleration the wrong property to measure if one wants to compare the effect of gravity on particles or structures.

Variations in the gravitational interaction affect directly and instantaneously the momentum of the interacting bodies. It is the variations in momentum that determine the variations in speed and not the reverse.

Note: Unlike classical or general relativity gravity, QGD gravity does not have an infinite attractive range. QGD's equation for gravity predicts that attractive gravity is dominant for $d < d_\Lambda$ and decreases with distance until $d = d_\Lambda$ at which distance attractive and repulsive components of gravity cancel each other and gravity becomes null. For $d > d_\Lambda$, the repulsive component of gravity becomes dominant, and gravity becomes repulsive and increases with distance.

So, a body b moving away from a body a will be gravitationally decelerated until it reaches a distance d_Λ , beyond which it will be accelerated from that distance on. Only an object with sufficient momentum can escape attractive gravity from a second object. If a and b are gravitationally interacting bodies, $\vec{P}_a > \Delta_{d \rightarrow d_\Lambda} \vec{G}(a;b)$, where d is the initial distance from which we make the calculation.

Comparison between the Newtonian and QGD Gravitational Accelerations

From $\Delta v_b = m_a \left(\left(k - \frac{d_1^2 + d_1}{2} \right) - \left(k - \frac{d_2^2 + d_2}{2} \right) \right)$ we have

$$m_b \Delta v_b = m_a m_b \left(\left(k - \frac{d_1^2 + d_1}{2} \right) - \left(k - \frac{d_2^2 + d_2}{2} \right) \right) = \Delta G(a; b) \text{ which is equivalent to Newton's}$$

second law of motion relating force, mass and acceleration $F = m \Delta v_a$ where $F = \Delta G(a; b)$.

The equations appear similar, and it would be tempting to equate Newton's second law and its QGD equation, but this cannot be done directly.

Newtonian gravity varies with distance and is time independent. However, Newton's second law of motion when applied to gravity ignores the distance dependency but treats the force as if it were constant. And most importantly, even though Newtonian gravity is instantaneous (as must be its effects) Newtonian mechanics introduces a time dependency on the effect of gravitational acceleration. The introduction of the time dependency of the gravitational acceleration is not in agreement with Newton's law of gravity. And while the time dependency approximates its dependency on distance (since $\Delta d \propto \Delta t$ and $\vec{v}_b \propto \vec{v}_b$ where \vec{v}_b is the classically defined speed) it introduces delays on the action which according to Newton's law of gravity does not exist.

Newton's second law of motion applied to gravity gives $\Delta \vec{v}_b = \frac{\vec{G}(a; b) \Delta t}{m_b}$ where $\vec{G}(a; b)$

represents the Newtonian force of gravity. Since the QGD equation is $\Delta \vec{v}_b = \frac{\Delta \vec{G}(a; b)}{m_b}$, it

follows that $\vec{G}(a; b) \Delta t \approx \Delta \vec{G}(a; b)$. But the assumed time dependency of the effect introduces a delay in the effect of gravity on the momentum of a body while it should be instantaneous. So

for Newtonian mechanics we have $\frac{\Delta \vec{v}_b}{\Delta t} = \frac{\vec{G}(a; b)}{m_b}$ while in QGD $\Delta \vec{v}_b = \frac{\Delta \vec{P}_b}{m_b} = \frac{\Delta \vec{G}(a; b)}{m_b}$. So

the Newton's law of motion introduces a delay of $\Delta t = \frac{m_b \Delta \vec{v}_b}{\vec{G}(a; b)}$.

Such delays of the effect of gravitational acceleration are very small since the distance between two positions in quantum-geometrical space is fundamental, and it would be difficult if not impossible to detect over short variations in distance, especially if there are no changes in direction of the gravitationally accelerated body. But over an astronomical number of changes in direction, such as experienced by a planet orbiting the sun, the predicted delays would add up to observable differences with the observed motion of the planet. As we will discuss in detail [later in this book](#) by removing the time dependency in accordance to QGD, Newtonian gravity correctly predicts the precession of the perihelion of Mercury.

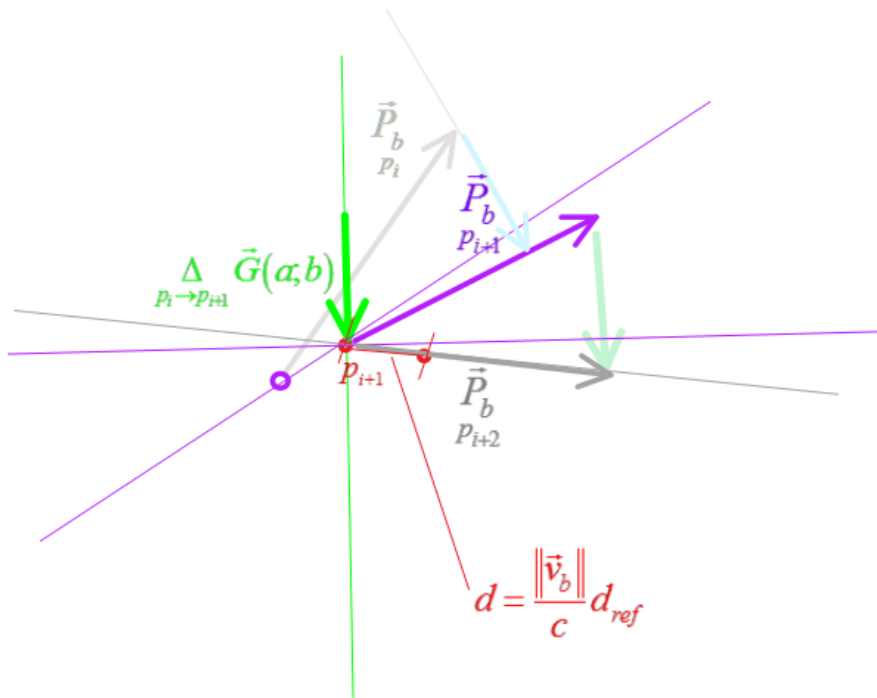
Therefore, the discrepancy between Newtonian mechanics' prediction of the motion of Mercury and observation is due to the time dependency introduced when using Newton's second law of motion; incorrectly making the effect of an instantaneous force dependent on time.

It is also interesting to note that the application of general relativity to the motion of Mercury (or other bodies) does the exact opposite since the effect of a change in position of a body in a gravitational field instantly changes its direction because it instantly follows the predicted geodesics. This may explain why general relativity correctly predicts the precession of the perihelion of Mercury.

Application to Celestial Mechanics

If gravity is instantaneous, then its actions are also instantaneous. Therefore, the momentum vector of body instantly changes to reflect all variations in gravitational interactions, hence a body is always at equilibrium. We will refer to this as the *principle of equilibrium*.

As we will see, the principle of equilibrium governs all dynamics of all gravitationally interacting system, thus will be central to QGD's description of the motion of gravitationally interacting celestial objects.



Therefore, the change in momentum of a body from one position to the next corresponds to the change in the instantaneous change in net magnitude of the forces acting on it between the two positions. We will now see how this applies to describe the motion of a planet orbiting a star.

From the principle of equilibrium it follows that at a position p_i the momentum of a body b gravitationally interacting with a body a is given by $\vec{P}_b_{p_{i+1}} = \vec{P}_b_{p_i} + \Delta \vec{G}(a,b)_{p_i \rightarrow p_{i+1}}$ where p_{i-1} is the

are in motion so since $\Delta_{p_{i-1} \rightarrow p_i} \vec{G}(a; b)$ is greater when the bodies move towards each other than when moving in opposite direction that the shape of the orbit around a moving body will be elliptical.

Also, since $\vec{v}_b = \frac{\vec{P}_b}{m_b}$ then $d = \frac{\|\vec{v}_b\|}{c} d_{ref} = \frac{\|\vec{P}_b\|}{m_b c} d_{ref} = \frac{\|\vec{P}_b\|}{E_b} d_{ref}$ which gives an interesting relation between the momentum and energy of b and the distance travelled. So for *preons*⁽⁺⁾, photons and neutrinos, since $\|\vec{P}_b\| = E_b$, $d = d_{ref}$.

An Important Distinction between QGD and other Gravity Theories

There is an important distinction between QGD's description of gravity or other theories of gravity in that it is not the magnitude of the gravitational interaction that causes gravitational acceleration but instantaneous variations in the gravitational vectors resulting from discrete changes in positions.

N-Body Gravitationally Interactions

For a system consisting of n gravitationally interacting bodies,

$$\Delta \vec{P}_{a_{i;s+1}} = \Delta \vec{G}_{j=1}^n(a_{i;s}; a_{j;s+1})$$

where a_i and a_j are gravitationally interacting astrophysical bodies of the system, $j \neq i$ and

$$\Delta \vec{G}_{j=1}^n(a_{i|s+1}; a_{j|s+1}) = \Delta \vec{G}_{s+1}(a_{i|s+1}; a_{1|s+1}) + \dots + \Delta \vec{G}_{s+1}(a_{i|s+1}; a_{n|s+1}) \text{ where}$$

$\Delta \vec{G}_{s+1}(a_{i|s+1}; a_{j|s+1}) = \vec{G}(a_{i|s+1}; a_{j|s+1}) - \vec{G}(a_{i|s}; a_{j|s})$ and s and $s+1$ are successive states of the system (a state being understood as the momentum vectors of the bodies of a system at given co-existing positions of the bodies) and $a_{i|s+x}$ is the body a_i and its position when at the state $s+x$. The position itself is denoted $\varepsilon_{a_i|s+x}$.

To plot the evolution in space of such a system, we must choose one of the bodies as a reference so that the motions of the others will be calculated relative to it. A reference distance travelled by our reference body is chosen, d_{ref} , which can be as small as the fundamental unit of distance (the leap between two *preons*⁽⁻⁾ or *preonic leap*) but minimally small enough as to accurately follow the changes in the momentum vectors resulting from changes in position and gravitational interactions between the bodies.

So given an initial state s , the state $s + 1$ corresponds to the state described by the positions and momentum vectors of the bodies of the system after the reference body travels a distance of d_{ref} . For simplicity, we will assign a_1 to the reference body.

$$s + 1 = \left\{ \begin{array}{l|l} \vec{P}_{a_1|s+1} = \vec{P}_{a_1|s} + \Delta \vec{G}_{j=1}^n(a_1|s; a_{j|s+1}) & \varepsilon_{a_1|s+1} \\ \dots & \dots \\ \vec{P}_{a_n|s+1} = \vec{P}_{a_n|s} + \Delta \vec{G}_{j=1}^n(a_n|s; a_{j|s+1}) & \varepsilon_{a_n|s+1} \end{array} \right\} \quad (5)$$

Using the state matrix, the evolution of a system from one state to the next is obtained by simultaneously calculating the change in the momentum vectors from the variation in the gravitational interaction between bodies resulting from their change in position. Changes in the momentum vectors have are as explained earlier. Changes in position are given by

$$\varepsilon_{a_i|s+1} = \varepsilon_{a_i|s} + \frac{v_{a_i}}{v_{a_1}} \frac{d_{ref}}{\|\vec{P}_{a_i}\|} \vec{P}_{a_i}. \text{ The distance travelled by } a_i \text{ from } s \text{ to } s+1 \text{ is } \frac{v_{a_i}}{v_{a_1}} d_{ref} \text{ (for } j=1,$$

the distance becomes simply d_{ref}) and distance between two bodies of the system at state $s + x$ is $d_{a_i;a_j|s+x} = \varepsilon_{a_i|s+x} - \varepsilon_{a_j|s+x}$. It is interesting to note here that that for $i = j$, then $d_{a_i;a_j|s+x} = 0$, so that

$$\begin{aligned} \Delta \vec{G}_{s+1}(a_{i|s+1}; a_{j|s+1}) &= \vec{G}(a_{i|s+1}; a_{i|s+1}) - \vec{G}(a_{i|s}; a_{i|s}) \\ &= m_a m_a \left(k - \frac{d^2_{a_i;a_i|s+1} - d_{a_i;a_i|s}}{2} \right) - m_a m_a \left(k - \frac{d^2_{a_i;a_i|s} - d_{a_i;a_i|s}}{2} \right), \\ &= m_a m_a k - m_a m_a k \\ &= 0 \end{aligned}$$

the variation in the gravitational interaction between a body with itself is equal to zero, which implies that its momentum vector will remain unchanged unless $n > 1$ and $\Delta \vec{G}_{j=1}^n(a_n|s; a_{j|s+1}) \neq 0$. This is the QGD derivation of the first law of motion.

Non-Gravitational Interactions and Momentum

The momentum of a particle or structure may also change as the result of absorption of particles.

For example, if a absorbs a photon λ then $\vec{P}_{a,s_2} = \vec{P}_{a,s_1} + \vec{P}_\lambda$. Similarly, if it emits a photon then

$\vec{P}_{a,s_2} = \vec{P}_{a,s_1} - \vec{P}_\lambda$. Note that depending of the relative direction of a and the absorbed photon, \vec{P}_{a,s_2} may be greater or smaller than \vec{P}_{a,s_1} .

The mass of particle or structure increases or is reduced by an amount that is equal to the mass of the absorbed or emitted photon (or other particles).

Since $v_{a,s_2} = \frac{\vec{P}_{a,s_1} + \vec{P}_\lambda}{m_a}$ and $\Delta v_{a,s_2} \approx \frac{\vec{P}_\lambda}{m_a}$ the acceleration is inversely proportional to the mass of the

object that is accelerated. Gravitational acceleration being independent of its mass, there is no equivalence between gravity and non-gravitational acceleration as suggested by Einstein's famous thought experiment. We will show that it is possible to distinguish the effect of gravity from constant acceleration because their effect on mass, momentum and energy are different for different bodies.

Transfer and Conservation of Momentum

Another consequence of the discreteness of space is that the momentum of an object a can only change by a multiple of its mass (each component $preon^{(+)}$ must overcome the effect of n-gravity which are discrete units). All changes in momentum obeys must obey the law $\Delta \vec{P}_a = x m_a \vec{\rho}$ where $\vec{\rho}$ is the momentum necessary to overcome one unit of n-gravity (g^-)

At the scale at which Euclidean space emerges, $\|\vec{G}(a;b)\| = m_a m_b \left(k - \frac{d^2 + d}{2} \right)$ so that gravitationally induced changes in momentum du to variations in gravity are proportional to the mass of the body subjected to it so that $\|\Delta \vec{G}(a;b)\| = x m_a \rho \|\Delta \vec{P}_a\| = x m_a \rho$.⁶

Gravity and variation in gravity between two objects are multiples of their masses of the object, but this is not the case for non-gravitational interactions.

For instance, the momentum of a photon will only in special cases be a multiple of the mass of the object it interacts with.

For instance, for an electron e^- and a photon γ , we have the three possibilities:

1. $\vec{P}_\gamma < m_e \vec{\rho}$ or
2. $\vec{P}_\gamma = m_e \vec{\rho}$ or
3. $\vec{P}_\gamma \geq m_e \vec{\rho}$ where $x \in N^+$

In case 1, the momentum of the photon is below the minimum allowed change in momentum of the electron. The photon cannot be absorbed (become bounded) and so will be reflected or refracted depending on its trajectory relative to the electron.

In case 2, the photon will be absorbed and all its $preons^{(+)}$ will become part of the electron's structure, the electron's mass will increase by m_γ its momentum by \vec{P}_γ .

In case 3, though the photon's momentum is greater than the minimum allowed change in momentum for a , absorption is not possible as it would imply a fractional change in the momentum of e^- and thus is forbidden. A fractional change in momentum would imply that

⁶ This is not necessarily the case for scales below Euclidean where $\|\vec{G}(a;b)\| = m_a m_b k - \sum_{i=1}^{m_b} \frac{d_{i,j}^2 + d_{i,j}}{2}$.

material structure could move in between *preons*⁽⁻⁾ which is not possible since there is no space which can hold them.

The electron can absorb the higher momentum (or energy since for photons $\|\vec{P}_\gamma\| = E_\gamma$) but to respect the $\Delta\vec{P}_e = m_e \vec{\rho}$ law it must simultaneously emit a photon γ' that will carry the excess momentum.

The emitted photon γ' is such that $\vec{P}_{\gamma'} = \vec{P}_\gamma - m_e \vec{\rho}$.

This, we shall see later, describes why atomic electrons can only absorb photons have specific momentum and thus explain the emission and adsorption lines of elements.

Momentum Conservation and Impact Dynamics

A postulate of quantum-geometry dynamics is that space is fundamentally discrete (quantum-geometrical, in QGD terms). If as QGD suggests the discreteness of space exists at a scale that is orders of magnitude smaller than the [Planck scale](#), then the fundamental structure of space (and matter) lies way below the limits of the observable.

That said, the discreteness of space and matter, as described by QGD, carries unique consequences observable at larger scales. In fact, the laws that govern the dynamics of large systems can be derived from the laws governing space and matter at its most fundamental.

We will now re-examine observations which, when interpreted by QGD, supports its prediction of the quantum-geometrical structure of space, more specifically, we will show the law of conservation of momentum at the fundamental scale explain the conservation of momentum at larger scales.

The Physics of Collision and Conservation of Momentum

Three laws govern the physics of collision:

1. So, two objects cannot occupy the same space at the same time (a consequence of the preonic exclusion principle).
2. The momentum of particles is conserved in non-gravitational interactions.
3. Changes in the momentum of an object is the product of a multiple of its mass by $\vec{\rho}$

$$\Delta\vec{P}_a = xm_a \vec{\rho}.$$

Case 1

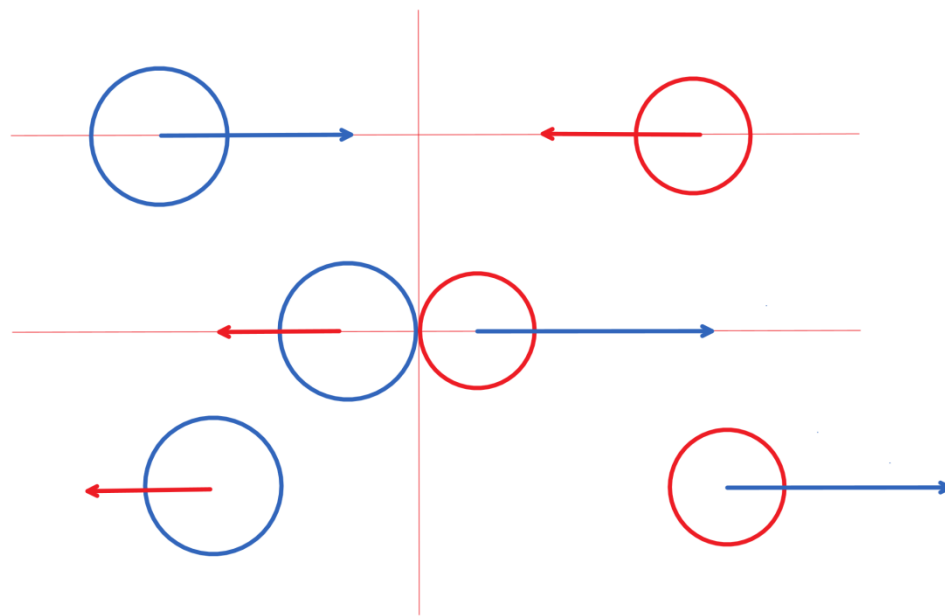
For simplicity, let *a* and *b* be two rigid spheres of same volume with momentum \vec{P}_a and \vec{P}_b , which are set on a direct collision course as in the figure below.

When the spheres reach the position of impact, the first law applies. Neither sphere can occupy that position. So, the spheres cannot move beyond the point of impact or, to be precise, the intersection of the volumes of the spheres along the line of impact, which is the line that passes through the centers of the spheres at impact.

To satisfy the second law, the spheres a and b in the simple example below must each emit photons whose momentums will be exactly those of a and b respectively. That is:

$$\sum_{i=1}^{n_a} m_{\gamma_i} c = \|\vec{P}_a\| \quad \text{and} \quad \sum_{j=1}^{n_b} m_{\gamma_j} c = \|\vec{P}_b\|$$

where n_a and n_b are respectively the numbers of photons emitted at impact by a and b .



The photons emitted by a will be absorbed by b , imparting it their momentum and the photons emitted by b will impart their momentum to a so that after impact

$$\vec{P}'_a = \sum_{i=1}^{n_b} m_{\gamma_i} c = \vec{P}_b \quad \text{and} \quad \vec{P}'_b = \sum_{i=1}^{n_a} m_{\gamma_i} c = \vec{P}_a$$

where \vec{P}'_a and \vec{P}'_b are respectively the momentums of a and b after impact.

As a result of the impact, the spheres will move in opposite direction at speed $v_a = \frac{\|\vec{P}_b\|}{m_a}$ and

$$v_b = \frac{\|\vec{P}_a\|}{m_b}.$$

Case 2

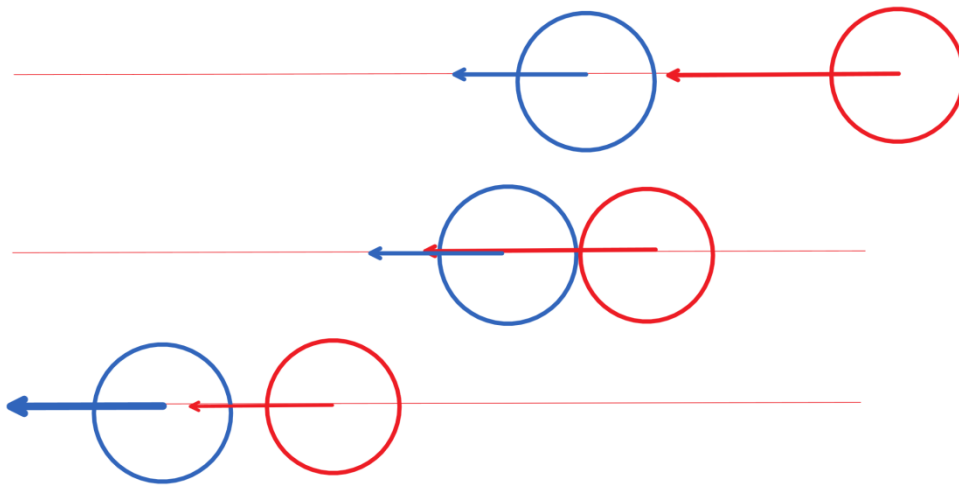
Consider two spheres of equal mass moving in the same direction as in the figure below.

Here, at the point of impact, the forbidden component of the momentum of a in direction of b is given by $(v_a - v_b)m_a$, but the component momentum of b in direction of a is equal to zero.

That is $\sum_{i=1}^{n_a} m_{\gamma_i} c = (v_a - v_b)m_a$ and $\sum_{j=1}^{n_b} m_{\gamma_j} c = 0$, hence after impact the momentums of a and

b will be

$$\begin{aligned} \|\vec{P}'_a\| &= \|\vec{P}_a\| - (v_a - v_b)m_a \\ &= \|\vec{P}_a\| - \left(\frac{\|\vec{P}_a\|}{m_a} - v_b \right) m_a \\ &= m_a v_b \end{aligned}$$



We can see that Newton's third law of motion is a direct consequence of the three laws governing collision physics but that it is not due, as Newton's third law implies, to the second body exerting a force equal magnitude and opposite direction, but to the loss of momentum of the first through the mechanism we have describe and which is equal to the momentum it imparts to the second

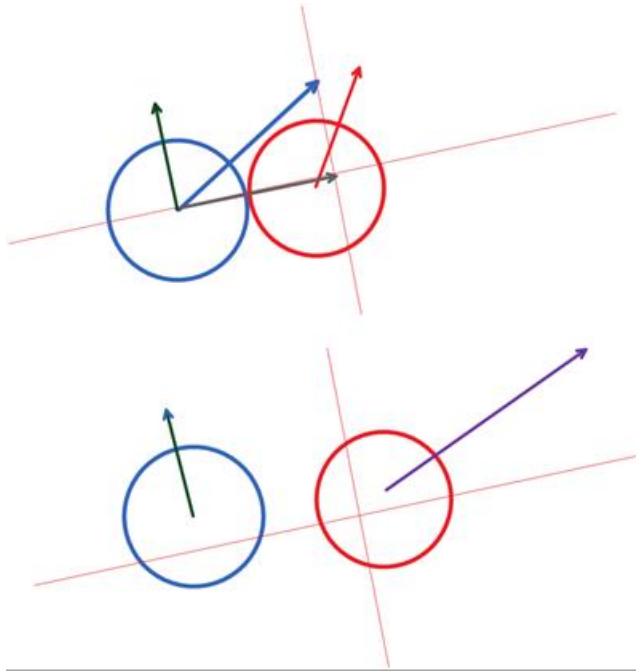
⁷ Note that for simplicity, we ignored here the changes in the masses of the spheres due to emission and absorption of photons. These variations in mass will be taken into account when significant.

body. Newton's third law of motion is special case of the laws of conservation of momentum of QGD.

Consider the same setup as above. The third law says that $\Delta \vec{P}_b = x m_b \vec{\rho}$ $\Delta \vec{P}_a = x m_a \vec{\rho}$. Now, if $\vec{P}_a < x m_b \vec{\rho}$, the momentum of a , which is the maximum momentum that it can impart, is smaller than the minimum allowable change in momentum of b . Hence b must emit back photons in opposite direction whose momentum is equal to the momentum of the photons emitted by a . Hence the Newton's third law of motion.

Case 3

So far, we have discussed the special cases of the physics of collision for spheres of similar volume which trajectories coincide. The same laws apply for all cases and when we take into account different angles and directions, we find that:



$$\sum_{i=1}^{n_a} m_{\gamma_i} \vec{c} = (v_a - v_b) m_a \text{ and}$$

$$\sum_{j=1}^{n_b} m_{\gamma_j} \vec{c} = (v_b - v_a) m_b \text{ where } v_a \text{ is the}$$

speed component of a towards b at the point of impact and v_b is the speed component of b towards a at the point of impact.

$$\text{Now since } \Delta \vec{P}_a = x m_a \vec{\rho} \quad \text{and}$$

$$\Delta \vec{P}_b = x' m_b \vec{\rho} \quad \text{and} \quad \text{since}$$

$$x m_a \vec{\rho} \leq \sum_{j=1}^{n_b} m_{\gamma_j} \vec{c} < (x+1) m_a \vec{\rho} \quad \text{and}$$

$$x' m_b \vec{\rho} \leq \sum_{i=1}^{n_a} m_{\gamma_i} \vec{c} < (x'+1) m_b \vec{\rho}, \quad \text{the}$$

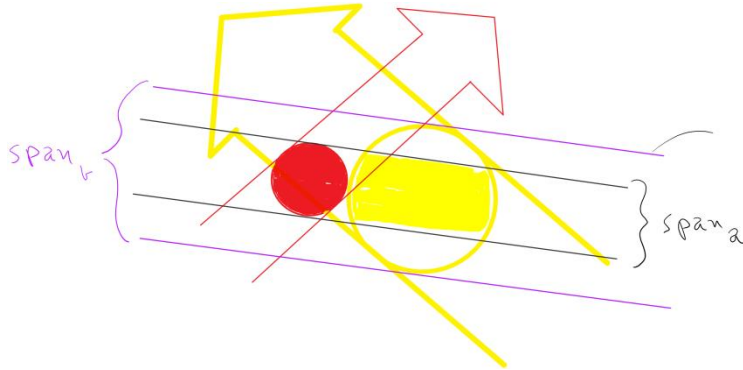
momentum carried by photons emitted by a that exceed the allowed change in momentum of b will be emitted, reflected or refracted (generally as heat) as will the momentum carried by photons emitted by b which exceed the allowed change in momentum of a .

We will now see how the laws that govern gravitational and non-gravitational change in momentum can be used to describe the dynamics of any system at larger scales.

Generalization of Momentum Transfer

Objects that collide are generally not spheres and even when they are, they are generally not of similar dimensions, mass, composition, etc.

If R_a and R_b are the regions occupied by a and b respectively prior to impact. If $span_a$ is the regions of space spanned by a in direction of b and $span_b$ that of b in direction of a then for bodies then:



$$\|\vec{P}_{a \rightarrow b}\| = (v_b - v_a) m_a \frac{R_a \cap S_a \cap S_b}{R_a} \quad \text{and} \quad \|\vec{P}_{b \rightarrow a}\| = (v_b - v_a) m_b \frac{R_b \cap S_a \cap S_b}{R_b}.$$

In the figure above, a is represented by the sphere on the left and $R_a \cap S_a \cap S_b$ is shown in red. Similarly, $R_b \cap S_a \cap S_b$ is in yellow. In the special illustrated here, $R_a = R_a \cap S_a \cap S_b$ so that

$$\|\vec{P}_{a \rightarrow b}\| = (v_b - v_a) m_a.$$

Note that non-gravitational acceleration is always a result of momentum transfer as described in this section. The same principles apply whether momentum is transferred from one solid object or from a group of particles such as in a gas. It follows that non-gravitational forces are not forces but the effects of momentum transfer and the so-called force is simply the momentum transferred.

Preonics (foundation of optics)

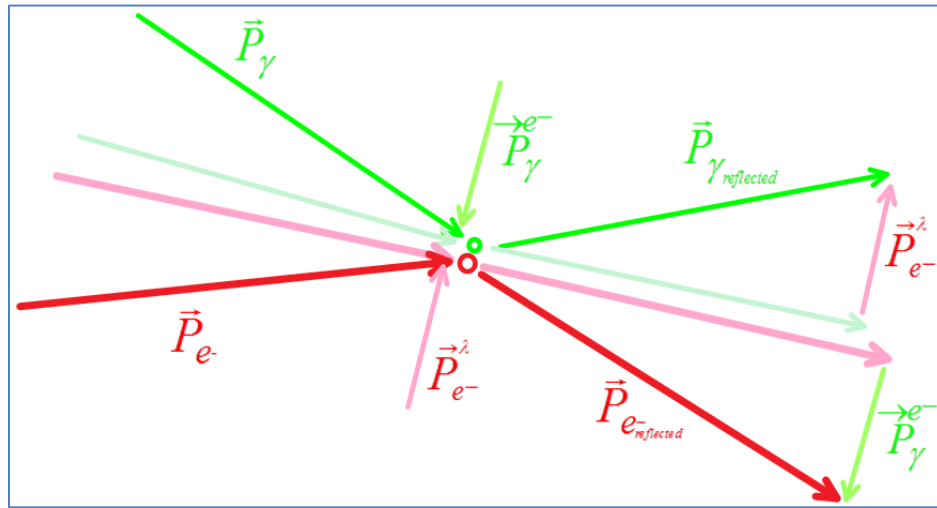
In this section we will show that optics, or the behaviour of light, is governed the [laws of momentum](#).

In fact, if QGD is correct, the same equations may be used to describe the dynamics of interacting objects however small or large they may be.

Reflection of Light

The third law of momentum we derived from the axiom set of QGD says that momentum can change only by discrete amounts. That is: $\Delta \vec{F}_a = x m_a \vec{\rho}$ where $x \in \mathbb{N}$ and a can be any particle or material structure.

When the trajectory of a photon γ and that of an electron e^- intersect, the same mechanism we described earlier applies. That is, γ will emit *preons*⁽⁺⁾ in the direction of e^- such that $\vec{P}_\gamma^{\rightarrow e^-} = \vec{P}_\gamma \cos \theta_1$ where $\vec{P}_\gamma^{\rightarrow e^-}$ is the momentum vector projection of the photon γ in direction of e^- , \vec{P}_γ is the momentum vector of γ and θ_1 is the angle between \vec{P}_γ and the line connecting the centers of γ and e^- . Similarly, $\vec{P}_{e^-}^{\rightarrow \gamma} = \vec{P}_{e^-} \cos \theta_2$.



Preons⁽⁺⁾ emitted by the electron will be absorbed by the photon so that $\vec{P}_{\gamma_{reflected}} = \vec{P}_\gamma - \vec{P}_\gamma^{\rightarrow e^-} + \vec{P}_{e^-}^{\rightarrow \gamma}$ and $\vec{P}_{e^-_{reflected}} = \vec{P}_{e^-} - \vec{P}_{e^-}^{\rightarrow \gamma} + \vec{P}_\gamma^{\rightarrow e^-}$ as a result, γ will and e^- be reflected

from each other as shown in the figure above. This mechanism describes and explains the

[Compton scattering](#) when $\vec{P}_\gamma > \vec{P}_{e^-}$ and inverse Compton scattering when $\vec{P}_\gamma < \vec{P}_{e^-}$.

Refraction of Light

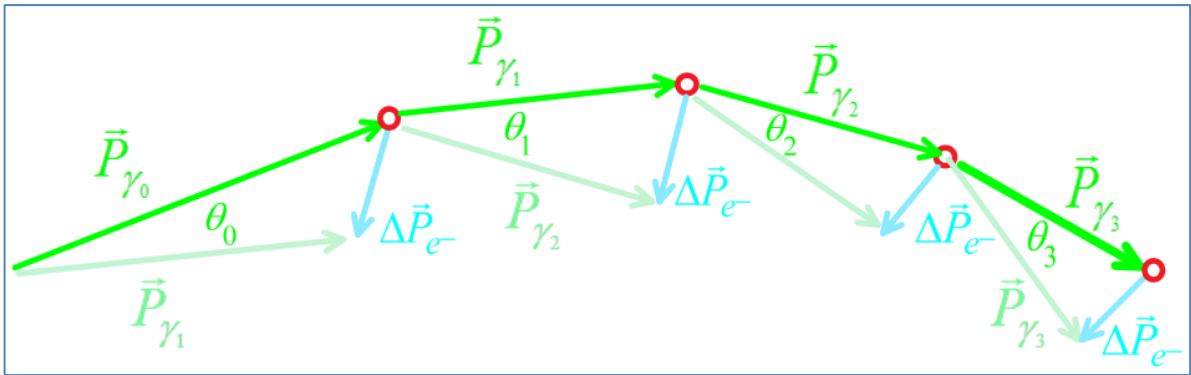
Changes in momentum of an electron are discrete increments proportional to its mass, that is,

$$\Delta \vec{P}_{e^-} = m_{e^-} \vec{\rho}$$

Now consider a photon γ_0 interacting with an atomic electron with $xm_{e^-}\vec{\rho} \leq \vec{P}_\gamma < (x+1)m_{e^-}\vec{\rho}$

where \vec{P}_γ is the momentum vector of the photon emitted by γ_0 in direction of e^- as a component of the interaction as we explained earlier, and $\vec{P}_{e^-} \ll \vec{P}_\gamma$.

