The Gaussian Law of Gravitation under Collision Space-Time

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Abstract

In this short note, we present the Gaussian law of gravitation, based on the concept that the mass is collision-time, see our paper Collision Space-Time, [1].

Key Words: Newton gravitation, Gaussian law, standard theory, collision space-time theory.

1 The Gaussian Law of Gravitation for Modern Newton and Collision-Space-Time

Newton's [2] law of gravitation is normally given by

$$F = G\frac{Mm}{r^2} \tag{1}$$

this is the case historically, even though Newton himself never introduced or described the gravitational constant G, see [1]. We can, therefore, call this the modern version of the Newton formula; the original Newtonian formula that Newton only stated by words was simply $F = \frac{\bar{M}\bar{m}}{r^2}$, where we are deliberately using the notation for mass $\bar{M}$, as Newton's view on matter was very different from the modern view on matter, and is much more in line with the mass definition in collision-space-time. Newton's law of gravitation has a corresponding Gaussian law of gravitation that we will look at here. In collision-space-time, the Newton force formula is given by

$$\bar{F} = c^3\frac{\bar{M}\bar{m}}{r^2} \tag{2}$$

when defining mass as $\bar{M} = \frac{l_p}{c}\frac{l_p}{\bar{\lambda}}$, where l_p is the Planck length, [3, 4], and $\bar{\lambda}$ is the Compton wavelength [5]. This mass indeed has units of time, and is what we call "collision-time," as it is related to the collision between indivisible particles, see [1]. Be aware that the Planck length can be found independent of any knowledge of G, see [6]. The modern Newtonian formula and the Haug-Newtonian formulas for gravitation do not give the same output, but after further derivations for all observable gravitational phenomena, they give the same predictions. The Haug formula is actually closer to Newton's original description than the modern Newton formula; what is now known as Newton's gravitational constant was actually first introduced in a footnote by Cornu and Baille in 1873, see [7].

The Gaussian law of gravitation in differential form, when we use the standard (incomplete) mass definition, is the well-known formula

$$\nabla \cdot \boldsymbol{g} = -4\pi G\rho \tag{3}$$

where ρ is the mass density at each point, $\rho = \frac{m}{V}$, and $\boldsymbol{g} = -\nabla\phi$, where ϕ is a scalar field, so we get the well-known formula (Poisson's equation)

$$\nabla^2\phi = 4\pi G\rho \tag{4}$$

while under collision space-time, we get

$$\nabla \cdot \boldsymbol{g} = -4\pi c^3\rho_c \tag{5}$$

where ρ_c is the mass density at each point, $\rho_c = \frac{\bar{m}}{V}$, and $\boldsymbol{g} = -\nabla\phi$, where ϕ is the gravitational scalar field, so we get (Poisson's equation)

$$\nabla^2\phi = 4\pi c^3\rho_c \tag{6}$$

The gravitational potential is a function of only one variable, $r = |\boldsymbol{r}|$, in radially symmetric systems. The Poisson equation then becomes

$$\frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial}{\partial r}\phi\right) = 4\pi c^3\rho_c(r) \tag{7}$$

and the gravitational field

$$\boldsymbol{g}(r) = \boldsymbol{n}_r\frac{\partial\psi}{\partial r} \tag{8}$$

where $\boldsymbol{n}_r$ is a unit vector.

In collision space-time it is important to bear in mind that the mass is defined as collision-time, namely $\bar{m} = \frac{l_p}{c}\frac{l_p}{\bar{\lambda}}$, where l_p is the Planck length. Further, $\bar{\lambda}$ is the reduced Compton wavelength, and c is naturally the speed of light (gravity). We also have that $GM = c^3\bar{M}$, as discussed by [6]. Our new Gaussian law and its formula of gravitation, however, give a very different interpretation than the standard view; it is now at least partly compatible with quantum gravity, as all masses contain the Planck length. In addition, it seems like the speed of light now plays a central role in Newtonian gravity as seen from this angle. The mass density in collision-space time is also a collision time density, where elementary masses are ticking at the Compton frequency.

We could also have expressed our equations in integral form. When using the standard mass definition, we have the well-known

$$\oint_{\partial V}\boldsymbol{g}\cdot d\boldsymbol{A} = -4\pi G\rho \tag{9}$$

while under collision space-time when we are using the collision-time mass definition, we get

$$\oint_{\partial V}\boldsymbol{g}\cdot d\boldsymbol{A} = -4\pi c^3\rho_c \tag{10}$$

where $d\boldsymbol{A}$ is a vector, whose magnitude is the area of an infinitesimal piece of the surface ∂V. The standard form of the equation when using the standard mass definition is

2 The Gaussian Law of Gravity from the Lagrangian

The modern Lagrangian density for modern Newtonian gravity is given by the well-known equation

$$\mathcal{L}(\boldsymbol{x},t) = -\rho(\boldsymbol{x},r)\Phi(\boldsymbol{x},r) - \frac{1}{8\pi G}(\nabla\Phi(\boldsymbol{x},r))\cdot(\nabla\delta\Phi(\boldsymbol{x},r)) \tag{11}$$

where the density $\mathcal{L}$ has units of $J\cdot m^{-3}$. The mass density here is ρ and has units $kg\cdot m^{-3}$.

Under collision-space-time we will have

$$\mathcal{L}(\boldsymbol{x},t) = -\rho_c(\boldsymbol{x},r)\Phi(\boldsymbol{x},r) - \frac{1}{8\pi c^3}(\nabla\Phi(\boldsymbol{x},r))\cdot(\nabla\delta\Phi(\boldsymbol{x},r)) \tag{12}$$

The mass density ρ_c has units $s\cdot m^{-3}$, which represent the collision-time density.

After doing the variation of the integral with respect to Φ and integrating by parts, the "final" formula becomes

$$\nabla^2\Phi(\boldsymbol{x},r) = 4\pi c^3\rho_c(\boldsymbol{x},r) \tag{13}$$

which basically is the Gaussian law of gravity for collision-space-time.

3 Further discussion

The formulas we have presented above are robust mathematically from a derivation perspective. One of the main issues with the field equation for Newton's gravity $\nabla^2\phi = 4\pi G\rho$ is that gravity seems to be instantaneous. If the matter density ρ changes, then it seems like the gravity field changes instantaneously. We are not fully certain if this is also the case with our new field equation: $\nabla^2\phi = 4\pi c^3\rho_c$.

One speculative idea would be to follow an approach similar to what Nördstrom [8, 9] originally did with the standard Newton field equation to change the Laplace-operator, $\Delta = \nabla^2$ with a d'Alembert operator $\Box = \frac{1}{c^2}\frac{\partial^2}{\partial t^2} - \nabla^2$, something that would give

$$\Box\phi = 4\pi c^3 \rho_c \tag{14}$$

That supposedly would ensure that the gravitational information propagates at the speed of light. However, there could be other issues with this method and further investigation is needed to evaluate whether or not the potential gravitational field equations are compatible with collision space-time.

4 Conclusion

We have presented a Gaussian law of gravitation based on original Newtonian gravity, combined with new insights on mass and gravity from collision space-time theory. This gives a Gaussian law gravitational formula $\nabla^2\phi = 4\pi c^3\rho_c$, which directly contains c and also a collision-time-density ρ_c, that is a deeper and in our view a more correct way to look at mass. Whether or not this alone gives a speed of gravity equal to the speed of light we need to investigate further. Interestingly, one can extract the speed of light (gravity) directly from gravitational observations with no prior knowledge of G, c, or h, as we recently have demonstrated [10, 11].

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