Gravity from a Minimal Axiom Set Capable of Describing Dynamic Systems

by

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Abstract

We did not anticipate finding gravity from a *minimal axiom set capable of describing dynamic systems*. The axiom set we chose to study and which we introduce in this essay assumes that space is discrete, assumes the existence of single fundamental particle and only two fundamental forces; one repulsive and the other attractive. It is only after deriving Newton's law of gravity from an equation for calculating the combined effects of those forces acting between objects that we realized the equation described gravity. Also, one of the most interesting consequences of the model derived from our axiom set is that anisotropies in the structure of space would have played a major role in the formation of particles and material structures.

Gravity from a Minimal Axiom Set Capable of Describing Dynamic Systems

In order describe dynamic systems we minimally need an axiom set that will describe space, matter and two opposing forces, one attractive and the other repulsive[1]. Because of the novelty of our approach, we will first introduce our minimal axiom set before proceeding to derive an equation for gravity.

Minimal Axiom Set

Implicit to virtually all physics theories is an assumption that space continuum. We will here assume that space, that is what holds matter, is discrete.

Axiom 1: $Preons^{(-)}$ are the fundamental units of space. We will call preonic space, space composed of $preons^{(-)}$.

Axiom 1.a: $Preons^{(-)}$ exist in subspace. Note that matter cannot exist in subspace. Matter exists in $preons^{(-)}$ which exists in subspace.

Axiom 2: $Preons^{(-)}$ interact with each other through a fundamental repulsive force we will call *n-gravity*.

Discreteness of space implies discreteness of matter hence,

Axiom 3: There is only one fundamental particle, the $preon^{(+)}$. [2] $Preons^{(+)}$ interact with each other through an attractive force we call *p-gravity*.

Axiom 4: $Preons^{(+)}$ are strictly kinetic particles that move by leaping from $preon^{(-)}$ to $preon^{(-)}$. The momentum of the $preon^{(+)}$ is the fundamental unit momentum.

We will refer to the fundamental momentum as $\vec{c}$. The momentum being fundamental, it is constant.

Definitions and Derivations

Mass: All particles, even those particles currently considered fundamental, are composed of $preons^{(+)}$. The $preon^{(+)}$ is to be understood as the fundamental unit of mass. Therefore, m_a, the mass of an object a is the number of $preons^{(+)}$ it contains.

[1] After discovering that the combined effect of the two forces described gravity, we named the repulsive and attractive forces *n-gravity* and *p-gravity*.

[2] In particle physics, preons are point particles, conceived of as subcomponents of quarks and leptons. The word was coined by Jogesh Pati and Abdus Salam in 1974 (from Wikipedia).

Momentum: The momentum of an object a is $\vec{P}_a = \left\| \sum_{i=1}^{m_a} \vec{c}_i \right\|$.

Energy: The energy of an object a is $E_a = \sum_{i=1}^{m_a} \|\vec{c}_i\|$ and since the momentum of a $preon^{(+)}$ is a constant and $\|\vec{c}_i\| = c$ then $E_a = \sum_{i=1}^{m_a} \|\vec{c}_i\| = m_a c$. [3]

Velocity: The velocity of an object a is $\vec{v}_a = \frac{\vec{P}_a}{m_a}$.

Acceleration: $\Delta\vec{v}_a = \frac{\Delta\vec{P}_a}{m_a}$. For gravitational acceleration, we will show that $\Delta\vec{P}_a = \Delta\vec{G}$, where $\Delta\vec{G}_a$ is the variation of gravity acting on a so that $\Delta\vec{v}_a = \frac{\Delta\vec{G}}{m_a}$.

Preonic distance: The distance between two units of space ($preons^{(-)}$) is equal to the number of $preons^{(-)}$ between them or number of leaps a $preon^{(+)}$ must take to move from between the two.

Geometrical distance: The geometrical distance between two $preons^{(-)}$ is the distance between their positions in substance. Distance here follows the conventional definition of distance for Euclidean space.

Preonic density: ρ_R , the preonic density of a geometrical region R is the ratio of it preonic volume (the number of $preons^{(-)}$ it contains) over its geometrical volume. $\rho_R^{(-)} = \frac{Vol_R}{geo\_Vol_R}$

Two sets of objects a, b and a' , b' maybe be separated by the same geometrical distance L yet may be at very different preonic distance depending on the preonic density of between the elements of each set.

Preonic region: A region is a defined a set of path-connected $preons^{(-)}$.

Preonic volume of a region: Vol_R , the volume of a region, is the number of $preons^{(-)}$ that form that region.

From the above definitions we understand that, within preonic space, points, lines or surfaces all have volumes which consist of a finite number of $preons^{(-)}$ and that their geometrical descriptions requires exactly three geometrical dimensions.