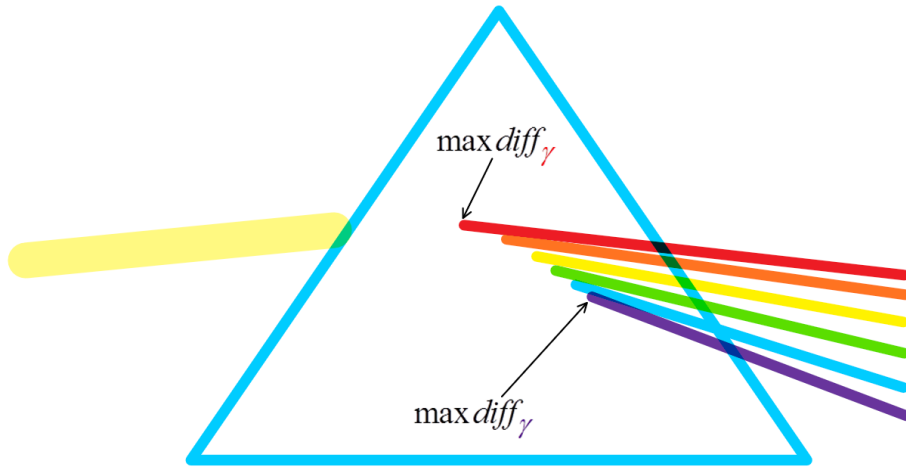
To be consistent with the laws of momentum transfer, $\Delta \vec{P}_{e^-} = m_{e^-} \vec{\rho}$ so upon absorption of the *preons*⁽⁺⁾ emitted by γ_0 the electron must emit a photon γ_1 such that $\vec{P}_{\gamma_1} = \vec{P}_{\gamma_0} - \Delta \vec{P}_{e^-}$ (see figure below). This is the basic mechanism of refraction.



From the equation, we see that θ_0 , the angle between γ_0 and γ_1 (angle of refraction), is inversely proportional to \vec{P}_{γ_0} . That is, the greater the momentum (which corresponds to higher energy or higher frequency in accepted physics), then the greater the refraction for a single interaction. But the refraction of light, by a prism for example, is the result of a series of interactions.

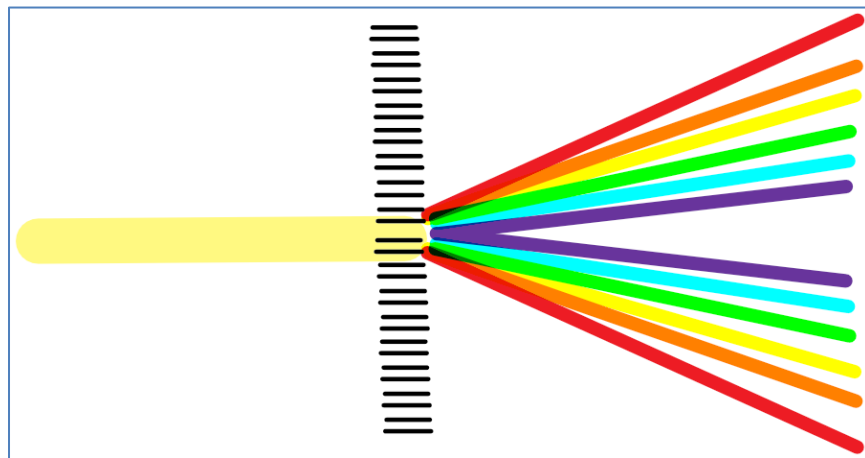
That is: since $xm_{e^-}\vec{\rho} \leq \vec{P}_{\gamma_0} < (x+1)m_{e^-}\vec{\rho}$, then for $i \geq x+1$ we have $\vec{P}_{\gamma_i} < m_{e^-}\vec{\rho}$ and $\vec{P}_{\gamma_i} = \vec{P}_{\gamma_{i+1}}$ and as a consequence $\theta_i = 0$. So, there is no refraction for photons once

$\vec{P}_{\gamma_i}^{e^-} < m_{e^-} \vec{\rho}$. The point at which a photon achieves maximum refraction is directly proportional to its momentum and this produces the colour separation by prism.



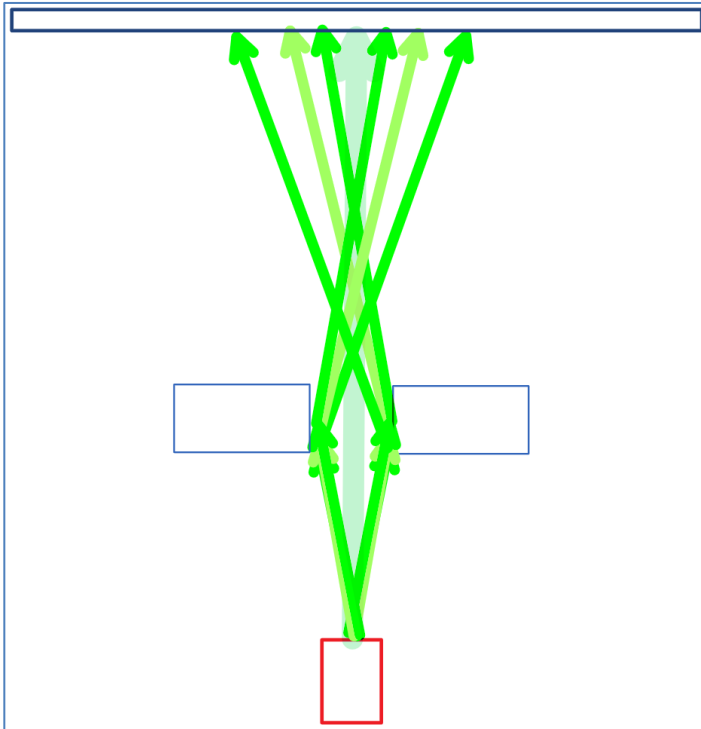
Note that the shape of the prism is ideal as it allows for photons of different momentums to achieve maximum diffraction.

If the number of refractive interactions is lower than what is necessary for photons to achieve maximum refraction, then the colours will be separated due to reflection and as we have seen, the angle of reflection is smaller the higher the momentum is. That explains why refraction using a grid is smaller for photons with higher momentums than photons with lower momentums.



Diffraction of Light

Diffraction is a simple consequence of reflection, that is, the interaction between light and matter and not, as thought, between light waves.



The light bands of diffraction patterns correspond to the allowed changes in momentum of particles or structures and the dark bands correspond to the forbidden changes in momentum.

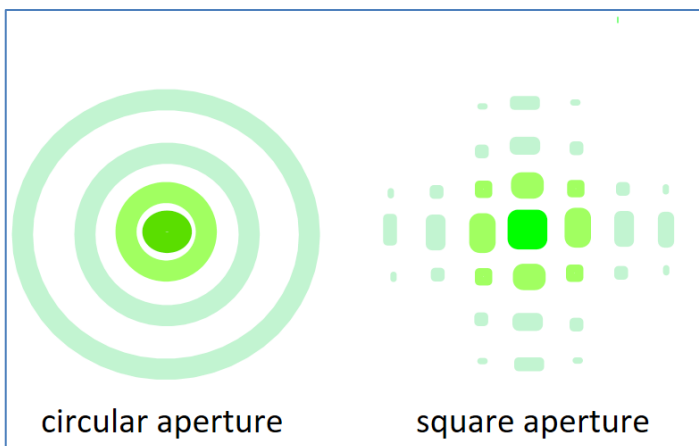
The bands will appear if there is one source of light and the photons composing the light have similar momentum. Applying our understanding of reflection of light, we find that the reflection angle of a photon depends not only on its angle of incidence but also on its momentum. The smaller the angle, the smaller will be the momentum from the electron it interacts with and the smaller will be the momentum

and angle of reflection of the reflected photon. The angle of reflection of a photon is close to but not equal to the incident angle.

In a strict description the reflection, we must also consider that that only certain changes in momentum are allowed as per the description of momentum and momentum transfer, we saw

here. So if $\vec{P}_e^{\rightarrow\gamma}$ is the momentum emitted by the electron in direction of the photon γ with

which it interacts and if $xm_\gamma\vec{\rho} < \vec{P}_e^{\rightarrow\gamma} < (x+1)m_\gamma\vec{\rho}$, then $\Delta\vec{P}_\gamma = xm_\gamma\vec{\rho}$ so that all photons within a range of incident angle will be reflected at the same exact angle, but none will be reflected at angles in the between the exact angle of reflection (this is only true of course for photons of the same momentum). The result will be as illustrated in the figure above.



The result will be as illustrated in the figure above.

The width between the bands is proportional to difference between the allowable momentums changes they correspond to given slit of the same depth and width.

As for the number of dark fringes, we will show in the next section

that it is proportional to the number of allowed changes in momentum within the angles of

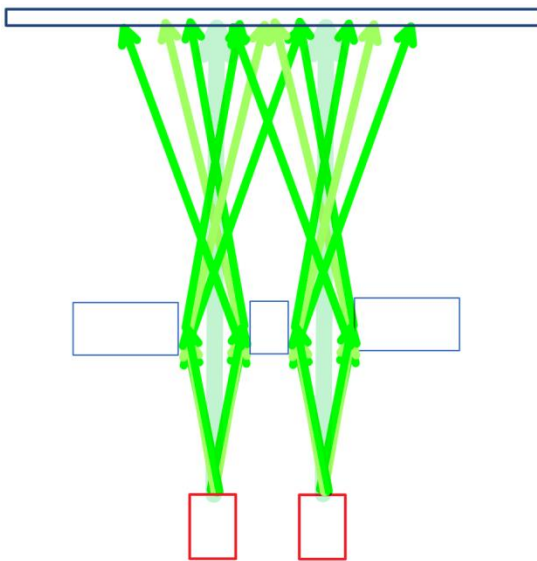
diffraction permitted by the aperture. That is: $n_{fringes} = 2 \left\| \frac{\vec{P}_\gamma \cos \theta_{max}}{m_{e^-}} \right\|$ where θ_{max} is half the

aperture angle and $n_{fringes}$ is the number dark fringes on the x or y axis.

As for the pattern of diffraction, it will depend on the shape of the aperture. Applying the above equations, we can predict the patterns generated by a group of photons.

Fringe Patterns from Double-slit Experiments

Following the failure of classical physics theories to explain the interference patterns observed in double slit experiments and other light diffraction experiments and because of the similarities



between these patterns and the interference patterns generated by waves at the surface of a liquid, physicists deduced that light was behaving as a wave. Other experiments showed that light behaved as a particle, the photon. Those contradictory observations led to the so-called wave-particle duality of light. Since the particle model alone could explain phenomena such as the photoelectric effect and since the wave model of light alone described the interference patterns of light, it made sense to deduce that light displayed corpuscular or wave-like depending on the experiment performed on it. The wave-particle duality of light is the product of the assumed impossibility to describe all

observed behaviours of light with either one model which is why, despite being mutually exclusive and contrary to logic, the models were “unified”. Logic dictates that only one or none of the models is consistent with nature but not both.

The patterns generated in double-slit experiment are thought to be the results of interferences between light waves, but as we will show below, they can be explained in terms of the reflection and absorption patterns of photons through a mechanism consistent with the laws governing optics (or more generally, preonics).

Though we describe the double-slit experiments that use photons, the same explanation applies for electrons or any other particle.

Single Slit Experiment

We will first describe single slit experiments.

The momentum vector components that can be imparted to an electron is given by $\|\vec{P}_\gamma \cos \theta\|$ where θ is the angle between the \vec{P}_γ and \vec{P}_{e^-} , but from the [laws of momentum](#) we know that

the momentum imparted by γ must be such that $\Delta\vec{P}_{e^-} = \alpha m_{e^-} \vec{\rho}$ and we have $\alpha = \frac{\|\vec{P}_\gamma \cos \theta\|}{m_{e^-}}$

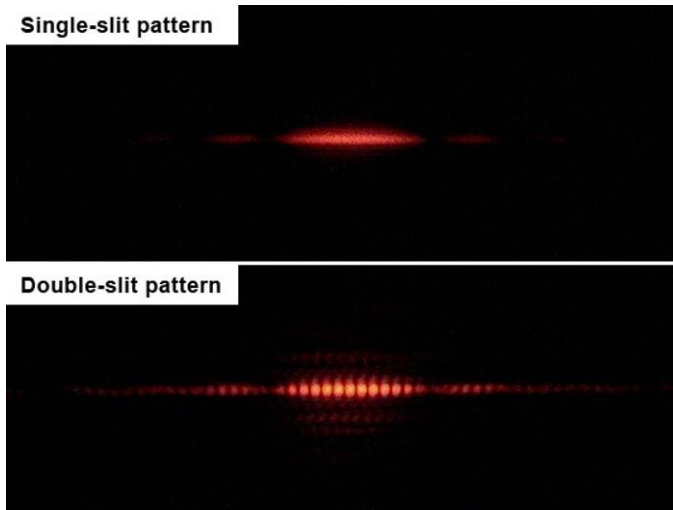
. So, the momentum that can be imparted to an electron by a photon is $\Delta\vec{P}_{e^-} = \frac{\|\vec{P}_\gamma \cos \theta\|}{m_{e^-}} m_{e^-} \vec{\rho}$

We see that when \vec{P}_γ is perpendicular to \vec{P}_{e^-} , $\|\vec{P}_\gamma \cos \theta\| = 0$ so that the photon is reflected back. As we move away from that angle towards, the photon will be absorbed when θ is such that $\|\vec{P}_\gamma \cos \theta\| = m_{e^-} \rho$. This will appear as a dark fringe on the screen which width depends on the width of the slit and the distance the slit and the screen.

The number of absorption fringes will be equal to $n_{fringes} = 2 \frac{\|\vec{P}_\gamma \cos \theta_{max}\|}{m_{e^-}}$.

Double-Slit Experiments

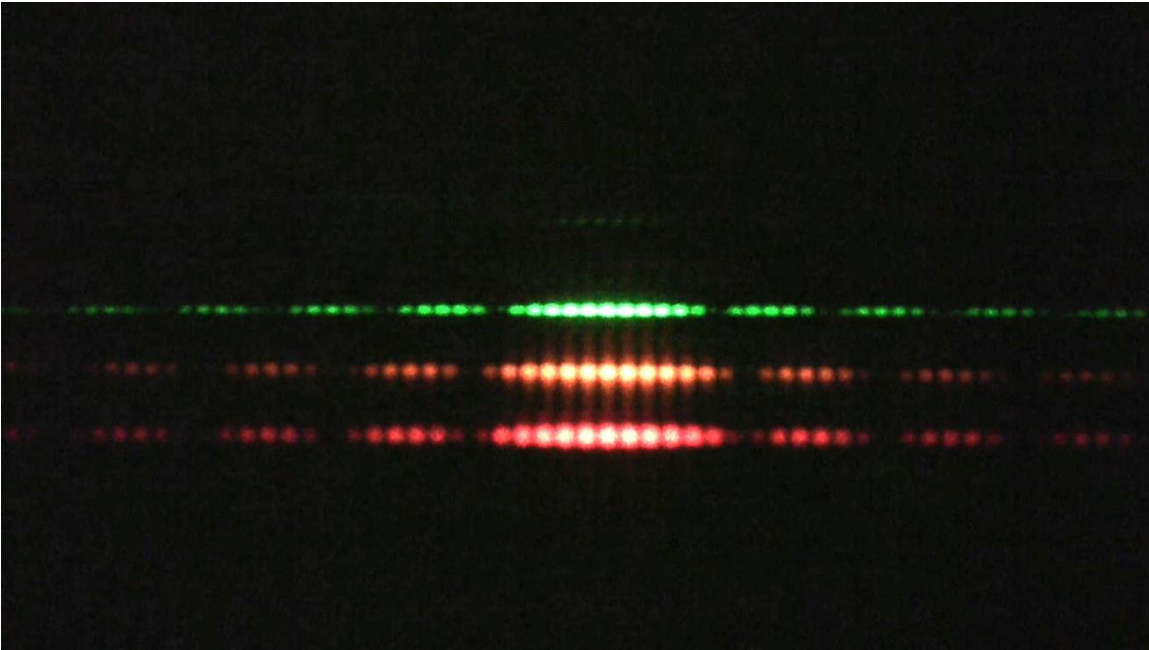
When there are two slits, two or more photons from different angles can simultaneously interact with an electron. In the case of two photons, they will be absorbed if $\vec{P}_{\gamma_1} \cos \theta_1 + \vec{P}_{\gamma_2} \cos \theta_2 = m_{e^-} \vec{\rho}$. If this condition is not met, then both photons γ_1 and γ_2 will be reflected.



At the centre of the screen (which is the point on the screen that is at equal distance from both slits), $\vec{P}_{\gamma_1} \cos \theta_1 + \vec{P}_{\gamma_2} \cos \theta_2 = \vec{0}$ and the photons will be reflected. But away from the centre, we there will be angles θ_1 and θ_2 such that $\vec{P}_{\gamma_1} \cos \theta_1 + \vec{P}_{\gamma_2} \cos \theta_2 = m_{e^-} \vec{\rho}$ creating dark fringes which width depend on the width of the slits and the distances from each other and from the screen.

As for the number of dark fringes (absorption fringes), it is a function of the angular ranges of photons from the two slits.

From the mathematical description we find that the momentum of the photons will affect the distances between the fringes. Everything else being equal, the greater the momentum of photons, the closer adjacent absorption fringes will be as shown in the picture below which compares the patterns emerging from photons of three momentums (energies).



Therefore, the distance between absorption fringes is inversely proportional to the momentum of the photons used in the experiments.

As we have seen in this section, the emergence of fringe patterns in double-slit experiments can be explained in terms of absorption and reflection of photons using the singularly corpuscular model of light proposed by QGD. In fact, QGD's corpuscular model and the laws of momentum together provide coherent a explanation consistent with optical phenomena which are normally attributed to wave-like behaviour of light.

Note: The counter-logical unification of the wave and particle models motivates the use of the equation for the energy of a wave ($E = \frac{hc}{\lambda}$, where h is the Planck constant, c the speed of light

and λ the wavelength) to calculate the energy of a photon, ignoring the essential fact that waves and particles are very distinct types of physical objects. The QGD equation for energy

$E_\gamma = \sum_{i=1}^{m_\gamma} \|\vec{c}_i\| = m_\gamma c$ applies to photons as well as any physical objects, structures, or particles.

Though QGD implies that photons have mass, this does not violate the postulate of constancy of the speed of light as a wave-particle model with massive photons (see [here](#)). That said, as we will show in the chapter [QGD Interpretations of Redshift Effects](#) that the wave-particle model gives an approximation of the singularly corpuscular model of light when we equate the frequency to the rate of emission of photons and the amplitude of the wave to the momentums of the photons.

Prediction

According to QGD, only discrete values of photon energies are permitted thus it predicts that the electromagnetic spectrum is discontinuous rather continuous as predicted by the wave-particle model. The gaps or non-permitted energy values correspond to fractional masses which cannot exist since mass in QGD is defined as the number of *preons*⁽⁺⁾ of a particle or structure.

The gap between any two permitted energies is constant and equal to ϵ . However, since sensors can only detect permitted energies, gaps cannot be observed. Still their non-existence may explain and be inferred from the discreteness of changes of in states of atomic electrons.

The Electromagnetic Effects

[QGD cosmology](#) predicts that in its initial state the universe only existed free $preons^{(+)}$ uniformly distributed in quantum-geometrical space, itself [dimensionalized by the interactions between \$preons^{\(-\)}\$](#) .

$Preons^{(+)}$ eventually combined to form particles and particles combined to form progressively more massive structures. The first particles to be formed were neutrinos, constituting the cosmic neutrino background and later formed the photons that form the cosmic microwave background radiation⁸. The observed isotropy of the CMBR would thus be a direct consequence of the isotropy of the distribution $preons^{(+)}$ in the initial state of the universe.

However, observations suggest that most $preons^{(+)}$ in the universe are still free or form particles which momentums are too small for instrumental observation (that is: $\vec{P}_a < m_e \vec{\rho}$). These constitute what we may call the preonic field. Magnetic fields are regions of the preonic field polarized through interactions with particles that have non-zero spin angular momentum. We will show in this section that we refer to as the magnetic spin momentum is an effect of their dynamic structure which reflect or absorb free $preons^{(+)}$ directionally, hence polarizing polarizes them.

Another important consequence, described later in this section. is that so-called charged particles do not possess intrinsic electrical charges which is why we will use the expression *polarizing particles* to describe particles such as electrons, protons, muons and other so-called charged particles.

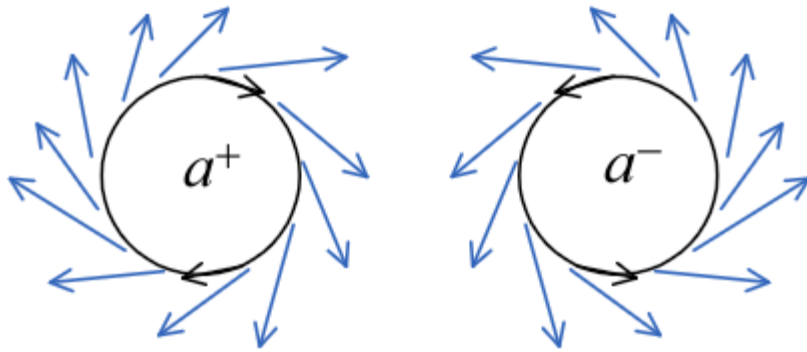
The Electromagnetic Effects of Attraction of Repulsion

The preonic field is composed of free $preons^{(+)}$ that, in the absence of polarizing particles or structures, move in random directions. The momentum of unpolarized region of the preonic field is equal to zero. Free $preons^{(+)}$ interact with particles or structures matter in accordance with [the laws of momentum](#) which as we have seen govern [preonics](#) which is a generalization of optics. When the motion of components of a particle or structure are random, the absorbed and reflected $preons^{(+)}$ are also random so that its magnetic moment $\vec{\Theta}_a$ is equal to zero. That is:

⁸ The mechanism of formation of particles and structures will be discussed in detail a section dedicated to the topic.

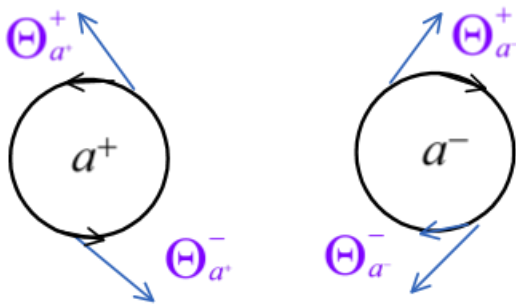
$\vec{P}_{\vec{\Theta}_a} = \sum_{i=1}^{m_{\Theta}} \vec{c}_i = \vec{0}$ where m_{Θ} is the number of *preons*⁽⁺⁾ of the preonic field that interact with

the particle and \vec{c}_i the momentum vector of the i^{th} *preons*⁽⁺⁾.



However, when a component of the particle or structure (an electron for example) are aligned, that is when it has a non-zero magnetic momentum, then

absorbed and reflected *preons*⁽⁺⁾ will consequently be aligned. The interactions between the preonic field and a polarizing particle or structure causes the polarization the preonic field and corresponds to what we commonly refer to as a magnetic field. From the discussion about optical reflection, we know that the direction of the reflection will depend on the direction of the particles the *preons*⁽⁺⁾ will interact with. The figure above is a diagram that illustrates the dependency of the reflection of *preons*⁽⁺⁾ on the orientation of a particle or structure. The black vectors represent the dominant direction of the components of the particles or structures a^+ and a^- , and the blue vectors represent the polarization of the preonic field in the regions neighbouring them.



When two polarizing particles or structures come into proximity, they each interact with each other's polarized preonic field. The figure on the left shows how we will represent, and label polarizing particles or structures and the interacting regions of the polarized preonic field.

Compton Scattering and the Repulsion and Attraction of Charged Particles.

We have shown in the [section on reflection of light](#) that when applying the laws of momentum to the interaction between photons and atomic electron that the Compton scattering occurs when

$\vec{P}_\gamma > \vec{P}_{e^-}$ and the inverse Compton scattering when $\vec{P}_\gamma < \vec{P}_{e^-}$ where γ is the incident photon

and \vec{P}_γ and \vec{P}_{e^-} are respectively the momentum of the *preons*⁽⁺⁾ emitted by the electron and

the momentum imparted by the photon with which it interacts. Conservation of momentum requires that the momentum of the electron must change by a vector of equal magnitude but

inverse direction of the sum of \vec{P}_γ and \vec{P}_{e^-} . That is, $\Delta\vec{P}_{e^-} = -\left(\vec{P}_\gamma + \vec{P}_{e^-}\right)$. This implies that

should $\vec{P}_\gamma > \vec{P}_{e^-}$ then the momentum vector of the electron will increase in the direction

opposite of the point of interaction by $\Delta\vec{P}_{e^-}$. Inversely, if $\vec{P}_\gamma < \vec{P}_{e^-}$ then the electron's

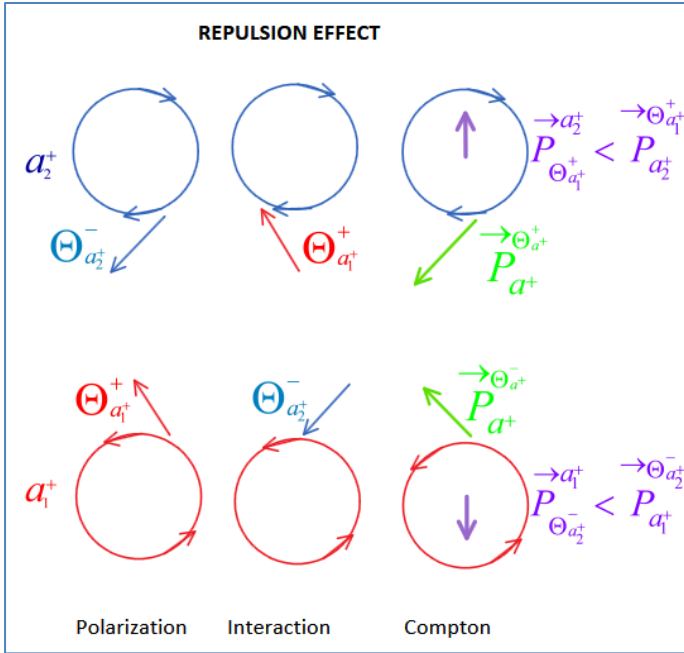
momentum vector will increase towards the point of interaction by $\Delta\vec{P}_{e^-}$. Whether we have a

Compton or reverse Compton scattering depends on the relative direction of the photon and electron (or particle or structure). That is, based on the laws of momentum, if the photon and

electron at the point of interaction move directly towards each other, then $\vec{P}_\gamma > \vec{P}_{e^-}$ and if their

trajectories intersect tangentially, then $\vec{P}_\gamma < \vec{P}_{e^-}$. The Compton scattering and its inverse are

special cases of preonic interactions which can explain the effects of repulsion and attraction between polarizing particles.

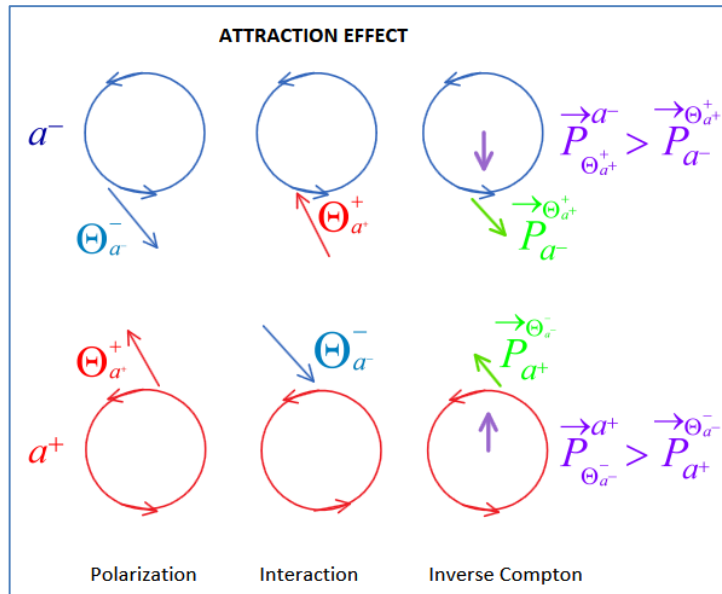


The figure on the left illustrates the interaction between two oppositely polarizing particles (a^+ and a^-). The circular vectors represent the angular momentum of the particles and the blue and red vectors correspond to the direction of the polarization preonic field respectively. Since the polarization of $\vec{\Theta}_{a_1^+}$ is opposite to orientation

of a_2^+ then $\vec{P}_{\vec{\Theta}_{a_1^+}^+} < \vec{P}_{a_2^+}$ and $\Delta\vec{P}_{a_2^+}$ will point away from $\vec{\Theta}_{a_1^+}^+$, thus a_2^+ will move away from a_1^+ .

Similarly, the polarization of $\vec{\Theta}_{a_2^-}$ is opposite the orientation of a_1^+ so that $\vec{P}_{\vec{\Theta}_{a_2^-}^-} < \vec{P}_{a_1^+}$, consequently a_1^+ will move away from a_2^+ . This explains the effect of repulsion between two similarly charged particles (and structures).

In the figure on the right, we have two particles of opposing polarization. Here since the polarization of the region $\vec{\Theta}_{a^+}$ is opposite to the orientation of a^- and the region $\vec{\Theta}_{a^-}$ is polarized in opposite the orientation of a^+ then $\vec{P}_{\vec{\Theta}_{a^+}^+} > \vec{P}_{a^-}$ and $\vec{P}_{\vec{\Theta}_{a^-}^-} > \vec{P}_{a^+}$ and as a result $\Delta\vec{P}_{a^+}$ will point to a^- and $\Delta\vec{P}_{a^-}$ will point to a^+ .



Therefore a^+ and a^- will move towards each other and appear to be attracted.

We have shown that the observed repulsion between like polarizing and attraction between particles does not result from repulsion and attraction between the particles themselves but from their interactions with the preonic regions polarized between them.

Also, since the polarized $preons^{(+)}$ are emitted radially from a polarizing particle or structure, the intensity or momentum of the polarized region follows the inverse square law. In fact, the inverse square law of the momentum of a magnetic field is a consequence of QGD's preonics.

Interaction between Large Polarizing Structures and the Preonic Field

Large structures that have aligned polarizing particles behave as one single polarizing particle. The main difference is that the effect of a large number of bounded and aligned polarizing particles creates more intense polarization over a much larger region of the preonic field.

Based on QGD's description electromagnetic effect, we can infer that the momentum of the preonic field polarized by a particle (its magnetic moment) is proportional to the product of the magnitude of angular spin momentum of the particle by the density of the preonic field. That is:

$$\vec{\Theta}_a^{+/-} \propto \|\vec{S}_a\| dens_{p^{(+)}} \vec{c}, \text{ where } a \text{ is a polarizing particle, } \vec{S}_a \text{ and } dens_{p^{(+)}} = \frac{m_R}{Vol_R}, \text{ that is,}$$

the number of $preons^{(+)}$ in the region R and \vec{c} is the fundamental momentum .

The momentum imparted to a particle b by a preonic field polarized by a particle a at a distance

$$r \text{ is } \|\Delta\vec{P}_b\| \propto \frac{\|\vec{\Theta}_a^{+/-}\| \|\vec{S}_b\|}{r^2} \text{ where } \vec{\Theta}_a^{+/-} \text{ is the momentum of the polarized preonic field generated}$$

by a and \vec{S}_b is the spin angular momentum of the interacting particle or structure.

Note: In a following section, we will discuss how the dynamics of atomic electrons follow from QGD's laws of momentum.

Electromagnetic Acceleration Particles and Theoretical Limits

As we have seen [here](#), the momentum \vec{c} of a $preons^{(+)}$ is intrinsic and fundamental. All properties are invariable except for their trajectories.

When a magnetic field imparts momentum to a polarizing particle, QGD predicts:

1. The mass of the particle increases by the sum of $preons^{(+)}$ it absorbs (which mechanism we describe here),

2. Its momentum increases by the sum momentum of the absorbed *preons*⁽⁺⁾,
3. As consequence of the constancy of the momentum of *preons*⁽⁺⁾, the spin angular momentum of a particle must decrease as its linear momentum increases. The follows from the relation $\sqrt{\|\vec{P}_b\|^2 + \|\vec{S}_b\|^2} = m_b c = E_b$ and consequently,
4. the polarization potential of a particle being a function of its spin angular momentum, a particle becomes increasingly less polarizing as it gains linear momentum, thus its capacity to interact with the preonic field decreases. In other words, the particle becomes increasingly neutral.

The momentum imparted by a uniform magnetic field to a polarizing particle is proportional to the product of the momentum of the momentum of the magnetic field, by the distance it travels, by the angular spin momentum of the particle.

The total momentum imparted by a magnetic field is then given by $\sum_{i=1}^n \|\Delta \vec{P}_b\| \propto \|\vec{\Theta}_a^{+/-}\| \|\vec{S}_b\| l$

where n is the number of momenta imparting events along the particle's trajectory of length l .

