Gravitation in a Gaseous Ether

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Newtonian gravitation arises from the Clausius term added to the ideal gas equation to account for the space occupied by cosmons, fundamental particles of cosmonic gas. The gravitational force is explained as a pressure due to static pressure and cosmon concentration.

Introduction

A new model is proposed to explain known physical phenomena. A gas, composed of particles moving in all directions, is assumed to pervade the entire Universe, even the space between so-called elementary particles and within elementary particles themselves. The particles that make up this gas are called cosmons.

Cosmons have no moving parts, and hence no internal energy or rest mass, inertial or gravitational. The space between cosmons is absolute void, and there are no fields at this level. Since a cosmon has a definite diameter, it occupies a volume of space that is impenetrable to other cosmons. In vacuum, individual cosmon speed may vary from zero to indefinitely large, according to the Maxwell speed distribution. Cosmons have zero spin (no forces or friction).

Interactions with other cosmons occur only through encounters. Between encounters, cosmons move at constant velocity (speed and direction). In encounters with other cosmons, there is an exchange of the velocity component along the centre line. The velocity component normal to the line of centres remains with each cosmon. The midpoint of the line of two centres describes the same straight line before, during and after the encounter.

There are no other physical phenomena at the cosmon level. Physics is infact reduced to pure kinematics. The concepts of momentum and energy are not applicable at this level. But at the level of the gas, the classical concepts of mass, momentum, energy, *etc*. are statistical effects due to cosmon kinematics. Because the cosmons have a diameter, the cosmonic gas is non-ideal, and viscosity is present. The properties of electromagnetism and elementary particles are described by the mechanical properties of the cosmonic gas. (Martin 1994a)

Equation of state of cosmonic gas

An empirical equation of state for a molecular gas was given by Van der Waals:

edited by Valeri V. Dvoeglazov (Montreal: Apeiron 2005)

$$\left(p+\frac{a}{V^2}\right)(V-b)=\mathrm{R}T\ ,$$

where p is static gas pressure, V is total gas volume per mole, T is temperature, and R is the universal gas constant, with dimensions ergs per mole per degree. Both a and b vary with temperature in this equation: a varies due to the variation of the attractive and repulsive forces between molecules, and b due to the variation of volume of the molecules with temperature.

In the cosmonic gas, however, there are no potentials between cosmons, and thus the a term disappears. Meanwhile, b is proportional to the cosmon sphere of exclusion, but the cosmon volume is invariant, and b must therefore be a constant. With these assumptions, the Clausius equation is fully applicable to the cosmonic gas in the form:

$$p\left(1-\frac{b}{V}\right)=\frac{\mathrm{R}T}{V}=NkT=N\mu\frac{kT}{\mu}=\rho\frac{kT}{\mu}, \qquad (1)$$

where N is the cosmon number density, k the Boltzman constant, μ the cosmon statistical interaction factor (or mass) and ρ the cosmonic gas mass density. From gas kinetic energy theory

$$\frac{b}{V}=\frac{\sigma}{L}=2\pi\frac{\sigma^3}{\sqrt{2}}N\ , \qquad (2)$$

where σ is cosmon diameter. If $N_{\max}$ is cosmon number density at maximum compaction or density, the volume occupied by one cosmon, including its surrounding void, is

$$\frac{\sigma^3}{\sqrt{2}}=\frac{1}{N_{\max}}\ .$$

But the cosmon mean free path $L = 0$ when $N = N_{\max}$. Equation (2) can therefore be modified to

$$\frac{b}{V}=\frac{\sigma}{L}=\frac{2\pi N}{N_{\max}-N}\ ,$$

and the Clausius equation for the cosmonic gas may then be written

$$p\left(1-\frac{2\pi N}{N_{\max}-N}\right)=NkT\ . \qquad (3)$$

Ratios of cosmon concentrations

Following the model of the large numbers hypothesis of Eddington, Assis (2001) has proposed a Principle of Physical Proportions, according to which all physical laws must be reduced to ratios of like quantities, *i.e.*, dimensionless fractions. The laws of physics deduced from the Clausius equation in its cosmonic gas form can be shown to comply with this principle.

We know that the Newton gravitational potential energy of a source M is GM/r, while the gravitational potential energy of a mass m in the gravitational field of M is GMm/r; the gravitational potential energy of mass M in the gravitational field of m is likewise GMm/r. Thus, both masses have the same potential energy. Similarly, the interaction force on each mass is GMm/r^2 toward the other mass. We also know that $\sqrt{G}$ has dimensions e.s.u./mass, and when applied to a mass, transforms it into electrostatic units, such that the Newton formula has the same form as the Coulomb law of electrostatics (Qq/r for potential energy, and Qq/r^2 for the attractive force between the charges).