[3] The relation between mass and energy is one of proportionality, not one of equivalence.

Preonic field density: The ratio of the number of $preons^{(+)}$ in a region, its mass, over the preonic volume of that region or $\rho_R^{(+)} = \frac{m_R}{Vol_R}$.

Note: Since preonic space is composed of discrete units of space, all regions are volumes with the smallest possible volume being a single $preon^{(-)}$. *This implies that lines or surfaces are to be treated as volumes as well. The notion of dimensions does not apply to preonic space.*

Fundamental unit of n-gravity: $\vec{g}^{\,-}$, the fundamental unit vector of n-gravity, is the interaction between two $preons^{(-)}$.

Fundamental unit of p-gravity: The fundamental unit of p-gravity is the interaction between two $preons^{(+)}$ and is denoted by the vector $\vec{g}^{\,+}$.

Gravity from a Minimal Axiom Set

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

It is interesting here to note that by expanding any of these equations as shown below in (3) we obtain the *weak equivalence principle*. The weak equivalence principle follows naturally from our minimal axiom set; hence we may consider promoting it from principle to law[i].

$$\Delta\vec{G}^-(a;b) = m_a m_b\left(\frac{d_1^2+d_1}{2}-\frac{d_0^2+d_0}{2}\right)\vec{u}_1 - m_a m_b\left(\frac{d_1^2+d_1}{2}-\frac{d_0^2+d_0}{2}\right)\vec{u}_0 \quad \textbf{(1)}$$

And for $\hat{u}_0 = \hat{u}_1 = \hat{u}$ we can reduce (1) to

$$\Delta\vec{G}^-(a;b) = (m_a m_b d)\vec{u} \quad \textbf{(2)}$$

and

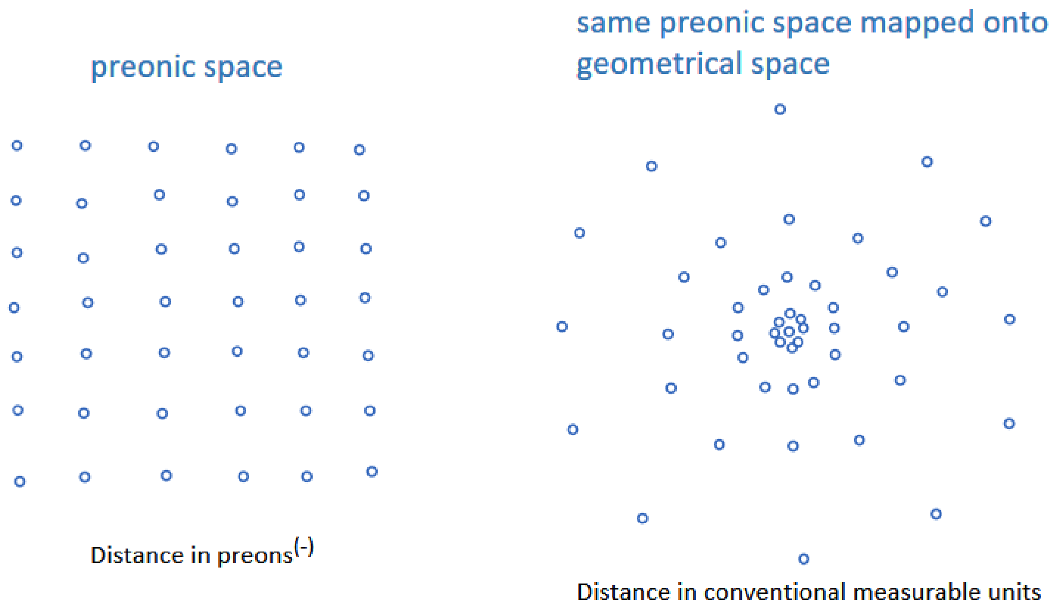
$$\Delta\vec{v}_b = \frac{\Delta\vec{G}^-(a;b)}{m_b} = (m_a d)\vec{u} \quad \textbf{(3)}$$

Derivation of Newton's Law of Gravity

In order 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. Therefore, since Newton's law of gravity describes gravity in geometrical space, we must map preonic space, which is a regular grid, onto geometrical space.

Equation (1) describes the gravitation interactions between materials objects and with space. Material objects are themselves composed of $preons^{(+/-)}$, which are transitory states in which $preons^{(+)}$ occupy $preons^{(-)}$. In that transitory state, the p-gravity interactions between $preons^{(+/-)}$ overcomes n-gravity by a factor of k. It seems reasonable to assume that during these transitory states, p-gravity would bring $preons^{(+/-)}$ closer in subspace the way n-gravity keeps $preons^{(-)}$ apart. It follows that matter would tend to condensate which would indirectly increase the preonic density of the region it occupies, itself furthering condensation of matter.

