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A Stocastic Explination of Newton's Law and Coulombs' Law

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Strictly as per the compliance and regulations of :

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I. Introduction

If one assumes that the information in the Universe is finite, one should conclude that space-time is discrete because not enough information exists to describe a variable or an observable to a continuous value. Haller [1] gives reasons why one would believe that the information in a system with finite energy and finite time is finite.

We must also understand the length scale of the discrete step size of a particle and that of the gravity field before we can make a viable theory. Haller [2] shows that the step size of a particle is equal to one over twice the particle mass and that of the vacuum is one over twice the reduced Planck mass.

With this we can derive an understanding of how gravity and electricity work; how they are similar and how they are different.

Work is still needed to fully integrate this derived stochastic process with relativity, however clues are left which indicates that the probability a particle steps to the left or steps to the right, is a feedback between the particle's state and the curvature of space.

II. Bernoulli Process

Introducing the Bernoulli process as reviewed by Chandrasakhar and Reif [3,4], we see a stochastic process where the result of a sample of a uniform distribution between zero and one is compared against the process parameter β. If the sample is less than β, the particle steps to the right, otherwise it steps to the left.The time between steps is quantized to δt and the length of the steps is also quantized to δx.

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The process can be expanded to 3+1 dimensions but for the purposes here we will forgo relativistic effects of the +1 time dimension and further align the particles on the x axis so we can focus on only the 1 spatial dimension.

a) *Step size of a particle*

Building on analysis by Kubo on the fluctuation dissipation theorem [5], we formalize the 2 time constants for a diffusing free particle: the collision time, δt and the relaxation time, τ . When the relaxation time is equal to the thermal time , $\tau = \hbar/2k_BT$, the diffusion constant becomes, $D = \hbar/2m$, [1,2,5-7] and the spatial variance is $(\Delta x(t))^2 = 2Dt = \hbar t/m$.

To derive the step size, δt , (or the collision time) we can look at the variance. The contribution to the spatial variance is balanced between drift and diffusion; when the probability parameter is ½ the variance is,

$$(\Delta x(K))^2 = \delta x^2 K + (\Delta v_K)^2 (\delta t K)^2$$

Here δx is the spatial step size, K is the number of steps $t = K \cdot \delta t$ is the duration of the process and $(\Delta v_K)^2$ is the variance in velocity after K steps. From Dirac, we know that $\delta x = c \cdot \delta t$ [8] which allows us to calculate $(\Delta v_K)^2$.

When K is large, the average variance of the sum of K samples of a distribution is equal to the variance of the individual sample divided by K [9].

$$(\Delta v_K)^2 = \frac{(\Delta v_1)^2}{K} = \frac{\frac{1}{2}\left(\frac{\delta x}{\delta t}\right)^2 + \frac{1}{2}\left(\frac{-\delta x}{\delta t}\right)^2}{K} = \frac{c^2}{K}$$

Equating $(\Delta x(t))^2$ and $(\Delta x(K))^2$ which $\hbar t/m = 2\delta x^2 K$, results in,

$$\delta t = \frac{\hbar}{2mc^2}$$

Thus when the relaxation time is equal to one over twice the temperature $\tau = \hbar/2k_BT$, the collision time is one over twice the energy $\delta t = \hbar/2mc^2$, and visa versa.

b) *Gravitational scale*

I will not go into the detailed theory of dark particles as a tradeoff of simplicity overdeep insight, yet one can find that analysis here [2].

The gist is that the vacuum is made up of particles with the reduced Planck mass

$$m_p = \sqrt{\frac{\hbar c}{8\pi G}}$$

A number of special conditions arise at this value of mass. One of these is that the quantum step, $\delta x = \hbar/2mc$, is equal to a circle's circumference with the Schwarzschild radius.

$$\ell_p = 2\pi R_S = \frac{4\pi G m_p}{c^2} = \delta x = \frac{\hbar}{2m_p c}$$

c) Electrical scale

The step size, or scale of the electric field, of a particle can be derived with the help of an old idea; namely electromagnetic mass[10,11].

Consider the electromagnetic energy, E_{em}, equal to the mass energy of the particle,

$$mc^2 = E_{em}$$

To find E_{em}, we add the electrostatic energy, E_{es}, to the Poincaré stresses, $E_{ps} = E_{es}/3$, we get the total electromagnetic energy, E_{em} [10], or

$$mc^2 = 4E_{es}/3 = 4E_{ps}$$

We can solve for r_e byusing an ansatz, such that the resulting r_e gives the correct form for Coulomb's Law. Note that appendix A gives further reason why this ansatz is reasonable.