And the momentum imparted by the magnetic field for each individual event must equal or greater than the [minimum permitted change in momentum](#) that is: $\|\Delta \vec{P}_b\| = m_b \rho$ or

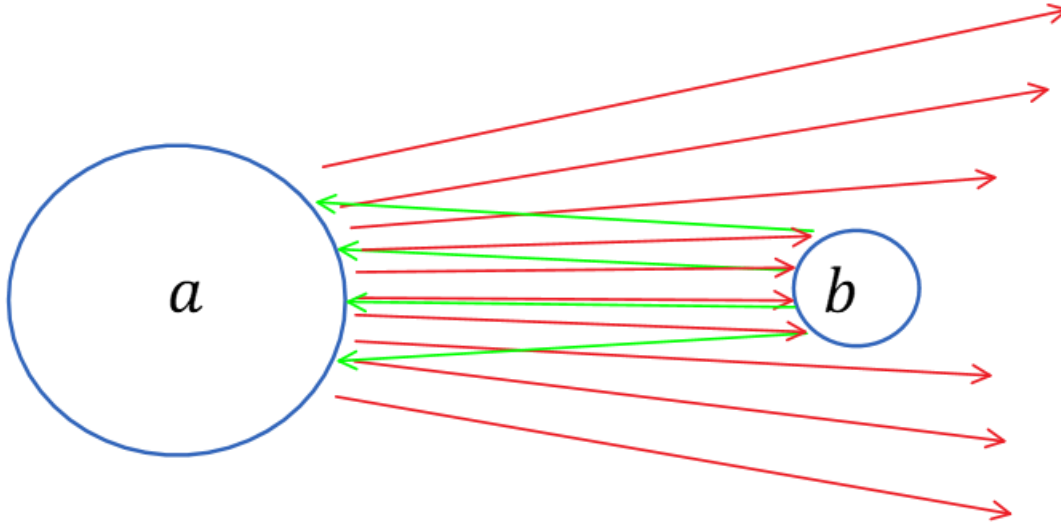
$$\|\vec{\Theta}_a^{+/-}\| \|\vec{S}_b\| = m_b \rho .$$

Also, $\sqrt{\|\vec{P}_b\|^2 + \|\vec{S}_b\|^2} = m_b c$, and $\Delta \vec{P}_b \propto \|\vec{\Theta}_a^{+/-}\| \|\vec{S}_b\|$ implies that the momentum imparted by a uniform magnetic field decreases as its linear momentum increases and as a consequence we can predict that the particle will cease to be accelerated by the magnetic field when its spin angular momentum falls below a certain value such that $\|\vec{\Theta}_a^{+/-}\| \|\vec{S}_b\| < m_b$. Below this minimum value, a magnetic field, not matter how powerful, will have no effect. It follows that the particles can not be accelerated or redirected by a magnetic field, which would lead to greater loses of accelerated particles in a circular electromagnetic accelerator than with a linear accelerator.

Asymmetric Polarization of the Preonic Field and Atomic Neutrality

It is currently believed that the electromagnetic interaction between any two polarizing particles at a given distance will have the same absolute value. The repulsion effects of any two like-polarizing particles is predicted to be same regardless of the type of particle as should the attraction between any two oppositely charged particles.

But if, as we have suggested, particles have no intrinsic charge, hence have no electrical charge, which leaves only the electromagnetic repulsion and attraction between particles which, as we have seen, is due to their interactions with the preonic field polarized as explained earlier. The repulsion or attraction between particles will be different depending on their type. That is, the momentum imparted by attraction or repulsion between two different types of particles is not symmetric.



In the figure above, the circles labeled a and b respectively represent two different types of particles electromagnetically interacting. The red and green arrows indicate the direction of polarizations of the preonic field from a and b . The momentum that can be imparted to one

particle interacting by the other's polarized field is $\Delta\vec{P}_a \propto \frac{\|\vec{\Theta}_b^{+/-}\| \|\vec{S}_a\|}{r^2}$ (green arrows) and

$\Delta\vec{P}_b \propto \frac{\|\vec{\Theta}_a^{+/-}\| \|\vec{S}_b\|}{r^2}$ (red arrows touching b). It follows that $\|\vec{\Theta}_b^{+/-}\| \|\vec{S}_a\| \neq \|\vec{\Theta}_a^{+/-}\| \|\vec{S}_b\| \rightarrow \Delta\vec{P}_a \neq \Delta\vec{P}_b$.

QGD Prediction

From this, we can predict that the momentum imparted through the electromagnetic interactions between a proton and an electron will differ from that between a proton and a muon, or between a positron and an electron. This allows QGD to make unique predictions that distinguishes it from classical electrodynamics.

This prediction may be tested experimentally by comparing measurements of electromagnetically imparted momentums of particles to measurements of gravitationally imparted momentums.

If classical electrodynamics is correct and particles have intrinsic charges, then $\frac{\Delta \vec{P}_a}{\Delta \vec{P}_b} = \frac{\Delta \vec{G}_a}{\Delta \vec{G}_b}$

where $\Delta \vec{P}_x$ is an electromagnetic imparted momentum and $\Delta \vec{G}_x$ is gravitationally imparted momentum.

If QGD is correct and particles have no intrinsic charges, then $\frac{\Delta \vec{P}_a}{\Delta \vec{P}_b} \neq \frac{\Delta \vec{G}_a}{\Delta \vec{G}_b}$.

Atomic Neutrality and Valence

If electrons and protons do not have intrinsic electric charge, then to achieve atomic electrical neutrality is only achieved when $\vec{\Theta}_{p^+}^+ = \vec{\Theta}_{e^-}^-$ where $\vec{\Theta}_{p^+}^+$ is the momentum of the polarization by the protons and $\vec{\Theta}_{e^-}^-$, that by the electrons, both taken outside the atomic radius.

The chemical valence of an elements can then be predicted from the relation between the protons and electrons polarization. We have two possibilities:

1. $\|\vec{\Theta}_{p^+}^+ + \vec{\Theta}_{e^-}^-\| > 0$; two more atoms can form molecules. The number of chemical bonds

depends on the valences of bounding atoms. Here $valence = \frac{\|\vec{\Theta}_{p^+}^+ + \vec{\Theta}_{e^-}^-\|}{\|\vec{P}_{e^-}\|}$ where \vec{P}_{e^-} is

the orbital momentum of outer electrons of atoms.

2. $\|\vec{\Theta}_{p^+}^+ + \vec{\Theta}_{e^-}^-\| \leq 0$; atoms that are chemically inert, thus cannot form chemical bonds with other atoms.

Final Notes and Testable Predictions of QGD's Electromagnetic Effects Description

In the absence of any intrinsic electrical charge, the interaction between polarizing particles must be completely accounted for by the electromagnetic and gravitational effects.

This, if correct, would greatly simplify calculations of, for example, the behaviour of polarizing particles in a magnetic field, so how can QGD's description of the electromagnetic effects be tested?

QGD Prediction

QGD predicts also predicts that dark matter is composed of free $preons^{(+)}$, which also, when polarized, form magnetic fields. Since the density of dark matter (or preonic density) is greater in center of galaxies than at its periphery, then the magnetic moment of polarizing particles and magnetic fields of structures in the center of galaxies should be greater than those of similar particles or structures in the outer regions of galaxies.

Therefore, observations of the Zeeman effect should show that the magnetic fields of stars near the center of our galaxy are greater than those of comparable stars at the outskirts of our galaxy.

QGD at Short Distances

QGD is scale independent which implies that dynamic systems, regardless of scale, can be fully described using nothing more than the forces and effects we have introduced in the section [Forces, Interactions and Laws of Motion](#). In this section we will explain how QGD can be applied to describe systems at the smallest scales; scales comprising the nuclear and subnuclear scales, some which are orders of magnitude smaller than nucleons, or even the electron.

We will describe short distance interactions in terms of the gravity, the electromagnetic effect and momentum transfer as discussed in the section [The Physics of Collision and Conservation of Momentum](#).

We will also discuss the problem of stability of nuclear and subnuclear structures, which includes particles that are considered fundamental by dominant physics theories.

The Gravitational Effect at Very Short Distances

QGD describes gravity as the resultant of two fundamental forces, p-gravity and n-gravity, which are respectively attractive and repulsive.

At large scale, the n-gravity component of the equation describes the repulsive effect of space, which is sum of the n-gravity interactions between objects is proportional to the square of the number of *preons*⁽⁻⁾ between them. We saw that repulsive gravity overcomes the attractive component of gravity beyond the threshold distance d_Λ where $k < \frac{d_\Lambda^2 + d_\Lambda}{2}$ from which point gravity becomes repulsive proportionally to the square of distance.

Observations suggest that $d_\Lambda = 10Mpc$, so that since $\vec{G}^+ + \vec{G}^- = 0$ at $d = d_\Lambda$, and since \vec{G}^+ is independent of distance, assuming the conventional geometrical distances are proportional to discrete preonic distances, we can predict that at $d = 1$, gravity is attractive and approximately 10^{104} times greater than at $d = d_\Lambda - 1$. Therefore, gravity at the nuclear scale can overcome electromagnetic repulsion, thus capable of binding nucleons. Nucleons and their component particles can escape gravity at the smallest scale when the sum of their momentum, the electromagnetic repulsion and punctual momentum transfer from collisions is sufficiently large.

The n-gravity component of gravity is reduced significantly at very short distances so the equation for gravitational interaction between any two nucleons within a nucleus is reduced to the p-gravity component. That is $\vec{G}(n_i; n_j) \approx km_{n_i} m_{n_j} \hat{u}_{i,j}$, where n_i is the i^{th} nucleon of a

nucleus containing j nucleons. So that $\Delta\vec{G}_{n_i} = \sum_{\substack{j=1 \\ j \neq i}}^{n_j} \Delta\vec{G}(n_i; n_j) \hat{u}_{i,j}$.

Below a certain threshold distance between nucleons, if the mass of the nucleus is large enough, the gravitational momentum of a nucleon towards center of mass of the nucleus is greater than the momentum imparted by electromagnetic interaction (electromagnetic repulsion between protons); allowing nucleons to be bounded within the nucleus.

However, the periodic table tells us that stable nuclei of atoms from the second element and on, that the gravitational interaction between protons is insufficient to insure their stability. Neutrons, electromagnetically neutral particles, which increase the mass, hence gravity, without cranking up electromagnetic repulsion are needed. The helium atom, for example, having two protons and two neutrons increases by a factor of three the gravitational magnitude of the p-gravity component of the gravitational interaction between any of its nucleon and the three other nucleons. This increase in gravity compensates not only for the electromagnetic effect but also the momentums of the nucleons, and the potential transfer of momentum due to collision between nucleons, their components or with external particles.

Electromagnetic Interactions between Nucleons

As does the electron, the proton polarizes the preonic field when it interacts (reflects) free $preons^{(+)}$ that intersect with the proton's component $preons^{(+)}$. Magnetic fields are made of polarized $preons^{(+)}$. Therefore, the electromagnetic repulsion between so-called charged particles, is a function of the preonic density, the distance between the particles, and the spin angular momentum of the particles.

At the very short distances of the nuclear scale, the repulsion is also a function of the volume between two charged particles, $Vol(a;b)$, since the number of $preons^{(+)}$ within that volume may be so small that the momentum of the polarized $preons^{(+)}$ with which protons interact is lower than the minimum change in momentum allowed. That is: $\vec{\Theta}_a(a;b) < m_{p^+} \vec{\rho}$.

Momentum of the preonic field in a given direction is $Vol_R dens_{p^{(+)}} \vec{c}_a$

From this we understand that when $Vol(a;b) < \min_vol$ where $vol_{\min}(a;b)$ is the minimum volume for a given density for which $\vec{\Theta}_a(a;b) \geq m_{p^+} \vec{\rho}$, that is, the minimum volume between two protons necessary to generate a magnetic field capable of imparting momentum to a proton.

So, if the distance between two protons is such that $Vol(a;b) < \min_vol$, the electromagnetic repulsion between protons is insufficient to impart momentum and protons stop repulsing each other. Up to that minimal distance, there is no repulsion. Beyond the minimal distance the electromagnetic repulsion increases proportionally to $vol(a;b)$ up to the distance at which we

have maximum repulsion and from that point, the electromagnetic repulsion follows the inverse square law.

Nuclear Interactions and the Laws of Momentum

If attractive gravity between nucleons is dominant, what keeps the nucleus from becoming a singularity in which they would be reduced to their components? The answer: the very same mechanism that describes momentum transfer during collisions of bodies or particles which is described [here](#).

The electromagnetic repulsion between two protons, as does all charged particles, depends on the preonic field density, the number of free $preons^{(+)}$ they interact with, which itself depends on the preonic density and the number bound $preons^{(+)}$ or m_a with, and on the distance separating and the preonic density $dens_{preons^{(+)}}$. Based on our description of the electromagnetic effect, the interactions between two protons at the nuclear scale are governed by the following equations.

$$[4] \vec{\Theta}(a;b) \propto vol(a;b) dens_{preons^{(+)}} \vec{c}$$

$$[5] \Delta \vec{P}_a > 0 \rightarrow \vec{\Theta}^a(a;b) = xm_a \vec{\rho}$$

and

$$[6] \Delta \vec{P}_b > 0 \rightarrow \vec{\Theta}^b(a;b) = xm_b \vec{\rho}$$

$$[7] \vec{\Theta}^a(a;b) = \vec{\Theta}^b(a;b) \text{ where both } a \text{ and } b \text{ re protons.}$$

Note that though the equation [4] holds when a is a proton and b an electron, we must keep in mind that the region polarized by a proton is larger than the region polarized by an electron (protons interact with more free $preons^{(+)}$). The $preons^{(+)}$ components move at velocity \vec{c} in closed paths within the proton and as they do, they interact directly with free $preons^{(+)}$, redirecting and refocusing them. Being composed of much larger number of bound $preons^{(+)}$ proton polarize proportionally a greater number of free $preons^{(+)}$. The "excess" number of polarized $preons^{(+)}$ would contribute to the formation of molecules.

From [1] and [2] and [3] we find the electromagnetic interaction is null at distances $d < d_{\min}$, where at d_{\min} we have $\vec{\Theta}(a;b) = m_a, m_b$. Here again, if $m_a < m_b$, we can have $\Delta \vec{P}_a > 0$ while $\Delta \vec{P}_b = 0$. That would be the case if a is an electron and b a proton.

The relation between the electromagnetic repulsion and gravitational interaction in a stable atomic nucleus is given by

$$\sum_{j=1}^Z \vec{\Theta}(p_i^+; p_{j \neq i}^+) = \sum_{j=1}^A \Delta \vec{G}(p_i^+; \eta_j)$$

where Z is the atomic number, A is the mass number, p_i^+ is a proton of the atomic nucleus and η_j a nucleon.

If $\sum_{j=1}^Z \vec{\Theta}(p_i^+; p_{j \neq i}^+) > \sum_{j=1}^A \Delta \vec{G}(p_i^+; \eta_j)$ then the nucleus is instable (not in equilibrium). The system will resolve itself to equilibrium by the reducing the electromagnetic repulsion. Observations tell us that it does so by reducing the atomic number (the number of protons). This can be accomplished by the conversion of one or more protons into neutrons by emissions of electrons (beta radiation), or by ejecting protons (alpha radiation) which results in a stable nuclear configuration.

After the change in atomic number, it is likely that $\sum_{j=1}^Z \vec{\Theta}(p_i^+; p_{j \neq i}^+) < \sum_{j=1}^A \Delta \vec{G}(p_i^+; \eta_j)$. The

nucleus is stable but still not in equilibrium just yet. The mass of the nucleus must be reduced to achieve equilibrium. From observations, the system will resolve itself by emitting neutral

particles which will reduce gravity by $\sum_{j=1}^A \Delta \vec{G}(p_i^+; \eta_j) - \sum_{j=1}^Z \vec{\Theta}(p_i^+; p_{j \neq i}^+)$.

This may also explain why certain atomic nuclei are unstable and why there is a limit as to their size. As the number of protons increase, the size of the nucleus increases and so does the distances between some protons. If the distances increase beyond the threshold distance, the number of free *preons*⁽⁺⁾ becomes large enough to restore electromagnetic repulsion making the nucleus instable. To reach equilibrium, either the number of protons must decrease and/or the mass neutral mass must increase.

This can be achieved by having one of more protons emits electrons and convert to neutrons in sufficient number to achieve the equilibrium state.

A proton or neutron may then be ejected to bring the size of the nucleus down so that the distances between the protons are below the threshold distance.

An unstable nucleus may also become stable by absorbing neutrons, increasing the mass so that the additional gravity compensates for the repulsion between certain protons or proton may emit an electron, converting to a neutron which then brings stability by reducing or eliminating electromagnetic repulsion within the nucleus.

The reader will note that radioactive decay is attributed here to mechanisms that restores equilibrium states.

Principle of Strict Causality and Equilibrium

From what we have laid out in [The Principle of Strict Causality](#) and the [Fundamentality and the Conservation Law](#) sections, we understand all events are strictly causal. So though probabilistic models may help predict the likelihood of decay events in large statistical samples, the events are not spontaneous but results from sequences of causality related events which mechanisms we have discussed.

Derivations of Predictions of Special and General Relativity

Though the axiom sets of QGD and those of the special and the general relativity are mutually exclusive, our theory is not exempt from having to explain observations and experiments; particularly those which confirm the predictions of the relativity theories.

We will now derive some of the key predictions of special relativity and general relativity and since a new theory must do more than explain what is satisfactorily explain current theories, we will also derive new predictions that will allow experiments to distinguish QGD from the relativity theories.

Constancy of the Speed of Light

Light is composed photons, themselves composites of *preons*⁽⁺⁾ which move in parallel directions.

The speed of a photon is thus

$$v_\gamma = \frac{\left\| \sum_{i=1}^{m_\gamma} \vec{c}_i \right\|}{m_\gamma} = \frac{\sum_{i=1}^{m_\gamma} \|\vec{c}_i\|}{m_\gamma} = \frac{m_\gamma c}{m_\gamma} = c$$
 which is the fundamental speed of *preons*⁽⁺⁾ and by definition constant.

Why nothing can move faster than the speed of light

We know that $v_a = \frac{\left\| \sum_{i=1}^{m_a} \vec{c}_i \right\|}{m_a}$ and that $\left\| \sum_{i=1}^{m_a} \vec{c}_i \right\| \leq \sum_{i=1}^{m_a} \|\vec{c}_i\|$ then since $\frac{\left\| \sum_{i=1}^{m_a} \vec{c}_i \right\|}{m_a} \leq \frac{\sum_{i=1}^{m_a} \|\vec{c}_i\|}{m_a}$ and $\frac{\sum_{i=1}^{m_a} \|\vec{c}_i\|}{m_a} = \frac{m_a c}{m_a} = c$ it follows that $v_a \leq c$.

The Relation between Speed and the Rates of Clocks

QGD considers time to be a purely a relational concept. In other words, it proposes that time is not an aspect of physical reality. But if time does not exist, how then does QGD explain the different experimental results that support time dilation; the phenomenon predicted by special relativity and general relativity by which time for an object slows down as its speed increases or is submitted to increased gravitation interactions?

To explain the time dilation experiments we must remember that clocks do not measure time; they count the recurrences of a particular state of a periodic system. The most generic definition possible of a clock is a system which periodically resumes an identifiable state coupled to a counting mechanism that counts the recurrences of that state.

Clocks are physical devices and thus, according to QGD, are made of molecules, which are made of atoms which are composed of particles; all of which are ultimately made of bounded *preons*⁽⁺⁾.

From the axioms of QGD, we find that the magnitude of the momentum vector of a *preon*⁽⁺⁾ is fundamental and invariable. The momentum vector is denoted by \vec{c} the momentum is $\|\vec{c}\| = c$.

We have shown that the momentum vector of a structure is given by $\vec{P}_a = \left\| \sum_{i=1}^{m_a} \vec{c}_i \right\|$ and its speed

by $v_a = \frac{\left\| \sum_{i=1}^{m_a} \vec{c}_i \right\|}{m_a}$. From these equations, it follows that the maximum possible speed of an object

a corresponds to the state at which all of its component *preons*⁽⁺⁾ move in the same direction.

In such case we have $\left\| \sum_{i=1}^{m_a} \vec{c}_i \right\| = \sum_{i=1}^{m_a} \|\vec{c}_i\| = m_a c$ and $v_a = \frac{m_a c}{m_a} = c$. Note here that $\sum_{i=1}^{m_a} \|\vec{c}_i\|$

corresponds to the energy of a so the maximum speed of an object can also be defined as the state at which its momentum is equal to its energy.

From the above we see that the speed of an object must be between 0 and c while all its component *preons*⁽⁺⁾ move at the fundamental speed of c .

Now whatever speed a clock may travel, the speed of its *preons*⁽⁺⁾ components is always equal to c . And since a clock's inner mechanisms which produce changes in states depends fundamentally on the interactions and motion of its component *preons*⁽⁺⁾, the rate at which any mechanism causing a given periodic state must be limited by the clock's slowest inner motion; the transversal speed of its component *preons*⁽⁺⁾.

Simple vector calculus shows that the transversal speed of bound *preons*⁽⁺⁾ is given by $\sqrt{c^2 - v_a^2}$ where v_a is the speed at which a clock a travels. It follows that the number of recurrences of a state, denoted t for ticks of a clock, produced over a given reference distance d_{ref} is proportional to the transversal speed of component *preons*⁽⁺⁾, that is

$\frac{\Delta t}{d_{ref}} \propto \sqrt{c^2 - v_a^2}$. As the speed at which a clock travels increases, the rate at which it produces

ticks slows down and becomes 0 when its speed reaches c .

We have thus explained the observed slowing down of periodic systems without using the concepts of time or time dilation.

The predictions of special relativity regarding the slowing down of clocks (or any physical system whether periodic or not, or biological in the case of the twin paradox) agree with QGD however, the QGD explanation is based on fundamental physical aspects of reality. Also, since according to QGD, mass, momentum, energy, and velocity are intrinsic properties of matter, their values are independent of any frame of reference, avoiding the paradoxes, contradictions and complications associated with frames of reference.

However, though both QGD and special relativity predict the speed dependency of the rates of clocks, there are important differences in their explanation of the phenomenon and the quantitative changes in rate. While for special relativity the effect is caused by a slowing down of time, QGD explains that it is a slowing down of the mechanisms clocks themselves.

If Δt and $\Delta t'$ are the number of ticks counted by two identical clocks counted travelling respectively at speeds v_a and v'_a over the same distance d_{ref} then QGD predicts that

$$\Delta t' = \Delta t \frac{\sqrt{c^2 - v_a'^2}}{\sqrt{c^2 - v_a^2}} = \Delta t \frac{\sqrt{1 - \frac{v_a'^2}{c^2}}}{\sqrt{1 - \frac{v_a^2}{c^2}}}.$$

The speeds in the above equation are absolute so cannot be directly compared to special relativity's equation for time dilation which is dependent on the speed of the one clock relative to that of the other. However, the special relativity equation can be derived by substituting for v_a the speed of the second clock relative to the first clock v , then v'_a must be the speed of the second clock relative to itself, that is $v'_a = 0$, substituting in the equation above we get

$$\Delta t' = \frac{\Delta t}{\sqrt{1 - \frac{v^2}{c^2}}} \text{ which is the special relativity equation describing time dilation.}$$

Then using the derivations $\Delta x' = v\Delta t' = \frac{v\Delta t}{\sqrt{1 - \frac{v^2}{c^2}}} = \frac{x_2 - x_1}{\sqrt{1 - \frac{v^2}{c^2}}}$, $y' = y$ and $z' = z$, we can easily

derive the relation between two inertial frames of reference.

The Relation between Gravity and the Rates of Clocks

We know that $v_a = \frac{\|\vec{P}_a\|}{m_a}$ then $\frac{\Delta t}{d_{ref}} \propto \sqrt{c^2 - v_a^2} = \sqrt{c^2 - \left(\frac{\|\vec{P}_a\|}{m_a}\right)^2}$. We have also shown that gravity

affects the orientation of the component $preons^{(+)}$ of structure so that $\Delta \vec{P}_a = \Delta G(a;b)$ and

$\Delta \vec{v}_a = \frac{\Delta \vec{G}(a;b)}{m_a}$, and since $v'_a = \left\| \vec{v}_a + \frac{\Delta \vec{G}(a;b)}{m_a} \right\|$ in order to predict the effect of gravity on

the rates of clocks, all we need to do is substitute the appropriate value in $\Delta t' = \Delta t \frac{\sqrt{c^2 - v_a'^2}}{\sqrt{c^2 - v_a^2}}$

and we get
$$\Delta t' = \Delta t \frac{\sqrt{c^2 - \left\| \vec{v}_a + \frac{\Delta \vec{G}(a;b)}{m_a} \right\|^2}}{\sqrt{c^2 - v_a^2}} = \Delta t \frac{\sqrt{1 - \frac{\left\| \vec{v}_a + \frac{\Delta \vec{G}(a;b)}{m_a} \right\|^2}{c^2}}}{\sqrt{1 - \frac{v_a^2}{c^2}}}$$

And if $\Delta \vec{G}(a;b) = \vec{0}$ then the equation is reduced to $\Delta t' = \Delta t$.

As we can see, the greater the gravitational interaction between a clock and a body, the slower will be its rate of recurrence of a given periodic state. This prediction is also in agreement with general relativity's prediction of the slowing down of clocks by gravity.

Predictions

QGD is in agreement with special relativity and general relativity's predictions of the slowing down of clocks, but it differs in its understanding of time. For QGD, time is a relational concept useful to relate the states of dynamical systems to the states of reference dynamical systems that are clocks. Clocks are shown not to be measuring devices but counting devices which mark the recurrences of a particular state of a periodic system chosen as reference. So, if clocks are understood to measure time, then time is simply the number of times a given change in state occurs over a distance. It is not physical quantity.

We have shown that the slowing down of clocks resulting from increases in speed or the effect gravity is explained not as a slowing down of time, but as a slowing down of their intrinsic mechanisms.

The effects of time dilation predicted by special relativity and general relativity are both described

by
$$\Delta t' = \Delta t \frac{\sqrt{c^2 - \left\| \vec{v}_a + \frac{\Delta \vec{G}(a;b)}{m_a} \right\|^2}}{\sqrt{c^2 - v_a^2}}$$
 since this equation accounts for both the effect of the

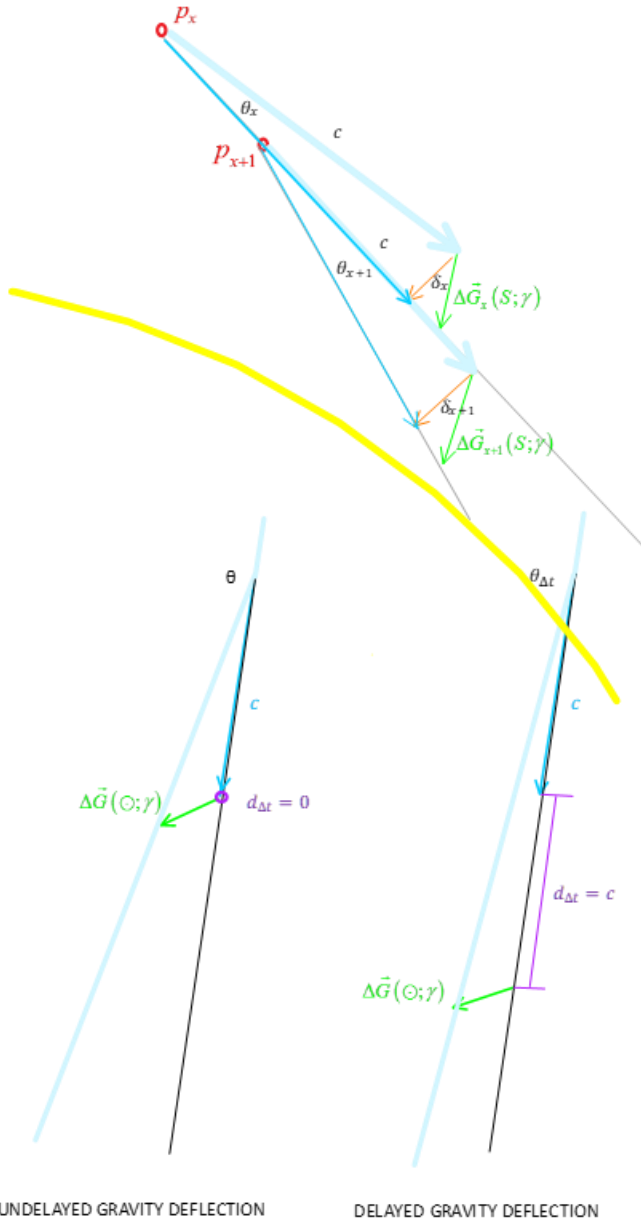
speed and gravity on a clock. Thus, if QGD is correct, the predictions of SR and GR are approximations of solutions of the QGD equation.

Although both general relativity and QGD's qualitatively predict changes in the frequencies of clocks subjected to variations in the magnitude of the gravity effect, their predictions quantitatively differ. There is hope that, in the next few years, experiments such as [Atacama Large](#)

[Millimeter/submillimeter Array](#) in Chile will discover pulsars moving in proximity to the supermassive black hole predicted to exist at the center of our galaxy (SGR A). The predictions of general relativity would then be tested against variations of the rate at which pulsars emit pulses as they are subjected to the intense gravity of the black hole. QGD makes distinct predictions which could also be tested against the same measurements.

Bending of light

The introduction of time delays on the effect of gravity via the second law of motion is



incompatible with Newtonian gravity which is instantaneous. This causes of the discrepancies between the Newtonian based predictions of the bending of light and observations.

According to our minimal axiom set, photons are composed of *preons*⁽⁺⁾. It follows that photons interact gravitationally as do all other material body. Applying our equation for gravity to the trajectory of a photon

coming into proximity to the sun \odot we find that a photon γ changes direction at a position p_i by an angle θ_i given by

$$\theta_i = \frac{\left\| \frac{\Delta}{p_{i-1} \rightarrow p_i} \vec{G}(\odot; \gamma) \right\| \cos \delta_i}{2\pi c}$$

where δ_i is the angle between the vector $\frac{\Delta}{p_{i-1} \rightarrow p_i} \vec{G}(S; \gamma)$ and the perpendicular to the vector \vec{p}_γ .

The total angle of deflection θ of a photon is then

$$\theta = \sum_{-i}^i \frac{\left\| \frac{\Delta}{p_{i-1} \rightarrow p_i} \vec{G}(\odot; \gamma) \cos \delta_i \right\|}{2\pi c}.$$

The acceleration towards the sun

expressed as units of distance per units of time. At the speed c this corresponds to a displacement of the vector $\frac{\Delta}{p_{i-1} \rightarrow p_i} \vec{G}(\odot; \gamma)$ equal to the distance travelled by a photon in one second or c units of distance (see figure 1 and 2).

Since $\theta_i = \frac{\left\| \frac{\Delta}{p_{i-1} \rightarrow p_i} \vec{G}(\odot; \gamma) \right\| \cos \delta_i}{2\pi c}$ for non-delayed gravity and $\theta_{\Delta t} = \frac{\left\| \Delta \vec{G}(\odot; \gamma) \right\| \cos \delta}{2\pi * 2c}$ for time

delayed gravity then $\theta_i = \frac{\theta_{\Delta t}}{2}$ and $\theta = \sum_{-i}^i \frac{\left\| \vec{G}_{p_i N}(\odot; \gamma) \right\| \cos \delta}{2\pi c} = 2\theta_{\Delta t}$. Non-delayed gravity predicts an angle of deflection θ that is exactly twice the angle $\theta_{\Delta t}$ predicted by time delayed Newtonian gravity. Hence, our prediction agrees with general relativity and observations. That is for $\theta_{\Delta t} = .875''$ we get $\theta = 1.75''$.

Precession of the Perihelion of Mercury

The time dependency introduced when Newton's second law of motion also causes errors in Newtonian mechanics predictions of the motion of planets which causes the discrepancy between the predicted position of the perihelion of Mercury and its observed precession. The general equation for the angle of deviation due to gravity is

$\theta = \sum_{-i}^i \frac{\left\| \frac{\Delta}{p_{i-1} \rightarrow p_i} \vec{G}(a; b) \right\| \cos \delta_i}{2\pi \left\| \vec{P}_b \right\|}$ so the angle of non-delayed gravitational deflection of Mercury

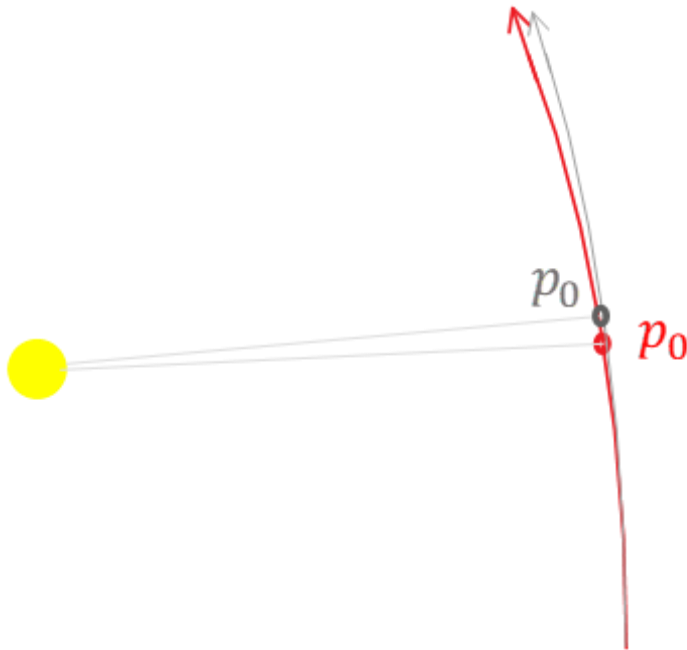
from its momentum vector at a given position is $\theta = \sum_{-i}^i \frac{\left\| \frac{\Delta}{p_{i-1} \rightarrow p_i} \vec{G}(\odot; b) \right\| \cos \delta_i}{2\pi \left\| \vec{P}_b \right\|}$. The angle for

delayed gravity corresponds is obtained after a displacement of the gravity vector equal to

$\left\| \vec{v}_b \right\| \Delta t$ that is: $\theta_{\Delta t} = \sum_{-i}^i \frac{\left\| \frac{\Delta}{p_{i-1} \rightarrow p_i} \vec{G}(\odot; b) \right\| \cos \delta_i}{2\pi \left(\left\| \vec{P}_b \right\| + \left\| \vec{v}_b \right\| \Delta t \right)}$.