The equation $\vec{G}(a;b)=\left(m_a m_b k - m_a m_b \frac{d^2+d}{2}\right)\hat{u}$ tells us that the gravitational effect, hence the geometrical distance between $preons^{(-)}$ will decrease proportionally to square of the preonic distance, hence the preonic density will follows the inverse square law.



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

Taking preonic density into account, we find that $d \propto dens_{preons^{(-)}} \propto \frac{1}{r^2}$ where d is the preonic distance and r is the geometrical distance from the center of a massive structure. Substituting in equation (2) we get

$$\Delta\vec{G}^{-}(a;b) \propto m_a m_b \frac{1}{r^2}\hat{u} \quad \textbf{(4)}$$

which is Newton's law of gravity expressed in natural discrete units of mass.

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; regions with higher preonic density being able to contain more $preons^{(+)}$ per geometrical volume than region with lower preonic density.

The Dark Energy Effect

For distances shorter than the threshold distance d_Λ, where $k = \frac{d_\Lambda^2 + d_\Lambda}{2}$, the p-gravity component of $\vec{G}(a;b) = \left(m_a m_b k - m_a m_b \frac{d^2 + d}{2} \right) \hat{u}$ dominates and gravity is attractive while for distances beyond the threshold $d > d_\Lambda$ it is the n-gravity component of gravity that is dominant and gravity become repulsive. Therefore, the gravity equation we derived from our minimal axiom set accounts for the cosmological expansion of the universe without having to introduce an exotic new form of energy.[4]

This allows us to deduce the following unique prediction that the acceleration between two cosmic objects will be not only a function of distance, but proportional to the products of their masses.

The Dark Matter Effect

Observations suggest the existence of matter that appears to only interact gravitationally over large distances.

Our minimal axiom set requires that all particles, even those we consider elementary, be made of $preons^{(+)}$. This implies that in its initial state, the Universe contained nothing but $preons^{(+)}$ uniformly distributed throughout preonic space. It follows that the least massive particles were first formed, which would be the lower momentum photons, which collectively became the cosmic microwave background (CMBR). The isotropy of the CMBR is consistent with an initial isotropic state we predict existed. Later, more massive photons and progressively more massive particles would form through the mechanism consistent with our minimal axiom set (which we will describe elsewhere).

The observation of dark matter effects suggests that most $preons^{(+)}$ are still unbounded and concentrated into dark matter halos. What is interesting about dark matter halo being composed of $preons^{(+)}$ is that a minimal dark (critical) matter density is required for visible matter to form. That means that the rate of production of visible matter increases with density which in turn prevents the formation of a dark matter cusp near the center of galaxies. The increased rate of production of visible matter keeping the density in check at a level at or below the critical density explains the absence of dark halo cusp that cold dark matter models predict.

Testing the Preonic Model of Space

A model needs not only describe and explain current and past observations, it must also allow for predictions unique to the model.

[4] Some observations suggests that $d_\Lambda \cong 10Mpc$

The most obvious predictions that we can derive here is that the observed speed of light in vacuum, its geometrical speed, depends on the preonic density of the space it travels in. That is: $c_{pd_1} = \frac{pd_0}{pd_1} c_{pd_0}$, where c_{pd_0} and c_{pd_1} are respectively the geometrical speeds of light in regions with preonic density pd_0 and pd_1 .

Thus, if the preonic model is correct, space in proximity of massive structures would have a refractive index which would in part be responsible for the lensing of light; adding to the gravitational lensing of light.

Also, though the preonic speed of light remains constant[5], the geometrical speed of light would be slower when moving through regions with higher preonic density than in regions with lower preonic density.

Observations confirming these predictions would support the preonic model of photons.

Conclusions and Consequences

We have shown that gravity can indeed be derived from a minimal axiom set capable of describing dynamic systems. We would like to mention that in addition to Newton's law of gravity, it is also possible to derive the seminal predictions of special relativity and general relativity[ii], the laws of optics[iii], the laws governing electromagnetic interactions[iv], and special relativity's constancy of the speed of light postulate (which makes it a theorem derived from our axiom set).

Our hope is that what we have shown will motivate the development of the preonic model.

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[i] QGD and the Equivalence Principle
[ii] Special and General Relativity Axiomatic Derivations.
[iii] Preonics, the Foundation of Optics
[iv] Electromagnetic Repulsion and Attraction

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[5] The trajectories of the component $preons^{(+)}$ of a photon are parallel so we have

$$v_\gamma = \frac{\left\| \sum_{i=1}^{m_\gamma} \vec{c}_i \right\|}{m_\gamma} = \frac{\sum_{i=1}^{m_\gamma} \left\| \vec{c}_i \right\|}{m_\gamma} = \frac{m_\gamma c}{m_\gamma} = c$$