Deriving Newton's Gravitational Law from a Le Sage Mechanism

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In this paper we derive Newton's law of gravity from a general Le Sage model. By performing a general derivation without a specific interaction process model, we can identify generic requirements of, and boundaries for, possible Le Sagian gravitational process models. We compare the form of the interaction found to the "excess" energy of the gas giants and find good agreement.

Introduction

In the eighteenth century, Georges-Louis Le Sage proposed that a universal field of ultra-mundane corpuscles interacting with matter gives rise to a shadowing effect. This shadowing in turn causes matter bodies to be pushed together, resulting in our observation of a gravitational force. Since Le Sage's time similar derivations have been performed by many others (*e.g.*, Shneiderov, 1943, 1961; Radzievskii and Kagalnikova, 1960). For the most part, however, the Le Sage approach has fallen from favor and general knowledge, largely due to the popular belief that phenomenological arguments make the entire idea untenable.

The authors' present purpose is twofold. First, we wish to determine general requirements for any such theory to replicate the Newtonian gravitational formula, in some limit. Secondly, we wish to determine phenomena that result from such a theory, and examine these against experimental limitations. This first paper focuses on the static properties of Le Sagian models. Static properties are those that do not depend on the speed of propagation of gravitational effects. The latter effects are addressed in the companion paper in this volume by Stowe [1].

Derivation of Newtonian Gravitation

If one begins with the postulate that there exists a fluidic medium (aether) composed of some particulate or corpuscular nature, one may be able to make use of many of the known fluid dynamic equations in later derivations. The postulate is therefore made that a fluidic medium is, as Le Sage proposed, comprised of "energetic corpuscles" pervading all of known space. We also take as a basic postulate that these corpuscles are in free motion with respect to each other and make no claims as to the substance or composition of these corpuscles. Let us further postulate that the collisions between corpuscles are fully

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elastic. These corpuscles are not necessarily required to be matter (particles) or mass in the standard sense. What is of interest at this point is not the corpuscles themselves, but the effect of the corpuscles on matter.

We do not, at this point, claim any knowledge about the corpuscles. Likewise we do not claim knowledge of the innate structure of matter or the microscopic interactions that would take place between aether "corpuscles" and matter "particles." Instead, our approach is the reverse.

The purpose of any theory of gravitation is to produce, at a minimum, the Newtonian gravitational equation in its entirety. Most Le Sagian models manage the inverse square portion of Newton's equation without trouble. Many then go wide of the mark on the strict mass dependence of the resulting equations. Others appear to get into trouble as a result of discrepancies with calculated absorptive heat fluxes [17].

We begin our development therefore with a single premise of the *form* of the interaction with some physical flux, and then see if Newton's law can be derived at all. From Newton's law, we can then determine the specific type of flux that the interaction is *required* to affect. In this paper, we will not attempt to justify *how* that interaction might arise. The result will be a generic requirement that a Le Sagian model may meet, in order to produce Newton's law.

Our primary assumption is based upon standard exponential removal equations. We first define a flux per unit area to be represented by Φ. We presume that, on average, each interaction of the flux with a differential unit volume removes the same fraction of the incident flux, Φ_0. The change in flux due to interaction with matter is generally given in a differential distance by:

$$d\Phi = -\mu_l \Phi dx\,,$$

where μ_l is the linear flux attenuation (loss) coefficient (in units of inverse length) and x is the thickness of the shield.

One-Body Problem:

We next determine the effect of a stationary, spherical matter body of uniform density on the corpuscular field. Figure 1 identifies the geometric relationships.

The flux at point P along the line T will be affected by the interaction of the corpuscles with the sphere. This interaction may be a removal of corpuscles, a scattering of corpuscles, a removal of corpuscle energy/momentum (without scattering), or some combination of the three. It is not yet necessary to know what the mechanism of interaction will be. The flux will change regardless of the type of interaction taking place. Later, we will determine the type of flux needed to give Newton's law.

The interactions change the flux, Φ, in a given unit volume. This general interaction is then similar to standard ionizing-radiation interactions. It gives rise to a standard thin-shield reduction equation of:

$$\Phi_i = \Phi_0 e^{-\mu_l x}, \tag{1}$$

where Φ_i is the flux after interaction and Φ_0 is the initial flux.

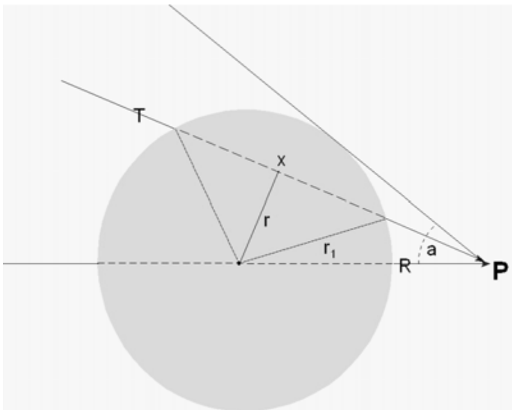

Figure 1

Because we still have the possibility of multiple scattering (multiple interactions in shields of sufficient size and thickness), the thin-shield equation is expanded using a general "buildup" term, $B(\mu_l x)$. This buildup term will correct the equation for multiple scattering events (if any) by corpuscles that are not initially traveling along the line T. The buildup term will depend on the relative importance of each of the three possible interaction modes (removal, scattering, and slowing) in the body, the shape of the body, the size of the body, and the distance of the body from point P. The corrected general removal equation is:

$$\Phi_i = \Phi_0 B e^{-\mu_l x} . \tag{2}$$

In an otherwise isotropic fluid medium, the flux from all directions is identical except where the fluxes traverse the matter body. These interacted fluxes are reduced according to the flux attenuation equation. In Figure 1, the net flux at point P is given as the sum (integral) of the all flux from the left and from the right of point P. The net contribution of fluxes outside angle *a* is therefore zero. The contribution of fluxes within angle *a* can be determined by rotating the figure around the line RP. The rotation angle θ coupled with the plane angle *a* gives the solid angle Ω. The difference between the fluxes from the right (Φ_0) and the fluxes from the left (Φ_i) is:

$$\Delta\Phi = (\Phi_0 - \Phi_i)d\Omega = (\Phi_0 - \Phi_i)\left(\frac{dr}{R}\right)\left(\frac{rd\theta}{R}\right). \tag{3}$$