Therefore, the angle of gravitational deflection for non-delayed gravity is greater from a given position p_x than for delayed gravity. The difference between θ and $\theta_{\Delta t}$ is the cause of the discrepancy between observations of the position the perihelion and that predicted by Newtonian mechanics. So, in order to correctly predict the precession of the perihelion of Mercury, we need to reduce the effect of the time delays as much as possible. We can do so by making the interval Δt as small as possible. For a given position we have

$$\lim_{\Delta t_i \rightarrow 0} \frac{\left\| \frac{\Delta}{p_{i-1} \rightarrow p_i} \vec{G}(\odot; b) \right\| \cos \delta_i}{2\pi \left(\left\| \vec{P}_b \right\| + \left\| \vec{v}_b \right\| \Delta t_i \right)} = \frac{\left\| \frac{\Delta}{p_{i-1} \rightarrow p_i} \vec{G}(\odot; b) \right\| \cos \delta_i}{2\pi \left\| \vec{P}_b \right\|}.$$

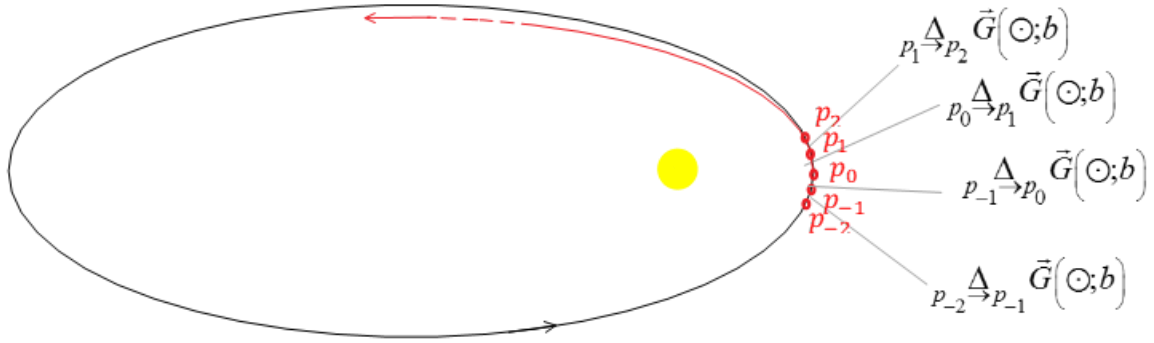


And using the relation $\frac{\Delta}{p_{i-1} \rightarrow p_i} \vec{G}(\odot; b) \approx \vec{G}(\odot; b)$ where $\vec{G}(\odot; b) \Delta t$ is the Newtonian gravity at a position p_i allows us to work in conventional units since

$$\lim_{\Delta t_i \rightarrow 0} \frac{\left\| \vec{G}(\odot; b) \right\| \Delta t_{i-1} \cos \delta_i}{2\pi \left(\left\| \vec{P}_b \right\| + \left\| \vec{v}_b \right\| \Delta t_i \right)} = \frac{\left\| \frac{\Delta}{p_{i-1} \rightarrow p_i} \vec{G}(\odot; b) \right\| \cos \delta_i}{2\pi \left\| \vec{P}_b \right\|}.$$

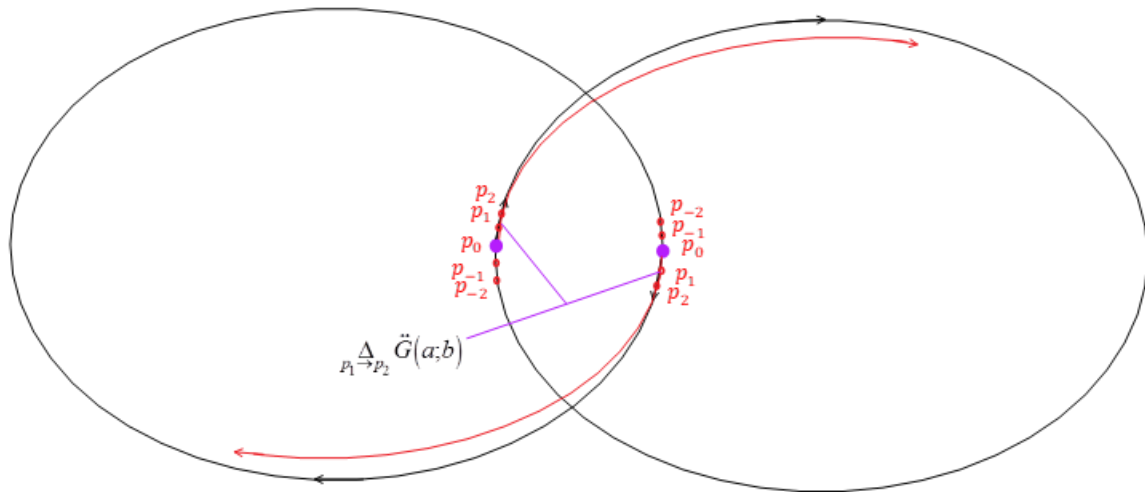
The angle of precession of the perihelion may then be obtained from initial position p_0 (in grey in the figure on the left) at a perihelion by calculating the position of the next perihelion (in red).

The figure below compares the non-delayed gravity prediction for a single orbit of Mercury (in red) in red to the prediction from Newtonian mechanics delayed gravity.



Orbital Decay of Binary Systems

The mechanisms using which we described and explained the precession of the perihelion of Mercury in the preceding section also predicts the precession of binary systems. Therefore, we will not repeat the explanation here. Suffice to say all systems of gravitationally interacting systems are governed by the same laws and described by the same equations. QGD thus explains that the observed orbital decay such as that of the Hulse-Taylor system is not due to loss of energy



emitted as gravitational waves but increase in the momentum towards of each body towards the other due to gravitational acceleration. As we have explained earlier, gravitational acceleration results from the reorientation of the trajectories of the component vectors of the bodies and such an increase in momentum does not change the number of component *preons*⁽⁺⁾, hence has no effect on the mass or energy of the bodies. As massive bodies such as black holes spiral approach, they speed approach that of the speed of light so that their momentum approach their energy,

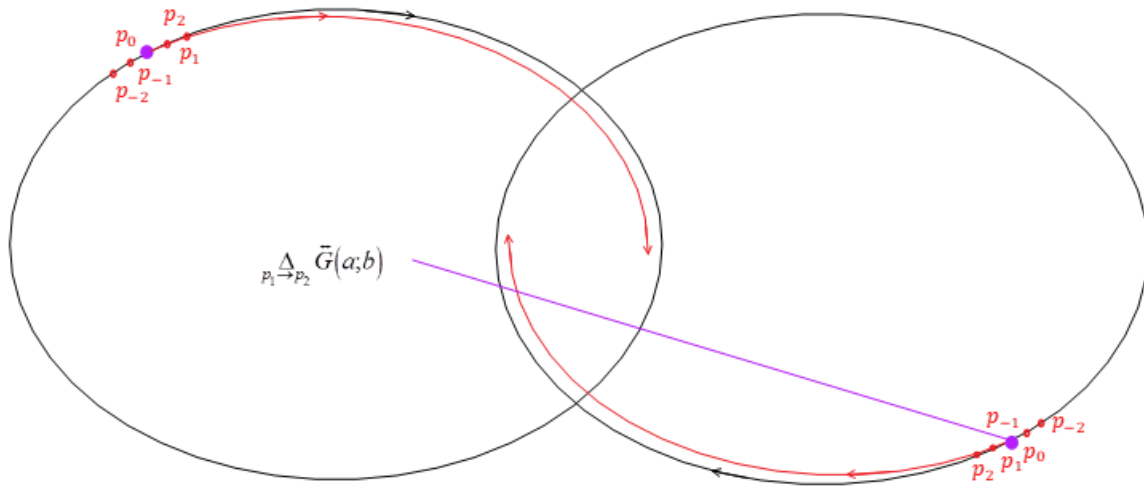
that is $\left\| \sum_{i=1}^{m_a} \vec{c}_i \right\| \rightarrow \sum_{i=1}^{m_a} \|\vec{c}_i\|$. Momentum is not conserved during gravitational acceleration, but energy is.

Therefore, there is no loss of energy in the process of coalescence of massive bodies.

The mass and energy of resulting from the coalescence will be $m_{a+b} = m_a + m_b$, $E_{a+b} = E_a + E_b$ and $\vec{P}_{a+b} = \sum_{i=1}^{m_a} \vec{c}_i + \sum_{i=1}^{m_b} \vec{c}_i$. The resulting black hole (in the case of black hole merger) will spin at a speed equal to the speed of light.

The two figures illustrate how the QGD predictions (in red) diverge from that of Newtonian mechanics (in black).

The figure below extrapolates the orbital decay over the large number of orbits. As we see, the orbital decay will eventually lead to a collision of the two stars.



About the Relation Between Mass and Energy

As we have seen, the energy of a particle or structure is given by $E_a = \sum_{i=1}^{m_a} \|\vec{c}_i\| = m_a c$. Though similar in form to Einstein's equivalence equation, QGD's does not represent an equivalence but a proportionality relation between energy, mass and c which though numerically equal to c , the speed of light, here represents the intrinsic momentum of *preons*⁽⁺⁾ . This description of energy explains and provides the fundamental grounds for the principle of conservation of energy.

According to QGD's interpretation, when a body is accelerated by gravity, its mass and energy are both conserved. What changes is the net orientation of its *preons*⁽⁺⁾ components. Hence, the object's momentum, given as we have seen by $\|\vec{P}_a\| = \left\| \sum_{i=1}^{m_a} \vec{c}_i \right\|$, changes.

Applied to nuclear reactions, for example, we find that no mass is lost from its conversion to pure energy (there is no such thing as pure energy according to QGD). If the QGD prediction that photons have mass, a prediction that may be confirmed by deflection of light from the self-lensing

binary systems, then the amount of mass that appears to have been converted to energy is exactly equal to the total mass of photons emitted because of the reaction. The so-called pure energy is the total momentum of the emitted photons. That is:

$m = \sum_{i=1}^n m_{\gamma_i}$ and $E = \sum_{i=1}^n m_{\gamma_i} c$ where m is the mass of the photons resulting from the reaction and E , the momentum carried by the photons. The reader will note that since the momentum

vectors of the *preons*⁽⁺⁾ of photons are parallel to each other then $\left\| \sum_{i=1}^{m_\gamma} \vec{c}_i \right\| = \sum_{i=1}^{m_\gamma} \|\vec{c}_i\|$, that is the

momentum, and the energy of a photon are numerically equal. However, it is important to keep in mind that though they can be numerically equivalent, momentum and energy are two distinct intrinsic properties.

The production of photons alone does not account for the total production of heat. Consider the nuclear reaction within a system S_1 containing n_1 particles resulting in S_2 , which contains n_2 particles (including the n photons produced by the reaction). Following QGD's axioms, we find that the heat of S_1 and S_2 are respectively given by $heat_{S_1} = \sum_{i=1}^{n_1} \|\vec{P}_i\|$ and

$$heat_{S_2} = \sum_{j=1}^{n_2} \|\vec{P}_j\| < \sum_{j=1}^n m_{\gamma_j} c.$$

The temperatures of S_1 and S_2 , immediately after the reaction, before the volume S_2 expands

are respectively $temp_{S_1} = \frac{\sum_{i=1}^{n_1} \|\vec{P}_i\|}{Vol_{S_1}}$ and $temp_{S_2} = \frac{\sum_{j=1}^{n_2} \|\vec{P}_j\|}{Vol_{S_2}}$ where Vol_{S_1} is the volume of S_1 .

Implications

In its applications, the QGD equation relating energy, mass and the speed of light is similar to Einstein's equation. However, the two equations differ in some essential ways. The most obvious is in their interpretation of the physical meaning of the equal sign relating the left and right expressions of the equation. For QGD, the equal sign expresses a proportionality relation between energy and mass while Einstein's equation represents an equivalence relation.

Also, the equivalence interpretation of Einstein's equation implies the existence of pure energy and pure mass. QGD's axioms imply that mass and energy are distinct intrinsic properties of *preons*⁽⁺⁾ hence inseparable.

QGD's fundamental definitions of mass, energy, momentum and velocity that can be applied to all systems regardless of scale.

Other Consequences of QGD's Gravitational Interaction Equation

Dark Photons and the CMBR

Another implication of the axiom set of QGD which will be discussed in detail in the cosmology section of this book follows what the initial state of the universe it predicts. In its initial state, the only matter was in the form of free *preons*⁽⁺⁾ which were isotropically distributed throughout quantum-geometrical space.

During the isotropic state, *preons*⁽⁺⁾, as a result of the attractive force acting between them and over long travelling distances, started to form the simplest of all particles, low mass photons and neutrinos. And because *preons*⁽⁺⁾ were distributed isotropically, so was the distribution of these particles.

From the description of the laws of momentum, assuming that variations in gravity and electromagnetic effects are negligible, the permitted change in momentum for an electron must obey the relation $\|\Delta\vec{P}_{e^-}\| = xm_{e^-}$ ⁹. This means that photons γ (or neutrinos) whose momentum $\|\vec{P}_{\gamma}\| < m_{e^-}$ are undetectable and therefore dark (we'll refer to them as dark photons).

If QGD's is correct, then the first detectable photons, photons for which $\|\vec{P}_{\gamma}\| \geq m_{e^-}$, have been first observed in 1964 by Arno Penzias and Robert Wilson and correspond to the [cosmic microwave background radiation](#) (CMBR). The observed isotropy of the CMBR then follows naturally from the initial isotropic state of the universe.

Effect Attributed to Dark Matter

We will see in the section titled [QGD Cosmology](#) that the universe's initial state was that consisted of nothing but free *preons*⁽⁺⁾ which were homogenously distributed in space.

Under the effect of gravity, free *preons*⁽⁺⁾ formed large structures. The effect we attribute to dark matter is the interactions between light and material structures with regions of space in which free *preons*⁽⁺⁾ have condensed and which we call now dark matter halos.

⁹ The general equation is $\|\Delta\vec{P}_{e^-}\| = xm_{e^-} + \|\Delta\vec{G} + \Delta\vec{\Theta}\|$ where \vec{G} and $\vec{\Theta}$ are respectively the

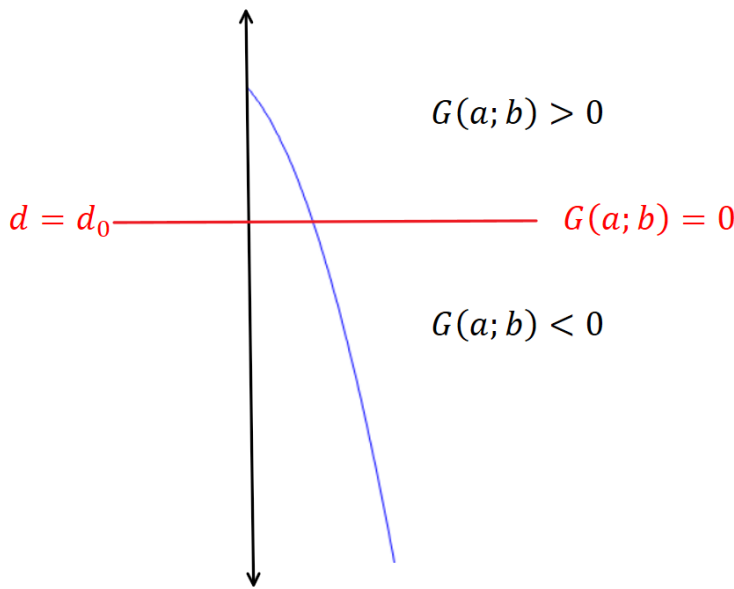
gravitational and electromagnetic effects acting on e^- . The general equation will be discussed and applied in the section [Preonics \(foundation of optics\)](#).

Effect Attributed to Dark Energy

QGD's equation for gravity predicts both attractive gravitational interaction, $G(a;b) > 0$ when $k > \frac{d^2 + d}{2}$, and repulsive gravitational interaction, $G(a;b) < 0$ when $k < \frac{d^2 + d}{2}$. For

distances shorter than the threshold distance d_Λ where $k = \frac{d^2 + d}{2}$, where $G(a;b) = 0$ regardless of m_a and m_b , p-gravity overcomes n-gravity, but at distances beyond d_Λ , gravity is repulsive and increases proportionally to the square of the distance. And acceleration being proportional to the derivative of gravity, QGD predicts a linear increase in acceleration as a function of distance.

QGD equation for gravity's prediction of repulsive gravity beyond the threshold distance may explain the acceleration we attribute to dark energy.



attribute to dark energy.

We have shown that:

1. QGD's law of gravity predicts that at very short distances the number of p-gravity interactions, hence the attractive gravity, is over a hundred orders of magnitude greater than gravity at large scale.
2. QGD law of gravity describes gravity at scales at which we apply Newtonian gravity, and
3. That at very large scale the equation accounts for the effect we

It follows that for distances between material structures greater than the threshold distance d_Λ , and assuming there is no matter in the space that separates them, the gravitational interaction will be repulsive and proportional to the square of the distance beyond d_Λ , resulting in a gravitational acceleration proportional the distance.

We have also shown that the effect we attribute to dark matter can be the gravitational effect of free *preons*⁽⁺⁾ over large regions of space.

Einstein's Equivalence Principle

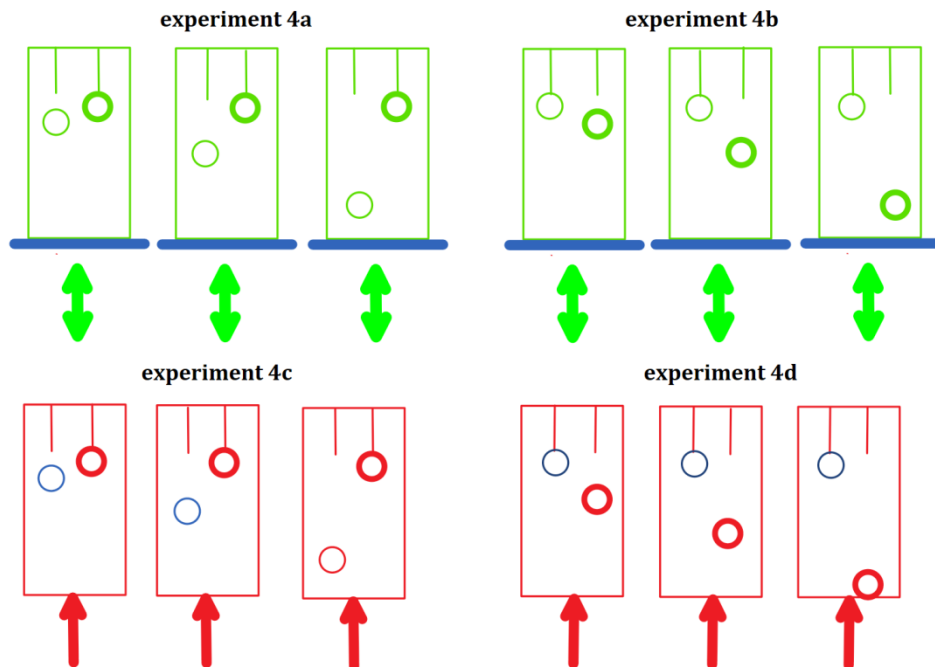
QGD defines and uses only one kind of mass: the intrinsic mass of an object being simply the number of *preons*⁽⁺⁾ it contains. The intrinsic mass determines not only the effect of gravity but all non-gravitational effect.

The gravitational mass is that property which determines the magnitude of gravitational acceleration while the inertial mass determines the magnitude of non-gravitational acceleration. It is important in describing a dynamic system that we understand that the distinction made between the gravitational and inertial masses are distinctions between gravitational and non-gravitational effects. Doing so, we will show that the intrinsic mass determines both gravitational and non-gravitational effects and that these effects are very distinct, thus distinguishable.

The acceleration of an object is given by $\Delta v_a = \frac{\|\Delta \vec{P}_a\|}{m_a}$ where $\|\Delta \vec{P}_a\| = \|\Delta \vec{G}\|$ for gravitational acceleration and $\|\Delta \vec{P}_a\| = \|\vec{F}\|$ for non-gravitational force \vec{F} imparting momentum to a . From
$$\Delta v_a = \frac{\|\Delta \vec{G}\|}{m_a} = \frac{1}{m_a} m_a m_b \left(\left(k - \frac{d_1^2 + d_1}{2} \right) - \left(k - \frac{d_2^2 + d_2}{2} \right) \right) = m_b \left(\left(k - \frac{d_1^2 + d_1}{2} \right) - \left(k - \frac{d_2^2 + d_2}{2} \right) \right)$$

we know that gravitational acceleration is independent of the mass of the accelerated body, while

$\Delta v_a = \frac{\|\vec{F}\|}{m_a}$ tells us that non-gravitational acceleration is inversely proportional to the mass of



the accelerated body. Let us consider the experiments represented in the figure below which based on Einstein's famous thought experiment.

The green rectangles represent a room at rest relative to Earth's gravitational field.

The Earth and green room dynamics is described by the equation $\vec{v}_{\boxed{g}} = \frac{\vec{P}_{\boxed{g}}}{m_{\boxed{g}}} = \frac{\vec{P}_{\boxed{\mathcal{E}}}}{m_{\boxed{\mathcal{E}}}} = \vec{v}_{\boxed{\mathcal{E}}}$

where \boxed{g} represents the green room and $\boxed{\mathcal{E}}$ the Earth. Applying the laws of momentum [discussed earlier](#), we know that green room and the Earth are moving at the same speed hence, since $(v_{\boxed{g}} - v_{\boxed{\mathcal{E}}})m_{\boxed{g}} = 0$ and $(v_{\boxed{\mathcal{E}}} - v_{\boxed{g}})m_{\boxed{\mathcal{E}}} = 0$ there is no momentum transfer between the Earth and the green room, consequently no non-gravitational acceleration. And since there is no change in distance between \boxed{g} and $\boxed{\mathcal{E}}$, there is no variation in the gravity, so no gravitational acceleration either.

The red room is in region of space where the effect of gravity is negligible. A non-gravitational force imparts momentum \vec{F} to the red room from the floor up.

Einstein's thought experiment assumes that it is possible to apply a force which will accelerate the red room so that, to an observer within the room, the acceleration will be indistinguishable from that of gravity. That is, he assumes that $\vec{F} = \Delta\vec{G}$.

Before going into a full description of the experiment, we need to keep in mind the distinctions between gravitational acceleration and non-gravitational acceleration. For one, gravitational acceleration of body is independent of its mass while non-gravitational acceleration of a body is inversely proportional to its mass. That is: $\Delta\vec{v}_a = \frac{(\vec{v}_F - \vec{v}_a)m_{\vec{F}}}{m_a}$ where \vec{v}_F is the speed of the

particles carrying the momentum \vec{F} (in the case of a rocket engine, this is the speed of the molecules of gas produced by the engine which interact with the room) and v_a the speed of the room. It follows that we can set $\vec{F} = \Delta\vec{G}$ for a given m_a but for an object of mass $m_b \neq m_a$, we can have $\vec{F} = \Delta\vec{G}$ but $\vec{F} \neq \vec{F}'$ and $\Delta\vec{v}_a = \frac{(\vec{v}_F - \vec{v}_a)m_{\vec{F}}}{m_a} \neq \frac{(\vec{v}_F - \vec{v}_b)m_{\vec{F}}}{m_b} = \Delta\vec{v}_b$. Which means

that, to maintain an acceleration equivalent to gravitational acceleration, \vec{F} must be adjusted to take into account the mass of the accelerated to compensate for its speed since the imparted momentum of a rocket engine (or any other form of propulsion) decreases as the speed increases.

Returning to experiment 4, the green and red rooms will have the same mass and composition. In each room, there will be a set of two spheres of mass m_a and m_b where $m_a < m_b$. In the rooms

initial states, the spheres are suspended from rods fixed to the ceilings. The spheres can be released on command. In each of the room is an observer that is cut off from the outside world. They have no clue as to which of the two rooms they are in. The observers however, being experimental physicists, are trusted to measure the accelerations of the spheres in the two experiments and see if they can determine whether the room each is in is at rest in a gravitational field or uniformly accelerated.

In the first experiment, the spheres with mass m_a will be dropped in each room. In the second experiment, from the same initial state, spheres with mass m_b will be dropped.

The green room observer finds that both spheres have the same rate of acceleration relative to the room despite having different masses. He finds this to be consistent with gravitational acceleration but cannot exclude based on these two experiments alone that he may be in a uniformly accelerated room.

The red room observer however finds that rate of acceleration of the a sphere is slower than the rate of acceleration of the more massive b sphere relative to the room. His observations of the accelerations of the spheres being inconsistent with gravitational acceleration he must conclude that the room is accelerated by an external non-gravitational force \vec{F} .

Furthermore, being a physicist, the red room observer knows that at the moment a sphere is released, the momentum imparted by \vec{F} is no longer transferred to the sphere. The sphere stops accelerating instantly and will move at the speed it had prior to its release. Therefore, it is the room that is accelerated and not the sphere. The acceleration of the red room in its initial state

is $\Delta v_{\square} = \frac{\|\Delta \vec{F}\|}{m_{\square} + m_a + m_b}$. When the a sphere is released, there is a sudden change in the

rate of acceleration of the room given by $\Delta \Delta v'_{\square} = \frac{\|\vec{F}\|}{m_{\square} + m_b} - \frac{\|\vec{F}\|}{m_{\square} + m_a + m_b}$. The change the

rate of acceleration after the release of sphere b is $\Delta \Delta v'_{\square} = \frac{\|\vec{F}\|}{m_{\square} + m_a} - \frac{\|\vec{F}\|}{m_{\square} + m_a + m_b}$. The

higher variation the in the rate of acceleration after the release of b is seen from within the room as a larger acceleration of b relative to the room.

So, it appears that observers can easily distinguish between being in a room at rest in a gravitational field from being in a uniformly accelerated room away from any significant gravitational field. This appears to invalidate the weak equivalence principle. Being an experimental physicist, the observer in the red room requires confirmation of his observation. He decides to repeat the experiment. After all, one experiment is not enough, and one has to be able

to reproduce the results before doing something so drastic as to refute the weak equivalence principle.

Again, the more massive sphere accelerates faster than the lighter sphere, but something is different. The acceleration rates of sphere *a* and sphere *b* in the second set of experiments are slower than the accelerations of the same spheres in the first set of experiments. After conducting a few more experiments he finds the observations to be consistent with $\Delta\vec{P}_{[r]} = (v_{\vec{F}} - v_{[r]})m_{\vec{F}}$ and concludes that the momentum imparted by the non-gravitational force decreases as speed of the room increases which allows him to predict that the maximum possible speed the red room can

achieve is $\vec{v}_{[r]} = \vec{v}_{\vec{F}}$ at which speed $\Delta\vec{P}_{[r]} = (v_{\vec{F}} - v_{[r]})m_{\vec{F}} = 0$ and $\Delta v_{[r]} = \frac{\Delta\vec{P}_{[r]}}{m_{[r]}} = 0$.

The above experiments would confirm QGD predictions that:

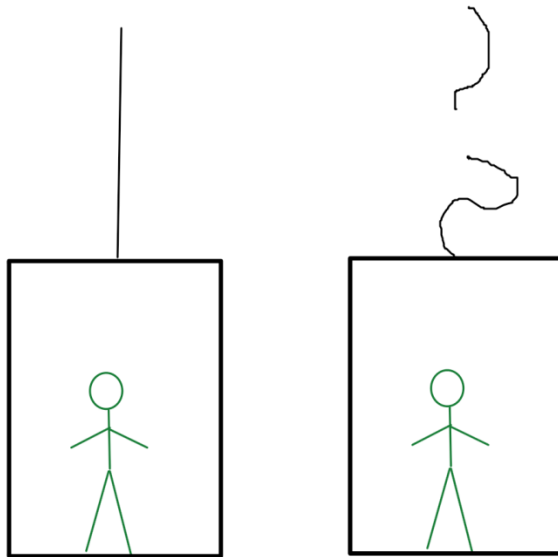
- Gravitational acceleration and non-gravitational acceleration are not equivalent
- The outcome of an experiment may be affected by the velocity of the laboratory

Note: The force acting on the red room being non-gravitational, its observer would feel an acceleration when one or both spheres are released. But the observer in the green room would feel no acceleration when one of both spheres are released. This makes it possible to distinguish between gravitational and non-gravitational acceleration within a room without instruments.

Weightlessness in Einstein's thought Experiment

Consider a man standing in an elevator when suddenly the elevator cable breaks. After the rupture of the cable the elevator and its passenger are in free fall and, as if gravity had been

turned off, they are weightless.



There is, it seems, no acceleration; an interpretation that is supported by the fact that if we were to put an accelerometer on the floor of the elevator, it would measure no acceleration. In fact, an accelerometer alone in free fall measures no acceleration. In the absence of other forces (assumed to be inexistent for the experiment) zero acceleration implies that zero force and a logical interpretation would be that gravity is not a force. This interpretation leads to the idea that gravity is an effect of curvature of space-time.

Let us describe the dynamics of the elevator and its passenger from Einstein's thought experiment of 1907. If the elevator is at rest before the rupture of the cable, then the dynamics is

$$\vec{v}_{[g]} = \frac{\vec{P}_{[g]}}{m_{[g]}} = \frac{\vec{P}_{[E]}}{m_{[E]}} = \vec{v}_{[E]} \text{ where } [g] \text{ represents the elevator with the passenger and } [E]. \text{ In}$$

order to correctly describe the system, we need to use the intrinsic speed and momentum since the relative speed is misleading. Even though the speed of the passenger relative to the elevator is equal to zero, we know that it, along with the Earth, the solar system, and the entire galaxy, is speeding through space. Using conventional definitions of speed and momentum, which have null values, do not describe the system.

Before the cable ruptures

If the passenger were to jump in the elevator, that is, increase its speed by bending its legs and suddenly extending them, then $\Delta\vec{P}_{[E]} = \Delta\vec{v}_{pass} m_{pass}$ and $\Delta\vec{P}_{pass} = -\Delta\vec{v}_{pass} m_{pass}$. The momentum of the passenger after the jump is $\vec{P}'_{pass} = \vec{P}_{pass} - \Delta\vec{v}_{pass} m_{pass}$ and its speed is $\vec{v}'_{pass} = \vec{v}_{pass} - \Delta\vec{v}_{pass}$ where $-\Delta\vec{v}_{pass}$ is the passenger's speed relative to the Earth.¹⁰

Now, applying the gravitational interaction equation, we know that after the jump the passenger will lose momentum proportionally to ΔG , that is $\Delta\vec{v}_{pass} = \frac{\Delta\vec{P}_{pass} - \Delta\vec{G}}{m_{pass}}$ so that when

$\Delta\vec{G} = \Delta\vec{P}_{pass}$ the passenger speed will be back to its initial speed (zero relative to Earth) and the passenger will be gravitationally accelerated towards the Earth.

When the passenger lands back on the floor, the momentum of passenger will be $\vec{P}''_{pass} = \vec{P}_{pass} + \Delta\vec{G}$ resulting in a [transfer of momentum](#) from the passenger to the Earth (mediated by the elevator) and equal to $\Delta\vec{G}$ and since $\Delta\vec{G} = \Delta\vec{P}_{pass}$ the initial state is and conserving the momentum of the system.

We can now focus our attention on the thought experiment 3.

After the cable ruptures

When the cable is ruptured, $\vec{H} = \vec{P}_{[g]}$, the force that prevented the elevator from accelerating towards the Earth and which is transmitted via the cable is cut off. The elevator and passenger

¹⁰ We ignore here the negligible acceleration of the Earth from the jump which is $\Delta v_{[E]} = \frac{\Delta v_{pass} m_{pass}}{m_{[E]}}$

will move at their initial speed towards the Earth that is $\vec{v}_{[g]} = \frac{\vec{P}_{[g]}}{m_{[g]}}$. What the passenger

perceives as weightlessness is correct. Since the weight is simply the measurement of \vec{H} , when the cable is cut off, \vec{H} is no longer imparted to the passenger and thus he feels weightless. But feelings are evidently not reliable measures of reality (which is something our physicist passenger knows). He understands that the removal of the effect of weight is not the removal gravity but the removal of the force that opposes gravity. There is increase in momentum, hence acceleration, which the passenger will be transferred to the Earth when the elevator hits the ground.

Since all components of an accelerometer are accelerated uniformly and at the same rate (see [universality of free fall](#)) it cannot measure gravitational acceleration. What an accelerometer measures is the effect of weight. That is: it measures \vec{H} . And \vec{H} ceases to be transferred to the elevator and content after rupture of the cable so it will measure zero weight.

