Particles Of Space-Time a Brief 'Experimental' Approach

Carlton Frederick*

Central Research Group

Nicholas Taylor

Central Research Group†

Abstract

Some theoretical physics models take space-time to be discontinuous. We concur. Further, we suggest that all of space-time consists of real, charged, Planck-scale, particles that move in an imaginary manifold under the influence of a force acting between those particles. We propose such a force, an amalgam of the strong and electro-weak forces. In addition, the gravitational force and the force between charged particles is included. We then drop a large number of the particles into the manifold and observe their motions. The motions can be observed in 3D on a website. This lets us explore various quantum mechanical phenomena.

*Electronic address: `relativity@duck.com`; URL: `http:www.darkzoo.net`

†Electronic address: `nicholas.h.taylor@gmail.com`

Brief Introduction

In the literature, one can find approaches to, and models of, space-time that is non-continuous at the scale of the Planck time and length. Examples are: 'Loop Quantum Gravity'[1], 'Granular Stochastic Space-time'[2, 3], 'Lattice Space-time'[4, 5], 'String Theory'[6], and 'Particles Of Space-Time'. These theories address physics at the Planck scale: The Planck length is about $1.6 * 10^{-35}$meters and the Planck time is about $5.4 * 10^{-44}$seconds. For comparison the diameter of a proton is approximately $1.7 * 10^{-15}$meters, and it would take light around $3.3 * 10^{-26}$seconds to traverse that diameter. These models attempt to integrate gravity into quantum mechanics.[6].

The 'Particles Of Space-Time' Model

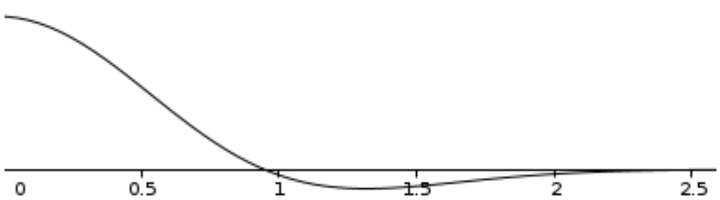
The POST model considers space-time to be made up of Planck scale sized chunks (topologically four dimensional tesseracts). These chunks (which we call 'venues' to distinguish them from point-like 'events') are real and are embedded in an imaginary manifold. But the venues are four-dimensional so we need four orthogonal components. This suggests quaternions. (Quaternions: independent orthogonal imaginary numbers i, j, k. $i^2 = j^2 = k^2 = -1$. i*j=k, j*i=-k, j*k=i, k*j=-i, k*i=j, i*k=-j, i*j*k=-1.) Note: Viktor Ariel[7] has considered quaternions as a basis for a coordinate system. Our four coordinates then, are the real line (representing time) and the three imaginaries, i, j, and k (representing the the three spacial coordinates).

The manifold contains only venues and forces. The venues in the manifold move freely under the influence of forces between venues. We call this manifold 'i-space'.

There are two kinds of venues in the manifold: venues (mostly) devoid of mass (the overwhelming majority of venues as space-time is mostly vacuum), and venues containing mass (that which stuff is made of). But because of zero point energy (quantum field theory requires that every point in space-time has zero point energy) the venues in empty space have a tiny amount of mass (an element of mass). As the venues can move freely, the cumulative gravitational mass of the vacuum venues would collapse space-time. To avoid this we postulate that the empty space venues have inertial mass but not gravitational mass. This, of course, violates the equivalence principle. However, recent theoretical and experimental work[8, 9] has shown that at the quantum level, gravitational and inertial mass can be very different. The venues with mass though, have both gravitational and inertial mass, consistent with the equivalence principle.

The force in the i-space manifold, an amalgam of the strong and electroweak, is at short inter-venue distances strongly repulsive. This is to keep venues from sticking together. As the distance increases the force becomes less repulsive and then attractive (to prevent venues from moving out into nothingness). Then as the distance increases further, the force asymptotically decreases to zero. The POST equation for the force, the universal force, has the following graph.

The force is repulsive above the horizontal line, below it is attractive.



The POST force equation was devised to generate the above graph. The equation for the force between two particles is taken as, $f(d) = e^{-(-0.8d+0.4)^2*2.2} * (e^{-0.8d+0.4} - 0.7)$ where d is the distance between the particles. (Of course the graph is not unique, but we need a graph for the following animations.)

One would like the venues and forces in the manifold to elucidate much of modern physics. But to do this we must include electric charge.

Charge

There is no charge without mass. So it seemed natural to include an element of charge with the mass elements. Charges interacting with other charges have energy, and thus equivalently, mass.