The sum of all fluxes on possible lines T is then given by the integral:

$$\int \Phi d\Omega = \int \frac{1}{R^2}(\Phi_0 - \Phi_i)rdrd\theta , \tag{4}$$

which yields:

$$\Phi_{net} = \frac{2\pi\Phi_0}{R^2}\int_0^{r_1}\left[1 - B(\mu_l x)e^{-\mu_l x}\right]rdr . \tag{5}$$

The relationship between x, r, and r_1 is given by geometry as:

$$\left(\frac{x}{2}\right)^2 = \left(r_1 + r\right)\left(r_1 - r\right) = \left(r_1^2 - r^2\right). \tag{6}$$

Noting that x may be replaced by $2(r_1^2 - r^2)^{1/2}$, the general solution for the current (net flux) at a point is provided by:

$$\Phi_{net} = \frac{2\pi\Phi_0}{R^2}\int_0^{r_1}\left[1 - B\left(2\mu_l\sqrt{r_1^2 - r^2}\right)e^{-2\mu_l\sqrt{r_1^2 - r^2}}\right]rdr\ . \tag{7}$$

The Weak Solution:

The weak solution to equation 7 is given when $2\mu_l\,(r_1^2 - r^2)^{1/2}$ is much less than 1. This is the case when only a small fraction of the flux is removed to or removed by the body. In this case the buildup term is essentially 1 (there is no significant scattering), and the exponential term may be replaced by the first two terms of the power series approximation. The weak solution simplifies to:

$$\Phi_{net} = \frac{4\pi\mu_l\Phi_0}{R^2}\int_0^{r_1}\sqrt{r_1^2 - r^2}\,rdr\ . \tag{8}$$

Integrating the above equation gives:

$$\Phi_{net} = \frac{\Phi_0}{R^2}\left(\frac{4\pi r_1^3}{3}\right)\mu_l\ . \tag{9}$$

The term in brackets is the volume of the sphere. The linear attenuation coefficient is generally a function of the density of the material. A more general parameter is the mass attenuation coefficient, μ_s. It is defined as $\mu_s = \mu_l/\rho$, where ρ is the material density. Noting that the mass of our uniform sphere is given by $M = \rho V$, the above equation becomes:

$$\Phi_{net} = \frac{\Phi_0}{R^2}\left(\frac{M}{\rho}\right)\mu_l = \Phi_0\frac{\mu_s}{R^2}M\ . \tag{10}$$

The weak solution to the one-body problem quantifies the creation of currents (differential flux) in the corpuscular aether fluid that would result from placing a uniform matter sphere in the fluid. The strength of the current is proportional to the mass of the sphere. The direction of the current is *toward* the center of the sphere.

The Strong Solution:

The strong solution to the one-body equation (7) is given when $2\mu_l\,(r_1^2 - r^2)^{1/2}$ is much greater than 1. This is the case for very strong interactions (of any kind) or when the body is very large. In the strong solution case, essentially all of the flux is removed to or by the body. In this case, the buildup term is inconsequential because essentially all of the flux will be absorbed. The exponential term goes to zero. This strong solution simplifies to:

$$\Phi_{net} = \frac{2\pi\Phi_0}{R^2}\int_0^{r_1} r dr \,. \tag{11}$$

This equation may be integrated and rearranged to give (where $r_1 < R$):

$$\Phi_{net} = \frac{\Phi_0}{R^2}\left(\pi r_1^2\right). \tag{12}$$

This is the maximum current that can be created, the strength of which is independent of the mass of the sphere.

Two-Body Problem (weak limit):

The equations determined above provide a description of the effect of a single body on the surrounding field. If a second body is placed in the vicinity of the first, it will be affected by the field's vector potential created by the first body. Suppose a second spherical body (body 2) is placed at the same point P in Fig. 1, where $r_2 \ll r_1 \ll R$. Under these conditions the flux lines that transit both body 1 and body 2 are essentially parallel. Sphere 2 will then see a current (net vector flux) flowing toward the center of the first sphere.

Up to this point, we have been working in very general terms of flux. In order to convert to the observed Newtonian gravitational force equation, we must identify the appropriate type of flux. Newton's second law requires a specific form of flux change:

$$\overline{F} = \frac{d\left(\overline{mv}\right)}{dt} = \delta\Phi A \,, \tag{13}$$

where A is the effective cross-sectional area of the body and where the bars indicate vector quantities. The flux must therefore be a vector *momentum* flux having units of kg/m-sec^2.