However, though the accelerometer (denoted *acc* below) cannot measure gravitational acceleration, it can inform of its momentum, its gravitational acceleration and its speed if we record and correctly interpret the measurement α it makes before release, the null reading during free fall, the measurement α' at impact and α'' after impact since:

$$\vec{H} = \vec{P}_{acc} \rightarrow \vec{P}_{acc} = \alpha ,$$

$$\Delta G = \alpha' - \alpha'' \text{ and } \Delta v_{acc} = \frac{\Delta G}{m_{acc}} , \text{ and}$$

$$\vec{H} = \vec{P}_{acc} \rightarrow \vec{P}_{acc}'' = \Delta \alpha'' .$$

If there were a second elevator cabin in space and moving at uniform speed, as described in another one of Einstein thought experiment, it would be in a state of weightlessness and without gravity, so that $\alpha = \alpha' = \alpha'' = 0$. That would allow an observer to easily distinguish the experience of being in a cabin in space from being in a cabin free falling in a gravitational field.

We have shown that though there is only one kind of [mass](#), the effects of gravity and non-gravitational force can never be equivalent. And even when cut off from the outside world, as is imagined in Einstein's thought experiments, observers can correctly describe and distinguish between the forces acting on their environment through experiments as long as measurements are made of the initial, transitory and final states of the experiments and a minimum of two distinct experiments are conducted for each measured property.

Gravitational Waves

QGD precludes the existence of gravitational waves so how can it be reconciled with the advanced LIGO-Virgo observatories detections of signals that are consistent with gravitational waves predicted from general relativity? How does QGD explain these signals if, as it predicts, gravitational waves do not exist?

LIGO-Virgo detected several signals that were thought to be due to gravitational waves but only the detection of the event known as GW170817 had electromagnetic counterparts. This observation makes it possible to narrow down the possible explanations of what LIGO-Virgo measured to one.

If QGD's theory of gravity is correct, then the observations of electromagnetic counterparts rather than confirming the existence of gravitational waves falsifies it. Or at the very least excludes the possibility that GW170817 is a gravitational signal. The question we must then answer is: If not gravitational, then what is the nature of the signals detected by LIGO-Virgo observatories?

First, we must keep in mind that:

"A gravitational wave (GW) is detected by measuring the differential arm length (DARM) of an interferometer (and converting it to a GW strain), so coupling between the external environment and the interferometer readout can reduce a detector's Environmental Noise in Advanced LIGO Detectors sensitivity to gravitational waves and potentially produce transient non-astrophysical signals in the detector. The environment can influence the detector through physical contact (via vibrations or temperature fluctuations), electromagnetic waves, static electric and magnetic fields, and possibly high-energy radiation. These effects are monitored with the physical environmental monitoring (PEM) system of sensors"¹¹

The LIGO-Virgo detectors are sensitive to electromagnetic waves and cannot of themselves distinguish between gravitational and electromagnetic waves having similar amplitude, frequency, and envelope. So, though the signals detected are consistent with gravitational waves, it may also very be electromagnetic in nature.

First, since LIGO-VIRGO detected the GW170817 only 1.7 seconds before the detection of a gamma ray burst GRB170817, if the signal was generated by the same event, we can assume that it must have travelled at the speed of light. Now, according to QGD, only $preons^{(+)}$, photons and neutrinos can travel at the speed of light. According to QGD, the GW170817 signal maybe be composed of $preons^{(+)}$, specifically polarized $preons^{(+)}$ resulting from the polarization of a large regions of the preonic field (the mechanism of polarization has been discussed in detail [here](#)) or by [dark photons](#).

¹¹ [2101.09935.pdf \(caltech.edu\)](#)

Secondly, the event produces a wave-like signal which increases in both frequency and amplitude which is consistent with the polarization of the preonic field by a coalescing binary system.

As the stars of a binary system accelerate towards each other, they themselves become increasingly polarizing. The intensity of the polarization of the preonic field is by each one of the stars proportional to the size and density of the stars, their orbital velocity and the [preonic density](#) in the region of space they are located in. The mechanism of polarization of the preonic field by stellar objects is identical to that of polarization by particles such as electrons and described by the same equations (see [The electromagnetic Effects](#) section).

For a binary system, the polarization of a neighboring region of the preonic field will vary as polarized stars pass through them. So, the closer there orbit each other, the higher the orbital speed, the higher the frequency and the more intense the polarization of the neighbouring region of the preonic field.

The frequency of the signal is the proportional rotation speed of the binary system $f = \frac{v_\theta}{\pi}$

As for the amplitude of the signal $\|\vec{P}_\Theta\|$ we have

$$\|\vec{P}_\Theta\| \propto \frac{\|\vec{P}_{b_1}\| dens_{b_1} dens_{p^{(+)}} \cos \delta + \|\vec{P}_{b_2}\| dens_{b_2} dens_{p^{(+)}} \cos(\delta + \pi)}{d} v_\theta \cos \theta$$

where v_s is the rotation speed of the system, δ is the angle of the star relative to the line of sight, θ is the inclination of the plane of rotation, d the distance of the observer, and $dens_{b_1}$ and $dens_{b_2}$ are the density of the stars b_1 and b_2 .

From the above, we can see that the signals detected by LIGO-Virgo may be caused displacements of its mirrors by polarized *preons*⁽⁻⁾ ¹² (which the reader will recall, is what magnetic fields are composed of) and dark photons¹³ also polarized by the coalescence of a binary system, or both.

The magnetic field generated by the polarization by a coalescing binary system can certainly mimic the predicted gravitational waves. So, as we can see, the effects on the LIGO-Virgo detectors of a gravitational waves and magnetic fields generated by the coalescence of two massive bodies are undistinguishable. Therefore, a testable prediction unique to QGD is necessary to determine which one of the interpretations of the observations is correct.

¹² [Magnetism and Advanced LIGO](#) by Christina Daniel and Robert Schofield.

¹³ [Searching for dark photon dark matter in LIGO O1 data \(nature.com\)](#)

How to Distinguish Observationally Undistinguishable Predictions of QGD and GR

Preonic waves are composed of polarized *preons*⁽⁺⁾. The signals detected by the LIGO-VIRGO observatories are likely magnetic fields modulated by the motion of the coalescing massive bodies. It follows that if the signal is due to preonic waves, QGD predicts that it would cause fluctuations in the magnetic moment of a magnet and the signal formed by the fluctuations will mirror the signal detected by LIGO-Virgo observatories or other gravitational wave detectors. Testing the prediction requires high precision magnetic field sensors or instruments measuring the Zeeman effect to monitor the fluctuations in the magnetic fields and comparing those measurements to signals detected by LIGO-Virgo or future detectors.

On the Relations between Local and Non-Local Interactions

Locality is the notion that spatially separated systems are independent. That is, an event which affects one system cannot affect another. All such events, according to QGD, must be [non-gravitational interactions](#). The terms “local” and “non-gravitational” are here interchangeable.

QGD predicts that gravitational effects are Instantaneous, and since local events always cause changes in momentum and mass, hence affects the gravitational interactions between the objects of the events and all other objects in the universe, then no system is independent. All local events have non-local effects, and all non-local events have local effects.

Readers may reasonably object to the idea of instantaneous gravity which by all account has been proven to move at the speed of light. After all, LIGO/Virgo observations support general relativity’s prediction that gravity moves at the speed of light; particularly the [GW170817](#) event where the LIGO and Virgo detectors received gravitational wave signals within two seconds of gamma ray and optical telescopes detections of electromagnetic signals from the same direction, which is strong evidence that gravitational waves move at the speed of light. But despite appearances, GW170817 does not contradict QGD’s description of gravity.

Let us be clear; We do not question the LIGO/Virgo observations. Quite the opposite since the detected signals are consistent with QGD predictions that predate the detections by several years and according to which the detected signals are not be gravitational but rather electromagnetic in nature. The signals would then be produced by the polarization of the preonic field by the binary system during merger event.

We also propose that means by which gravitational events may be detected instantly regardless of distance.

As we have seen earlier, quantum-geometry dynamics provides a non-perturbative description of the evolution of a system consisting of n gravitationally interacting bodies. The evolution of such a system of gravitationally is described completely using a *state matrix* such as the one below.

$$s + 1 = \left\{ \begin{array}{l|l} \vec{P}_{a_{1|s+1}} = \vec{P}_{a_{1|s}} + \Delta \vec{G}_{j=1}^n(a_{1|s}; a_{j|s+1}) & \varepsilon_{a_{1|s+1}} \\ \dots & \dots \\ \vec{P}_{a_{n|s+1}} = \vec{P}_{a_{n|s}} + \Delta \vec{G}_{j=1}^n(a_{n|s}; a_{j|s+1}) & \varepsilon_{a_{n|s+1}} \end{array} \right\} \quad (1)$$

Where s is and $s + 1$ are two successive states, $\vec{P}_{a_{i|s}}$ is the momentum of the i^{th} body out of a system consisting of n bodies, and a_j are bodies of the system, $j \neq i$ and

$$\Delta \vec{G}_{j=1}^n(a_{i|s+1}; a_{j|s+1}) = \Delta \vec{G}_{s+1}(a_{i|s+1}; a_{1|s+1}) + \dots + \Delta \vec{G}_{s+1}(a_{i|s+1}; a_{n|s+1}) \quad (2)$$

where $\Delta \vec{G}_{s+1}(a_{i|s+1}; a_{j|s+1})$ is the variation in gravity between two successive states s and $s + 1$ of the system and $a_{i|s+x}$. The position itself is denoted $\mathcal{E}_{a_{i|s+x}}$.

A system can be a planetary system, a galaxy, group of galaxies or even the entire universe. All that changes is the scale of the objects which must be appropriately chosen.

Note however that the state matrix of systems smaller than the universe excludes forces external to the systems acting on them which, as we will show below, can have significant effects. A complete state matrix, one which includes all objects in the universe, is impossible to create but unnecessary to describe dynamic systems when scale simplification is possible.

For example, when describing the gravitational interaction between a local object¹⁴ at a chosen scale¹⁵ and a sufficiently distant system (which may be as large as a large scale structure), the distant system may be treated as single massive object with dynamics described by a single momentum vector.

Non-local Effects of Local Events

Local interactions are events involving momentum transfers between objects. Momentum transfers may result from collisions, partial or total absorption of photons or particles or absorption of *preons*⁽⁺⁾ from polarized preonic fields (magnetic fields) which impart their momentum.

Let a be a particle in state s of the universe that undergoes a local interaction. As we have seen, this implies a_{s+1} in the following state $s + 1$ if the universe s that $m_{a_s} \neq m_{a_{s+1}}$ and

$$\vec{P}_{a_s} \neq \vec{P}_{a_{s+1}}.$$

¹⁴ We define an object as a bound components that behave at a given scale and under a given interaction as a single indivisible object.

¹⁵ We define the scale as that at which bounded components behave as one object under a given interaction.

Let b_s be a non-local particle in state s of the universe. Let us assume for the sake of simplicity that the quantum-geometrical distance between a and b does not change from states s and $s+1$.

Following the interaction a undergoes in state s , we know that $\vec{G}(a_s; b_s) \neq \vec{G}(a_{s+1}; b_{s+1})$. So the gravitationally change of the momentum of b is $\Delta \vec{P}_{b_{s+1}} = \Delta_{s \rightarrow s+1} \vec{G}(a; b)$ where $\Delta_{s \rightarrow s+1} \vec{G}(a; b)$ is the variation in the gravitational interaction between a and b between the states s and $s+1$.¹⁶

According to QGD, reality is strictly causal, so the evolution of any dynamic system is a sequence of causality linked states. The evolution of the gravitational interaction between a and b from an initial state s to a state $s+n$ is then:

$$\sum_{i=s}^n \Delta \vec{P}_{b_{i+1}} = \sum_{i=s}^n \Delta_{i \rightarrow i+1} \vec{G}(a; b) \quad (3)$$

If the interaction with a is a measurement at a local detector D1 in a Bell type experiment between states s and state $s+n$, and b a non-local particle simultaneously¹⁷ measured at detector D2, then equation (3) describes the non-local effect on particle b of measurement of particle a . This however is an incomplete description of the dynamics of b in the sequence $[s; s+n]$ since it does not account for its interactions with all other objects.¹⁸

Going back to the above Bell type experiment, if the sum of all other gravitational interactions is close to $\vec{0}$, then to predict the outcome of a measurement of b at D2 in the sequence of states $[s; s+n]$ one would first need to calculate $\sum_{i=s}^n \Delta_{i \rightarrow i+1} \vec{G}(a; b)$ based on the change in mass of a , itself proportional to the momentum it imparts to detector D1.

Effects at Non-Euclidean Scales

We have seen that at scales at which Euclidean geometry emerges, gravity is described by

$\vec{G}(a; b) = m_a m_b \left(k - \frac{d^2 + d}{2} \right) \vec{u}$ where a and b are spherical homogeneous objects¹⁹. At

Euclidean scales, $\Delta \vec{G}(a; b) = \Delta \vec{P}_a$ and $\Delta \vec{P}_a = x m_a$ and $\Delta \vec{P}_b = x' m_b$ where x and x' are positive

¹⁶ $\Delta \vec{G}_{s+1}(a; b) = \vec{G}(a_{s+1}; b_{s+1}) - \vec{G}(a_s; b_s)$

¹⁷ Events involving two objects are simultaneous if the state at which the objects interact gravitationally

¹⁸ A complete description requires a sequence of state matrixes which include all objects interacting with it.

¹⁹ This is the scale at which Newton gravity emerges (see derivation [here](#))

integers. Hence variations in the gravitational interactions are always equal to changes in momentum permitted by the laws of momentum, a direct consequence of which is [the equivalence principle](#). But $\vec{G}(a;b) = m_a m_b \left(k - \frac{d^2 + d}{2} \right) \vec{u}$ is what we may call and Euclidean approximation of QGD's exact equation for gravity:

$$\|\vec{G}(a;b)\| = m_a m_b k - \sum_{\substack{i=1 \\ j=1}}^{m_a} \frac{d_{i,j}^2 + d_{i,j}}{2} \quad (4)$$

where $d_{i,j}$ is the quantum-geometrical distance between a_i and b_j , respectively component *preons*⁽⁺⁾ of a and b . The exact equation must be used when describing gravitational dynamics at non-Euclidean scales (see explanation [here](#)).

A noteworthy implication of equation (4) is that, except for special cases, $\Delta \vec{G}(a;b) \neq x m_a \vec{\rho}$ and/or $\Delta \vec{G}(a;b) \neq x' m_b \vec{\rho}$. What that means is that at non-Euclidean scales (which includes quantum scales), variations in the gravitational interaction are no longer equal to permitted changes in momentum for a and b , thus [the equivalence principle](#) no longer holds. This means that the interaction cannot resolve itself through instant action on the momentums of the gravitationally interacting particles since the changes in momentum induced by the variations in gravity are forbidden by the laws of momentum. Instantaneous action being fundamental in QGD, the interaction must resolve itself through the mechanism described below.

If $x m_b \vec{\rho} = \Delta_{s \rightarrow s+1} \vec{G}(a;b) < (x+1) m_b \vec{\rho}$ then the interaction is resolved by b emitting a particle b' such that $\vec{P}_{b'} = \Delta_{s \rightarrow s+1} \vec{G}(a;b) - x m_{b_{s+1}} \vec{\rho}$ and $\Delta \vec{P}_b = x m_{b_{s+1}} \vec{\rho}$ where $m_{b_{s+1}} + m_{b'} = m_{b_s}$.

Similarly, if $x m_a \vec{\rho} = \Delta \vec{G}(a;b) < (x+1) m_a \vec{\rho}$ then a emits a particle a' such that $\vec{P}_{a'} = \Delta_{s \rightarrow s+1} \vec{G}(a;b) - x m_{a_{s+1}} \vec{\rho}$ and $\Delta \vec{P}_a = x m_{a_{s+1}} \vec{\rho}$.

Example of Nuclear Scale Effect from Distant Event

Let us consider an atomic nucleus a_s and a massive binary system B_s at a distance $d \gg d_\Lambda$ from a_s ²⁰ and d_Λ is the distance beyond which gravity becomes repulsive (see [here](#)). The dynamics of the binary system causes discrete variations in the gravitational interaction between B and a

²⁰ Two particles or structures coexist only when they are in the same S state, that is, they interact gravitationally. A particle in state S cannot interact gravitationally with a particle in state other than S .

(and simultaneously between B and all other particles and structures in the universe, but for simplicity we will focus on the interaction between a and B .

As we have seen earlier, the equivalence principle breaks down at the nuclear scale when $xm_a\vec{\rho} < \Delta\vec{G}(a;B) < (x+1)m_a\vec{\rho}$ and as a consequence gravitational acceleration of a which normally would be equal to $\Delta\vec{G}(a;B)$ is forbidden by the laws of momentum (see [Transfer and Conservation of Momentum](#)).

As we have seen earlier, the change of state must resolve itself by a emitting one or more particles a'_i such that $\sum_{i=1}^n \Delta\vec{P}_{a'_i} = \Delta\vec{G}(a;B) - xm_{a_{s+1}}\vec{\rho}$ where n is the number of particles emitted and $\Delta\vec{P}_a = xm_{a_{s+1}}\vec{\rho}$.

For a given dynamic system S , the type and momentums of the radiated particles will depend on m_a and d . The larger m_a , the wider the range $]xm_a, (x+1)m_a[$ and the wider the range of possible radiated particles. So, all other factors being equal, the more massive an atomic nucleus and larger $\Delta\vec{G}(a;S) - xm_a$, the wider the momentum range of gravitationally triggered particle radiation. Also, this equation for gravity implies that repulsive gravity increases with distance, so beyond $d \gg d_\Lambda$ the most distant systems exert the largest gravitational effect.

We must remind the reader here that equation describes a universe which would contain only a and S . To account for all objects in the universe interacting with a significantly, we must use the appropriate state matrixes and scales. There is much work to be done to develop experiments that would test the effects we have described here but should such test support QGD's predictions of nuclear decay triggered by distant events, then they may be used to inform us in "real time" of evolution of distant systems and possibly help map out distant systems in their actual present states.

Local Effect on Molecules and Bound Molecules from Distant Events

Molecules behave as one object under gravitational interaction with distant objects. Take a molecule composed of x number of atoms. In such a case, it is the gravitational interaction between the molecule and the distant structure that must be used to predict gravitationally induced decay of nuclei.

As one can easily infer, only a small number of nuclei need to radiate to maintain equilibrium. The ratio of radiating nuclei will depend on the mass of the nuclei, the number of atoms in the molecules, and on whether the molecules are bound into a larger structure in which case, we must consider the interaction with the larger structure. It will also depend on difference between

the amplitude of the gravitational variations and the permitted changes in momentum of the molecule. All these may be factors in the radioactivity of isotopes and their [half-life](#).

Theorem

All local interactions have non-local effects. Conversely, all non-local events have local effects.

It follows that although both QGD and quantum mechanics agree on the existence of a non-local effect, QGD differs in that it predicts that though instantaneous, the non-local effect of the measurement of a local particle will vary with distance, quantum-geometrical distance to be specific, as well as the scale of the objects that are measured.

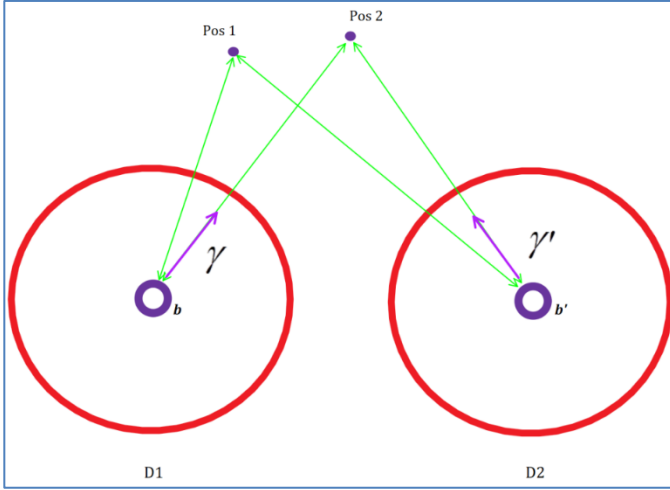
If QGD's equation for gravity holds, then the amplitude of the effect is not only inversely proportional to the square of the distance as Newtonian gravity predicts but repulsive gravity is proportionally the quantum-geometrical distance for $d > d_{\Lambda}$, where d_{Λ} is the threshold distance beyond which gravity becomes repulsive.

Instantaneity and the Uncertainty Principle

The uncertainty principle states that two conjugate properties cannot be known with certainty. The most common example being that of the properties of momentum and position. According to the Heisenberg's uncertainty principle, as the certainty of the measurement of momentum increases, the uncertainty of the position increases as well. This is described by the famous equation $\sigma_x \sigma_p \geq \frac{\hbar}{2}$ and thought to be inherent to wave-like systems. But if space is discrete (specifically quantum-geometrical as per QGD's axiom of discreteness of space), then the wave function provides only a probabilistic approximation of the state of singularly corpuscular particles and the uncertainty principle is a consequence of quantum mechanics; not of a fundamental aspect of reality in which space is discrete rather than continuous.

Position and Momentum of Particles (or Structures)

Consider a particle which momentum and position are unknown and two gravitational detectors as shown in figure 1. The red circles in the figure represent arrays of photon detectors which will detect and measure the photons energy and direction. At the core of the detectors are variable mass spherical structures b and b' (the mechanism by which the mass of the cores vary may be by laser pulses or a form a induce decay of its structure).



According to QGD, when the position of a particle a (purple dots changes position, $G(a;b)$ and $G(a;b')$, respectively the gravitational interactions between it and the cores b and b' at the center of the detectors $D1$ and $D2$ instantly change.

A consequence of space being discrete is that only changes in momentum which are multiple of m_b units of

momentum are allowed.²¹ So, if $|\Delta G(a;b)| < m_b$, the change in the gravitational interaction is insufficient to impart momentum to b . In order to satisfy the gravitational interaction equation

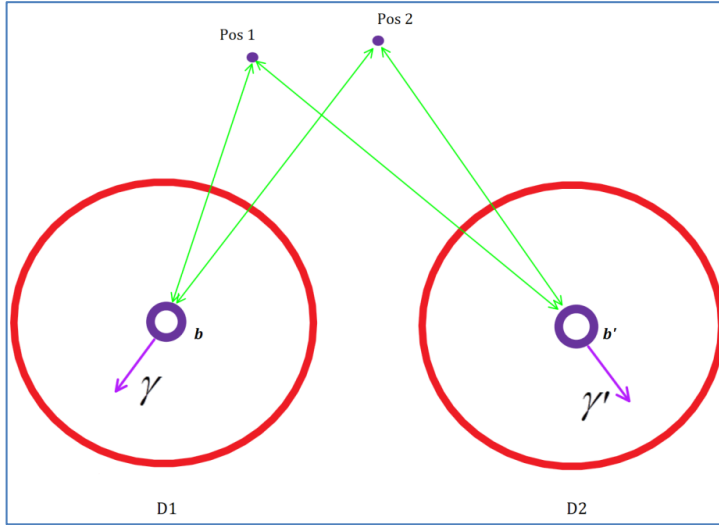
$$\|\vec{G}(a;b)\| = m_a m_b k - \sum_{i=1}^{m_b} \frac{d_{i,j}^2 + d_{i,j}}{2}, \quad b \text{ and } b' \text{ must emit photons } \gamma \text{ and } \gamma' \text{ which}$$

momentum must exactly equal $\Delta \vec{G}(a;b)$ and $\Delta \vec{G}(a;b')$ units of momentum²². That is:

$$\vec{P}_\gamma = \Delta \vec{G}(a;b) \text{ and } \vec{P}_{\gamma'} = \Delta \vec{G}(a;b') \text{ where the directions of the momentum vectors } \vec{P}_\gamma \text{ and } \vec{P}_{\gamma'} \text{ (purple arrows) coincide with } \vec{G}(a;b) \text{ and } \vec{G}(a;b').$$

²¹ This explains why atomic electrons can only absorb photons of specific energy. QGD attributes the different absorption energies to minute variations in the masses of orbital electrons.

²² A principle of conservation of momentum (induced momentum for gravity) comes into play here. If a change in the magnitude of the interaction between a and b is smaller than that which is required to achieve the minimum change in momentum in one or both particles, then one or both must emit photons that will carry the would be change in momentum.



By triangulation, the instantaneous position and distance of a can be found and depending on the distance and direction we can make the following interpretation:

1. If distance is such that $k > \frac{d^2 + d}{2}$ and \vec{P}_γ points towards a , then a is receding from b ;
2. If $k > \frac{d^2 + d}{2}$ and \vec{P}_γ (or $\vec{P}_{\gamma'}$) points away from a then a is moving towards b ;
3. If $k < \frac{d^2 + d}{2}$ and \vec{P}_λ points towards a , then a is moving towards b ;
4. If $k < \frac{d^2 + d}{2}$ and \vec{P}_γ points away from a , then a is receding from b .

The momentums (which for photons is equal to their energy) $\|\vec{P}_\gamma\|$ and $\|\vec{P}_{\gamma'}\|$ provides an exact measure of $\Delta\vec{G}(a;b)$ and $\Delta\vec{G}(a;b')$. Since m_b and $m_{b'}$ are known, we can resolve the gravitational interaction equation for m_a , hence obtain an exact value of its mass.

Thus, a first measurement gives us the instantaneous position and mass of a .

A second measurement will give us a second position, hence the distance travelled between position 1 and position 2. This allows us to calculate speed $v_a = \frac{d_x}{d_{ref}} c$ where d_{ref} is the distance

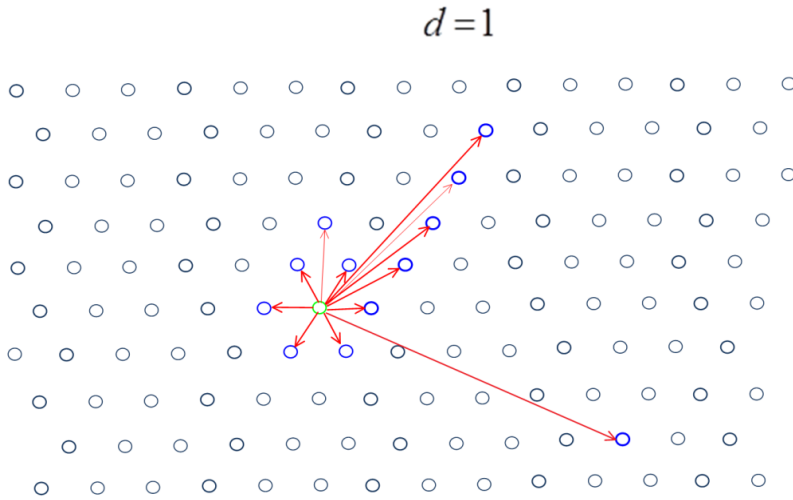
light would have travelled during the same interval. From QGD's definition of speed we know that

$\vec{v}_a = \frac{\vec{P}_a}{m_a}$ where \vec{P}_a is the momentum vector of a so that $\vec{P}_a = m_a \vec{v}_a$. Therefore, a second

measurement allows us to find simultaneously the position and momentum of a with certainty.

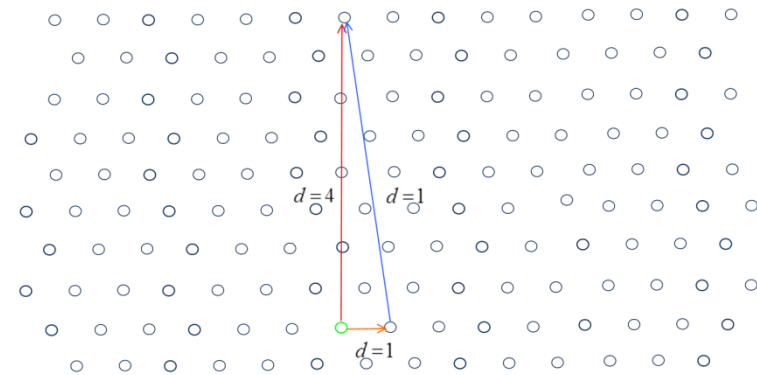
Non-local interactions

If space is discrete as per QGD's axiom, then we know that there can be significant differences between the geometrical distance and the physical distance between any two positions in space. The physical distance between two particles, even when large, may be significantly reduced even by a small shift in their positions.



In the figure on the left, the geometrical distance may be associated with the lengths of the red arrows, while the physical distance, corresponds to the number of leaps necessary to move from an initial position (green circle) to a second position (blue circles).

As we can see, though the geometrical distances between the green position and the blue positions may vary greatly, the physical distance between them is the same and equal to one unit.



In the figure on the left, we see that at the fundamental scale, Pythagoras's theorem does not hold. How Euclidean space emerges at larger scales is explained in [here](#). If we assume the existence of a particle *b* positioned at the top vertex and particle *a* at the bottom left vertex

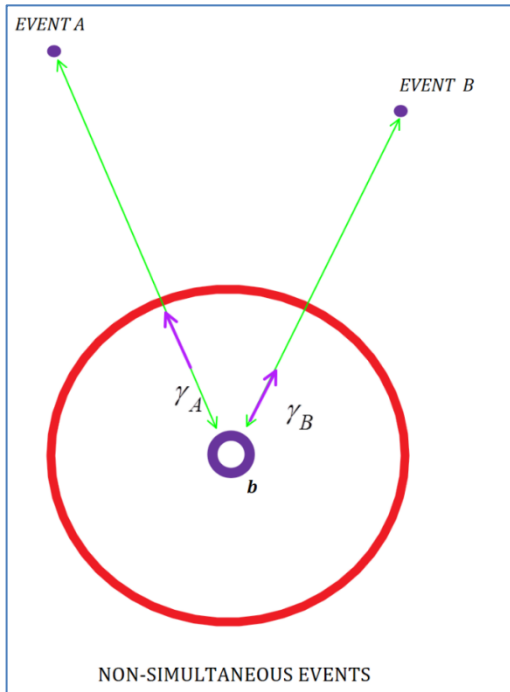
particle *a* moves one position to the right to the bottom right vertex, the physical distance between *a* and *b* becomes four times smaller even though the geometrical distance increased. Such changes in physical distance will cause significant instantaneous changes in the gravitational interaction between the particles and additionally, if the particles are not electrically neutral, significant changes the magnetic field they generate.

Since experiments use electronic components, they contain particles or structures *a* and *b* which are not electrically neutral. In such case, the change in the momentum of the magnetic field they generate can impart will be orders of magnitude greater than that of purely gravitational changes and photons emitted by *b* will have significantly greater energy.

When in one experiment a particle is measured, it causes changes in the momentum of some of its component particles (changes in electrons within the electrical current which powers its

detectors for example), these changes are compounded and will cause components of a second experiment to emit photons instantly. Some of the photons produced within the second experiment will have energies in the range of the sensitivity of detectors.

The Notion of Simultaneity



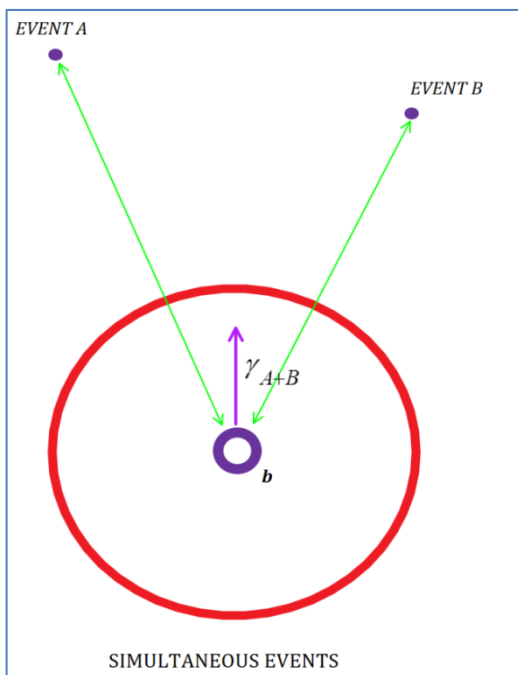
If gravity is instantaneous then all objects in the universe are interacting. That means that if an event affects an object anywhere in the universe, the gravitational interactions between that object and all other objects in the universe regardless the distances that separate them will be affected instantly.

An event can be defined as a change in mass, density, direction, speed, momentum, or position, all of which affect either the magnitude and/or direction of the gravitational interaction between the object of the event and all other objects in the universe.

If A and B are events anywhere in the universe then if the events are non-simultaneous b will emit two photons γ_A and γ_B and the order in which they

are emitted correspond to order in which the events took place (figure on the left). But if the

events are simultaneous, the changes in gravitational interactions will be additive and b will emit a single photon γ_{A+B} such that $\vec{P}_{\gamma_{A+B}} = \Delta\vec{G}_A + \Delta\vec{G}_B$ (figure on the right).



Note: since a single photon is emitted, it will be necessary to distinguish the emission of a photon resulting from simultaneous events from the emission of a photon resulting from a single event.

It follows that two events are simultaneous if the variations in the gravitational interactions resulting from the events are additive. And since, because of gravity being instantaneous, any event must be simultaneously detected by all observers in the universe regardless of their chosen frame of

reference and distance. If gravity is instantaneous, then simultaneity must be frame independent and absolute.

Furthermore, position, speed and momentum which can be derived from \mathcal{Y}_{D_1} and \mathcal{Y}_{D_2} will also be frame independent, determined with certainty and instantaneously.

Can Quantum-Mechanical Description of Physical Reality Be Considered Complete?

If a refutation of Bell's refutation of the EPR paper of the same title were possible, chances are it would have been found a long time ago. Generations of some of the best minds of mathematics and physics have put it to the test.

That said, if we remain rigorous, we must remember that a refutation of the arguments presented in the EPR is exactly what Bell's paper offers and nothing more. The proof of Bell's theorem confirms without doubt that aspects of nature are fundamentally non-local as opposed local when we take the EPR definition of locality. But locality in the EPR paper is kept in agreement with special relativity's prediction that no classical interactions can propagate faster than the speed of light.

It follows that Bell's paper may also be taken as a refutation of locality as derived from special relativity or even as a refutation of special relativity's prediction precluding faster than light interactions.