The ansatz is that the Poincaré stresses are equal to the electrostatic energy of a spherical shell of total charge equal to the minimum quantum charge, $q_e/3$.

$$E_{ps} = \frac{(q_e/3)^2}{2(4\pi\varepsilon_0) r_e}$$

Or,

$$r_e = \frac{2{q_e}^2}{9(4\pi\varepsilon_0) mc^2}$$

However the length we are interested in is, ℓ_e, the wavelength that fits around a sphere of this radius, (just like $\ell_p = 2\pi R_S$) thus

$$\ell_e = 2\pi r_e = \frac{{q_e}^2}{9\varepsilon_0 mc^2}$$

III. Force as a Stochastic Process

a) Velocity as a probability

Going back to the Bernoulli process of motion we can see a relationship between the average velocity and the probability parameter, β.

$$\overline{x(K)} = (2\beta - 1)\delta x K$$

Where $\delta x K = c\delta t K = ct$. We know from above the relaxation time is $\tau = \hbar/2k_B T$ and is representative of how long the process stays coherent. In other words, τ is the time over which the particle forgets its state. Thus we can define the moving average velocity as

$$\bar{v} = \frac{\overline{x\left(K = \frac{\tau}{\delta t}\right)}}{\tau} = c(2\beta - 1)$$

Or,

$$\beta = \frac{\overline{x\left(K = \frac{\tau}{\delta t}\right)}}{2c\tau} + \frac{1}{2}$$

Note that the instantaneous velocity is one of the two velocity Eigen values, ±c, however $\bar{v} \in$[-c,c]; which is mathematically nice since $\beta \in [0,1]$.

b) Resistive Force – an aside

In the derivation of dark particles [2], one finds a resistive force for dark particles that we need to briefly consider here as it adjusts our expression for β. The force can be derived a few ways and has the simple expression $F = -mx/\tau^2$. Haller shows that when this force is in play, it contributes to β an amount $\beta = -x/4c\tau + 1/2$ [2].

Thus our expression for β for dark particles becomes,

$$\beta - \frac{1}{2} = \frac{\overline{x\left(K = \frac{\tau}{\delta t}\right)}}{2c\tau} - \frac{\overline{x\left(K = \frac{\tau}{\delta t}\right)}}{4c\tau} = \frac{\overline{x\left(K = \frac{\tau}{\delta t}\right)}}{4c\tau}$$

c) β changing due to a force

With this definition of $\bar{v}$ we can consider how $\bar{v}$ and β (through feedback) are a function of time and thus also a function of space as it moves.

As stated above we will limit ourselves to non-relativistic particles, thus we have the relationship between the force on a particle of mass m_1 and β

$$F = \frac{dp}{dt} = m_1 \frac{d\bar{v}}{dt} = 2cm_1 \frac{d\beta}{dt}$$

d) Stocastic process

Now imagine the force between two particles. For the sake of simplicity (since we assume Newton's third law), we will consider only the force on particle 1 due to interaction with particle 2. Again for simplicity we take particle 1 at the origin and particle 2 on the x axis at R.

Particle 2, like particle 1, follows the Bernoulli process. As such it accelerates between its two velocity Eigen values, ±c. As it accelerates at each step, it radiated energy δt_2. Thus $dt = \Phi\delta t_2$, or

$$dt = \Phi \frac{\hbar}{2m_2 c^2}$$

Where Φ is the probability the emitted radiation from particle 2 is in the direction of particle 1 and captured (and processed).

Since the direction of the radiation wave vector is random and uniformly distributed across solid angle, Φ, is the cross section of particle 1, σ, divided by the surface area of a sphere, A, with a radius equal to the distance between particle 1 and particle 2, R.

$$\Phi = \frac{\sigma}{A} = \frac{\sigma}{4\pi R^2}$$

Putting this together we have,

$$F = \frac{4m_1 m_2 \sigma c^3 d\beta}{4\pi R^2 \hbar}$$

e) Findingd β

Now if particle 1 captures the emitted radiation the effect is to change the probability parameter β, by artificially (outside the Bernoulli process) stepping the particle towards or away from the direction of the radiation a distance ζ.

If particle 1 artificially steps the distance ζ, then the difference in average displacement (to first order in low velocity) between the artificial step and no artificial step is ζ.

$$\overline{x\left(\frac{\tau}{\delta t}\right)}_{extra\ step} - \overline{x\left(\frac{\tau}{\delta t}\right)}_{no\ extra\ step} = \zeta$$

IV. Gravity

Using our result above for the quantization of the gravity scale, we have the artificial step size, ζ, equal to the quantum step size of the dark particle, or

$$\zeta = \ell_p \widehat{\boldsymbol{k}}$$

Where $\widehat{\boldsymbol{k}}$ is in either the positive or negative direction of the vector pointing from particle 1 to particle 2.