Because the average path distance through sphere 2 is $4/3r_2$, and the cross-sectional area of sphere 2 is πr_2^2, we can combine equations 9 and 13. The weak solution then becomes:

$$F = \Phi_{net}\left(\mu_{l2}\frac{4r_2}{3}\right)\pi r_2^2 = \Phi_{net}\left(\frac{4\pi r_2^3}{3}\right)\mu_{l2}\,, \tag{14}$$

where μ_{l1} and μ_{l2} are the linear absorption coefficients for spheres 1 and 2 respectively. Substituting for Φ_{net} (equation 9) then gives the net interaction as:

$$F = \frac{\Phi_0}{R^2}\left(\frac{4\pi r_1^3\mu_{l1}}{3}\right)\left(\frac{4\pi r_2^3\mu_{l2}}{3}\right) \tag{15}$$

and, using equation 10:

$$F = \frac{\Phi_0}{R^2}\left(M_1\mu_{s1}\right)\left(M_2\mu_{s2}\right). \tag{16}$$

For ordinary matter we may write $\mu_{s1} = \mu_{s2} = \mu_s$. We therefore obtain:

$$F = \frac{\left(\Phi_0 \mu_s^2\right) M_1 M_2}{R^2}\,. \quad (17)$$

Since the term in brackets is a constant, this is the same form as the standard Newtonian gravitational force equation. The experimentally derived constant G would be:

$$G = \Phi_0 \mu_s^2\,. \quad (18)$$

This is both unsurprising and yet unusual. It is unsurprising because Newton's second law is based on momentum as $F = d(mv)/dt$**.** Since the basic gravitational formulations are based on relationships of *force* between matter bodies, momentum is the quantity of prime concern in this derivation of apparent forces. It is unusual, because as students we are used to dealing with fluxes of scalar quantities such as mass, particles, or energy. The requirement of exponential interaction of *vector* momentum flux gives rise to some deviations from the "standard" renditions of Le Sage theory—which are based on the absorption of fluxes of scalars (particles, mass, or energy).

The weak solution to the basic interaction with matter has *derived* the standard Newtonian gravitational formula for stationary bodies (under conditions where the Newtonian applies). The formulation also provides a *limit* for the effectiveness of the Newtonian formula for stationary bodies. This limit is the limit of the weak solution: $2\mu_l\,(r_1^2 - r^2)^{1/2} << 1$ or $2\mu_s\,(r_1^2 - r^2)^{1/2} << \rho$. This also gives an upper limit to the force, based on the strong solution:

$$F = \Phi_0 \left(\mu_s^2 M_2\right)\left(\frac{\pi r_1^2}{R^2}\right). \quad (19)$$

One can see from the above equations that the weak, stationary (non-relativistic) solution reproduces the Newtonian gravitational force equation. G is seen as proportional to the product of the momentum flux and the square of the total mass interaction coefficient, μ_s. If this formula is correct, we know that the interaction is very weak. There are no obvious deviations from proportionality (departure from the weak solution) for masses from sizes from dust particles to stellar bodies. In validating these derivations against observation, one must keep in mind that all current mass estimates of planetary and stellar bodies are all based on strict use of the Newtonian (and Einsteinian) formulations, and might have to be adjusted according to the Le Sagian formulae.

If we examine equation 16, our momentum flux postulate gives a more physical explanation of the Newtonian empirical formulation:

$$F = \frac{\Phi_0}{R^2}\left(M_1 \mu_s\right)\left(M_2 \mu_s\right). \quad (20)$$

Here we explicitly see the momentum current set up at any point around a single body as the first two terms. A second matter body (represented by the third term) feels a force from this momentum current as a product of its interaction coefficient and its mass—*not* as a result of its mass alone. The empirical constant, G, has historically "hidden" portions of the matter interaction. We can therefore distinguish between the standard Newtonian gravitational field of body M_1 ($I = F/M_2$) and the Le Sagian "field":

$$I = \frac{F}{M_2\mu_s} = \frac{\Phi_0}{R^2}\left(M_1\mu_s\right). \tag{21}$$

The Newtonian "field" is purely an empirical mathematical concept. The Le Sagian field is a physical measure of the local momentum current imposed by body 1. It is not mass alone, but the mass interaction coefficient of matter that gives rise to the force of gravity. This derivation also includes an implicit derivation of the material-independence of the gravitational force, otherwise known as the relativistic equivalence principle (as confirmed by Eötvös-class experiments).

Energy Deposition

As mentioned in the introduction and illustrated in the derivation above, the Le Sage process involves the interaction of a proposed external field within material bodies. This situation should result in energy deposition. This is a unique prediction of Le Sagian models and has been pointed out by many in the past, including Lorentz and Poincaré. Indeed, it has been argued that if all of the flux is absorbed, a large gravitating body could vaporize [17]. In general, attenuation processes can include pure absorption, pure specular scattering, pure dissipative scattering, or any combination thereof. In the generic approach derived above, we cannot know *a priori* what the ratio of any or all of these are since the actual distribution of the underlying mechanistic processes are not identified or defined. However, we do know that any energy deposition must be proportional to the incident flux Φ_0 and the actual mass attenuation coefficient μ_s. In this model, at the weak static limit, the gravitational interaction is governed by equation 17, and as shown, is proportional to $\Phi_0\mu_s^2$. The gravitational constant (G) becomes $\Phi_0\mu_s^2$ in this evaluation. Since we cannot determine the individual values of Φ_0 or μ_s from G alone, we cannot directly derive what the heat deposition is from this Newtonian force equation. However, we do know that any power dissipation must result from the mass exponential-removal postulate we made at the very beginning.

We can now look at known astrophysical phenomena to quantify any excess energy emissions that are observed coming from planetary bodies. The earlier derivation of the Newtonian force equation required a weak solution. That is, $2\mu_l\,(r_1^2 - r^2)^{1/2} << 1$. Under these conditions, we can treat an entire planetary body as a single lump for energy deposition.

