Time Standards and Particle Interactions in a Fractal Universe, with Remarks on Gravity*

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A fractal particle is a three-dimensional, standing-wave pattern. This paper examines how fractal particles can become shorter in wavelength — and vibrate faster — with the passage of time. 'Absolute' time is defined independently of particles, and hence is unchanging. 'Relative' time is based on the period of oscillation of fractal particles; it changes relative to the age of a fractal universe. In this paper, a simple, elegant equation is derived to correlate these two time standards, and calculate the age of our universe. I show here how particle interactions are possible: the standing wave around a source particle interacts with the maximum energy density at the core of a test particle, resulting in a redirection of energy, *i.e.*, a force. For a test particle starting at rest, this electrostatic force increases the kinetic energy of the test particle. Repulsion between like-particles and attraction between unalike-particles is explained by the cylindrical or spherical symmetries of fractal particles. Gravitational attraction occurs because, as particle wavelengths become shorter with time, a portion of the energy stored around the test particle gradually is released in a way that causes an attractive force.

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1. Introduction

The fractal cosmos concerns a natural way of describing the physical universe as a 3D object in Euclidean space and absolute Newtonian time. The admission of multiple universes into physics [1] makes it easier to consider the radical idea of the fractal cosmos, but the fractal cosmos under discussion here has little in common with multiverses based on quantum field theory [2] or general relativity [3]. Better described as a Galilean multiverse [4], this fractal cosmos is composed of fractal particles and fractal universes.

Fractal particles are three-dimensional (3D) standing waves (SW's), which reach a maximum energy density in the innermost core region. In our universe, the stratum particles have a radius r_0 equal to about 10^{-15} meters, corresponding approximately to the effective radius of a proton. In the universe immediately beyond our own, stratum particles have a radius r_i equal to about 10^{-30} meters.

A fractal universe consists of a solid substrate of higher-ranked (smaller) substrate particles upon which lower-ranked (larger) stratum particles are superimposed. Our own universe serves as a good example of a fractal universe. It is a zero-order fractal universe with a radius R_0 of about 10^{26} meters. The universe immediately beyond our own is a first-order fractal universe with a radius R_1 of perhaps 10^{70} meters.

The *size ratio* of any universe at any moment is characterized by the radius of that universe divided by the effective radius of its stratum particles. The *fractal cosmos* is an integrated object in which larger, higher-order universes contain smaller, higher-order particles; hence the size ratio increases exponentially with the order of the universe. These fundamental principles of the fractal cosmos are thoroughly described elsewhere [4-6].

2. Time Standards

A fractal universe has an unchanging measure of time that is independent of the behavior of particles. Meanwhile, the particles have built-in clocks oscillating at a frequency dependent on the age of our universe.

These two time-standards can be referred to as absolute and relative times, corresponding to universe and particle times, respectively. These time standards have nothing to do with the application of Lorentz transformations to moving particles [7]. Absolute time was briefly mentioned in the latter paper, in the context of mechanics in the fractal cosmos. Now its significance can be more fully explained.

Absolute time is measured in terms of the radius of the universe and the speed of light. The absolute unit of time T_0 is defined as the time for a light signal to traverse the radius of our universe.

$$C_y = \frac{\text{one light year}}{\text{year}} = 1 \text{ LY/yr} = \text{the speed of light}$$

$$R_0 \approx 13.7 \text{ billion light years} = \text{the radius of our universe}$$

$$T_0 = 1 \text{ absolute time unit} = 1 \text{ a.t.u.} =$$

$$\frac{R_0}{C_y} \approx \frac{13.7 \text{ billion LY}}{1 \text{ LY/yr}} = 13.7 \text{ billion yr}$$

$$1 \text{ a.t.u.} = 13.7 \text{ billion yr} \left(\frac{31.5 \text{ million sec}}{1 \text{ yr}} \right) = 4.32 \times 10^{17} \text{ sec}$$

Any period of absolute time can be expressed as a fraction or a multiple of the absolute time unit T_0, *e.g.*, $T_0/10$, $T_0/2$, $10T_0$ or $100T_0$.