Using our expression for β for dark particles from section 3.2, we find

$$d\beta = \frac{\zeta}{4c\tau} = \frac{\ell_p}{4c\tau}\widehat{\boldsymbol{k}}$$

To find the cross section, σ, of dark particles Haller uses a modified Langevin equation that accounts for the resistive force mentioned in section 3.1 [2]. Or,

$$\sigma = (\Delta x)_p^2 = \frac{\hbar^2}{2m_p k_B T}$$

Plugging these in and reducing we have,

$$F = \frac{Gm_1 m_2}{R^2}\widehat{\boldsymbol{k}}$$

We learn through empirical evidence that the artificial step of particle $1, \zeta$, is always in the direction towards particle 2, $\widehat{\boldsymbol{k}} = -\widehat{\boldsymbol{R}}$, thus we derive Newton's Law of Gravity,

$$F = \frac{-Gm_1 m_2}{R^2}\widehat{\boldsymbol{R}}$$

V. Electricity

Using our result above for the quantization of the electric scale, we have the artificial step size, ζ, equal to the circumference, ℓ_e, of a sphere of radius, r_e.

$$\zeta = \ell_e \widehat{\boldsymbol{k}} = \frac{{q_e}^2}{9\varepsilon_0 m_2 c^2}\widehat{\boldsymbol{k}}$$

Using our original expression for β from section 3.1,

$$d\beta = \frac{\zeta}{2c\tau}$$

However this is not the whole picture as we must account for the charge of either particle 1 or particle 2 being a multiple ofthe minimum quantum charge, $q_e/3$. If $|q_2|/(q_e/3)$ is greater than one, then the frequency of interaction, $1/dt$, will go up by this amount since there are more charged particles which are radiating. Thus

$$\frac{1}{dt} \rightarrow \frac{3|q_2|}{q_e}\frac{1}{dt}$$

Also if $|q_1|/(q_e/3)$ is greater than one, then ζ will go up by this amount. It is as if the massive charged particle is a Turing Machine [12] that executes the following computer code:

for i = 1 to $(3|q_1|/q_e)$

$$\beta = \beta + \frac{\zeta}{2c\tau}\widehat{\boldsymbol{k}}$$

The cross section will be similar to σ from section 4, in that σ equals the spatial variance. However in this case the resistive force is not in play, thus $(\Delta x)_{m1}^2$ reduces to the common expression [10].

$$\sigma = (\Delta x)_{m1}^2 = \frac{\hbar^2}{4m_1 k_B T}$$

Plugging these in and reducing we have,

$$F = \frac{|q_1||q_2|}{4\pi\varepsilon_0 R^2}\widehat{\boldsymbol{k}}$$

Again through empirical evidence

$$\widehat{\boldsymbol{k}} = \frac{q_1}{|q_1|}\frac{q_2}{|q_2|}\widehat{\boldsymbol{R}}$$

We thus returnCoulomb's Law,

$$F = \frac{q_1 q_2}{4\pi\varepsilon_0 R^2}\widehat{\boldsymbol{R}}$$

VI. Discussion

Since most experiments require many data points to find the signal of interest, we are in the realm of the weak law of large numbers; which means the mean (or measurements) approaches the expectation (or calculation) of the underlying continuous theory.

However if we look at the individual measurement we might be able to identify tell tale signs of particles being more stochastic in Nature.

Another way to find evidence of this stochastic description of motion and of force is to change the notion of evidence away from the average value to the value of the variance. One example comes in the nuances of an attempt to make this theory conform to special relativity.

Sparing the reader more details, the gist can be found by looking at the quantum step size , δt. If we consider δt proportional to the inverse of the relativistic energy and not the rest mass [13], we have

$$\delta t_\gamma = \frac{\hbar}{2\gamma m_0 c^2}$$

Where

$$\frac{1}{\gamma} = \sqrt{1-\left(\frac{v}{c}\right)^2}$$

Now looking at the variance of the displacement which contracts with relative velocity we have from the continuous solution

$$(\Delta x(t))^2 = \frac{2Dt}{\gamma^2} = 2Dt\left(1-\left(\frac{v}{c}\right)^2\right)$$

From the stochastic solution when $\beta \neq \frac{1}{2}$ we have

$$(\Delta x(K))^2 = 4\beta(1-\beta)(\delta x^2 K + (\Delta v_K)^2(\delta t K^2))$$
$$= 4\beta(1-\beta)2Dt$$