Incident sunlight heats a planetary body through combinations of reflection and absorption of the incident sunlight and the reemission of thermal energy. If there is an energy deposition from the interaction of Le Sage-type field, then there should exist an "excess" heat that cannot be readily accounted for by present theory. Regardless of what theory of formation is used, planets should eventually come into equilibrium with the input of solar energy. If we therefore select planetary bodies with relatively small metallic cores and either small size or good thermal mixing, we can quantify this "excess" heat output. The Jovian planets and the Earth's moon all fit these requirements. As it turns out, these bodies all exhibit an emission of "excess" heat. Figure 7 on page 121 of [10] clearly shows an effect consistent with an internal heat source for both Jupiter and Saturn.

If we integrate the absorbed solar heat flux on Jupiter over its surface area, we get a planetary average excess emitted heat flux of 6.6 W/m^2. Now we need to develop a mathematical relationship to quantify the effect.

Up to this point we have focused solely on the transfer of momentum from the field's flux into material bodies. Now we need to look at the energy flux. For this we must look in more detail at the hypothesized particulate nature of the impinging field. We make the assumption that the constituent corpuscles are of a single mass and irrotational to simplify the analysis. This may not be generally true, but it is sufficient to get an estimate of the magnitude of the heating effect. We further assume that the corpuscles follow Newton's laws of motion under their own interactions—even though they are not necessarily matter in the usual sense. We infer that the average corpuscle speed is the square root of 3 times the wave speed in this corpuscular medium, as is true of standard gases of irrotational particles. Finally, we assume that the wave speed of this medium is equal to the speed of light. This last is a reasonable assumption, as general relativity postulates the speed of gravitational waves to be equal to the speed of light. One can expect the corpuscular fluid wave speeds to be of that order of magnitude.

As we saw in the one-body problem above, any single body imposes a net velocity vector or current potential at every point in the flux field that surrounds it. The current at a particular point arises from the removal of momentum flux by the body. The current increases in strength as the distance from the body diminishes. Mathematically, we may therefore treat the currents as arising from an equivalent average acceleration of free corpuscles towards the body. A second matter body would respond to the corpuscular momentum current produced by the first body. The apparent acceleration of the corpuscles that defines this momentum current should be the same order as the acceleration imparted to matter bodies.

We assume that the rate of energy deposition in a body is equal to the increased energy flux associated with the accelerated corpuscles meeting the body. The increase in kinetic energy of corpuscles that have 'fallen' from an infinite distance to the surface of the body, relative to their initial energy, is then given simply by the change in their gravitational potential energy. We would then have:

$$\frac{\Delta E_k}{E_k} = \frac{\Delta v^2}{c^2} = \frac{2GM}{r_0}, \tag{22}$$

where E_k is the kinetic energy and m is the corpuscle mass. If the energy flux in free space is Ψ_0 (= $\Phi_0 c$), then the equilibrium rate of energy deposition in the body per unit of its spherical surface area, Ψ_{abs}, is:

$$\Psi_{abs} \approx \Psi_0 \frac{2GM}{r_0 c^2}. \tag{23}$$

The last unknown in the resulting equation is the power flux term Ψ_0, and as such must be normalized to a known quantity. Jupiter was selected for this purpose, since its excess heat flux is the best known of the gas giants. The relevant information is taken from reference 10 (p. 121-Fig. 7). The average excess heat flow from Jupiter is 6.6 W/m^2. Setting Ψ_{abs} equal to this value, and with $M = 1.97 \times 10^{27}$ kg and $r_0 = 7 \times 10^7$ m, the predicted total spherical power flux of the Le Sagian field is then:

$$\Psi_0 = \frac{\Psi_{abs} r_0 c^2}{2GM}. \tag{24}$$

$$\Psi_0 = 1.6 \times 10^8 \, W/m^2 . \tag{25}$$

Since this is a calculated value based upon an assumption that Jupiter's excess thermal power is coming from this source, validation can only be confirmed by now using this calculated value to attempt to predict the excess from other planetary candidates. We can combine the constants $2\Psi_0 G/c^2$ into a single term k_f, which has the value of 2.4×10^{-19} m/sec^3. This results in the simple equation for equilibrium power emission of

$$\Psi_{abs} = k_f \frac{M}{r_0}. \tag{26}$$

Utilizing this equation, we obtain the results for the "excess heats" for specified bodies (Table 1). The values for Uranus and Neptune were back calculated from gross temperatures and albedo estimates and so are less reliable than for Jupiter, Saturn and the Moon.

Table 1

	Predicted	Measured
Earth's Moon	10 mW/m^2	10 mW/m^2
Saturn	2.4 W/m^2	2.7 W/m^2
Uranus	0.83 W/m^2	0.4 W/m^2
Neptune	1.0 W/m^2	0.7 W/m^2

These results are of the proper order of magnitude, and within the limits of measurement uncertainties.

We can also do a similar evaluation of the power balance of the Sun. Equation 23 assumed a uniform density throughout the planet. Expected internal variations in the densities of gas giants are under two orders of magnitude. But density variations in the Sun are more than four orders of magnitude (Bahcall, 1989, figure 4.1). If we solve equation 23 for the Sun, then multiply the result by the surface area of the Sun, we get a result of 3.8×10^{23} W, or 0.1% of the total solar photon flux of 3.9×10^{26} W (Bahcall 1987, Table 4.1).