In classical electromagnetism, $Qq/r = e^2/r = m_E c^2$ is the total energy of electrostatic field. The total potential energy for two masses interacting gravitationally is analogously $\sqrt{G}M\sqrt{G}m/r$. The effect of a mass on its surrounding gravitational field is the potential energy $\phi = \sqrt{G}M\sqrt{G}/r$ (energy per mass), and the effect of a charge on its electrostatic field is potential energy $\psi = Q/r$ (energy per charge). But $M = (4/3)\pi r^3 \rho_0$ and $Q = (4/3)\pi r^3 \rho_E$. Hence we obtain a simple ratio

$$\frac{\phi}{\psi} = \frac{\sqrt{G}\rho_0}{\rho_E} = 1.52 \times 10^{-22},$$

where $G = 6.672 \times 10^{-8}$ dynes cm^{2}g^{-2} ($\sqrt{G} = 2.583 \times 10^{-4}$ e.s.u g^{-1}), and ρ_0 is vacuum mass density, and ρ_E vacuum charge density *at earth's surface*. A ratio of the same order of magnitude can be formed from the electron mass and charge:

$$\sqrt{G}m_E/e = 4.896 \times 10^{-22},$$

where standard values of $e = 4.803 \times 10^{-10}$ e.s.u. and $m_E = 9.10 \times 10^{-28}$ g are used.

In a companion paper (Martin 2005), values of mass density ρ_0 and electrical charge density ρ_E were calculated by an iterative method for the electron as follows:

$$\rho_0 = N_0\mu_0 = 4.62 \times 10^8 \text{ g cm}^{-3},$$

where μ_0 is the cosmon mass-energy equivalent ($= (5/2)kT_0/c^2$, $T_0 = 2.736$ K) and N_0 (vacuum cosmon density at or near Earth's surface) is obtained from pressure energy divided by pressure energy per particle, or $N_0 = p_0/kT_0$ ($= 4.4 \times 10^{44}$ cosmons cm^{-3}); and

$$\rho_E = \frac{3}{4\pi}\sum\frac{e_c}{a^3} = 7.85 \times 10^{26} \text{ e.s.u. cm}^{-3},$$

where e is the charge of a polytropic gas sphere and a its radius. When the cosmonic gas parameter $N_{\max}$ (concentration of cosmons at maximum compaction) is evaluated geometrically from the $N_{\max} = \sqrt{2}/\sigma^2$, using cosmon diameter $\sigma^2 = 1/\sqrt{2}\pi N_0 L_0$, L_0 being cosmon mean free path $h/\rho_0 c$, we obtain a value $N_{\max} = 1.18 \times 10^{67}$ cosmons cm^{-3}.

The value of the Clausius term in the cosmonic gas equation may then be calculated for vacuum at Earth's surface:

$$\frac{b}{V} = \frac{\sigma}{L} = \frac{2\pi N}{N_{\max} - N} = 2.34 \times 10^{-22}.$$

Considering the order of magnitude involved, the agreement obtained between ratios formed from experimentally known values G, m_E, e, on the one hand, and values derived from the description of the electron in terms of cosmonic gas ρ_0, ρ_E and N_0 and $N_{\max}$ (Martin 2005), we can state that the fundamental equations of physics, when expressed as ratios of like quantities, reduce to ratios of cosmon concentrations: $\psi/\phi = \sqrt{G} m_E / e = 2\pi N_0 / (N_{\max} - N_0)$. The parameters of cosmonic gas theory would thus appear to be corroborated by experimentally known values.

The mechanism of gravity

In the cosmonic gas, gravitation is accounted for by this extra term added to the equation of state of an ideal gas by Clausius to account for the finite volume occupied by the particles, the cosmons in this instance. The added term is a negative dimensionless factor multiplying the static pressure in the ideal gas equation. The product of the static pressure and the Clausius term (simply the ratio of cosmon diameter to mean free path) will be called gravitational pressure, denoted $p_G = -p\left(2\pi N / [N_{\max} - N]\right)$.