The electrostatic potential energy U_p stored in a system of N charges $q_1, q_2, ..., q_N$at positions $r_1, r_2, ..., r_N$ respectively, is:

$U_p = \frac{1}{4\pi e_0} \sum_{j=1, j\neq i}^{N} \frac{q_j}{r_{ij}}$, where $r_{ij}$is the distance between $q_i$and q_j. This is for a unit charge.

For a charge element, of course, the value is far, far less. U_p is energy which is equivalent to mass. And this says that the zero point energy (mass) has an ongoing uncertainty caused by the motion of the venues.

The Dynamic Animations

The animations are deterministic. Although Quantum mechanics is presumed to have a stochastic element, we take it to be not stochastic, but chaotic. This is indeed deterministic but due to the sensitivity to initial conditions there is little if any practical difference between stochastic and chaotic. (The POST model is intended to be a precursor to the previously published 'Stochastic Space-time and Quantum Theory' paper[2]. That paper is now being rewritten as 'Chaotic Space-time and Quantum Theory'. The follow-up paper[3] is also being rewritten.)

In the simulations, we first randomly place particles in the i-space and let them move under the influence of the POST universal force as well as the gravitation, charg, and magnetic forces. (This is the 'Experimental' approach to doing theoretical physics.)

We then generate a dynamic 3D animation of the motions. The animation is in stereographic (left eye and right eye) images.

The red venues represent venues with mass, and the mass is both gravitational and equivalently inertial (via the equivalence principle). The blue venues represent empty space-time venues containing very small amounts of only inertial mass. Note that the red venues do not gravitationally attract the blue venues. Although the gravitational force is many orders of magnitude weaker than the universal force, it is always attractive so, eventually, as the number of red venues increases, the gravitational force would predominate.

In this model, the venues are taken as points. But we postulate that at the sub-quantum level there is a minimum possible volume, so a cluster of red venues cannot collapse to a point.

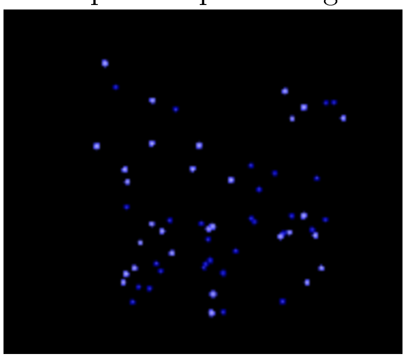
Both red and blue venues have elements of charge.

The implementation of the above is as follows:

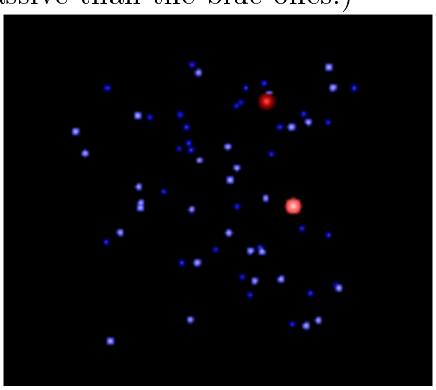
For the blue venues, initially a number of venues are placed in the i-space with random positions and zero velocities. At every frame of the simulation, the distances of each venue to each of the others is calculated. And then the total universal force is calculated for each venue. The red venue implementation is the same but with the addition of the Newtonian gravitational force to the universal force. The electrical force (due to charge) and magnetic force between venues is also in effect.

Although the full-motion animations are on a dedicated URL (accessible by going to the URL below), we'll show a few stills from those animations (but not in stereo):

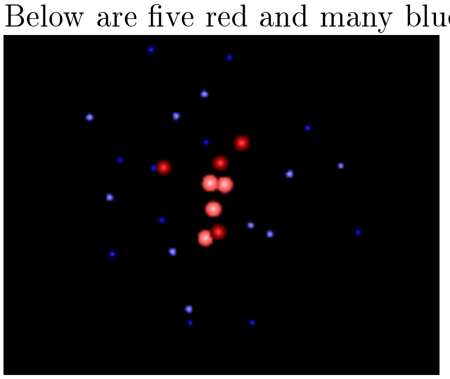
Below is a cluster of blue venues (and no red ones). Over time, (without the stabilizing influence of the red venues) the venues will drift away from each other. (The dark blue venues represent plus charge elements, the light blue represent minus.)



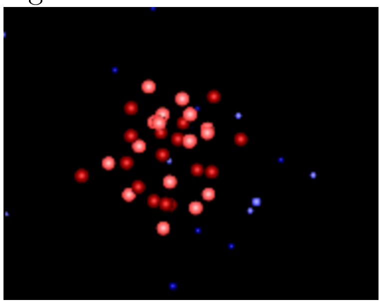
Below is a pair of red venues (one plus charge element, one minus) and many blue venues. Notice how the blue venues cluster around the red one. (The red venues are much more massive than the blue ones.)