Seconds are measured by atomic clocks, which in turn are based on the behavior of particles in present time. A more basic unit of relative time can be defined as the period of oscillation of

a fractal particle. It is equal to the wavelength of a fractal particle divided by the speed of light.

$t_0 = 4r_0 / c = 1$ oscillation = 1 relative time unit (r.t.u.)

As an appoximation, $4r_0 \approx 4\ (6.6\times10^{-16}\ \text{m}) \approx 2.64\ \times10^{-15}$

$$t_0 = 1\ \text{r.t.u.} \approx \frac{2.64\times10^{-15}\ \text{m}}{2.99\times10^{-8}\ \text{m/s}} = 8.80\times10^{-24}\ \text{sec}$$

$$\frac{T_0}{t_0} = \frac{1\ \text{a.t.u.}}{1\ \text{r.t.u.}} \approx \frac{4.32\times10^{17}\ \text{sec}}{8.80\times10^{-24}\ \text{sec}} \approx \frac{10^{41}}{2}$$

$1\ \text{a.t.u.} \approx 5\times10^{40}$ r.t.u.

Hence, the unit of absolute time is readily expressed in terms of the present-time units of relative time; however, as absolute time elapses, i.e., as the universe ages, the number of oscillations of a fractal particle per absolute time unit increases. In other words, the relative time unit depends on the particle frequency, which changes with the age of the universe. The next step is to show how fractal-particle frequency changes with time.

3. Evolution of Fractal Particles

In previous papers [4, 6], the energy E_n in the core of a nucleon was related to the initial energy E_0 contained in a fractal universe and the number of particles.

$E_0 =$ available reversible energy in the fractal universe

$E_n = \left(r_0 / R_0\right)^3 E_0 =$ energy in one nucleon core

$E_f =$ energy in one fractal particle, including the core and all the wave shells

$$E_f = E_n\left(R_0 / r_0\right) = \left(r_0 / R_0\right)^2 E_0$$

$N = E_0 / E_f =$ number of particles in the universe

$$N = \left(R_0 / r_0\right)^2$$

$E_t = NE_n =$ sum of energy in the cores of all the particles

$$E_t = \left(R_0 / r_0\right)^2 E_n = \left(R_0 / r_0\right)^2 \left(r_0 / R_0\right)^3 E_0 = \left(r_0 / R_0\right) E_0$$

$$E_t / E_0 = r_0 / R_0$$

This energy E_t depends on the size and number of particles. It also depends on how much energy appears as cosmic microwave background radiation. It can be speculated (and possibly proved) that the energy in the cores varies with time. When the standing waves impinge upon the inside surface of the fractal universe, some energy is lost. The exact rate of energy loss depends on the internal reflectance of the surface of the fractal universe but approximate equations can be derived. Here it is assumed that none of the energy impinging on the inside surface is reflected back into the existing particles.

It is helpful to view the standing wave in terms of nodes and wave shells of thickness $2r_0$. The standing wave does not require that all of the energy is reflected back into the wave but only that each wave shell is balanced by its neighboring wave shells. Despite the loss of energy from the outermost wave shell, the standing wave remains stable because any given wave shell is only affected by the two adjacent wave shells.

If the maximum energy loss at the surface is evenly divided among all wave shells (each of wavelength $4r_0$, including the cores) then the loss from the cores can be related to the "number of waves" (dn) that impinge on the surface during the time dt as follows

$$dE_t = -E_t\left(4r_0 / R_0\right)dn$$

$$dn = \left(\frac{\text{length of wave pattern hitting surface in time } dt}{\text{one wavelength}}\right)$$

$$= \left(C_y dt / 4r_0\right)$$

$$dE_t = -E_t\left(4r_0/R_0\right)\ C_y dt / 4r_0$$

$$dE_t = -E_t\left(C_y / R_0\right)dt$$

$C_y / R_0 = 1 / T_0$; hence

$$dE_t = -E_t\left(dt / T_0\right)$$

$$dE_t / E_t = -dt / T_0$$

This differential equation is easily solved, using the initial condition $E_t = E_0$ when $t = 0$.