In the viewpoint of a contiguous fluid, a force is produced by a pressure gradient over an element of gas volume. For the case of gravitation, the force is due to the gradient of the ratio of gravitational pressure p_G to mass density (force/unit mass):

$$-\mathrm{grad}\left(\frac{p_G}{\rho}\right) \to -\mathrm{grad}\,\phi_M = -\frac{GM}{r^2} = \text{acceleration}\ .$$

Force density per gas volume element is thus $-\left(GM/r^2\right)\rho$, and the force on a test mass is just $-\left(GM/r^2\right)m$. The equations of gravitation, which have been used successfully since Newton, emerge from this fundamental relation. However, this does not elucidate the mechanism of gravitation, which must be explained from the properties of the cosmonic gas.

In the cosmonic gas, the gravitational pressure term p_G is a negative pressure—as is gravity—acting against the static pressure of the gas. Around each massive body, the difference of these two pressures must result in constant vacuum pressure p_0 in order to satisfy the equilibrium condition. As the mass increases, the static pressure p therefore increases to compensate for the increasing number density N, according to

$$p\left(1 - \frac{2\pi N}{N_{\max} - N}\right) = NkT = p_0 \text{ constant, or } p_G = p - p_0$$

We thus see that in the gravitational field of each mass, temperature T has to *decrease* as *N increases*, keeping vacuum pressure $p_0 = N_0 k T_0$ constant. (There is no mass outside material bodies.)

Expressed in cosmonic gas terms, the gradient of gravitational potential would then take the form:

$$-\text{grad}\left(\frac{p_G}{\rho}\right) = -\text{grad}\,\frac{p}{\rho}\left(\frac{2\pi N}{N_{\max} - N}\right) + \frac{p}{\rho}\left(\text{grad}\,\frac{2\pi N}{N_{\max} - N}\right)$$

In other words, increase of cosmon density disturbs the equilibrium of the gravitational field of each body acting on each element of volume of the other, creating a cooling effect. This is a local phenomenon which transforms the internal energy of each element of volume into kinetic energy of free fall. The cooling is due to the fact that the body's internal energy is distributed over a greater number of particles as it moves into a region of higher cosmon density. The process is perfectly reversible; in Keplerian orbital motion, when masses move away from each other, kinetic energy is transformed back into heat as masses enter the warmer parts of gravitational fields. There is no transfer of energy or momentum between the two fields, as each mass remains constant during the whole orbit. Hence there is no need for the concept of gravity propagation speed. It can be treated as zero, in accordance with observation. (Van Flandern and Vigier, 2002) There is a change of mass only in non-elastic collisions of two bodies, as observed in astronomy.

Mass and inertia

The main difference between the behaviour of cosmons and the behaviour of molecules is due to the fact that cosmons travel in a void, while molecules travel in cosmonic gas, which is viscous. Mechanical resonances in the cosmonic gas (quantum conditions) neutralize viscosity effects, thus permitting the existence of long-lived phenomena. At the gas level, the definition of mass, applied to any kind of energy, is $m = E/c^2$.

As shown above, the gravitational pressure around each mass is equivalent to the static pressure of the cosmonic gas multiplied by the ratio of cosmon numerical concentration N to the maximum concentration $N_{\max}$. Inertia is likewise determined by cosmonic gas properties. Every moving fundamental particle is accompanied by a spherical vortex having energy equivalent to the kinetic energy of the particle. An applied force on a mass produces an acceleration. And when a mass is accelerated, an Euler reaction force is produced that is equal and opposite to the applied force.

At the cosmon level, however, the void surrounding each cosmon has no momentum or energy, and thus there is no gravitation potential or inertia. Consequently, the three conditions for mass are not present at the cosmon level. An individual cosmon therefore has no rest mass or dynamical mass, since these are phenomena at the cosmonic gas level. The step from a medium of continuous density (the cosmonic gas) to a particulate medium (the cosmon) requires division by particle concentration N, which yields a statistical mean cosmon mass μ, as required by the equations of kinetic gas theory.

No singularities

If we posit that the ratio of cosmon diameter to mean free path is equal to the ratio of a fundamental (minimal) radius R_1 to radius r, *i.e.*,

$$\frac{R_1}{r} = \frac{\sigma}{L} = \frac{2\pi N}{N_{\max} - N}$$

then a relation is obtained for the variation of N along the radius of a gravitational field:

$$N = \frac{N_{\max}}{\left[\left(2\pi r/R_1\right) + 1\right]}. \qquad (4)$$

At $r = R_1$ the cosmon mean free path $L = \sigma$ (cosmon diameter), and the cosmon concentration becomes $N = 0.1373\ N_{\max}$, which nullifies the factor multiplying the static pressure in (3) above. Gravitational pressure (centripetal) therefore equilibrates static pressure (centrifugal) at $r = R_1$. Outside the fundamental radius, the negative gravitational term $p\sigma/L$ is always smaller than the static pressure. At the fundamental radius, it is equal to but of opposite sign to the static pressure term. The gravitational forces just counterbalance the static pressure forces. Inside the fundamental radius, gravity dominates and the cosmon density varies from $N_{\max}$ at the centre to 0.1373 $N_{\max}$ at the fundamental radius R_1.