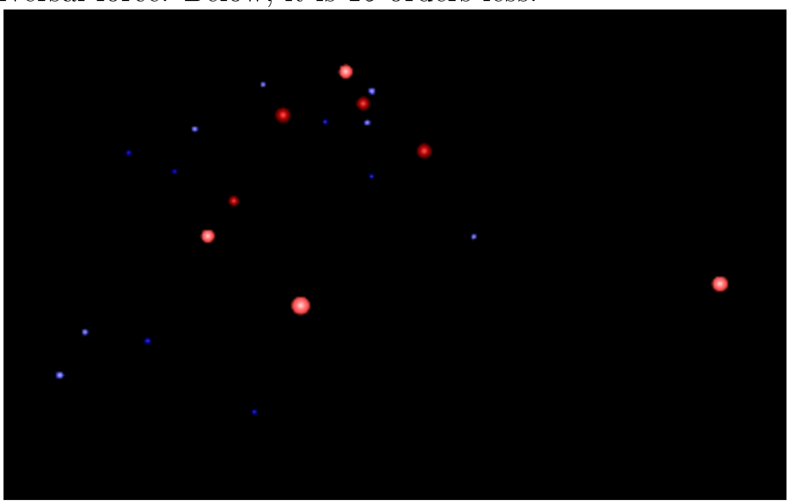
Below are five red and many blue. Notice how the reds cluster together.



In the frame below we see that as the number of red venues increase, they tend to increasingly clump together. This is to be expected as the red venues collectively represent 'things'.



In the above images, the gravitational force was 3 orders of magnitude less than the universal force. Below, it is 15 orders less.



Again, the above images can be better appreciated by viewing them in 3D.

For example:,

Left eye Right eye

To go to a to a dedicated URL for the dynamic simulation, *point your browser to www.darkzoo.net. Then click on POST. Then click on Simulator. (You could also click on PDF to see this paper as a Pdf.)*

In the simulation:

Key **o** to toggle this menu (on/off),

s to toggle Stereo (Left eye, full screen)/Both eyes, split screen),

spacebar to pause/unpause the animation,

r to set motions to zero, **R** to reset simulation to its initial state,

i to toggle inertia,

up arrow/**down** arrow to move the camera in/out,

+/- to increase/decrease number of subframes per time interval,

Key **f** to turn off, **F** to turn on the universal force,

c to turn off, **C** to turn on the electric force,

b to turn off, **B** to turn on the magnetic field,

u to decrease, **U** to increase the universal force by a factor of 5,

g to decrease, **G** to increase the gravitational force by a factor of 5,

e to decrease, **E** to increase the electric force by a factor of 5,

Key **w** to decrease, **W** to increase the mass of the blue venues times 2,

q to decrease, **Q** to increase the number of blue venues,

m to decrease, **M** to increase the mass of the red venues by a factor of 5,

n to decrease, **N** to increase the number of red venues.

In the above, the plus charges (with inertial mass) are represented as light red, and the negative charges (with inertial mass) are represented as dark red. The plus charges (with no inertial mass) are represented as light blue, and the minus charges (with no inertial mass) as dark blue.

Summary

We assume that at the Planck scale, space-time is not continuous. That is to say that space-time exists in discrete chunks (which we call 'venues'). If discrete is to have meaning, those venues are not contiguous and are not in a fixed position relative to other venues. This implies that venues move in the the space-time manifold. That manifold contains venues (all venues contain charge elements) and also a 'universal' force (an amalgam of the strong and electroweak force) that acts between all venues. The manifold also contains the Newtonian gravitational force and also the magnetic force.

Space is mainly empty (and mass-free). But because of zero-point energy, these 'empty' venues contain a trace of mass. The cumulative gravitational mass of all the empty space venues would then collapse the space-time. To avoid this we postulate that the empty space venues have inertial mass but not gravitational mass. (All venues also are posited to have an element of charge.) For venues with actual mass (the red venues in the simulation), in addition to the 'universal' force acting between all the venues, the gravitational force also acts, but only between the red venues.

In the simulation, we randomly drop a number of red and blue venues into the manifold and observe how the venues then move under the influence of the forces. One can change the mass and number of venues and also the relative strength of the universal versus the gravitational force (and also the charge and magnetic forces) using the above keys.

It would be good if all of quantum mechanics could be inferred from particles and fields in the manifold. Another variable in the manifold is the diameter of the particles. But in the current simulations, the diameters play no part so they are not included in the interactive quantities.

To connect with conventional physics, one should consider that there is an implicit (optimal) mapping from quaternian coordinates to space-time as we know it. As Paoli Zizzi[10] and Brian Greene[11] suggest, entanglement might connect discrete space-time, Planck scale objects. And that, we feel, could define such a mapping.

We hope that subsequent (and revised previous) papers can use the venue dynamics to illuminate some quantum phenomena.

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