$$t / T_0 = \ln\left(E_0 / E_t\right)$$

$$\exp\left(t / T_0\right) = E_0 / E_t$$

$$\boxed{E_t = E_0 \exp\ \left(-t / T_0\right)}$$

As previously shown, $E_t / E_0 = r_0 / R_0$, so another important set of relationships is

$$\exp\left(-t / T_0\right) = r_0 / R_0$$

$R_0 = cT_0$ and $r_0 = ct_0$, so $R_0 / r_0 = T_0 / t_0$ and hence

$$\exp\left(-t / T_0\right) = t_0 / T_0$$

Using the boxed equation above,

$$E_t = E_0 \exp\ \left(-t / T_0\right)$$

$$dE_t = -E_0 \exp\left(-t / T_0\right)dt / T_0$$

$$dE_t = -E_t \Delta t / T_0$$

Compare the time interval Δt to the distance $R = c\Delta t$ traveled by a wave during that same period of time.

$$\Delta t = R / c$$

$$\mathrm{d}\,E_t = -E_t (R / c) / T_0$$

$$\mathrm{d}\,E_t = -E_t R / R_0$$

Dividing both sides by the number of nucleons in the universe, a similar relation is obtained for a single nucleon:

$$dE_n = -E_n R / R_0$$

The latter relationship will prove useful later in the Section on gravitation.

4. The Age of the Universe

If the present value for r_0 is estimated as the effective radius of a nucleon, then the "absolute age of the universe" T_U can be approximated as follows.

$$T_U = T_0 \ln\left(R_0 / r_0\right)$$
$$T_U \approx T_0 \ln\left(10^{26} / 10^{-15}\right) \approx T_0 \ln\left(10^{41}\right) \approx 94 T_0$$

$T_U =$ 94 × 13.7 billion years ≈ 1.3 trillion years

In other words, the age of the universe is 94 absolute time units. An absolute time unit is equal to the time for a beam of light to travel from the center of the universe to the edge, which is 13.7 billion years as measured by our time standard. T_0 serves as the absolute of time. It is a measure of Newtonian time within any fractal universe.

The effects of these two time standards can be measured and account for such diverse phenomena as cosmic microwave background radiation the Hubble red shift.

The above equations will be essential for understanding the underlying mechanism for gravitational attraction between particles. Before the riddle of gravitational attraction can be unraveled, it is instructive to examine electrostatic particle interactions.

4. About Mechanisms

Fractal mechanics offers intuitive insight into the underlying mechanisms of particle interactions. The physical laws that govern particle interactions are tantamount [8]. Coulomb's Law and the Newton's Law of Universal Gravitation can be expressed in terms of an inverse-distance-squared law, a local potential law or the principle of least action. Each of these different formulations provides its own intuitive and practical advantages, but none define an *underlying mechanism* for particle interactions.

Isaac Newton (1643-1727) began working on a theory of universal gravitation in 1666, while on leave from Cambridge. Newton expressed his sentiments about mechanisms in the *Principia* [9] with his famous statement "*Hypotheses non fingo*," translated as "I feign no hypotheses." Here is Newton's famous "*Hypotheses non fingo*" in context:

> I have not as yet been able to discover the reason for these properties of gravity from phenomena, and I do not feign hypotheses. For whatever is not deduced from the phenomena must be called a hypothesis; and hypotheses, whether metaphysical or physical, or based on occult qualities, or mechanical, have no place in experimental philosophy. In this philosophy particular propositions are inferred from the phenomena, and afterwards rendered general by induction.

Despite Newton's humble proclamation, mechanical models for gravity have a rich history. Newton, Huygens and their contemporary Nicolas Fatio de Duillier (1664-1753) contributed to the early development of such models [10]. Georges-Louis Le Sage (1722-1823) further developed the explanation of gravity referred to as "push gravity" and modern versions continue to attract attention [11]. Similarly, as the science of electromagnetism was developed in the 18th and 19th centuries, and countless hypotheses have been advanced about underlying mechanisms.

The search for a mechanical explanation of the particle interactions is revitalized through the following analysis of the structure and behavior of fractal particles.

Source and Test Particles

Typically, to analyze particle interactions, one particle is designated the "source particle" (which produces a field of interaction); and the other is designated the "test particle" (which interacts with the field).