The Schwarzschild solution to the Einstein field equations of General Relativity gives a relation between time t as observed from a great distance from a massive object and proper time τ as measured by a clock in free fall toward the object, including the effect of velocity $v = dr/dt$ as found in special relativity. According to Thorne *et al.* (1990) at $r = R_S = 2GM/c^2$, the observed time t becomes infinite while proper time τ remains finite all the way to the centre of the object, assuming a point mass. It is well known that the Schwarzschild solution is valid only outside R_S, as the Newtonian form of gravitational potential $\Phi = GM/r$ is valid only outside the radius of the mass. This could mean that the entire mass of a body must be within its Schwarzshild radius, with its density spherically distributed. In the case of the cosmonic gas, the radius R_1 is where the centrifugal and centripetal forces are equal and opposite, making the factor $(1 - 2\pi N/N_{\max} - N) = 0$, irrespective of the value of static pressure p. The resultant pressure $NkT = p_0 = N_0kT_0$, would require an infinite static pressure p at $r = R_1$. Since at the centre of the mass, due to maximum compaction $N_{\max}$, the mean free path $L = 0$, temperature $T = 0$, root mean speed $C = 0$, static pressure $p = 0$, and mass density $\rho = 0$. At R_1 it becomes physically impossible to have p = infinite, especially in a gas.

The static pressure should vary smoothly for an observer entering into the mass from vacuum value p_0 at great distance from the body to a maximum value at the surface of the body, then decreasing to 0 as the observer approaches the mass centre. The variation of pressure from maximum to 0 inside the mass depends on the spherical distribution of mass density. In a gas this distribution cannot be other than smooth, thus producing a smooth variation through R_1, even for black holes. There are no singularities!

Discussion

Throughout most of space there are no solid surfaces in the cosmonic gas, except perhaps near the centres of black holes and high density concentrations. To define static pressure in the cosmonic gas, we must appeal to the definition of kinetic gas theory: static pressure $p = \rho C^2 / 3$ is pressure energy per unit volume, with C the root mean square of the random speed of cosmons. This is irrespective of encounters, the reason being that the root mean square of cosmon speed does not vary, whether there are encounters or not.

Static pressure is a scalar, since random speed is assumed equal in all directions. This argument rests on the fact that the energy of each particle in an element of volume—including heat energy $e = \rho C^2 / 2$—does not depend on volume, but only on temperature, *i.e.*, $p + e = NkT5/2$.

To determine cosmon parameters a zero point datum of the cosmonic gas is required. Due to particle-antiparticle charge symmetry, values at the centre of the electron-positron configuration can be taken as the zero point vacuum values for physical measurements. Vacuum properties that emerged from a study of electron structure in the cosmonic gas (Martin, 2005) are as follows: the cosmon mean free path is $L_0 = 2 \times 10^{-3}$ m; the cosmon diameter is $\sigma = 4.93 \times 10^{-25}$ m; the cosmon vacuum density is $N_0 = 4.4 \times 10^{50}$ m^{-3}, while $N_{max} = 1.18 \times 10^{73}$ m^{-3}. As a result, cosmons rarely encounter other cosmons in the lighter fundamental particles with radius on the order of 10^{-15} m.

In electromagnetism, where the gradient of *total* pressure acts only on *electric charge density* (Martin 1994), whereas in gravitation the gradient of *gravitational* pressure (*static* pressure multiplied by the Clausius term) acts only on *material mass density* (of test particles).

In both gravitation and electrostatics, the potential is in the form $\int \rho 4\pi r^2 dr / r$. The potential around each individual source is obtained by integrating its mass and adding the potentials arithmetically for many sources. In certain cases the force field given by $-\text{grad}\phi$ for each source may be added to other fields vectorially to obtain the direction of the resultant force. The divergence of the force field is $\text{div} g = G 4\pi\rho$ for gravitation, and $\text{div} E = 4\pi(\rho_E)$ for electrostatics, giving the gravitational and electrical densities respectively. It is noteworthy that electrostatics is fully described by replacing mass, pressure, gravitational potential, and gravitational force field with charge, total pressure, electrical potential, and electrical force field and setting the gravitational constant $G = 1$ in the same equations.

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