At first glance, this would be a very minor correction to standard solar models. The basic result of this correction would be to *lower* the apparent core temperature of the Sun. This lowering of the core solar temperature comes about from the need to match the boundary condition of measured solar energy flux. If the solar output is unchanged when this new energy term is added to the model, then the amount of energy required from hydrogen fusion to maintain hydrostatic equilibrium in the Sun will be reduced by 0.1%. The core temperature would then be lower than currently expected.

The current solar neutrino "problem" arises from the difference between the measured neutrino flux and the theoretical neutrino flux from the Sun. The neutrino measurements evaluated by the authors included chlorine, water, and gallium detectors. The chlorine and water detectors find between 20 to 50% of "expected" neutrinos. The gallium detectors see a flux that is a "little low" (Bahcall, 1987). Each type of detector looks at slightly different neutrino energy spectrums. The water and chlorine detectors look primarily at the ^{8}B neutrinos, due to their relatively high energy. According to Bahcall, there is a 37% theoretical uncertainty in the results for these neutrinos. The bulk of this uncertainty is the extremely strong temperature dependence of the ^{8}B-neutrino reaction (T^{24}). If the solar core energy is reduced by 0.1%, the core temperature would be reduced by 0.1% to the one-quarter power*. The apparent reduction in ^{8}B neutrino reaction rates would then be $1.01^{(24-4)}$, or 22%. The gravitational heat contribution would reduce the theoretical ^{8}B neutrino fluxes approximately to the level measured. However, an analysis of this kind really needs to be run through a standard solar model simulation, due to the extreme density variations and temperature dependencies.

Unfortunately, the combination of our momentum derivation and our energy correlation do not allow us to solve uniquely for Φ_0, Ψ_0 or μ_s because of the radial dependence of our correlation of Φ_0.

Shielding Effects

If models of this nature are used, the effect of gravitational shielding will arise when dealing with three or more matter bodies. This effect arises because a third body will shadow some of the momentum flux passing between two bodies on opposite sides of itself. The available flux is therefore lowered by a fraction that depends on the degree of removal by the third body.

A cursory review of the literature shows it is generally accepted that there is no gravitational shielding effect. Although experiments do exist that show a shielding effect, other experiments apparently show no such effect. Modanese (1995) states flatly that "…experiments, starting from the classical measurements of Q. Majorana, have shown that the gravitational force is not influenced

* By the Stephan-Boltzmann law, $E = \sigma T^4$

by any medium". Although commonly repeated, this statement is not correct. Majorana (1920) reported very definite positive effects.

The authors note that there is a significant difference in the type of experiment and analysis performed between the interpretations. Direct measurement experiments have found positive effects (*e.g.*, Majorana, 1920; Podkletnov, 1995). Indirect measurement experiments have not found positive effects (*e.g.*, Eckhardt, 1990). There are also theoretical "proofs" that the positive direct measurements "cannot" be valid (*e.g.*, Russell, 1921; Modanese, 1995).

If there are shielding effects, precise measurements of the constant, G, would not be consistent. This would result from unaccounted variations in the positions of the Sun, moon and nearby environmental massive objects during the experiments. A review of the literature shows that unexplained variations in precise measurements of G do exist. Gillies (1987) summarizes the most precise claims (see Table 2) and notes: "… that all these values exclude each other within the limits of the errors quoted. If we weight each of these three results equally, then it is clear that we do not know the value of G with an uncertainty of 10^{-4} as is otherwise suggested by the individual measurements."

Table 2

Authors	Year	Technique	Result ($\times 10^{-11}$ m^3/kg sec^2)
Facy, Pontikia	1972	resonant pendulum	6.6714 ± .0006
Sagitov *et al.*	1979	torsion pendulum	6.6745 ± .0008
Luther, Towler	1982	torsion pendulum	6.6726 ± .0005
CODATA	1986	N/A	6.67259 ± .00085

Precise measurements of the value of G in underground chambers show a greater value for G than those made on the surface of the Earth (Stacey *et al.*, 1987), but the values are not accepted to be consistent with any shielding effect. A good test would be measurements of the value of G during a total solar eclipse. We can use the results we obtained for estimating the planetary energy deposition to get an estimate of the shielding that would be expected from the Moon during a total solar eclipse. Equation 23 gives an estimate of the reduction. $\Psi_{abs}/\Psi_0 = 2GM/c^2r = 6.4 \times 10^{-11}$ per lunar passage. The authors would therefore expect an apparent diminution of the solar gravitational force on the order of 10^{-10} G during a solar eclipse.

As of yet NASA has not released the results of their efforts of August 11, 1999. De Sabbata (1987, p. 202) states that to date "(t)he most carefully done of the dozen or so such experiments appears to be that of Slichter, Caputo and Hager. They used a LaCoste-Romberg gravimeter to search for gravity variations before, during and after the total solar eclipse of February 15, 1961. Power spectrum analyses of their data indicate that λ* is less than 8.3×10^{-16} cm^2/gm." This is four orders of magnitude below Majorana's ex-

* λ is given in the weak solution (De Sabbata, 1987, p. 200) as: $q = q_0\ \{\lambda\ \rho\ x\}$. In this equation, q is the intensity of a gravitational "ray." λ is therefore equivalent to our mass interaction coefficient, μ_s, if the "ray" is momentum flux.

perimental results. De Sabbata does note, however, that "Majorana was known to be a very careful and competent experimentalist". The authors also note that Slichter *et al*. used an indirect measurement and had to build some unstated assumptions into their "power spectrum analyses" of the raw data.