Immediately, the fractal particle model is seen to hold promise for explaining particle interactions. The fields are a consequence of the standing wave pattern that surrounds every fractal particle; and particles interact with the field because the particle core pressure (or energy density) periodically oscillates through a maximum value.

The substrate particles, which are the basis for the standing wave pattern, impose a very important boundary condition on the standing wave pattern: Energy densities more than $2P_0$ are not supported by substrate particles. This maximum pressure in the core of a fractal particle accounts for the reversal of the direction of the incoming wave and hence is the source of the outgoing wave [6]. More important for the present analysis, this same maximum energy density, occurring in the core region of a test particle, accounts for the interaction of the test particle with the fields of other particles.

Positive and Negative Aspects of Charges

The existence of two and only two types of charges is an extraordinary fact in physics. To my knowledge, this oddity has not been satisfactorily explained by any physical mechanism.

Fractal particles could account for the existence of two types of charges by modeling a proton as a spherical standing wave (SSW) and an electron as a cylindrical standing wave (CSW). Thus, these four rules could account for the directions of electrostatic forces:

1) A SSW source particle accumulates energy on the front-side of a test particle (energy accumulates in-between the particles).
2) A CSW source particle accumulates energy on the backside of a test particle (energy accumulates in regions that are not in-between the particles).
3) A SSW test particle moves away from accumulated energy.
4) A CSW test particle moves toward accumulated energy.

A little thought shows that these rules produce mutual repulsion between like particles and mutual attraction between unalike particles, in agreement with electrostatics.

Support for the above rules comes from the geometry of the wave patterns. Energy imbalances are backed-up in the spherical shells of a SSW source particle (rule 1 above) but the ring-like or donut-like (*i.e.*, torus) shells of a CSW source particle easily transfer energy around the core of the test particle (rule 2 above). Reacting to these energy accumulations, a SSW test particle must circulate the excess energy around its core (rule 3 above), but a CSW reacts to the excess energy simply by moving along its axis toward the accumulated energy (rule 4 above).

Although the above explanation is qualitative, a detailed, mathematically rigorous analysis of SSW and CSW patterns could support this hypothesis and allow for comparison with experimental results.

Field-Energy Storage

The initial energy imbalance clearly follows the inverse square law for the distance between particles. The cross-sectional area πr_0^2 of the core of a fractal particle intersects a spherical shell of area $4\pi R^2$.

The stability of the standing wave pattern demands that the maximum value of the integral of pressure with respect to volume — evaluated over any wave shell of thickness $2r_0$ — should be identical for all wave shells. Moreover, for any wave shell, this integral should be equal to the core energy E_n. The initial energy imbalance or excess energy E_{ex} therefore can be approximated as an area ratio times the core energy.

$$E_{ex} = E_n \left(\pi r_0^2 / 4\pi R^2\right)$$

$$E_{ex} = E_n \left(r_0^2 / 4R^2\right)$$

For a SSW test particle, this energy is multiplied by a field-energy storage factor g. This factor is the ratio of the total energy circulating around the shells of a SSW test particle (E_{SSW}) compared to the initial excess energy E_{ex}.

$$E_{ssw} = g\ E_{ex}$$

$$E_{ssw} = gE_n \left(r_0^2 / 4R^2\right)$$

Qualitatively, each oscillation of the test particle redirects more energy from the shell of the source particle until an equilibrium condition is reached. This energy builds up around the test particle, dropping off exponentially with distance from the test particle.

Harry W. Schmitz (HWS) used g as the symbol for the "field energy storage" factor in his calculations [6]. The value of 980 is obtained from the multiplication of several power-series summations. HWS dubbed the result g as a mnemonic: The estimated value of $g =$ 980 brings to mind the value of the acceleration due to gravity at the Earth's surface, *i.e.*, $g = 981$ cm/s^2. Coincidentally, these two varieties of "little-g" are very near to each other numerically; however, the reader should understand that, dimensionally, they are completely different quantities. The "field energy storage" factor is dimensionless, *i.e.*, it is a pure number; meanwhile, the conventional g, which is widely used in the dynamics, has units of acceleration.