As we have seen, QGD distinguishes between propagation which is the motion of particles or structures which velocity cannot exceed the speed of light, gravitational interactions which is instantaneous and without mediating particles²³ and non-gravitation interactions which implies absorption and/or emission of particles and transfer of their momentum. It follows that only non-gravitational interactions are limited to the speed of light.

Implications for Bell Type Experiments

If classical forces and quantum entanglement both violate locality as it is described in the EPR paper and which description assumes that no classical force can propagate faster than c , then how can we know whether a violation of Bell's inequalities is due to a classical or to a quantum mechanical effect? Would this render the proof of Bell's theorem via the violation of Bell's inequality irrelevant? Or should it be taken as taken not as a refutation of the EPR locality, but of the understanding and description of locality it assumes?

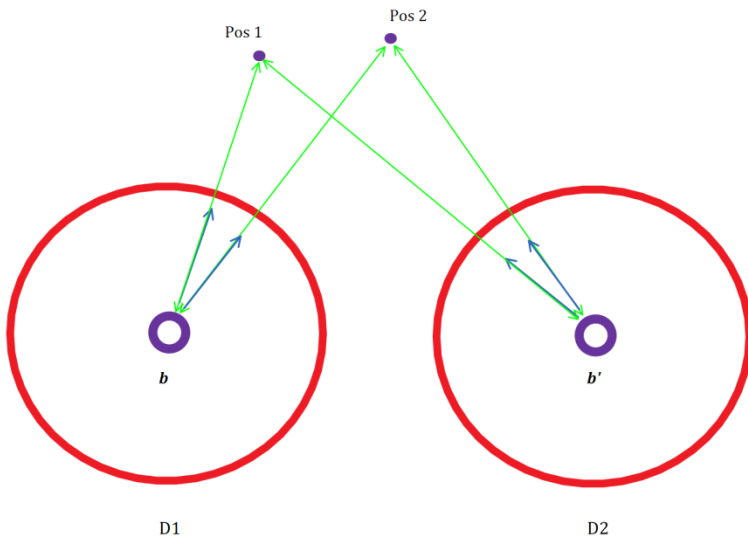
If any observed violation of Bell's inequality could be attributed to instantaneous classical effects Bell-type experiments would no longer allows us to distinguish between the two.

²³ According to QGD, particles do not mediate forces. They can, as in magnetic fields, impart momentum to particles or structures.

It would however be possible to determine if such violation is caused by classical instantaneous interactions since realism would be preserved and, as we have shown above, we could simultaneously and with certainty measure conjugate properties such as momentum and position; something that would not be possible if reality was quantum mechanical.

On the Effect of Gravitational Interactions on Particle Decay and how it Can be Used for Gravitational Telescopes

In figure 1, if b and b' are massive nuclei such that $\Delta G(a;b) < m_b$ and $\Delta G(a;b') < m_{b'}$, then b and b' will emit particles x and x' for which $\|\vec{P}_x\| = \Delta G(a;b)$ and $\|\vec{P}_{x'}\| = \Delta G(a;b')$ respectively. So if x and x' are simultaneously emitted (and detected by the array) and their directions converge, then there is a probability that their emissions result from a change in their gravitational interactions between b and b' and a . But when considering that all matter in the universe interacts, the convergence of the directions of the particles emitted by b and b' only means that the objects they interact with are somewhere along the directions



of their emitted particles and that the changes in gravitational interactions are simultaneous. For a gravitational telescope that exploits the effect we described requires that this probability be significantly increased.

This could be done by augmenting the number of massive nuclei of the apparatus. If n is the number of massive nuclei so that

$\Delta G(a;b_i) < m_{b_i}$ where $i \leq n$, then we can predict n simultaneously emitted particles x_i which have the predicted momentum and which directions converge onto a sufficiently small region of space, then for a certain value of n the probability that the simultaneous emission of particles result from the nuclei's gravitational interactions with a approaches certainty. That is, the number of possible objects which would cause the observation is reduced to 1.

A gravitational telescope exploiting the effect can thus discriminate precisely between the objects it observes and provide their position, momentum, and mass with certainty.

Note: The type of particles emitted by nuclei will depend on the strength of the bonds between the particles when they were components of the nuclei, their masses as well as the magnitude of the variation in the gravitational interactions. Since, as shown earlier, even small changes in

position can cause disproportionately large changes in the physical distance between objects, they induce emissions of particles with significantly greater momentum than would be possible if space were continuous.

Note: The effect described in this section may already have been observed. See [Evidence for Correlations Between Nuclear Decay Rates and Earth-Sun Distance](#) by Jere H. Jenkins, Ephraim Fischbach, John B. Buncher, John T. Gruenwald, Dennis E. Krause, Joshua J. Mattes.

States of Atomic Electrons

In this section, we show how the energy states of atomic electrons follow naturally from the [laws of momentum](#).

For simplicity, we will describe of the energy states of the electron of the hydrogen atom system, but the same principles apply to complex atomic systems.

A ground state of an atomic electron is the state of equilibrium between the extrinsic forces acting on it. For hydrogen, which consists only of a proton and an electron, the extrinsic forces are the forces between them that act on the electron. For more complex elements, the extrinsic forces are produced by the interactions of a given electron, the other electrons and the components of the nucleus. And as we will see, each of the electrons has a ground state that is dependent on the ground states of all the other electrons.

At ground state $\sum_{i=1}^{n_{e^-}} \vec{F}_i = \vec{0}$ where the i indexes the n_a extrinsic forces acting on e^- . These forces are either gravitational (which QGD's equation for gravitational interactions predicts must be over a hundred orders of magnitude greater at the atomic scale than at cosmic scale) or electromagnetic which is the resulting effect of the interactions between charges particles and the free *preons*⁽⁺⁾ which as we have seen earlier for the magnetic field.

The third law of momentum dictates that permitted changes in momentum of any particle or structure a is proportional to its mass. That is: $\Delta \vec{P}_a = \alpha m_a \vec{\rho}$.

Let δ_0 denote the ground state of the electron of a hydrogen atom and γ_0 be a photon such that $\vec{P}_{\gamma_0} = m_{e_{\delta_0}} \vec{\rho}$. The electron $e_{\delta_0}^-$ can absorb γ_0 since it imparts a change in momentum that respects the third law; that is: $\vec{P}_{\gamma_0} = \Delta \vec{P}_{e^-} = \alpha m_{e^-} \rho$ where $\alpha = 1$. After absorption of the photon, the electron's momentum has changed from state δ_0 to state δ_1 . The momentum vector, mass and energy of the electron in δ_1 states are respectively $\vec{P}_{e_{\delta_1}^-} = \vec{P}_{e_{\delta_0}^-} + \vec{P}_{\gamma_0}$,

$$m_{e_{\delta_1}^-} = m_{e_{\delta_0}^-} + m_{\gamma_0} \text{ and } E_{e_{\delta_1}^-} = E_{e_{\delta_0}^-} + E_{\gamma_0} = \left(m_{e_{\delta_0}^-} + m_{\gamma_0} \right) c.$$

The change in the momentum vector also changes the distance between the electron and the proton so that $\sum_{i=1}^{n_{e_{\delta_1}^-}} \vec{F}_i = \vec{F}_{\delta_1} = - \frac{\Delta P}{\delta_0 \rightarrow \delta_1} \vec{\rho}$. So if there is no other force acting on $e_{\delta_1}^-$, it will downshift

to its δ_0 state and it can be on this state of equilibrium by respecting by emitting a photon which momentum is equal to the difference in momentum between the two states. That is $\vec{P}_{\gamma_{emit}} = \vec{P}_{e_{\delta_{\alpha+\alpha'}}} - \vec{P}_{e_{\delta_0}}$ or, since momentum and energy are numerically equal for photons, we can also say that photon emitted has an energy equal to the difference in the energy between the two states or $E_{\gamma_{emit}} = E_{e_{\delta_{\alpha+\alpha'}}} - E_{e_{\delta_0}}$ but the momentum description preferred since it is complete and specific while the energy description is general.

From the above we can generalize in the following manner.

A state δ_α is that which results from a transition $\delta_0 \rightarrow \delta_\alpha$ by photon such that $\vec{P}_{\gamma_0} = m_e \vec{\rho}$ or by a series of x transitions such that $\sum_{i=1}^x \vec{P}_{\gamma_i} = m_e \vec{\rho}$.

From this we understand that the difference in momentum of an electron between any two states δ_x and δ_y is $\vec{P}_{e_{\delta_y}} - \vec{P}_{e_{\delta_x}} = (y-x)m_e \vec{\rho}$.

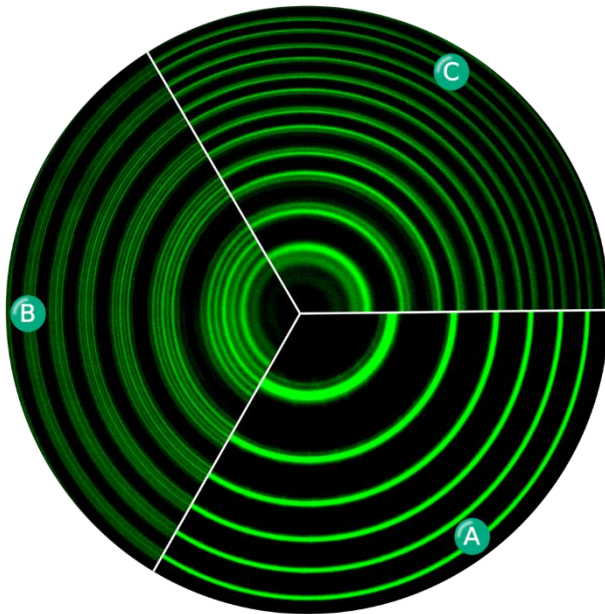
Also, if an electron (or other similarly charged particle) is captured by a proton (or more generally by an atom), it will emit a photon or series of photons which sum will be equal to the difference between its momentum and the momentum of an electron at ground state following the mechanism we described.

The Zeeman Effect

The Zeeman Effect is easily derived from the laws of optics we have described earlier.

We know that any change in momentum of an electron must obey the law $\Delta\vec{P}_{e^-} = m_{e^-}\vec{\rho}$. That tells us that, absent of any other effects acting on it, an electron can absorb a photon γ if and only if $\vec{P}_{\gamma} = m_{e^-}\vec{\rho}$. This relation allows us to predict the different states of atomic electrons.

But when magnetic field $\Delta\vec{\Theta} > \vec{0}$ is applied to the electron, then the magnetic field and the photon will both act on the electron. A photon must still obey the law $\Delta\vec{P}_{e^-} = m_{e^-}\vec{\rho}$ but here we have $\vec{P}_{\gamma'} = m_{e^-}\vec{\rho} - \Delta\vec{\Theta}$ and $\vec{P}_{\gamma''} + \Delta\vec{\Theta} = m_{e^-}\vec{\rho}$ where $\vec{P}_{\gamma'}$ is in direction opposite to the imparted momentum of the magnetic field and $\vec{P}_{\gamma''}$ is in the same direction. Therefore, photons with lower and higher momentum will be absorbed, and photons that could be absorbed in the absence of a magnetic field can no longer be. This explains the longitudinal Zeeman effect (see section C in the image on the following page).



absorbed. Additionally, the transverse magnetic field will induce a Zeeman effect with so that

The spectral lines of mercury vapor lamp at wavelength 546.1nm, showing anomalous Zeeman effect. **A.** without magnetic field. **B.** With magnetic field, spectral lines split as transverse Zeeman effect. **C.** With magnetic field, split as longitudinal Zeeman effect.

Image Warren Leywon/Wikimedia Commons

From the above, we have

$\vec{P}_{\gamma''} - \vec{P}_{\gamma'} = 2\Delta\vec{\Theta}$ so it follows that the gaps between absorption bands of the spectrum due to the Zeeman effect are proportional the momentum imparted by the magnetic field. That is:

$$\vec{P}_{\gamma''} - \vec{P}_{\gamma'} \propto \Delta\vec{\Theta}.$$

When a transverse magnetic field is applied, its longitudinal momentum is $\Delta\vec{\Theta}_l = \vec{0}$ and $\vec{P}_{\gamma} + \pm\Delta\vec{\Theta}_t = m_{e^-}\vec{\rho}$. So, photons with longitudinal momentum \vec{P}_{γ_l} with momentum $\vec{P}_{\gamma_l} = m_{e^-}\vec{\rho}$ will be

transverse photons with momentum $\vec{P}_{\gamma_t} + \Delta\vec{\Theta}_t = m_{e^-}\vec{\rho}$ will also be absorbed. Partition B of the image on the left shows the absorption of both longitudinal and transverse photons.

The Photoelectric Effect

Consider a state δ_x of an atomic electron interacting with a photon γ where $\vec{P}_\gamma = m_{e_{\delta_x}} \vec{\rho}$. If

$P_{e_{\delta_{x+1}}}^{\vec{A}} > \sum_{i=1}^{n_{e^-}} \vec{F}_i$, then the electron will become unbounded, and the momentum of the

unbound electron will be $\vec{P}_{e_{\delta_{x+1}}} = \vec{P}_{e_{\delta_x}} + \vec{P}_\gamma$. The above $\delta_x \rightarrow \delta_{x+1}$ transition is the photoelectric effect.

Conclusion

We have shown that the mechanisms of atomic electron transition as derived from QGD's axiom set not only describes observations but provides a fundamentally based explanation.

QGD Interpretations of Redshift Effects

We have shown in previous chapter that light is singularly corpuscular, and the wave-like behaviour is entirely explained by discrete interactions between photons and structures. The reader undoubtedly may think that QGD's description of light is contradicted by the Doppler redshift of light, which is attributed to a change in the frequency of light due to the relative motion of a source, hence requires light to be wave-like. But, as with all other optical phenomena we discussed earlier, the observed Doppler redshift can be explained using a strictly corpuscular model of light.

We will also discuss intrinsic redshift effects which, in addition to the Doppler redshift, may contribute significantly to observed redshifts.

The Doppler Effect

Definitions

Let us first introduce the annotations we will need to describe the Doppler effect in QGD.

\mathcal{S}_n : the set of n permitted states of an atomic electron where given that $\mathcal{S}_i, \mathcal{S}_{i'} \in \mathcal{S}_n$ then $i' > i \rightarrow \|\vec{P}_{e_i'}\| > \|\vec{P}_{e_i}\|$.

$\mathcal{S}_i \uparrow \mathcal{S}_{i+x}$: upshift from a state i to a state $i+x \leq n$, shift to a higher energy state.

$\mathcal{S}_i \downarrow \mathcal{S}_{i-x}$: downshift from a state i to a state $i-x \geq 1$, shift to a higher energy state.

\ddot{d}_{ε_i} : the spatial interval between of an upshift of upshift or downshift from state \mathcal{S}_i of the source.

\ddot{d}_{ε_i} : the spatial interval two photons that will successively be received photons from the source.

\ddot{d}_{ref_i} : the spatial interval between of an upshift of upshift or downshift from state \mathcal{S}_i of the reference.

\ddot{r}_{ε_i} : The rate at which a source electron shift from state i . We define this rate as the inverse of the spatial interval separating two successively emitted photons or $\ddot{r}_{\varepsilon} = \frac{1}{\ddot{d}_{\varepsilon_i}}$

\ddot{r}_{ζ_i} : The rate at which photons are received from the source and is defined as the of inverse of the spatial interval separating two photons that will successively be received (observed) or

$$\ddot{r}_{\zeta_i} = \frac{1}{\ddot{d}_{\zeta_i}}$$

\ddot{r}_{ref_i} : The rate at which a reference electron of the same element shifts states from the same given state \mathcal{S}_i .

$E_{\vec{d}_{\gamma_i}}$: the total momentum of photons in the spatial interval \ddot{d}_{ζ_i} where $\|\vec{P}_{\vec{d}_{\gamma_i}}\| = \frac{\ddot{r}_{\zeta}}{\ddot{r}_{ref}} \vec{P}_{\gamma_i}$

\mathcal{Z} : The Doppler redshift where $\mathcal{Z} = \frac{\ddot{r}_{ref} - \ddot{r}_{\zeta}}{\ddot{r}_{\zeta}}$

$\tilde{\mathcal{Z}}$: The intrinsic redshift where $\tilde{\mathcal{Z}} =$

\mathcal{Z}_{obs} : observed redshift

Assuming that there are no intrinsic redshifts, that is $\ddot{r}_{ref_i} = \ddot{r}_{e_i}$, then we have the following cases:

[Doppler effect when relative distance between the source and the reference increases.](#)

Based on the [laws of momentum](#) as they apply to the [states of atomic electrons](#), an electron can shift momentum from a state \mathcal{S}_i only if the momentum of photons received within the spatial interval \ddot{d}_{ref_i} corresponds to a permitted change in momentum (change of state), that is

$\|\vec{P}_{\gamma_i}\| \frac{\ddot{d}_{ref_i}}{\ddot{d}_{\zeta_i}} = m_{e_i} \rho$ where $\|\vec{P}_{\gamma_i}\| \frac{\ddot{d}_{ref_i}}{\ddot{d}_{\zeta_i}}$ is the total momentum of photons within a spatial interval

\ddot{d}_{ζ} and ρ is minimum momentum necessary to overcome n-gravity between two *preons*⁽⁻⁾.

When the source moves away from the observer, the distance between the source and the

receiving electrons increases and $\|\vec{P}_{\gamma_i}\| \frac{\ddot{d}_{ref_i}}{\ddot{d}_{\zeta_i}} < m_{e_i} \rho$. As a consequence, photons emitted by a

source electron in state \mathcal{S}_i and received at the rate $\ddot{r}_{\zeta_i} < \ddot{r}_{ref_i}$ cannot be absorbed by an electron

in state S_i but only by an electron at state S_{i-x} such that $\|\vec{P}_{\gamma_i}\| \frac{\ddot{d}_{ref_{i-x}}}{\ddot{d}_{\zeta_i}} = m_{e_{i-x}} \rho$ which observationally appears as a redshift of the absorption line of the photons from the source relative to the reference and $z_{obs} = z = \frac{\ddot{r}_{ref} - \ddot{r}_{\zeta}}{\ddot{r}_{\zeta}} > 0$.

The relative distance between the source and the reference decreases.

When the source moves towards the observer, the distance between the source and the receiving

electrons decreases and $\|\vec{P}_{\gamma_i}\| \frac{\ddot{d}_{ref_i}}{\ddot{d}_{\zeta_i}} > m_{e_i} \rho$. As a consequence, photons emitted by a source

electron in state S_i and received at the rate $\ddot{r}_{\zeta_i} < \ddot{r}_{ref_i}$ cannot be absorbed by an electron in state

S_i but only by an electron at state S_{i+x} such that $\|\vec{P}_{\gamma_i}\| \frac{\ddot{d}_{ref_{i-x}}}{\ddot{d}_{\zeta_i}} = m_{e_{i+x}} \rho$ which observationally

appears as a blueshift of the absorption line of the photons from the source relative to the

reference and $z_{obs} = z = \frac{\ddot{r}_{ref} - \ddot{r}_{\zeta}}{\ddot{r}_{\zeta}} < 0$

The relative distance between the source and the reference is constant.

If the relative distance of the source remains constant, then $\|\vec{P}_{\gamma_i}\| \frac{\ddot{d}_{ref_i}}{\ddot{d}_{\zeta_i}} = m_{e_i} \rho$, then the photons

emitted by an electron in S_i will be absorbed by an electron in the same state. In this case

$$z_{obs} = z = \frac{\ddot{r}_{ref} - \ddot{r}_{\zeta}}{\ddot{r}_{\zeta}} = 0$$

Intrinsic Redshifts

The momentums of photons emitted by atomic electrons of an element from a distant source may differ from the momentums of photons emitted by a reference's atomic electrons of the

same element. That is $\|\vec{P}_{\gamma_i}^{\varepsilon}\| \neq \|\vec{P}_{\gamma_i}^{ref}\|$.

In such case we can have $z_{obs} = \tilde{z}$ at $z = 0$.

For example, if $z=0$ and $\left\| \vec{P}_{\gamma_i}^{\varepsilon} \right\| < \left\| \vec{P}_{\gamma_i}^{ref} \right\|$ then $\tilde{z} > 0$ and $z_{obs} = \tilde{z}$ which would be observational similar to a Doppler redshift.

Since observed redshifts compound both Doppler and intrinsic redshifts, the actual velocities and distances of distant sources may differ, sometimes significantly, from estimates based on the assumption that observed redshifts are solely caused by the Doppler effect. Consequently, it is necessary to observationally distinguish between Doppler and intrinsic redshifts.

We may be able to do so based on the mechanisms responsible for intrinsic redshifts.

Intrinsic Redshift Mechanisms

We have seen that changes in momentum of electrons obey the law:

$$[1] \quad \Delta \vec{P}_{e^-} = m_{e^-} \vec{\rho}$$

which imposes that only photons such that,

$$[2] \quad \vec{P}_{\gamma_i} = m_{e^-} \vec{\rho} \text{ can be absorbed or emitted.}$$

Equation [1] governs not only changes in momentum that are induced by the absorption or emission of a photon, but also momentum changes resulting from variations in gravity and/or the electromagnetic field effect, the latter resulting from a variation in the preonic density. Hence taking gravity and the electromagnetic effect into account we get:

$$[3] \quad \Delta \vec{P}_{e^-} = \vec{P}_{\gamma_i}^{\varepsilon} + \Delta \vec{G} + \Delta \vec{\Theta} = m_{e^-} \vec{\rho} \text{ where } \Delta \vec{G} \text{ is the variation in gravity and } \Delta \vec{\Theta} \text{ is the}$$

variation in the magnitude of electromagnetic interaction of the atomic electron is subjected to

which varies depending on the preonic density of in the spatial region occupied by the source and the mass of electrons which as we have seen earlier has been evolving since their formation. For simplicity and the purpose of the present discussion, we will assume that $\Delta \vec{\Theta} = \vec{0}$ and will use

$$\Delta \vec{P}_{e^-} = \vec{P}_{\gamma_i}^{\varepsilon} + \Delta \vec{G} = m_{e^-} \vec{\rho}$$

Since the law of momentum [1] must be obeyed then from equation [3] we see that an increase in gravity or the preonic density or both proportionally decreases the permitted momentum of photons an electron can absorb or emit, hence intrinsically redshifts it. Conversely, if gravity and/or the preonic density decrease(s) then the permitted momentum for photons to be absorbed or emitted increases proportionally, hence intrinsically blueshifts it, since

$$[4] \quad \vec{P}_{\gamma_i}^{\varepsilon} = m_e \vec{\rho} - \Delta \vec{G}.^{24}$$

Gravitational Redshift

Though general relativity and QGD gravitational redshifts may be observationally similar, they result from very distinct mechanisms and give differing pictures of the sources.

Unlike general relativity which predicts that photons become redshifted because they lose energy when coming out of gravitational wells (and blue shifted when they enter them), QGD predicts that photons are intrinsically redshifted at the source itself.

From [3] we find that $\vec{P}_{\gamma_i}^{\varepsilon} = m_e \vec{\rho} - \Delta \vec{G}$, where $\Delta \vec{G}$ is the variation of gravity on the emitting electron. The influence of gravity can be hugely significant either when the source is near of massive object or at cosmological distances. As we have seen, the n-gravity component of gravity is proportional to the square of the distance and that beyond the threshold distance d_{Λ} it overcomes the p-gravity component, so that $\Delta \vec{G} < \vec{0}$, and gravity becomes repulsive.

N-gravity being proportional to the square of the distance, QGD predicts that at cosmological distances $\|\vec{P}_{\gamma_i}^{\varepsilon}\| \ll \|\vec{P}_{\gamma_i}^{ref}\|$, that the source may emit photons with momentums orders of magnitude smaller than photons from our reference atomic electrons which observationally will appears greatly redshifted.

This implies that an important component of the observed cosmological redshift is the direct result of gravitation acceleration predicted by QGD's equation for gravity, a gravitational redshift, which along with the Doppler effect completely explains observations. It does so without invoking the so-called cosmological Doppler effect.

Using the equations [4] and the equation we can calculate the observed redshift in the following way.

First we must find what the equivalent Doppler redshift would be. From measurements of

$$\|\vec{P}_{\gamma_i}^{\varepsilon}\| \frac{\ddot{d}_{ref_i}}{\ddot{d}_{\varepsilon_i}}, \text{ and } \|\vec{P}_{\gamma_i}^{ref}\|,$$

²⁴ $\vec{P}_{\gamma_i}^{\varepsilon} = m_e \vec{\rho} - \|\Delta \vec{G} + \Delta \vec{\Theta}\|$ being the complete equation

To find the equivalent Doppler redshift we will assume that $\|\vec{P}_{\gamma_i}^e\| = \|\vec{P}_{\gamma_i}^{ref}\|$ and $\vec{z} = \mathbf{0}$ that so

that $\|\vec{P}_{\gamma_i}^e\| \frac{\ddot{d}_{ref_i}}{\dot{d}_{\hat{s}_i}} = \|\vec{P}_{\gamma_i}^{ref}\| \frac{\ddot{d}_{ref_i}}{\dot{d}_{\hat{s}_i}} = \|\vec{P}_{\gamma-x}^{ref}\|$. Which is the magnitude of the momentum of a photon

emitted by a reference electron in state S_{i-x} . Since all values except $\ddot{d}_{\hat{s}_i}$ can be measured, thus

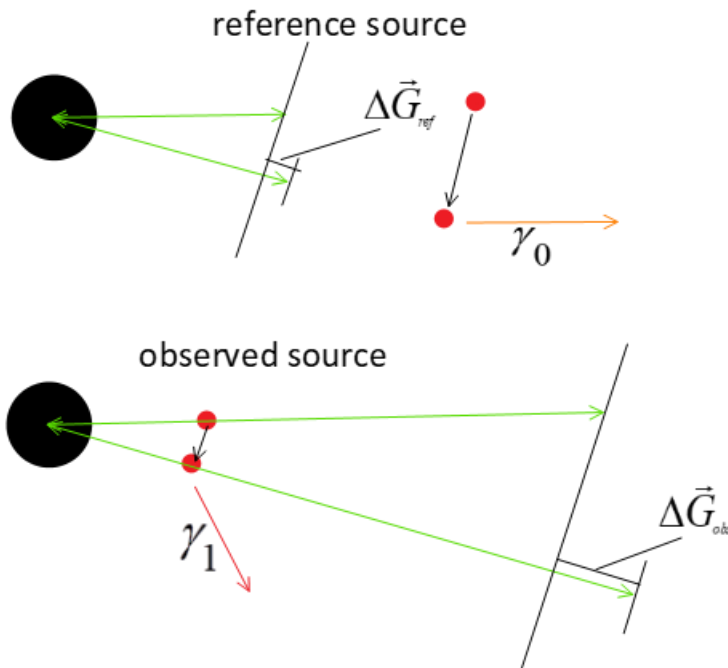
known, we can resolve $\|\vec{P}_{\gamma_i}^{ref}\| \frac{\ddot{d}_{ref_i}}{\dot{d}_{\hat{s}_i}} = \|\vec{P}_{\gamma-x}^{ref}\|$ for $\ddot{d}_{\hat{s}_i}$. And from $\ddot{d}_{\hat{s}_i}$ and \ddot{d}_{ref_i} we get \ddot{r}_{ζ} and \ddot{r}_{ref}

from which we get $z_{obs} = \frac{\ddot{r}_{ref} - \ddot{r}_{\zeta}}{\ddot{r}_{\zeta}}$.

Cosmological expansion, which we will be discussed in detail in the section on [QGD Cosmology](#), is driven by gravity which at the cosmological scale is repulsive (scale at which structure are separated by distances $d > d_{\Lambda}$).

Important note: Even though QGD predicts the effect gravity on the rates of clocks (see section [The Relation between Gravity and the Rates of Clocks](#)), it does not, as Einstein's Equivalence Principle does, imply that light is redshifted when coming out of a gravitational well. The gravitation effect on the rates of clocks supports but does not necessarily imply GR's gravitational redshift. GR's gravitational redshift is a distinct prediction require a different type of tests such as those suggested above. EEP and QGD make different predictions therefore experiment 1 and 2 can be considered tests of Einstein's equivalence principle.

Gravitational redshift caused by proximity massive object.



From the previous section we understand that the greater $z_{obs} \propto \Delta\vec{G}$, thus the effect will be most noticeable when a star moves close to a high-density object such as a black hole. The redshift of the spectrum of a star near a black hole has been

recently observed²⁵ and though it is taken as confirmation of the [gravitational redshift](#) predicted by general relativity, the observation is also consistent with the predictions of QGD as shown in the figure on the left where the light from a star orbiting a black hole will redshifted relative to a reference source orbiting at a larger distance.

Other Important Factors to Consider for Real World Observations

If QGD is right, then all objects in the universe are interacting gravitationally and those interactions are instantaneous. Also, though for $d < d_{\Lambda}$ gravity is attractive with the magnitude of the gravitational interaction between two objects approximately inversely proportional to the square of the distance, for $d > d_{\Lambda}$ gravity becomes repulsive and sees its magnitude increasing exponentially and vastly exceeding the maximum possible magnitude of attractive gravity. That is $\vec{G}(a;b) \gg -\max \vec{G}^+(a;b)$ where $\max \vec{G}(a;b) = m_a m_b k$ which the equation for gravity reduces to for $d = 1$, the shortest possible distance in quantum-geometrical space.

It follows that all objects in the universe are subject of gravitational interactions from objects in all directions located at very large distances making them even more powerful than local interactions. The questions is, what is the resultant of the sum of all significant gravitational interactions?

In a homogeneous universe, much of these powerful interactions converging on an object or system would cancel each other, but the net gravitational effect may still be very significant to induce gravitational acceleration which in turn causes intrinsic redshifts.

So, observations of the relative redshift of a distant object should account for the instantaneous gravitational effect the object has on the local reference light source. The photons from the observed source may have been emitted from the position the object was at billions of years ago, but the gravitational effect is from the object in current position.

It is true that this model makes interpretations of observed redshifts much more complicated, but if the theory the model is derived from is correct, then isolation and analysis of local effects of non-local events is possible and may allow us to map out the universe and its evolution in real time. [Local effects of non-local events](#) will be discussed in a [separate section](#).

²⁵ <https://arxiv.org/abs/1807.09409v1>

Mapping the Universe

Different cosmologies provide different interpretations of observational data and draw different maps of the Universe. As we will see in the section on [QGD cosmology](#), QGD predicts that the universe is finite therefore it must have a center and an edge. Interpreted by QGD, the measurements of redshifts along with other methods of estimating distances will draw a map that is different from that obtained by applying standard redshift interpretations.

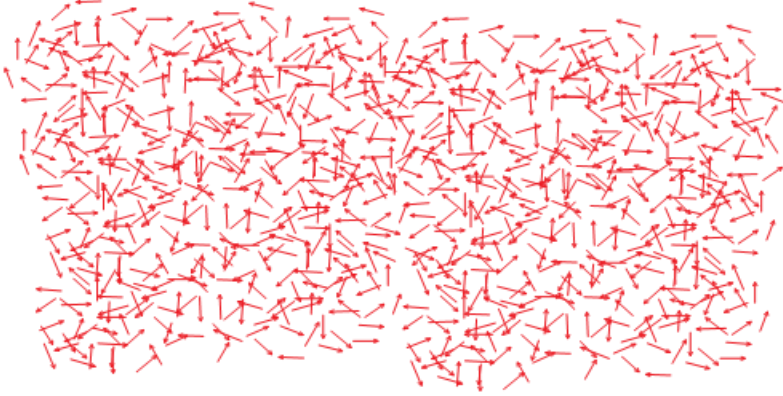
QGD's description of the Universe is consistent with the law of gravity and the laws of momentum and does not require spatial dimensions beyond the three that we observe, nor does it need any ad hoc particles or mechanisms to explain such things as the dark matter or dark energy effects. QGD describes reality using the smallest possible number of initial assumptions; a minimal axiom set necessary to describe dynamic systems.

We will continue this discussion in the [QGD Cosmology section](#).

QGD Cosmogony and Cosmology

The Initial or Isotropic State

Quantum-geometry dynamics implies that the universe as we observe it is consistent with an initial state in which only free $preons^{(+)}$ existed and were homogeneously distributed throughout space (we will refer to this state as the initial or isotropic state). The observable



universe is the result of condensation of $preons^{(+)}$ into slow massive particles (dark matter particles), which fused to form visible particles, atoms, gases, the stars, galaxies, and galaxy clusters. Therefore, the matter density of the Universe's initial state was homogeneous. That is

$$dens_U = \frac{m_U}{Vol_U}, \text{ where } m_U$$

is the number of $preons^{(+)}$ in the Universe and Vol_U , its volume expressed in $preons^{(-)}$.

We find that the Universe evolved naturally from an initial isotropic state given that the same physical laws that rule the universe today prevailed throughout its entire existence.

Heat, Temperature, Energy of the Initial State

In the initial state of the Universe, QGD theorizes that all $preons^{(+)}$ were free. That means that the energy of the Universe was equal to its heat. So, if that its entropy was equal to zero. That is:

$$m_U c - \sum_{i=1}^n P_i = 0, \text{ where } m_U \text{ is the masse of the Universe in } preons^{(+)} \text{ and since all } preons^{(+)}$$

are free $m_U = n$. It follows that the temperature of Universe in its initial state was $T_0^U = \frac{m_U c}{Vol_U}$.