Although the evidence is suggestive, it is not consistent and there is significant disagreement on the interpretation of results. Resolution of the apparent discrepancies in the observational status of gravitational shielding effects is beyond the scope of this paper.

Conclusions

This general approach to the Le Sagian mechanism has resulted in three areas that must be addressed in any physical Le Sage-type model. The Newtonian force law can be derived for a weak solution case. The model will require some internal heating of matter bodies. And gravitational shielding effects must occur. The derivation of the Newtonian force law is a strength of this approach. "Excess" planetary and solar heat is highly suggestive, but not conclusive.

References

1. Stowe, P., "Dynamic Effects in Le Sage Models," in *Pushing Gravity*, Apeiron, Montreal.
2. Majorana, Q., 1920. *Phil. Mag.* [ser. 6] **39**, 488-504.
3. Russell, H.N., 1921. "On Majorana's theory of gravitation," *Astrophys. J.* **54**, 334-346.
4. Shneiderov, A.J., 1943. *Trans. Amer. Geophys. Union*, 61-88.
5. Shneiderov, A.J., 1961. *Bollettino di Geofisica Teorica ed Applicata* **3**, 137-159.
6. Radzievskii, V.V. and Kagalnikova, I.I., 1960. "The nature of gravitation," *Vsesoyuz. Astronom.-Geodezich. Obsch. Byull.,* **26** (33), 3-14.
7. Podkletnov, E. and Nieminen, R., 1992. *Physica C* **203**, 441.
8. Podkletnov, E. and Nieminen, R., 1995. "Gravitational shielding properties of composite bulk $YBa_2Cu_30_{7-x}$ superconductor below 70 K under electro-magnetic field," Tampere University of Technology Report.
9. Modanese, G., 1995. "Theoretical Analysis of a Reported Weak Gravitational Shielding Effect**,"** MPI-PhT/95-44.
10. *The New Solar System*, 1981 (J.K. Beatty, B. O'Leary, A. Chaikin eds.), Cambridge University Press, p. 121.
11. Eckhardt, D. H., 1990. "Gravitational Shielding," *Phys Rev D* **42**, 2144-2145.
12. Web site: http://science.nasa.gov/newhome/headlines/ast12oct99_1.htm
13. Stacey, F. D. *et al*, 1987. *Rev. Mod. Phys*. **59**, 157.
14. Gillies, G. T., 1987. "Status of the Newtonian Gravitational Constant," in *Gravitational Measurements, Fundamental Metrology and Constants*, p. 195 *et seq*., (V. De Sabbata and V.N. Melnikov eds.), NATO ASI, Series C, Vol. 230, Kluwer Academic Publishers.
15. Slichter, L. B. *et al*, 1965. *J Geophys Res* **70**, 1541.
16. Bahcall, J. N., 1989. *Neutrino Astrophysics*, Cambridge University Press.
17. Poincaré, H., 1946. *The Foundations of Science*, Science Press, pp. 517-521.

Dynamic Effects in Le Sage Models

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In this article, we will explore and quantify specific dynamical processes related to the interaction of material bodies with an energetic medium, such as that proposed by Le Sage. Specifically quantified herein are the effects of increased directional attenuation due to inertial motion (Drag), finite propagation speed on the orbital processes (Gravitational Aberration), and field coupling effects due to rotating bodies (Frame Dragging).

Introduction

From its inception, Le Sage's postulate has inherently contained all the elements that are now known to exist as part of the gravitational process. It also has other features that are not currently recognized in modern theories of gravity. One of these is the Le Sage field's power dissipation (induction heating) [1]. In addition, there are various dynamical aspects of the model, such as linear drag and aberrational fling. Historically, it has been argued that these specific elements appear to be in direct conflict with known observations. It is these dynamical elements of Le Sage's theory and their quantification that are the focus of this paper. We will show that, contrary to the historical arguments, these elements need not be in conflict with astronomical observations.

The basic concepts and terms that will be used were discussed in the companion paper in this volume by the author and Barry Mingst. First and foremost is Le Sage's idea of a sea of energetic corpuscles interacting with matter. A key concept associated with this is a term called flux (Φ), which is simply a count of the number of 'events' which, from any direction, will intercept a specified unit surface area in a unit of time. We can define this for many different physical properties, such as mass, momentum, energy, power, *etc*. The term 'current' defines any net or resultant when the vector components of flux are evaluated and summed through a solid 4π angle. The flux is considered isotropic if, at the point of evaluation, the resulting current is zero.

The other key parameter needed to define the Le Sage process is the mass attenuation coefficient μ_s [2]. This term, commonly used in ionizing radiation transport, characterizes field particle interactions with matter on a per unit area basis.

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Drag from Inertial Motion

Consider an arbitrary slab of matter situated in a one-dimensional corpuscular fluid. Half the momentum flux is impinging from the left and half from the right. Therefore, the resulting current is defined by the simple relationship:

$$\Phi_{net} = \frac{\Phi_0}{2} - \frac{\Phi_0}{2} = 0 \,. \tag{1}$$

Here Φ_0 is the momentum flux in free space well away from masses, with units of kg/m-sec^2. Therefore, when the slab is at rest with respect to the field, the impinging flux is isotropic, and $\Phi_{net} = 0$. However, if the slab is set in motion, say towards the right, the result is a non-zero current Φ_{net}. The magnitude of this is defined by the equation:

$$\Phi_{net} = \frac{1}{2}\Phi_0\left[\left(1 - \frac{v}{\gamma}\right) - \left(1 + \frac{v}{\gamma}\right)\right] = -\Phi_0 \frac{v}{\gamma} \,, \tag{2}$$

and, as indicated by the negative sign, opposes the motion.