The value of g perhaps approximates the interaction of the core of the test particle with the field of a source particle, but there are limitations on its application. For example, the value for g only applies to large R; if R is of the same order as r_0 then the field energy storage is greatly complicated by the close proximity of the source particle. Nonetheless, the proposed value of 980 for this field energy storage factor is a useful first approximation.

Conversion to Kinetic Energy

The total stored energy behaves like a potential energy (Φ).

$$\Phi = E_{ssw}$$

$$\Phi = gE_n \left(r_0^2 / 4R^2\right)$$

Distances R between the particles could also be expressed as multiples of the core radius, *i.e.*, $R = Nr_0$. The wave shells around the core could be numbered $N/2$.

$$R^2 = N^2 r_0^2$$

$$\Phi = 245 \frac{\mathrm{E_n}}{\mathrm{N}^2}$$

This potential energy is a function of the position of the test particle and can be converted into a force, which is also a function of position.

Imagine some of this energy passing through a plane that bisects the test particle normal to a line between the particles. If the test particle is held in static equilibrium by another force, then the stored energy circulates around to the backside of the particle, back through the core region, and finally appears again near the front-side of the particle. As long as the particle is held still, the stored energy continues to re-circulate around the particle in this manner, creating a force equal and opposite to the restraining force.

However, if the restraining force is removed then the test particle begins to accelerate. Some of the potential energy Φ is transformed into kinetic energy K of motion.

$$\Phi + K = gE_n \left(r_0^2 / 4R^2\right) = \text{constant}$$

Differentiating, we find that

$$\frac{d}{dx}\Phi + \frac{d}{dx}K = 0$$

$$\frac{d}{dx}K = -\frac{d}{dx}\Phi$$

$$F = \frac{d}{dx}K$$

It is quite reasonable to assume that the rate at which the potential energy is converted into kinetic energy is proportional to the potential energy, and that the electrical force F_E on the test particle times some distance ΔR is equal to the energy stored in the wave shells of the test particle. ΔR is of the same order as .

$$F_E\ \Delta R = \Phi$$

$$F_E = E_n\ g\left(r^2 / 4R^2 \Delta R\right)$$

Since ΔR is of the same order as r_0.

$$F_E \propto E_n g\left(r_0^2 / 4R^2 r_0\right)$$

$$F_E \propto \frac{1}{4} E_n\ g\ r_0 / R^2$$

As the particle begins moves, the potential energy stored around the test particle is continually replenished, so a continuous force is exerted, although its magnitude depends on the inverse square law. By Newton's second law of motion, if the particle is not constrained, this force accelerates the test particle in proportion to the mass of the test particle:

$$a = F_E / m_n$$
$$a = E_n g r_0^2 / 4 m_n R^2 \Delta R$$

where m_n and a are the mass and acceleration of the test particle, respectively. The mass is related the energy that must be absorbed to change the velocity of the particle. The usual implications for dynamics and mechanics apply here, *i.e.*, as more energy is added to the particle, more and more energy must be circulated to increases the particle velocity, especially near the speed of light.

The electric field is independent of the test particle. The electric field is a somewhat artificial construction that is obtained by normalizing the force with a unit of charge.

$$\mathbf{E} = \mathbf{F}_E / e$$
$$\mathbf{E} = \frac{\mathbf{E}_n \; g \; r_0^2}{4 \; e \; \Delta R} \frac{1}{R^2}$$

Though cursory, the above analysis suggests that fractal particles could account for many fundamental phenomena of electrostatics, including 1) the inverse square law and 2) the existence of two types of charges. Still, there is much unfinished business, including rigorous treatments of a) energy storage and b) the conversion of stored energy into kinetic energy. Nonetheless, the analysis above provides considerable insight into previously vague concepts of charge and mass. It also provides insight into the equivalence of mass and energy.

Accounting for the mechanism behind the force of gravity, however, is of more immediate interest.

Mechanism for Gravity

The force of gravity can be understood in terms of the time-related loss of energy from the wave shells. As derived above, fractal particles are continuously losing energy at the surface of a fractal universe, as a result of a surface ringing effect.