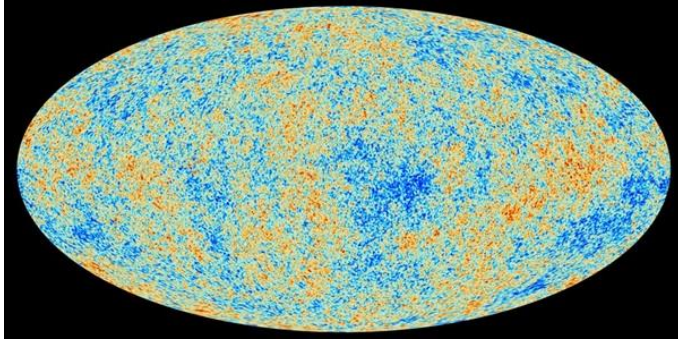
Though the Universe as evolved, its total energy remains $m_U c$, but as particles and structures are formed its heat decreases resulting in an increase in entropy according. In formal terms we

$$\text{have } m_U c - \sum_{i=1}^n \|P_i\| > 0).$$

In its initial state the temperature of the universe was $T_0 = \frac{c}{\sqrt{k}}$ where c the kinetic energy of the $preons^{(+)}$ and k the proportionality constant between the n-gravity and p-gravity.

Cosmic Microwave Background Radiation (1st observable state)

We have seen how gravity at the microscopic scale is a hundred orders of magnitudes greater



than that at the Newtonian scale due to the weakness of the n-gravity component of gravity. Gravity at very short distances between $preons^{(+)}$ is such that they become gravitationally bounded and form progressively more massive particles and eventually, neutrinos and photons.

The simplest composite particles are made from two $preons^{(+)}$. In order for two $preons^{(+)}$ a and b to become bounded, they must come at a distance such that $\Delta\vec{G}(a;b) \geq \cos\theta * \vec{P}_i$ where $i \in \{a,b\}$, \vec{c}_i is the momentum of the $preons^{(+)}$ and θ is the angle between converging trajectories.

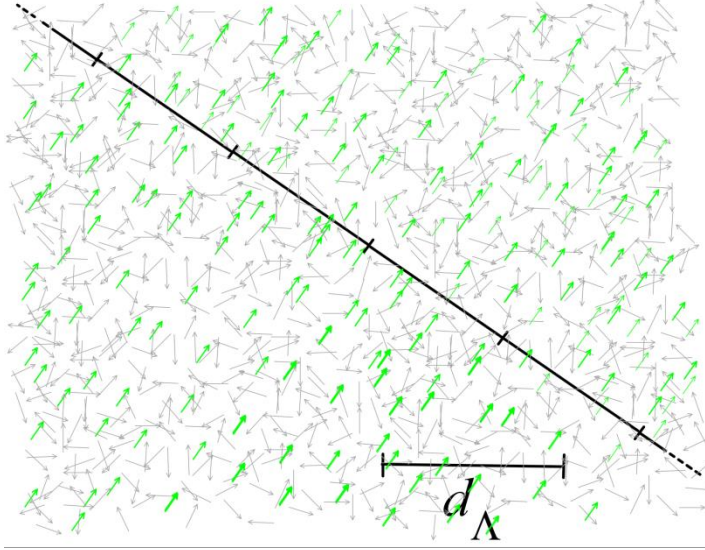
If $\vec{c} \gg \Delta\vec{G}(a;b)$ then, following the initial isotropic state, $preons^{(+)}$ became bound when θ was very small. That is they became bounded when their trajectories are convergent and nearly parallel. **This binding of $preons^{(+)}$ would only happen over large travelling distances exceeding galactic scales and would form photons.**

Photons (or any other particle for that matter) become observable when their momentum is sufficient to affect an electron, that is when $\|\vec{P}_\gamma\| \geq m_e$. A number of particles of the photon and neutrino types formed following the initial preonic state, but the first photons to be observable collectively composed what we know as the cosmic microwave background radiation (CMBR). As we have discussed earlier, the observed isotropy of the cosmic microwave background is a direct and natural consequence of the initial isotropic state.

Note that though the momentum of photons that formed during this stage of the evolution of the Universe possessed the minimum momentum necessary to be absorbed or emitted by electrons, electrons formed at a much later stage of the evolution of the Universe. This suggests that the luminosity of the CMBR was at some point much greater than what is now observed.

Particle Formation and Large Scale Structures

According to QGD, photons gained mass over long distances by binding with other photons and



preons⁽⁺⁾. During the formation of the CMBR, the particles momentum and energy were equal and their speed is equal to c or as we have seen

$$\|\vec{P}_\gamma\| = \left\| \sum_{i=1}^{m_\gamma} \vec{c}_i \right\| = \sum_{i=1}^{m_\gamma} \|\vec{c}_i\| = E_\gamma \text{ and}$$

$$v_\gamma = \frac{\left\| \sum_{i=1}^{m_\gamma} \vec{c}_i \right\|}{m_\gamma} = \frac{m_\gamma c}{m_\gamma} = c .$$

After travelling over very large distances, some photons became sufficiently massive from the absorption of *preons*⁽⁺⁾ or from

merging with other photons for them to bind with other massive photons when their trajectory

intersected at larger angles. That is when $\Delta\vec{G}(\gamma; \gamma') \geq \frac{\cos\theta * \vec{P}_\gamma}{\cos\theta * \vec{P}_{\gamma'}}$. The momentum of the

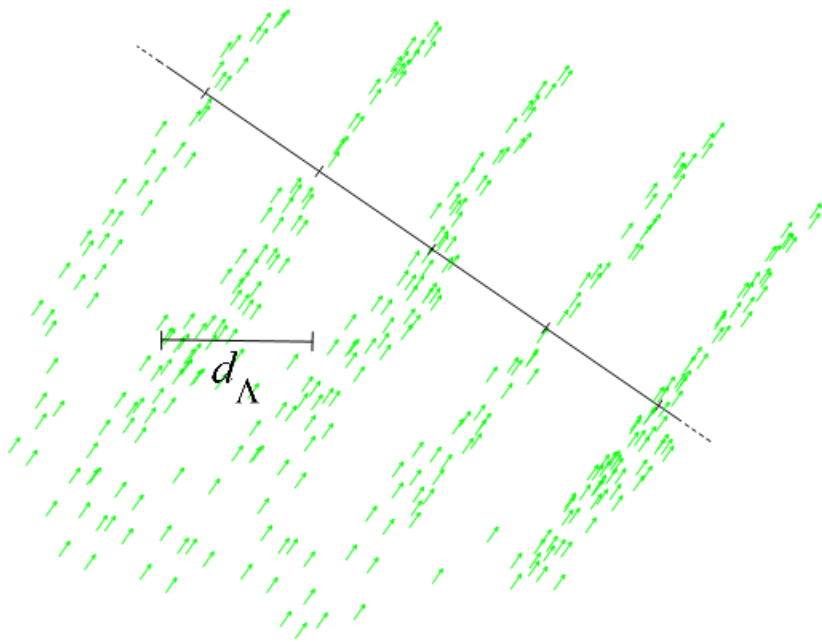
resulting particles would be much smaller than their combined individual momenta or energies. Hence the velocity of the new particles formed in that way would be orders of magnitude slower than c .

$$\|\vec{P}_{\gamma''}\| = \left\| \sum_{i=1}^{m_\gamma} \vec{c}_i \right\| + \left\| \sum_{i=1}^{m_{\gamma'}} \vec{c}_i \right\| = \left\| \sum_{i=1}^{m_\gamma} \vec{c}_i + \sum_{i=1}^{m_{\gamma'}} \vec{c}_i \right\| < \sum_{i=1}^{m_\gamma} \|\vec{c}_i\| + \sum_{i=1}^{m_{\gamma'}} \|\vec{c}_i\| \text{ and } v_{\gamma''} = \frac{\|\vec{P}_{\gamma''}\|}{m_{\gamma''}} \text{ and since}$$

$$\|\vec{P}_{\gamma''}\| < E_{\gamma''} \text{ then } v_{\gamma''} < c .$$

That is how particles with larger masses and subluminal velocity were produced, some many orders of magnitude slower than c .

Slow massive particles with momentum less than the minimum allowable change in momentum for an electron are as a consequence not detectable (dark) but they can be indirectly detected through their gravitational interactions with visible matter and light.

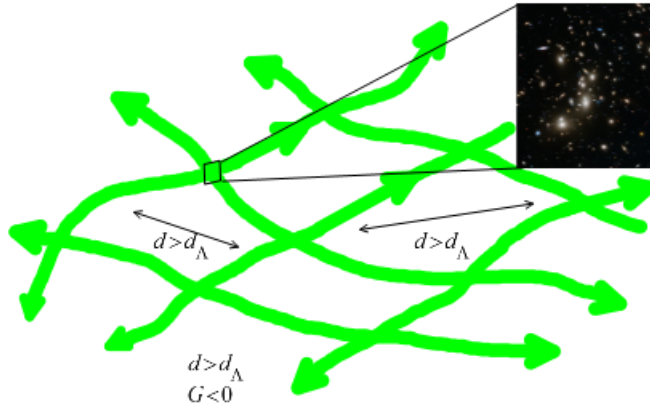


Under the effect of gravitational interaction (attractive for $d < d_\Lambda$ and repulsive for $d > d_\Lambda$, where the threshold distance $d_\Lambda \approx 10Mpc$) condensed into streams of dark matter which at their intersection formed halos. It is from and within these halos that progressively more massive particles formed, which eventually created the galaxies and galaxies

clusters.

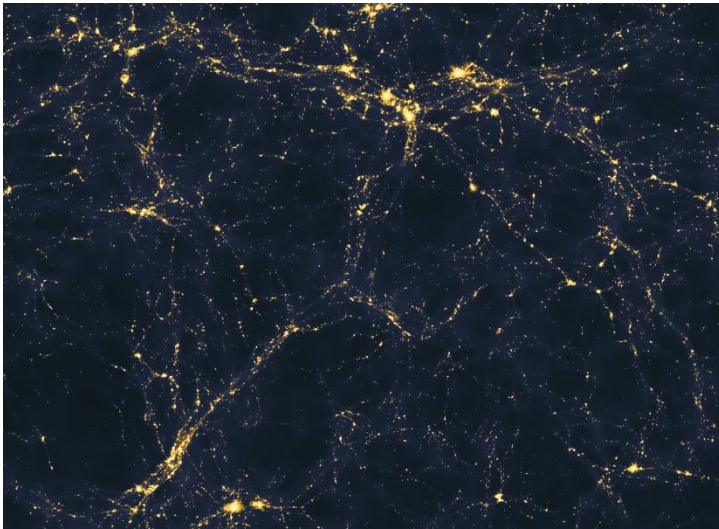
The above figure illustrates streams of dark particles (dark matter), shaped by attractive and repulsive gravity create the filaments of the observed large-scale structure of the Universe. Galaxy clusters are formed at the intersections of two or more streams.

Since the distance between intersections of filaments within which clusters are formed is greater than d_Λ , galaxies belonging to different clusters gravitationally repel each other and causing the expansion of the material Universe. The rate at which galaxies recess from one another is described by the [QGD's equation for gravity](#); hence it increases with distance between them and with their mass and most significantly as a function of their distance from the center of the Universe. Current theories assume that the universe is infinite, but if space is discrete (an axiom of QGD), then the fundamental elements of space, the *preons*⁽⁻⁾, must obey the law of conservation, hence there must be a finite number of them, hence the universe must be spatially finite with a finite number of dimension (three) and a finite amount of matter.



It is important here to emphasize the difference between the expansion of the Universe as it is currently understood, which implies the expansion of space itself, and the material expansion of the large scale structure due to repulsive gravity which requires [space](#) to remain fixed.

Galaxy Formation, Motion, Shape and Evolution



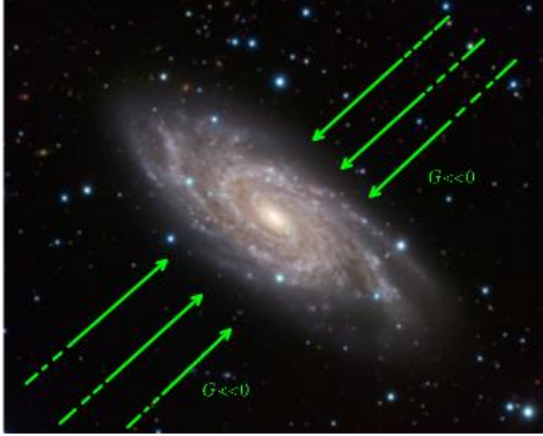
Once particles started to condense to form the large-scale structures, the distribution of matter became anisotropic and as a consequence, the non-homogeneous distribution of matter resulted in heterogeneous gravitational interactions between structures.

As more matter condensed, the magnitude of both attractive gravity from within proto-galaxies and net repulsive gravity from matter at distances beyond the

d_Λ threshold increased and became determinant in shaping galaxies.

A galaxy will be shaped by the gravitational interactions with other galaxies within their clusters, but even more so between galaxies belonging to different clusters at very large distances.

For example, when the net gravity acting on a galaxy on is along one axis, the galaxy will be flattened. Similarly, when the distribution of structures a galaxy interacts with is irregular, then its shape will be irregular. The more homogeneous the distribution of matter interacting will a galaxy, the more spherical it will be. Therefore, from the shape of galaxies, we can deduce the gravitational interactions it is subjected to and from it, the distribution of the structures gravitationally acting on them.



Galaxy Dynamics

In order to correctly describe the dynamics of galaxies we need to take into account all gravitational interactions.

An object b becomes locked into orbiting a more massive object a when the magnitude of the component momentum vector of b in direction of a is cancelled out by gravity. That

is: $\vec{P}_b \cos \theta = - \frac{\Delta \vec{G}}{p_1 \rightarrow p_2}(a; b)$ where

$$\frac{\Delta \vec{G}}{p_1 \rightarrow p_2}(a; b) = \vec{G}_{p_2}(a; b) - \vec{G}_{p_1}(a; b) \cos \theta \text{ and } \theta \text{ is the angle between } \vec{G}_{p_1}(a; b) \text{ and } \vec{G}_{p_2}(a; b).$$

\vec{P}_b is itself resultant the momenta of the components from which b was formed (see [laws of momentum](#)) and the gravitational interactions it is subjected to. For example, a star x belonging to a galaxy a within a given cluster, \vec{P}_x will be the resultant momenta of the converging streams of particles within which its cluster was formed and the gravitational interactions it is subjected to.

In the simplest case, the speed of an object b in orbit at a radial distance r from the center of

a massive structure a is $\vec{v}_b = \frac{\vec{P}_b}{m_b} = \frac{\frac{\Delta \vec{G}}{p_1 \rightarrow p_2}(a; b)}{m_b \sin \theta}$, where θ is the angle between \vec{P}_b and the

tangent to the orbital position of b but this simplest case is only to serve as a basis describe gravitational interactions which in reality are always much more complex.

For one, we must take into account gravitational effects attributed to dark matter.

Dark Matter Halo Density Distribution

To correctly describe the motion of stars within a galaxy, we must first understand the distribution of [dark matter](#) in the region containing the galaxy. Unlike other models which treat dark matter as an exotic type of matter, QGD predicts that all matter is fundamentally composed of *preons*⁽⁺⁾, themselves dark, which become bounded to form progressively more massive particles which as we have explained earlier become visible matter when photons they absorb or emit have at least the minimum momentum necessary to be absorbed by an electron.

This implies that Δm_{vm} , the rate at which visible matter is created from dark matter, must be proportional to the dark halo density Ω_{dm} but also that there is a critical density Ω_{min} below which visible matter cannot form. As a consequence, the density of the dark matter is not

expected to increase as we get closer to the center of a galaxy as dominant dark matter models predict. Under the influence of gravity, dark matter would concentrate towards the center, but the higher rate of production of visible matter would tend towards keeping Ω_{dm} below Ω_{min} .

QGD predicts that $\Omega_{dm} \approx \Omega_{min}$ within a radius $r < d_{\Omega_{min}}$ where $d_{\Omega_{min}}$ is the distance beyond which $\Omega_{dm} < \Omega_{min}$. These dynamics which limits the increase of dark matter density towards the center of a galaxy is consistent with the observed flat dark matter density profiles of galaxies^{26 27}. Thus, QGD precludes the formation of the dark matter cusps predicted by dominant dark matter models (see [cuspy halo problem](#)).

Rotation Curve of Galaxies

QGD's equation for gravity and its predicted dark particles (particles for with $\|\vec{P}\| < m_e$) explain the observed rotation curves of galaxies.

The orbital velocity of a star is $\vec{v}_b = \frac{\vec{P}_b}{m_b} = \frac{\Delta\vec{G}(a;b)}{m_b \cos \theta}$ where θ is the angle between the momentum vector \vec{P}_b and the gravitational vector between a and b .

Note that the p-gravity and n-gravity components of QGD's equation for gravity

$\vec{G}(a;b) = m_a m_b \left(k - \frac{d^2 + d}{1} \right)$ must be differentiated separately since gravity is the resultant

effect of the p-gravity force which is a function of mass only while n-gravity force is a function of both mass and distance. When only taking into account two objects with constant masses, then $\Delta\vec{G}^+(a;b) = 0$ and $\Delta\vec{G}(a;b) = \Delta\vec{G}^-(a;b)$, and objects behave as if governed by Newtonian gravity with gravity diminishing as a function of the square of the distance and

$\Delta\vec{v}_b = \frac{\Delta\vec{G}^-(a;b)}{m_b}$ and $\Delta\vec{v}_a = \frac{\Delta\vec{G}^-(a;b)}{m_a}$. The action is the same but where Newtonian gravity

is strictly attractive with variations due to variations in distance between a and b , QGD attributes the change in gravity to variations in repulsive gravity (n-gravity), while attractive gravity is invariant for constant masses.

²⁶ Moore, Ben; et al. (August 1994). "Evidence against dissipation-less dark matter from observations of galaxy haloes". *Nature*. **370** (6491): 629–631. [Bibcode:1994Natur.370..629M](#). [doi:10.1038/370629a0](#).

²⁷ Oh, Se-Heon; et al. (May 2015). "High-resolution Mass Models of Dwarf Galaxies from LITTLE THINGS". *The Astronomical Journal*. **149** (6): 180. [arXiv:1502.01281](#). [Bibcode:2015AJ....149..180O](#). [doi:10.1088/0004-6256/149/6/18](#)

In order to describe the rotation curve of a galaxy, we need to consider the influence of both visible and dark matter. That is, if R_a is a spherical region of space with radius $r = d$ which center coincides with the center of a galaxy a then the mass of matter within R_a is $m_{R_a} = m_a + m_{dm}$, where m_a and m_{dm} are respectively the amount of visible matter and dark matter in R_a , then $\Delta\vec{v}_b = \frac{\Delta\vec{G}^+(m_{R_a};b) + \Delta\vec{G}^-(m_{R_a};b)}{m_b}$.

$$\Delta\vec{G}^+(R_a;b) = \Delta m_{dm} m_b k \text{ and since } \Delta m_{R_{dm}} = 4\pi r^2 \Omega_{dm} r.$$

$$\begin{aligned} \Delta\vec{G}^-(R_a;b) &= \Delta\vec{G}^+(R_a;b) + \Delta\vec{G}^-(R_a;b) \\ &= 4\pi r^2 \Omega_{dm} m_b k - 2\pi r^3 \Omega_{dm} m_b \end{aligned}$$

and

$$\begin{aligned} \Delta\vec{v}_b &= 4\pi r^2 \Omega_{dm} k - 2\pi r^3 \Omega_{dm} \\ &= 4\pi r^2 \Omega_{dm} \left(k - \frac{r}{2} \right) \end{aligned}$$

And if conversion of dark to visible matter is as explained in the earlier section, then the density of dark matter is inversely proportional to the square of the distance from the center of the galaxy and $\Delta\vec{v}_b = 4\pi r^2 \frac{\Omega_{dm}}{r^2} \left(k - \frac{r}{2} \right) = 4\pi \Omega_{dm} \left(k - \frac{r}{2} \right)$, hence the observed flattening of the rotation curve of galaxies.

Recession Speed between Large Structures

The rate at which large structures accelerate away from each other is proportional to the variation in the gravitational repulsion between two positions and is given by

$$\Delta v_a + \Delta v_b = \frac{\Delta G(R_a;R_b)}{m_a} + \frac{\Delta G(R_a;R_b)}{m_b}.$$

If the universe evolved from an isotropic state such as we described earlier, then the speed of a structure b relative to a structure a is equal to the total acceleration between d_Λ , the threshold distance at which gravity becomes repulsive, and d the distance between the

structures a and b . That is,

$$v_{rel} = v_a + v_b = \frac{\sum_{d_\Lambda}^d \Delta G(R_a; R_b)}{m_a} + \frac{\sum_{d_\Lambda}^d \Delta G(R_a; R_b)}{m_b} = \frac{m_a + m_b}{m_a m_b} \sum_{d_\Lambda}^d \Delta G(R_a; R_b).$$

The acceleration from a galaxy from a large structure is independent of its mass but only dependent on the mass of the structure it is receding from.

Like acceleration from attractive gravity, acceleration from repulsive gravity is directly proportional to the distance. The derivative of QGD's equation for gravity over distance gives the gravitational acceleration over a distance or $v_{R_a} = m_{R_b} d$.

Then $v_{rel} = v_{R_a} + v_{R_b} = (m_{R_a} + m_{R_b})d$ where d may be understood as the proper distance between R_a and R_b .

The acceleration of the rate of recession between a and b is

$$\Delta v_{rel} \approx (m_{R_a} + m_{R_b}) \frac{d^2 - d_\Lambda^2}{2} = (m_{R_a} + m_{R_b})d$$

However, the recession speed between two structures does not only depend on the distance and masses of the structures, but on all masses and structures each interact with, that is, it depends on the gravitational interactions with the rest of the universe, therefore, it depends on each galaxies positions relative to the center of the galaxy. This is measured using the cosmological redshift as discussed in the following section.

Expansion Rate of the Material Universe and the Cosmological Redshift

According to QGD, space is composed of a finite number of fundamental discrete units, $preons^{(-)}$, which makes space a static structure through in which all matter exists. Hence space is finite and must have a center and an edge.

Material structures are strictly kinetic and as we have seen in previous sections gravitationally attract or repel one another depending on whether the distances that separate them is smaller or greater than the threshold distance d_Λ .

We define the cosmological acceleration as the effect of gravity on structures at a scale at which structures are separated by distances greater than the threshold distance beyond which gravity becomes repulsive or $d > d_\Lambda$. At the cosmological scale, since gravity is repulsive, the structures accelerate away from the center of the Universe at a rate that is proportional to their

distance from the center and the inversely proportional to their shortest distances from the edge of the Universe.

For an object a at a distance r from the center of the Universe and d_U , the diameter of the universe, we find that $\Delta\vec{P}_a = \Delta\vec{G}(m_{R_1}; m_a) + \Delta\vec{G}(m_{R_2}; m_a)$ where $m_{R_x} = \text{vol}_{R_x} \frac{m_U}{\text{Vol}_U}$.

Observationally, objects at the cosmological scale that are closer than we are to the center of the universe will appear blue shifted relative to light from the center of our galaxy and objects that are further than we are from the center of the Universe will appear redshifted relative to it.

However, since the cosmological acceleration affects a galaxy as a whole with negligible differences on individual components of a galaxy, we would observe, within a galaxy, stars that may be redshifted or blue shifted relative to a reference star depending on whether the observed star is respectively closer or further from the center of the galaxy.

Black Holes and Black Holes Physics

QGD predicts the existence of structures which exerts such gravitational pull that photons cannot escape. But contrary to the classical black holes predicted by relativity, the black holes predicted by quantum-geometry dynamics are not singularities. The QGD exclusion principle which states that a $preon^{(-)}$ cannot be occupied by more than one $preon^{(+)}$ implies that quantum-geometrical space imposes a limit to the density any structure can have. The density of black holes is also limited by the fact that $preon^{(+)}$, being strictly kinetic, must have enough space to keep in motion. It follows that black must have very large yet finite densities.

Angle between the Rotation Axis and the Magnetic Axis

The effect of the helical motions of the electrons in direction of the rotation of a body adds up so that, at a large scale, the body behaves as a single large electron interacts with the neighbouring preonic region to generate a magnetic field.

Since the magnetic field is the result of the polarization of free $preon^{(+)}$ along the loops of the helical trajectory, and since the inclination of these loops increases with the speed of rotation, so does the angle between these loops and the axis of rotation increases. It follows that the angle between the axis of rotation and the magnetic axis for bodies of given material composition is proportional to the speed of rotation about its axis and its diameter.

This angle between the axis of rotation and the magnetic axis is small for slowly rotating bodies but can never be so small that the axes coincide. From the above, it also follows that a faster

rotation not only implies a larger the angle between the rotation axis and the magnetic axis is, but also a flattening of the magnetic field and an increase in its intensity.

The Inner Structure of Black Holes

To understand the structure of a black hole we will look at what happens to a photon when it is captured by it the gravitational pull.

The model for light refraction that we introduced in earlier articles can be applied directly to photon moving through a black hole. Since we assume that the black hole is extremely massive, its trajectory will bring it towards the center of the black hole.

When moving along the magnetic axis of the black hole, the component $preons^{(+)}$ of the $preons^{(+)}$ pairs of the photon are pulled away from each other, splitting the photon into free $preons^{(+)}$ which may or not recombine into neutrinos. This works as follow:

As we have seen earlier in this book, the force binding the $preons^{(+)}$ of a $preons^{(+)}$ pairs is gravitational. The QGD gravitational interaction between particles at the fundamental scale is

$$G(a;b) = m_a m_b \left(k - \frac{d^2 + d}{2} \right),$$

and since a and b are $preons^{(+)}$, $m_a = m_b = 1$ and since

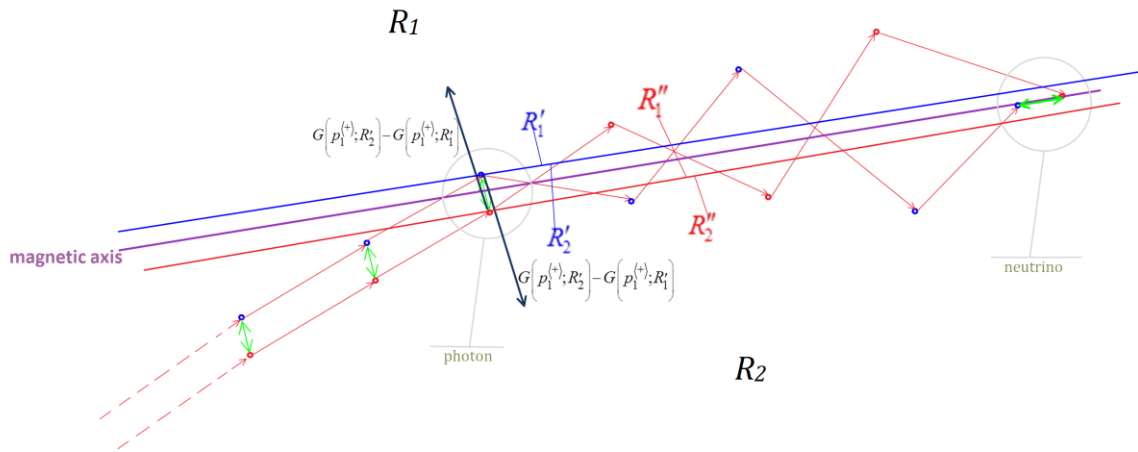
$d = 1$, the binding force between two $preons^{(+)}$ of a $preons^{(+)}$ pair is equal to $k - 1$.

For a photon moving along the magnetic axis, we have and $G(p_1^{(+)}; R_2) - G(p_1^{(+)}; R_1) > k - 1$ where $p_1^{(+)}$ and $p_2^{(+)}$ are the component $preons^{(+)}$ of a $preons^{(+)}$ pair of a photon.

The regions R_1 and R_2 , on each side of the black hole axis are equally massive regions. If we call R'_1 and R'_2 the regions each side of $p_1^{(+)}$ when the photon's trajectory is aligned with the black hole axis then $R'_2 > R'_1$ and $G(p_1^{(+)}; R'_2) - G(p_1^{(+)}; R'_1) > k - 1$. Similarly, if we call R''_1 and R''_2 the region on the each side $p_2^{(+)}$ then $R''_1 > R''_2$ and $G(p_2^{(+)}; R''_1) - G(p_2^{(+)}; R''_2) > k - 1$. So the force pulling the $preons^{(+)}$ of $preons^{(+)}$ pairs being greater than the force that binds them, the $preons^{(+)}$ pairs are split into single $preons^{(+)}$.

How do we that the gravitational forces within a black hole are sufficiently strong to cause the photons to be broken down into $preons^{(+)}$? If the gravitational forces within the black hole were not enough to breakdown the photons, then photons moving along a black hole axis would escape into space making the black hole visible. Since black holes do not emit light, then the

gravitational interactions must be strong enough to break photons down into $preons^{(+)}$ and neutrinos.



The image above shows how a simple two $preons^{(+)}$ photon is split into two free $preons^{(+)}$ which because of the electro-gravitational interactions move back toward the magnetic axis. But, because the quantum-geometrical space occupied by the black holes is densely populated by particles which affect randomly the trajectories of the single $preons^{(+)}$, our two $preons^{(+)}$ arrive at the magnetic axis of the black hole at different positions. And if they are in close enough proximity, the single $preons^{(+)}$ will combine to form a neutrino which structure, not being made of $preons^{(+)}$ pairs, remains structurally unaffected by the intense gravitational interactions within the black hole.

Once the trajectories of the $preons^{(+)}$ or the neutrino coincides with the magnetic axis of the black hole, the $preons^{(+)}$ or neutrinos will move through the center of the black hole and will exit it. $Preons^{(+)}$ and neutrinos can escape the gravitation of the black hole because gravitational interactions, though it affects the directions of $preons^{(+)}$, doesn't change their momentums which, as we have seen in earlier articles is fundamental and intrinsic (the momentum of a $preons^{(+)}$ is $\|\vec{c}\|$ where \vec{c} is momentum vector of a $preons^{(+)}$).

It follows, that all matter that falls into a black hole will be similarly disintegrated into $preons^{(+)}$ and neutrinos, which will exit the black hole. The black hole will thus radiate $preons^{(+)}$ and neutrinos, in jets at both poles of their magnetic axis of rotation. Since $preons^{(+)}$ and neutrinos interact too weakly with instruments to be detected by our instruments, they are invisible to them. To see the $preons^{(+)}$ -neutrinos jets from a black hole, instruments may need detectors larger than our solar system. However, the jets can be observed indirectly when they interact

with large amount of matter when the polarized $preons^{(+)}$ and neutrinos they contain impart it with their intrinsic momentum. It is worth noting that polarized $preons^{(+)}$ and neutrinos jets, as described by QGD, would contribute to the observed dark energy effect.

Based on QGD's model of the black hole, we can predict that the $preons^{(+)}$ /neutrino jets will form an extremely intense polarized $preons^{(+)}$ field along the magnetic axis creating the equivalent of a repulsive electromagnetic effect at both poles. The polarized preonic field would repulse all matter on their path, which may explain the shape of galaxies.

From what we have discussed in the preceding section, we can define a black hole as an object which mass is such that it can breakdown all matter, including photons, into $preons^{(+)}$. Therefore, any emission by a black hole being preonic, they are not visible. However, intense preonic fields (which as we have seen are essentially intense magnetic fields), will impart momentum to particles and structures, bringing them into excited states from which they emit photons.

The QGD model of the physics of black hole has another important implication. The $preons^{(+)}$ and neutrinos resulting from the breakdown of a particle or structure are indistinguishable from the $preons^{(+)}$ or neutrinos resulting from the breakdown of any other particle or structure. This means, if QGD is correct, that all information about the original particle or structure is lost forever. That said, since this consistent from QGD's axioms set and since, unlike quantum mechanics, QGD does not require that information be preserved, the loss of information it predicts does not lead to a [paradox](#) (see [this article](#) for an excellent introduction to subject).

Density and Size of Black Holes

QGD predicts that black holes are extremely dense but not infinitely so. Considering that $preons^{(+)}$ are strictly kinetic and that no two can simultaneously occupy any given $preons^{(-)}$ then $\max density_{BH} = \frac{1preon^{(+)}}{2preons^{(-)}} or \frac{1}{2}$. It follows that $\min Vol_{BH} = 2m_{BH}preons^{(-)}$ or, since $preons^{(-)}$ is the fundamental unit of space, we can simply write $\min Vol_{BH} = 2m_{BH}$ for the

minimum corresponding radius $\min r_{BH} = \left[\sqrt[3]{\frac{3m_{BH}}{2\pi}} \right]$.

For the radius of the black hole predicted to be a the center of our galaxy, $m_{BH} \approx 4*10^6 M_{\odot}$

and $\min r_{BH} = \left[\sqrt[3]{\frac{3m_{BH}}{2\pi}} \right] \approx 1.24*10^2 M_{\odot}$ where the mass is expressed in $preons^{(+)}$ and radius

in $preons^{(-)}$. Though converting this into conventional units requires observations to

determine the values of the QGD constants k and c , using relation between QGD and Newtonian gravity, we also predict that the radius within which light cannot escape a massive structure is $r_{qgd} = \sqrt{G_{const} \frac{M}{c}}$ where G_{const} is used to represent the gravitational constant.

Since the Schwarzschild radius for a black hole of mass M_{BH} is $r_s = G_{const} \frac{M_{BH}}{c^2}$ then

$$r_{qgd} = \sqrt{cr_s} .$$

Using r_{qgd} to calculate $\delta_{r_{qgd}}$ the angular radius of the shadow of Sagittarius A*, the black hole at the center of our galaxy, where $M_{BH} = 4 \cdot 10^6 M_{\odot}$ we get $\delta_{r_{qgd}} \approx 26.64 \cdot 10^{-5}$ arcseconds which is about 10 times the angular radius calculated using the Schwarzschild radius which is

$\delta_s = 27.6 \cdot 10^{-6}$ arcseconds. This prediction will be tested in the near future by the upcoming observations by the [Event Horizon Telescope](#) or similar equipment.

Neutron Stars, Pulsars and Other Supermassive Structures

When the mass of a structure is sufficient to bind photons, but insufficient to breakdown photons, electrons, and positrons, we get a stellar structure which can emit these particles.