At this point, we need to extend our one-dimensional case to three dimensions. In a manner analogous to the one-dimensional case, we obtain the factor of the square root of three in the three dimensional case [12]:

$$\Phi_{net} = -\sqrt{3}\Phi_0 \frac{v}{\gamma} \tag{3}$$

For a weakly attenuating body [1], the resulting deceleration is defined as:

$$a_d = -\Phi_{net}\mu_s \tag{4}$$

By inspection of equation 3, we see that as corpuscular speed goes to infinity the current vanishes. Thus, equation 4 will also go to zero, clearly demonstrating that the process of field attenuation resulting from very high corpuscle speed results in drag free inertial motion.

Given that $G = \Phi_0\mu_s^2$ per equation 18 of Ref. [1], we therefore have $\Phi_0 G = (\Phi_0\mu_s)^2$. Combining equations 3 and 4, we then obtain:

$$a_d = \sqrt{3\Phi_0 G}\ \frac{v}{\gamma} \,. \tag{5}$$

Note that, like normal gravitational acceleration, this term is mass independent, and the resulting deceleration is dependent only upon the speed of the body through the field.

A field power flux Ψ_0 of 1.6×10^8 W/m^2 was derived from equation 24 and given as 25 of Ref. [1]. If we use this value to obtain the related momentum flux, we get $\Phi_0 \propto \Psi_0/c$ or $\Phi_0 = k\Psi_0/c$. The constant k is a geometry factor and could be unity if the geometry of our evaluation were spherical, as was the case for the original derivation of Ψ_0. However, in the current linear situation we find that k needs to be 4π. We then have $\Phi_0 = 4\pi\Psi_0/c$ or 6.7 kg/m-sec^2. Given the assumption $\gamma = \sqrt{3}c$, where the value $\sqrt{3}$ relates the bulk transverse wave speed c to the mean speed of the particles (see Section 5, Chapter 11, Fig. 11-8 Ref. [8]), from equation 5 we obtain:

$$a_d = \sqrt{\Phi_0 G}\ \frac{v}{c} = \Phi_0 \mu_s \frac{v}{c}. \tag{6}$$

As an example we may use the anomalous acceleration of the Pioneer 10 spacecraft [3]. Using $\Phi_0 = 6.7$ kg/m sec^2 (for the case $k = 4\pi$) and given Pioneer 10's velocity of 12,000 m/sec, the computed result from equation 6 is 8.5×10^{-10} m/sec^2. This would be a perfect match with the observed drag on the Pioneer spacecraft.

Gravitational Aberration (Propagation Delay)

The classic Newtonian force equation $F = GMm/R^2$ and its gravitic potential $a = GM/R^2$ are expressions that define the instantaneous force and acceleration generated by the interaction of mass M with any other mass m at the given distance R. As this is explicitly a static solution, no attempt is made to account for any motion of M or m. However, orbiting masses are not a static problem. The above equations are therefore not strictly applicable for any such system if the speed at which the force is transmitted or communicated between the masses is not instantaneous. This is a well-known condition of the interaction of fields with finite propagation velocity. Feynman provides a very good discussion of this for the electric field interaction in Vol. II, Chapter 21 of Ref. [4] and Griffiths provides the full derivation in section 9.2.2 of Ref. [11]. In the case of gravity, the situation is similar: mass M will always see mass m where it was R/γ seconds ago and vice versa. In the literature, this is known by the term retarded potential.

As an illustration, consider two equal masses m and M orbiting each other around a common center. Let the line of sight path from M to m be R' and the actual distance be R. Note that different circular orbits are described by R' for each body. These are offset from each other by Rv/γ. As γ goes to infinity these converge to a single circular orbit (the traditional Newtonian orbit). Because the projected orbits are offset by Rv/γ at every position of the Newtonian projection, it has been argued [10] that there should be an outward radial component of acceleration on each body of the order of $v^3/\gamma R$. This would result in both bodies spiraling outward until they leave the influence of each other.

However, as Feynman points out in his discussion, this effect is canceled by the dynamical effects manifested in the first and second derivatives that result from the field's *potential*. In other words, the classical electrostatics potential equation,

$$E = \frac{e}{4\pi\varepsilon_0 R^2}, \tag{7}$$

also does not account for any motion or finite propagation. The modern Maxwellian formulation is

$$E = -\nabla \cdot V - \frac{\partial \mathbf{A}}{\partial t}. \tag{8}$$

It is this formulation that is key to the lack of observed aberration. Feynman puts it nicely (Vol. I, 28-1 Ref. [4]) when he says:

> The whole thing is much more complicated. There are several more terms. The next term is as though nature were trying to allow for the fact that the effect is retarded, if we might put it very crudely. It suggests that we should calculate the delayed coulomb field and add a correction to it, which is its rate of change times the time delay that we use. Nature seems to be attempting to guess what the field at the present time is going to be, by taking the rate of change and multiplying by the time that is delayed. But we are not yet through. There is a third term—the second derivative, with respect to *t*, of the unit vector in the direction of the charge. Now the formula *is* finished, and that is all there is to the electric field from an arbitrarily moving charge....

The resulting potential created in the Le Sagian momentum field has an analogous formulation:

$$a = -\nabla \cdot K - \frac{\partial \mathbf{g}}{dt}, \tag{9}$$

where $K = GM/R$ and **g** is the equivalent *vector potential* for the gravitic field. Like electrostatics, the second term vanishes under static conditions resolving equation 10 to $a = GM/R^2$.