The energy stored around a SSW is given by

$$E_{ssw} = E_n \left(g r_0^2 / 4R^2 \right)$$

The energy in a nucleon core E_n (which is the same as the energy in any nucleon wave shell) changes with time.

$$\Delta E_n = -E_n \Delta T / T_0$$

Likewise, to avoid any energy imbalances, the energy stored around a nucleon attempts to decrease with time.

$$\Delta E_{ssw} = \frac{E_n \; g \; r_0^2}{4R^2} \left(\Delta T / T_0 \right)$$

However, for this energy to be released back into the source particle, it must travel a distance equal to the distance between the source and test particle. Set ΔT equal to the time to travel a distance R at the speed c.

$$\Delta T / T_0 = R / c T_0 = R / R_0$$

Then, the energy trapped in the wave pattern of the test particle is

$$\Delta E_{SSW} = \frac{E_n \; g \; r_0^2}{4R^2} \left(\frac{R}{R_0} \right)$$
$$F_G = \frac{d}{dR} (\Delta E_{SSW})$$
$$F_G = -\frac{E_n \; g \; r_0^2}{4R_0} \left(\frac{1}{R^2} \right)$$

As described in the previous section, with ΔR is of the same order as r_0.

$$F_E \propto \frac{E_n \; g \; r_0}{4} \frac{1}{R^2}$$

Therefore, the force of gravity can be compared with the Coulomb force, *i.e.*, the electrostatic repulsion between nucleons.

$$\frac{F_G}{F_E} \propto \frac{r_0}{R_0} \approx 10^{-41}$$

Of course, the extreme weakness of the force of gravity compared with the electrostatic forces between the same particles is a well-known experimental fact.

The nucleon energy can be related approximately to the nucleon mass by summing kinetic energies for the three directions in space,

$$E_n = \tfrac{3}{2} m_n c^2 .$$

Then the force of gravity as derived above can be compared with Newton's law of gravitation:

$$F_G = -\tfrac{3}{8} m_n c^2 g r_0^2 \big/ R_0 R^2$$
$$F_G = -G m_n m_n \big/ R^2$$
$$\tfrac{3}{8} m_n c^2 r_0^2 \big/ R_0 R^2 = G m_n m_n / R^2$$
$$G = \tfrac{3}{8} c^2 g r_0^2 / m_n R_0$$

The nucleon mass m_n is related to the density of the substrate by the following equation:

$$m_n = A M_E r_0^3$$

where M_E is the unit volume of mass in the substrate.

$$M_E = P_0 / c^2$$

and A is geometric factor close to one [6].

$$A = 16(\pi^2 - 8) / 3\pi^2$$
$$A \approx 1.01$$

Thus,

$$G = \tfrac{3}{8} c^2 g / A M_E r_0 R_0$$

The only quantity that changes with time is r_0. At the time $t = 0$, r_0 was equal to R_0 and the gravitational constant was

$$G_0 = \tfrac{3}{8} c^2 g / A M_E R_0^2$$

This equation allows for relationships to be established between various orders of fractal universes, for parameters such as particle radius and universe radius [6].

Summary and Conclusion

Natural philosophy is distinguished from modern physics, perhaps, by the belief — or hope — that the Universe, in the fullest sense of the word, can be completely understood in terms of a simple, intuitive, physical model. After many decades of frustration and disappointment, mainstream physicists have largely abandoned mechanical models. Today, when professional physicists talk about a final theory, they have in mind a theory that will unite quantum field theory and general relativity. Since neither of these two theories relates to any simple physical model, the expectation is that the final theory would not relate to any simple physical models.

Experimental results are one layer above the physical universe. This reasoning leads many to conclude that, as long as theory matches experiment, the "bottom layer" is superfluous. But it makes just as much sense to say that the physical universe is superfluous! Experiment-based science is quite rational, since experiments are essential for testing hypotheses; however, the scientific method does not forbid physical models of the universe.

The twentieth century was a golden age of experiment. I believe that we are about to enter a new era where advances will be made in the area of physical models. The present paper showed how fractal particles and fractal universes guide the development of new physical models. These models can be created in the abstract without reference to physical constants, or they can be developed with our physical universe constants in mind.

Despite the rocky road of the past, I am excited by the prospect that numerical methods — based on fundamental physical mechanisms — could lead to precise calculations, not only for forces such as electrostatics and gravity but also for close range forces such as the weak interaction and strong nuclear force.

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