Plugging in our relationship $\bar{v} = c(2\beta - 1)$

$$(\Delta x(K))^2 = 2Dt\left(1-\left(\frac{\bar{v}}{c}\right)^2\right)$$

At first one might claim success and equate $(\Delta x(K))^2$ with $(\Delta x(t))^2$. However at second glance there are two problems wrong with this. First we used, δt not δt_γ. Plugging in for δt_γ

$$(\Delta x(K))^2 = 2Dt\left(1-\left(\frac{v}{c}\right)^2\right)\left(1-\left(\frac{\bar{v}}{c}\right)^2\right)$$

We now have two factors, $\left(1-\left(\frac{\bar{v}}{c}\right)^2\right)$ and $\left(1-\left(\frac{v}{c}\right)^2\right)$.We know the later is related to the contraction of space due to special relativity. However the former has a different origin.

We can see this origin by looking at the second problem, which is that β is the probability the particle steps to the right. A sample of this process will have the particle step to the left or step to the right. This distinction is absolute and does not dependent on reference frame.

The conclusion is that a preferred reference frame exists and $\bar{v} = c(2\beta - 1)$ is the velocity of the particle in the preferred frame. One might find more background on what this preferred frame looks like from Lorenz's ether theory [11].

a) Experiment

I propose two classes of experiments. One class is to measure the variance of diffusion and look for the additional factor of $\left(1-\left(\frac{\bar{v}}{c}\right)^2\right)$. The other class is to determine the direction of a particle's discrete step.

i. *Variance*

Two experiments within this class are to measure the variance of a particle 1) at rest in the laboratory frame, or 2) highly relativistic.

The first will require very high precision. A good guess for the preferred reference frame is that of the cosmic microwave background which moves at $0.001c$ relative to Earth. Thus $\left(1-\left(\frac{\bar{v}}{c}\right)^2\right)\sim 0.999999$ and any experiment would need to be more accurate than this.

Another experiment (which is more complicated to conduct but with a bigger signal) is measuring the variance of displacement of a relativistic particle.

If the theory proposed here is true, a measurement of $(\Delta x(t))^2$ of a relativistic particle will be

$$(\Delta x(t))^2 = 2Dt\left(1-\left(\frac{v}{c}\right)^2\right)\left(1-\left(\frac{\bar{v}}{c}\right)^2\right)$$

At high v one has $\bar{v} \sim v$, or

$$(\Delta x(t))^2 \sim 2Dt\left(1-\left(\frac{v}{c}\right)^2\right)^2$$

As v approaches c this will be a big difference between accepted theories. However Nature is not so easy to give away her secrets; there is also another source of variance from the Fourier diffusion [2], which grows proportional to the square of t.

ii. *Discrete step*

The other class of experiments is to determine if a particle steps to the left or steps to the right and with what probability.

One should start with two particles at rest a distance L apart. One (denoted the laboratory) will have a heavy mass and be on the left; the other (denoted the test particle) will have a mass much much lighter than the laboratory and be to the right. In this case, the laboratory will look like it has a more continuous trajectory and have smaller variance.

After the quantum step of the test particle, δt, the laboratory will drift in the perfered reference frame the amount $\bar{v}\delta t$. The test particle after one step will be displaced from the laboratory either a) $L + c\delta t - \bar{v}\delta t$ or b) $L - c\delta t - \bar{v}\delta t$.

The distinction between a) and b), should be observable at cold temperatures. Note that over many steps the displacement will be

$$\beta(L + c\delta t - \bar{v}\delta t) + (1-\beta)(L - c\delta t - \bar{v}\delta t)$$
$$= L + c(2\beta - 1)\delta t - \bar{v}\delta t = L$$

The trick will be to measure the individual step not the average. If K_x is the number of times out of K that the particle steps to the right, then the unbiased estimator of β_x is K_x/K.

V. Acknowledgements

JLH is grateful to his wife and two boys.

Appendix A

Poincaré stresses are also known as rubber bands that hold the electron together [10]. They might be just that.

If we look at the electrostatic energy of an elementary unit of charge, E_{es}

$$E_{es} = \frac{{q_e}^2}{2(4\pi\varepsilon_0)r_{es}}$$

And consider the relationship in section 2.4,

$$mc^2 = 4E_{es}/3 = 4E_{ps}$$

One can see that $r_{es} = 3r_e$. If $2\pi r_e$ is the length of a wave that fits the boundary conditions around a quantum of charge $q_e/3$, then three wavelengths places end to end would fit the boundary condition around an electron or elementary unit of charge.

I interpret this as saying that three quantum charges fit together to wrap themselves around the electron or elementary charge to hold it together. Perhaps all mass is electrical!

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