Re-writing Feynman's equation I-28.3 [ref 4] in the equivalent gravitational form we get:

$$a_g = GM\left[\frac{\mathbf{u}'}{R'^2} + \frac{R'}{\gamma}\frac{\delta}{\delta t}\left(\frac{\mathbf{u}'}{R'^2}\right) + \frac{1}{\gamma^2}\frac{\delta^2 \mathbf{u}'}{\delta t^2}\right], \tag{10}$$

where $\mathbf{u}'$ is the vector pointing to R'.

This should not be unexpected. If an instability due to aberration actually existed, it would be as problematic for the General Theory of Relativity (GR), which includes the Newtonian for the weak slow speed limit, as it would be for any Le Sagian model. Carlip recently addressed this specifically for GR [6] and concluded, like Feynman did for EM, that aberration due to finite propagation is almost exactly canceled. The slight residual imbalance remaining for GR results in orbital decay.

Rotational Coupling of Gravitating Bodies

This feature of Le Sage's process is probably one of its most interesting and unique attributes. Since the Le Sage process centers around the interaction of matter with a particulate field, if the matter rotates and the Le Sagian corpuscles have a finite speed, that rotational signature is impressed on, and will be manifested in, the resulting field's potential. As a result, other material objects subject to this will experience torsional field forces.

While standard Newtonian theory has no capacity for such effects (since it is centered solely around the single mathematical formula of the Le Sage weak static solution), the mathematics of the General Theory of Relativity does [5]. This is termed *Inertial, or Reference Frame Dragging*. However, within its conceptual framework, there is no physical basis for it– it is simply a result of the mathematical formulation. As noted by many, the mathematics of GR is inherently based on a hydrodynamic premise [5, 8, 9]; however, any literal interpretation of this as relating to any actual physical media is expressly denied. In the Le Sage concept, it is explicitly a result of inherent hydrodynamic processes.

To understand the basic effect let us consider what happens to a freely floating, centrally located material compass within a rotating hollow sphere or ring. As the outer body rotates, the field interacting with this body is slightly deflected, or twisted. This deflection in turn imparts a rotation or torque on the detached material compass located at the center of the body [7]. The result is that the central compass will slowly acquire the rotational speed of the outer ring. Similarly, a rotating planet or star imparts a torque or drag upon any physical bodies under the influence of its field potential.

The magnitude of this slight effect is related to the potential created by the rotating body (*GM*) and the maximum rotational velocity (ωr), such that the torsional acceleration a_t is of the order of

$$a_t = \frac{GM}{R^2}\frac{\omega r^2}{R\gamma} = \frac{GM\omega r^2}{R^3\gamma}, \tag{11}$$

where r is the radius of the mass M and R is the distance from the center of mass M to the point of interest. For example, the above equation gives a maximum acceleration on a GPS satellite in earth orbit at 12,500 miles of 3.67×10^{-8} m/sec^2 or 3.44 nano-*g*'s.

Summary

As one can see from these components, orbital dynamics in Le Sagian theories encompasses many subtle elements. There is the potential from aberration to fling masses apart; for orbital decay due to linear drag; as well as for either fling or drag (depending upon the direction of orbital motion) resulting from rotational coupling. One would think that under such conditions a Le Sage model with finite propagation speed would make dynamical stability of orbits rare or impossible. The key to orbital stability, however, lies in fact that in these models aberration is the predominant factor. Thus the controlling equation results from equation 10. As long as the retarded potential from this aberration exceeds the combined effects of all the others (linear drag, rotational coupling), the field will adjust its potential to compensate, maintaining an orbit. In his paper [6], Carlip asked the question "Is Cancellation a Miracle?". The answer of course is no, it is an intrinsic property of the field to seek and establish within itself a stable zero net energy configuration. This is also known as Noether's Theorem. In particular, the effect of drag due to linear motion would only be manifested when a body is not in an orbit, as is the case for the aforementioned Pioneer spacecraft.

Le Sage models have subtle differences from the current standard mathematical representations of gravity, which can have major consequences for large-scale cosmological processes. Looking into these in detail should prove an interesting endeavor.

References

1. B. Mingst, "Deriving Newton's Gravitational Law from a Le Sage Mechanism", *Pushing Gravity*, Apeiron, Montreal, 2002.
2. A. B. Chilton *et al.*, *Principles of Radiation Shielding*, Prentice-Hall, 1984.
3. Pioneer Spacecraft Deceleration, *http://www.aps.org/meet/CENT99/BAPS/abs/S5310002.html*
4. R. Feynman *et al.*, *The Feynman Lectures on Physics*, California Institute of Technology, 1964.
5. J. Islam, *Rotating Fields in General Relativity*, Cambridge University Press, 1985.
6. S. Carlip, "Aberration and the speed of gravity", *Phys Lett A* **267**, pp. 81-87, 2000.
7. E. Harrison, *Cosmology, The Science of the Universe*, Cambridge University Press, 1981.
8. E. Condon and H. Odishaw, *The Handbook of Physics*, McGraw-Hill, Second Edition, 1967. For GR see Section 2, Chapter 6, pp. 2-50.
9. Schutz, *A First Course in General Relativity*, Cambridge University Press, 1990.
10. Lightman *et al.*, *Problem Book in Relativity and Gravitation*, Princeton University Press, 1975.
12. D. Griffiths, *Introduction to Electrodynamics*, Section 9.2.2, Prentice-Hall, 1989.
13. Bueche, *Introduction to Physics for Scientists and Engineers*, McGraw-Hill, 1969, p. 269.