The internal gravitational interactions will redirect particles towards the magnetic axis of the stellar structures where, when its trajectory coincides with an axis, the gravitational force from the stellar object acting on the particles will cancel out and the particle will escape the object into outer space. Such structures may correspond to what we call [neutron stars](#). So what distinguishes neutron stars from black holes is that we have $G(p_1^{(+)}; R_2') - G(p_1^{(+)}; R_1') < k - 1$ and $G(p_2^{(+)}; R_1'') - G(p_2^{(+)}; R_2'') < k - 1$. That is, the gravitational force within the neutron star which acts on particles is insufficient to breakdown photon, electron and positrons.

Another prediction is that distinguishes quantum-geometry dynamics is that neutron stars are not composed of neutrons. The internal gravitational interactions being such that they would break down all particles into neutrinos, photons, electrons and positrons.

Pulsars

When a neutron star rotates at a sufficiently high rate, it interacts with the preonic field in such a way that it creates an intense magnetic field. Such magnetic field will be sufficiently strong to curve the trajectory of all neutrinos, photons, electrons and positrons that move past its surface back into pulsar. Particles that move along its axis of rotation, along which the electromagnetic force cancel out, will escape at the magnetic poles producing the known bidirectional emission characteristic of [pulsars](#).

The Preonic Universe

According to the principle of strict causality we can deduce the following:

Preons⁽⁺⁾ and *preons*⁽⁻⁾, are fundamental. As such and in accordance with the [fundamentality theorem](#), they have no components; hence they require no pre-existing conditions to exist. From this and to be in accordance with the Law of Conservation, all *preons*⁽⁺⁾ and *preons*⁽⁻⁾ always existed.

That is, *preons*⁽⁺⁾ and *preons*⁽⁻⁾ not only existed at the origin of the Universe. They are the origin of the Universe.

It follows that in its initial phase, the Universe consisted of *preons*⁽⁺⁾ uniformly distributed throughout the entire quantum-geometric space of the Universe; the preonic universe.

The theory proposes that the n-gravity and p-gravity fields were in perfect equilibrium. That is:

$$k(m_U^2 + m_U) / 2 = (Vol_U^2 + Vol_U) / 2$$

Where m_U is the mass of the preonic universe and Vol_U is the number of *preons*⁽⁻⁾ its space is composed of. But since $\lim_{x \rightarrow \infty} \left(\frac{x}{x^2} \right) = 0$, at the macroscopic scale, the relative value of m_U and Vol_U become negligible and we can simply write²⁸:

$$km_U^2 / 2 \approx Vol_U^2 / 2$$

Also, from the QGD definitions of heat, temperature and entropy we know that, since in the primordial universe contained only free *preons*⁽⁺⁾, the heat it contained was equal to its energy, that is $Heat = \sum_{i=1}^{m_U} \|\vec{c}_i\| = m_U c$, its temperature was $\frac{m_U c}{Vol_U}$ and its entropy being the difference between its energy and heat, and heat and energy being equal in the preonic universe, its entropy was equal to zero.

²⁸Since QGD implies that all quantities are finite, even mathematical quantities, ∞ represents the largest theoretical quantity of any physical property. In this equation it may be taken as the number of n-gravity interactions in the universe.

Interestingly, since $Vol_U = \sqrt{km_U^2}$ the temperature of the preonic universe is given by

$$\frac{m_U c}{\sqrt{km_U^2}} = \frac{c}{\sqrt{k}} .$$

Hence, the temperature of the preonic universe is a ratio of c and k ; the two fundamental constants of quantum-geometry dynamics.

Future Evolution of the Universe

If QGD's description of the universe is correct, then most matter would eventually collapse into black holes where it would be broken down in into *preons*⁽⁺⁾ which would be radiated and would reseed the universe, eventually resetting the initial isotropic state.

One question remains. What will happen to the galaxies that will be pushed to the limits of the universe? The most likely scenario that is consistent with QGD is that not being able to move any further, all matter will be broken down into *preons*⁽⁺⁾ and which would then be reflected towards back towards the center of the universe.

Deriving Testable Predictions from QGD

The usefulness of quantum-geometry dynamics as a physics theory depends entirely on whether its predictions can be tested, hence measured. This means that the quantities used in its equations must be expressible in measurable units.

We have explained [earlier](#) the relationship between the intrinsic velocity of light \vec{c} , the metric velocity $\overset{\mapsto}{c}$ (which is the displacement in quantum-geometrical space during that occurs during an interval t) and $\overset{\mapsto}{c}$, the measured two-way velocity of light.

Most important are the relations $\overset{\mapsto}{c} \propto \vec{c}$ and $\overset{\mapsto}{c} \propto c$ since they allow us to relate the intrinsic velocity of light to the two-way velocity of light, hence provide a bridge between the discrete fundamental units of QGD and a measurable quantity, the two-way velocity of light.

A two-way measurement of the velocity of light cancels the relative velocity of an inertial frame of reference which QGD predicts would be added to or subtracted from $\overset{\mapsto}{c}$. QGD thus predicts that one-way measurements of the velocity of light differs from two-way measurements and unlike two-way measurements are not constant.

In the next sections, we propose a way to measure the one-way velocity of light and show how this can be applied to derive the metric velocity of any object from its relative velocity. That is, we may find that the velocity of an object relative to space itself.

Measurement of One-way Velocity of Light

Quantum-Geometry Dynamics predicts that the intrinsic velocity of light and consequently its metric velocity, that is its velocity relative to quantum-geometrical space, are isotropic. This implies that the one-way metric velocity of light must be anisotropic. The clock synchronisation scheme used in the experiment described below uses timestamps encoded light signals which timestamps are unaffected by any predicted relativistic or other physical effects. It is also assumed that measurement of the two-way velocity of light is, in accordance with QGD, isotropic.

The experimental setup (see diagrams next page) requires two clocks A and B that have similar mechanisms which include memory, capability to transmit and receive timestamped encoded of light signals. The clocks are kept at a constant distance relative to each other which can be tested using the time of flight in two-way measurements. Light signals will be timestamped since the information encoded in timestamps are independent of measurements of time of flight.

There is no prior requirement to synchronize the clocks.

In step 1 of synchronization, clock A will send a light signal that will be reflected back from clock B . The delay between the transmission and reception of reflected signal will be used to calculate

$$\overset{\mapsto}{c}_{A \leftrightarrow B}, \text{ the two-way velocity of light from } A \text{ to } B \text{ to } A. \text{ Step 2 will give } \overset{\mapsto}{c}_{B \leftrightarrow A},$$

In step 3, clock A will transmit the value $\overset{\mapsto}{c}_{A \leftrightarrow B}$ and timestamp of time of transmission the signal in step 1 to clock B . Clock B will compare the two two-way measurements.

If $\overset{\mapsto}{c}_{A \leftrightarrow B} = \overset{\mapsto}{c}_{B \leftrightarrow A}$, the clock B will proceed to step 4 and using the difference between the timestamps of step 1 and step 2, will synchronize itself to clock A .

If $\overset{\mapsto}{c}_{A \leftrightarrow B} \neq \overset{\mapsto}{c}_{B \leftrightarrow A}$, the difference is measurement is attributable to differences in the clock rates of clock A and clock B and we must proceed to step 5. Clock B will adjust its frequency so that

$$\overset{\mapsto}{t}_{B \leftrightarrow A} = \overset{\mapsto}{t}_{A \leftrightarrow B} \text{ and } \overset{\mapsto}{c}_{B \leftrightarrow A} = \overset{\mapsto}{c}_{A \leftrightarrow B} \text{ then execute step 4 for time synchronization.}$$

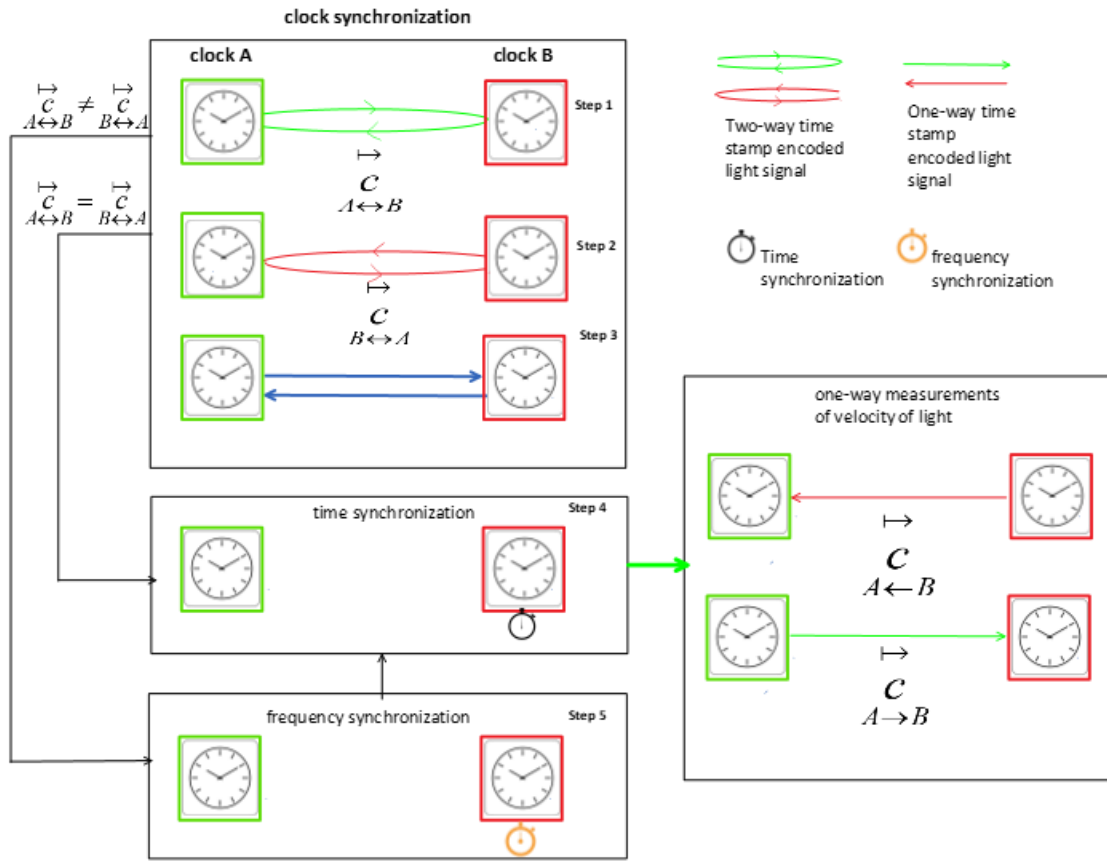
Synchronization of clock A and B can be checked by executing the synchronization steps again. Once synchronization is confirmed, we can proceed to one-way measurements of the velocity of

light from A to B , $\overset{\mapsto}{c}_{A \rightarrow B}$ and from B to A , $\overset{\mapsto}{c}_{B \rightarrow A}$.

Clock A will send a timestamp signal to B . B will compare to timestamp of the signal from A to the time of detection of the signal to establish time of flight and calculate $\overset{\mapsto}{c}_{A \rightarrow B}$.

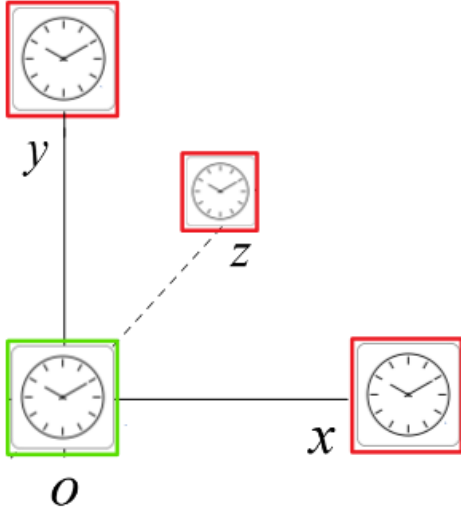
Clock A will similarly derive $\frac{c}{B \rightarrow A}$ from the timestamp signal from clock B.

The synchronization procedure we described above compensates for effects on the rate of clocks predicted by relativity or QGD. A flowchart describing the synchronization procedure and measurements of one-way velocity of light is shown below.



If QGD's prediction that one-way velocity measurements are not constant, then the difference between the two-way velocity and one-way velocity is attributable to the metric velocity component of the clocks along the axis between them. That is $\overset{\mapsto}{v}_{A \rightarrow B} = \overset{\mapsto}{c} - \overset{\mapsto}{c}_{A \rightarrow B}$. For the metric

velocity of an object, we must first create a setup similar to that on the left synchronized as we described above.



$$\overset{\mapsto}{v}_o = \overset{\mapsto}{v}_{o \rightarrow x} + \overset{\mapsto}{v}_{o \rightarrow y} + \overset{\mapsto}{v}_{o \rightarrow z} \text{ where } \overset{\mapsto}{v}_o \text{ is the metric velocity of clock } O.$$

Metric Velocity of an Object

The metric velocity of any object is then

$$\overset{\mapsto}{v}_a = \overset{\mapsto}{v}_{a \text{ rel}} + \overset{\mapsto}{v}_o, \text{ where } \overset{\mapsto}{v}_a \text{ is the metric velocity of object } a, \overset{\mapsto}{v}_{a \text{ rel}} \text{ is its measured velocity relative to the clock } O \text{ and } \overset{\mapsto}{v}_o \text{ is the metric velocity of clock } O.$$

Since quantum-geometrical space is finite and static, the derived metric velocity of any object is absolute thus observer independent.

According to QGD, all fundamental properties are associated with *preons*⁽⁺⁾ and *preons*⁽⁻⁾, and because they are intrinsic, they cannot be directly measured. However, the relations between physical quantities described by QGD remain valid when substituting metric properties for intrinsic properties. For example, the metric velocity of any object is proportional to its intrinsic, we can use substitute the former for the latter in a QGD equation if all other quantities in the equation are also metric.

Intrinsic Properties and their Metric Counterparts

Distance

$$\overset{\mapsto}{d} \propto d$$

Mass

$$\overset{\mapsto}{m}_a \propto m_a$$

The metric mass of a body may be obtained from the metric gravitational acceleration it imparts to reference body. However, one must remember that the metric gravitational acceleration is

the rate of change of the metric velocity (not the rate of change of the velocity relative to the body) and must be derived as described [above](#).

Velocity

$$\vec{v}_a \propto \vec{v}_a$$

Momentum

$$\text{Since } \frac{\vec{P}_a}{m_a} = \vec{v}_a \text{ and}$$

$$\vec{P}_a = m_a \vec{v}_a \text{ and}$$

$$\vec{v}_a \propto \vec{v}_a \text{ then}$$

$$\vec{P}_a \propto \vec{P}_a$$

Constants

There are three constants in QGD:

\vec{c} , the fundamental momentum, which is also numerically equal to the velocity of *preons*⁽⁺⁾ and consequently the velocity of photons.

k , the ratio between the magnitude of a unit of p-gravity over the magnitude of a unit of n-gravity.

d_Λ , the distance between two objects at which p-gravity and n-gravity cancel each other out.

Gravity

$$\text{Since } \vec{G}(a;b) = m_a m_b \left(k - \frac{d^2 + d}{2} \right) \text{ then } \vec{G}(a;b) \propto \vec{G}(a;b) \text{ and } \Delta \vec{P}_a = \Delta \vec{G}(a;b) = \Delta \vec{P}_b$$

where $\Delta \vec{P}_a$ and $\Delta \vec{P}_b$ are respectively the gravitationally induced change in momentum to objects a and b .

And since $\Delta \vec{v}_a = \frac{\Delta \vec{G}}{m_a}$ we have $\Delta \vec{v}_a = \frac{\Delta \vec{G}}{m_a}$. It is important to remember that in QGD, an

increase in momentum is not a consequence of an increase in velocity. Increase in velocity is a consequence of an increase in of the intrinsic momentum as described in the chapter titled [Forces, Interactions and the Laws of Momentum](#).

Note: When testing predictions against observations, metric value must be derived from measurements.

Assigning Value to k

QGD's equation for gravitational interactions is $G(a;b) = m_a m_b \left(k - \frac{d^2 + d}{2} \right)$ where m_a and m_b are the masses of objects of a and b . From the question we can predict that $G(a;b) = 0$ when $k = \frac{d_\Lambda^2 + d_\Lambda}{2}$ (d_Λ is the threshold distance beyond which gravity becomes repulsive²⁹).

Recent observations³⁰ suggest that $d_\Lambda \approx 10Mpc$ in which case $k \approx 4.5 * 10^{34}$ when using the meter as unit of distance in the gravity equation.

Rest Mass and Relativistic Mass

Unless an object absorbs particle (which it does only when non-gravitational forces are applied to a body) the mass of an object does not change as a function of its velocity.

The mass remains equal to the number of *preons*⁽⁺⁾ it contains. What changes under the influence of gravity is the net orientation of their components *preons*⁽⁺⁾, what we call its momentum given by the equation $\|\vec{P}_a\| = \left\| \sum_{i=1}^{m_a} \vec{c}_i \right\|$. The magnitude of \vec{P}_a increases in towards b

²⁹ for $d > d_\Lambda$ gravity becomes negative and is, as we explained, is responsible for the effect we call dark energy

³⁰ [Dark energy and key physical parameters of clusters of galaxies](http://arxiv.org/abs/1206.1433) <http://arxiv.org/abs/1206.1433>

when $G(a;b) > 0$ and increases away from b when $G(a;b) < 0$ but as we explained it mass m_a or its energy $\sum_{i=1}^{m_a} \|\vec{c}_i\|$ remain constant.³¹

The relation between mass and energy expressed by $E_a = \sum_{i=1}^{m_a} \|\vec{c}_i\| = m_a c$ where, if we may remind the reader, the “=” sign symbolizes is a proportionality relation and not an equivalence as interpreted by special relativity. Here again, the relativistic and QGD mass are one and the same.

Application to States of Gravitationally Interacting Bodies

The two bodies systems described by the simplified gravitational interaction equation is the basis of the state matrix used to describe the behaviour of a system composed of n gravitationally interacting bodies.

The change in momentum due to gravitational interaction is given by

$$\Delta \vec{P}_a = \Delta G_{1 \rightarrow 2}(a;b) = \frac{\|\vec{G}_2(a;b)\| - \|\vec{G}_1(a;b)\| \cos(\theta)}{\|\vec{G}_2(a;b)\|} \vec{G}_2(a;b) \quad (1)$$

where θ is the angle between $\vec{G}_1(a;b)$ and $\vec{G}_2(a;b)$ which are respectively the gravitational vectors between a and b in states 1 and 2 and $\Delta G_{1 \rightarrow 2}(a;b)$ is understood to be the difference in the magnitude of the gravitational interaction between a and b from state 1 to state 2 (or $1 \rightarrow 2$)

For a system consisting of n gravitationally interacting bodies,

$$\Delta \vec{P}_{a_{i \rightarrow j}} = \Delta \vec{G}(a_i; a_{j_{s+1}}) = \sum_{j=1}^n \frac{\|\vec{G}_{s+1}(a_i; a_{j_{s+1}})\| - \|\vec{G}_s(a_i; a_{j_{s+1}})\| \cos(\theta)}{\|\vec{G}_{s+1}(a_i; a_{j_{s+1}})\|} \vec{G}_{s+1}(a_i; a_{j_{s+1}}) \quad (2)$$

where a_i and a_j are gravitationally interacting astrophysical bodies of the system, $j \neq i$ and s and $s+1$ are successive states of the system (a state being understood as the momentum vectors

³¹ A body is at rest if its momentum is equal to zero. This implies that a body is at rest if $\vec{P}_a = \vec{0}$ which implies that its metric momentum and metric velocity are null vectors.

of the bodies of a system at given co-existing positions of the bodies) and $a_{i|s+x}$ is the body a_i and its position when at the state $s+x$. The position itself is denoted $\varepsilon_{a_i|s+x}$.

In order to plot the evolution in space of such a system, we must choose one of the bodies as a reference so that the motions of the others will be calculated relative to it. A reference distance travelled by our reference body is chosen, d_{ref} , which can be as small as the fundamental unit of distance (the leap between two *preons*⁽⁻⁾ or *preonic leap*) but minimally small enough as to accurately follow the changes in the momentum vectors resulting from changes in position and gravitational interactions between the bodies.

So given an initial state s , the state $s+1$ corresponds to the state described by the positions and momentum vectors of the bodies of the system after the reference body travels a distance of d_{ref} . For simplicity, we will assign a_1 to the reference body.

$$s+1 = \left\{ \begin{array}{l|l} \vec{P}_{a_{1|s+1}} = \vec{P}_{a_{1|s}} + \Delta \vec{G}_{j=1}^n(a_{1|s}; a_{j|s+1}) & \varepsilon_{a_1|s+1} \\ \dots & \dots \\ \vec{P}_{a_{n|s+1}} = \vec{P}_{a_{n|s}} + \Delta \vec{G}_{j=1}^n(a_{n|s}; a_{j|s+1}) & \varepsilon_{a_n|s+1} \end{array} \right\}$$

Using the above state matrix, the evolution of a system from one state to the next is obtained by simultaneously calculating the change in the momentum vectors from the variation in the gravitational interaction between bodies resulting from their change in position. Changes in the momentum vectors have are as explained earlier. Changes in position are given by

$$\varepsilon_{a_i|s+1} = \varepsilon_{a_i|s} + \frac{v_{a_i}}{v_{a_1}} \frac{d_{ref}}{\|\vec{P}_{a_i}\|} \vec{P}_{a_i}. \text{ The distance travelled by } a_i \text{ from } s \text{ to } s+1 \text{ is } \frac{v_{a_i}}{v_{a_1}} d_{ref} \text{ (for } j=1 \text{ ,}$$

the distance becomes simply d_{ref}) and distance between two bodies of the system at state

$$s+x \text{ is } d_{a_i;a_j|s+x} = \varepsilon_{a_i|s+x} - \varepsilon_{a_j|s+x}.$$

Of course, we find that for $i=j$, then $d_{a_i;a_j|s+x} = 0$, so that

$$\begin{aligned}
\left\| \Delta \vec{G}_{s+1} (a_{i|s+1}; a_{j|s+1}) \right\| &= \left\| \vec{G} (a_{i|s+1}; a_{i|s+1}) \right\| - \left\| \vec{G} (a_{i|s}; a_{i|s}) \right\| \\
&= m_a m_a \left(k - \frac{d^2_{a_i; a_j|s+1} - d_{a_i; a_j|s+1}}{2} \right) - m_a m_a \left(k - \frac{d^2_{a_i; a_j|s} - d_{a_i; a_j|s}}{2} \right), \\
&= m_a m_a k - m_a m_a k \\
&= 0
\end{aligned}$$

the variation in the gravitational interaction between a body with itself is equal to zero, which implies that its momentum vector will remain unchanged unless $n > 1$ and $\Delta \vec{G}_{j=1}^n (a_{i|s}; a_{j|s+1}) \neq 0$. This is the QGD explanation of the first law of motion.

Note also that for an object a_j freefalling towards an object a_i , $\theta = 0$ so equation (2) becomes

$$\Delta \vec{P}_{a_{i_{s+1}}} = \Delta \vec{G}_{j=1}^n (a_{i_s}; a_{j_{s+1}}) = \frac{\left\| \vec{G}_{s+1} (a_{i_s}; a_{j_{s+1}}) \right\| - \left\| \vec{G}_s (a_{i_s}; a_{j_{s+1}}) \right\|}{\left\| \vec{G}_{s+1} (a_{i_s}; a_{j_{s+1}}) \right\|} \vec{G}_{s+1} (a_{i_s}; a_{j_{s+1}}) \text{ and}$$

$$\left\| \Delta \vec{G}_{j=1}^n (a_{i_s}; a_{j_{s+1}}) \right\| = \left\| \frac{\left\| \vec{G}_{s+1} (a_{i_{s+1}}; a_{j_{s+1}}) \right\| - \left\| \vec{G}_s (a_{i_s}; a_{j_{s+1}}) \right\|}{\left\| \vec{G}_{s+1} (a_{i_{s+1}}; a_{j_{s+1}}) \right\|} \vec{G}_{s+1} (a_{i_{s+1}}; a_{j_{s+1}}) \right\| = \left\| \vec{G}_{s+1} (a_{i_{s+1}}; a_{j_{s+1}}) \right\| - \left\| \vec{G}_s (a_{i_s}; a_{j_{s+1}}) \right\|$$

Measurements of the Intrinsic Speed of a Distant Light Source

Once the metric velocity of the earth is known, their effects on the light received from a distant source can be factored out. Then, using the [QGD's description of the redshift effect](#), we may calculate the metric velocity of the distant light source at the time the light was emitted.

However, a much better option (when such option becomes technically feasible) would be the measurement of variations in gravitational interactions with distant objects we discussed [here](#) and which would provide current instantaneous position and velocity.

The Physics of Mathematical Practices and Infinities

Let me say at the outset that I am not happy with this state of affairs in physical theory. The mathematical continuum has always seemed to me to contain many features which are really very foreign to physics. [...] If one is to accept the physical reality of the continuum, then one must accept that there are as many points in a volume of diameter 10^{13} cm or 10^{33} cm or 10^{1000} cm as there are in the entire universe. Indeed, one must accept the existence of more points than there are rational numbers between any two points in space no matter how close together they may be. (And we have seen that quantum theory cannot really eliminate this problem, since it brings in its own complex continuum.)

Roger Penrose, On the Nature of Quantum-Geometry

The key axiom of quantum-geometry dynamics is that of space discreteness. If QGD's prediction that space is discrete, it follows that space continuum, infinities and even time would be nothing more than concepts. In this section, we argue that even mathematical continuum does not exist.

Incompleteness of purely mathematical proofs of infinities

Mathematics is a human activity. As such, the practice of mathematics is bound by the laws of physics. However, we act as if it operated outside of these laws.

For example, we learn early on in school that the set of natural numbers, the set of rational numbers, or that of irrational numbers all contain an infinite number of elements. We learn that the number line is a continuum composed of an infinite number of infinitesimal points, each of which corresponding to a real number. And to satisfy our inquisitive minds, our teachers provided irrefutable mathematical proofs of the existence of these (and other) infinities.

Consider the set of natural numbers \mathbb{N} . We know that $\forall x \in \mathbb{N}; x+1 \in \mathbb{N}$. That is, however large we chose x to be, we can always obtain a larger number by simply adding 1 to it. Since there is no upper limit to the size of x , the set of all natural numbers is thought to be limitless, hence infinite.

A similar reasoning is used to prove that the number line is continuous. However close two arbitrarily chosen points may be, we can always find an infinite number of points between them. There is an infinite number of points between even infinitesimally close points.

The above examples illustrate some of the irrefutable and definitive mathematical proofs of the existence of infinities. These proofs are so fundamental to our understanding of mathematics that we rarely question their validity.

But as we will show below, these purely mathematical proofs of infinities proofs are incomplete. They ignore the essential fact that mathematical objects, procedures, relations, concepts, etc.,

all are products of physical processes. And, as abstract as the mathematics may be, these processes require physical resources, energy to be brought into existence.

Even the constructivist argument according to which the existence of a number is proven only when it is constructed is paradoxical since it assumes that numbers have an objective existence prior to its constructions and ignores the physicality of such construction.

The fact is, you don't construct something that already exists, therefore constructing a number does not prove its existence, what it does is bring it into existence using processes are physical. The practice of mathematics is unquestionably physical.

Mathematics is practiced without concern about footing the bill for the material and energy resources it requires. But mathematical activities happen in physical reality and as such are not exempt from obeying the laws of physics. Every mathematical operation, the simplest addition or even the transcription of a result uses energy and consequently increases the universe's entropy. Even if there were an infinite amount of energy available for calculations, the number of operations will always be finite at any point in time.

When considering the physical aspect of mathematical proofs, we inevitably arrive at a counter proof of the existence of infinities.

Take proof that shows the set of natural numbers is infinite. We find that we cannot infinitely repeat the recursive operation implied in the mathematical proof. Each iteration requires energy and matter, each of the processes a sequence of causally linked states (the energy and steps of calculations necessary to construct them. And as any physical process, they rely on finite resources.

So, you can ultimately have a computer the size of the universe, with components the size the most fundamental particles, running at the speed of light for the entire existence of the universe, exhausting all energy, and that still would be insufficient to construct an infinite set. The same reasoning applies to the continuum of the number line and to irrational numbers.

The ineluctable conclusion is that neither infinite sets nor continuums exists.

One may argue that there are infinite possibilities from which to chose when constructing a number, but possibilities are not actualities, and the act of choice is a process that is also limited by the laws of physics and physical resources.

The non-existence of infinities or continuums has implications for both mathematics and physics. We'll examine a some of them here.

Some Obvious Mathematical Implications

Numbers are constructed hence must have a finite number of decimals, this implies all numbers can be expressed as a ratio of two natural numbers, which must then include irrational numbers.

The number of decimals is then a function of the number of iterations of a computational procedure. Then $\sqrt{2}$ is not a number in itself, but represents a construction mode which may more appropriately be written in the form $\sqrt[i]{2}$, where i is the number of iteration of the square root construction mode applied to 2.

$\sqrt{2}$ is thus an idealization of the existence of a number in a reality that is not subjected to

The proof that $\frac{1}{3} \neq 0.33333\dots$

Taking into account that we apply i number of iterations of the division by three to the number 1, we find

$$x = 0.33333\dots\underset{i}{3} \text{ and } 10x = 3.33333\dots\underset{i-1}{3}$$

hence

$$9x = 3.33333\dots\underset{i-1}{3} - 0.33333\dots\underset{i}{3} = 2.9999\dots 7$$

$$x = \frac{2.9999\dots 7}{9} \neq \frac{3}{9} \text{ or } \frac{1}{3}$$

Inexistence of Irrational Numbers

By the same reasoning, we find that all constructed numbers must have a finite number of decimals, hence can be expressed as the ratio of two integer numbers, hence are rational.

It would also be interesting to reinterpret theorems in terms of modes of construction.

Take for instance Fermat's last theorem which states there exist no positive integers x , y , z and integer n such that for $n \geq 3$ the equation $x^n + y^n = z^n$ is satisfied. We can rewrite the

equation as $\sqrt[i]{x^n + y^n} = z$ where the left side of the equation is the construction mode and

the right side the result of the application of the construction after i number of iterations of the construction mode (the algorithm being defined as the set of operations that extends the decimal sequence).

Modes of construction of number generate rational numbers.

No Mathematical Geometrical Continuum

The non-existence of a continuous number line implies the non-existence continuous surfaces or volumes, or that of any continuous space regardless of dimensions.

Physical Infinities?

The notions of continuum and continuous mathematics have shaped our understanding of the nature of space.

The space continuum is physically also impossible for the reason stated by Sir. Roger Penrose, but also because it violates the laws of conservation of space and energy.

Nothing supports the assumption of space continuum. Virtually all our physics theories implicitly assume the space is a continuum despite all the problems, the unphysical implications, that this assumption causes (see John. C. Baez excellent summary of problems and paradoxes that arise in physics from the assumption of the existence of the continuum ³²).

We chose to believe in the continuum despite all the paradoxes and problems such belief cause and even though singularities and infinities do not even arise if is instead we worked from an assumption of space discreteness.

The existence of discrete unit of distance and discrete unit of space implies that all quantities are discrete. We already showed that there are no infinities in mathematics. There are no fractional lengths, surfaces, or volumes if space is fundamentally discrete.

A mathematical operation such as division of a length is therefore a division of an integer number of discrete units. That the length expressed in discrete units is not divisible by a certain number then simply means that the operation will produce quotient and remainder, but never a non integer result.

If the measurement is expressed in anything other than discrete units, then whatever conventional measuring unit is used in physics, we must always keep in mind when doing any sort of calculation that it corresponds to an integer number of fundamental discrete units.

There are no zeros in nature.

The number zero is one of the greatest inventions of mathematics. It would be very difficult to do any calculation without it. But zero is not like other numbers that we use to express quantities. Rather, by itself, it is a symbol to express the absence of quantity. Things physical exist, absent things do not. They are not physical. They can't be measured, weighed, or interacted with. They don't exist.

Used in conjunction with other numerical symbols, zeros are place holders allowing us to assign orders or magnitude to numbers. When we writ the number 10, or 100, or 1010, the zero are

³² See [Struggles with the Continuum](#) by John C. Baez arXiv 1609.01421

place holder that conventionally allows us to express the order of magnitude of the non-zero digits. Use in such ways, the resulting value of the number is always non-zero.

We may also argue that the non-existence of infinities and non-existence of zero in nature make division by zero inconsistent with the laws of physics and by extension, mathematically inconsistent since it also implies an infinity, that is, an infinite number of possible answers.

In discrete space, the distance between any two objects can never be zero because no objects can be separated by a distance smaller than the fundamental unit of distance, hence gravity between any objects cannot become infinite, neither can there be objects of infinite density or any other kind of singularities.

The limit at which the result of a calculation becomes unphysical is when they are numerically smaller than the fundamental discrete unit of distance, or the fundamental unit of matter or momentum, both of which are direct consequences of space discreteness.

Can Continuous Mathematics be used to describe Discrete Physics?

The *theorem on the emergence of Euclidean space from quantum-geometrical space* says:

If d and d_{Eu} are respectively the quantum-geometrical distance and the Euclidean distance two preons⁽⁻⁾, then $\lim_{d \rightarrow \infty} d - d_{Eu} = 0$.

That is, non-fundamental scales, dynamics systems would appear as though as they evolve in continuous space.

Continuous mathematics can thus be used but with we must caution that measurements and calculations result in approximations of the evolution of dynamic systems in discrete space. The accuracy of the calculations, or its resolution, depends on the scale of the measurement units relative to the fundamental scale.

Also, discreteness of space precludes infinities so that any calculations that results in infinities is unphysical and an indication that the resolution used reached the limit of its applicability.