The Gaussian Law of Gravitation under Collision Space-Time

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October 23, 2020

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 matter density at each point and $\boldsymbol{g} = -\nabla\phi$ is the field strength of the gravitational field, 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 matter surface density at each point, 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 equation basically describe how mass generates gravitational potential. If 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

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

where M_i is the mass in kg inside the Gauss surface. while under collision space-time when we are using the collision-time mass definition, we get

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

where $d\boldsymbol{A}$ is a vector, whose magnitude is the area of an infinitesimal piece of the surface ∂V. Further $\bar{M}_i$ is the collision-time mass inside the Gauss surface.

It is worth noticing that we actually have

$$\nabla^2 \phi = 4\pi c^3 \rho_c = 4\pi G \rho \tag{11}$$

This is because $GM = \frac{l_p^2 c^3}{\hbar}\frac{l_p}{\bar{\lambda}}\frac{1}{c} = c^3 \frac{l_p}{c}\frac{l_p}{\bar{\lambda}} = c^3\bar{M}$. When we understand that G is nothing more than a composite universal constant, $G = \frac{l_p^2 c^3}{\hbar}$, which actually contains $\hbar$ to remove the Planck's constant from the incomplete kg mass definition of modern physics and to incorporate the Planck length into the mass, and also to get the speed of light (gravity) into the equation, then one can gain a better perspective on what gravity and mass truly are, see also [1, 6, 8]. This is more than a change of notation, while standard gravity theory here needs three universal constants, G, h and c we only need two, that is c and l_p as discussed in more detail by [9].

2 The Gaussian Law of Gravity from the Lagrangian

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

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

where the density $\mathcal{L}$ has units of $J \cdot m^{-3}$.

Under collision-space-time we will have

$$\mathcal{L}(\boldsymbol{x}, t) = -\rho_c(\boldsymbol{x}, r)\Phi(\boldsymbol{x}, r) - \frac{1}{8\pi c^3}(\nabla\Phi(\boldsymbol{x}, r)) \cdot (\nabla\delta\Phi(\boldsymbol{x}, r)) \tag{13}$$

The mass density ρ_c is the collision-time density, which is a a re-defined mass density based on the view that mass at the deepest level can be represented as collision-time $\bar{m} = \frac{l_p}{c}\frac{l_p}{\bar{\lambda}}$.

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

$$\nabla^2\Phi(\boldsymbol{x}, r) = 4\pi c^3 \rho_c(\boldsymbol{x}, r) \tag{14}$$

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 [10, 11] 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

$$\Box\phi = 4\pi c^3\rho_c \tag{15}$$

This would be a parallel to the Nördstrom 1912 model [10], but based on a collision-time definition of mass. An alternative would be to create a parallel to the Nördstrom 1913 model [11], which would be

$$\phi\Box\phi = -4\pi c^3 T_m \tag{16}$$

where T_m is the trace of the material stress-energy tensor, $T_{\mu v}$. Both of these alternatives should ensure that the gravitational information propagates at the speed of light. However, there could be other considerations, Including issues with the original Nördstrom theories. Further investigation is needed to evaluate whether or not the potential gravitational field equations are compatible with collision space-time and naturally also with gravitational observations.

Let us also go back to the standard Newtonian field equation, which is given by $\nabla^2\phi = 4\pi G\rho$. In 1899, Max Planck obtained the Planck units using dimensional analysis by assuming there were three universal fundamental constants, G, h, and c; from this he got a unique time, length, mass, and energy given by $l_p = \sqrt{\frac{G\hbar}{c^3}}$, $t_p = \sqrt{\frac{G\hbar}{c^5}}$, $m_p = \sqrt{\frac{\hbar c}{G}}$, and $E_p = \sqrt{\frac{\hbar c^3}{G}}$. There is nothing wrong mathematically in solving these with respect to G; this gives: $G = \frac{l_p^2 c^3}{\hbar}$, $G = \frac{t_p^2 c^5}{\hbar}$, $G = \frac{\hbar c}{m_p^2}$, and $G = \frac{\hbar c^5}{E_p^2}$. The fact that G was invented before the Planck units, G being in 1873 and the Planck units in 1899, does not mean that it is more fundamental. We will claim that G is a composite constant, and that it is the Planck length and the speed of light that are the only necessary universal fundamental constants, see also [1, 8]. Some will likely protest here, as it is assumed one needs to know G first, in order to calculate the Planck units. If that was the case, then setting G as a function of the Planck units would just introduce a circular problem. However, we have clearly demonstrated that the Planck units can be found without any knowledge of G, see [6, 9, 12]. This means we can rewrite the Newtonian field equation as

$$\nabla^2\phi = 4\pi\frac{l_p^2 c^3}{\hbar}\rho = 4\pi\frac{t_p^2 c^5}{\hbar}\rho = 4\pi\frac{\hbar c}{m_p^2}\rho = 4\pi\frac{\hbar c^5}{E_p^2}\rho \tag{17}$$

That is, we now have the speed of light visible in the field equation, even if it is basically the same field equation as before. The question is if this can lead to any significant new interpretation of the standard field equation. However, as we clearly can see, this field equation contains more constants than our new field equation $\nabla^2\phi = 4\pi c^3\rho_c$. The reason for this is that our model is based on an understanding that the current mass definition is incomplete. The standard mass contains the Planck constant, something that is supported by the concept that the new kg definition is directly linked to the Planck constant. The Planck constant embedded in the gravitational constant is needed to get the Planck constant out of the incomplete mass definition.

Table 1 summarize the field equations based on the Gaussian law we have mentioned here.

	Field equation differential form	**Field equation integral form**
Standard	$\nabla^2\phi = 4\pi G\rho$	$\oint_{\partial V} \boldsymbol{g}\cdot d\boldsymbol{A} = -4\pi G M_i$
Composite gravitational constant view: $G = \frac{l_p^2 c^3}{\hbar}$	$\nabla^2\phi = 4\pi\frac{l_p^2 c^3}{\hbar}\rho$	$\oint_{\partial V} \boldsymbol{g}\cdot d\boldsymbol{A} = -4\pi\frac{l_p^2 c^3}{\hbar}M_i$
$G = \frac{t_p^2 c^5}{\hbar}$	$\nabla^2\phi = 4\pi\frac{t_p^2 c^5}{\hbar}\rho$	$\oint_{\partial V} \boldsymbol{g}\cdot d\boldsymbol{A} = -4\pi\frac{t_p^2 c^5}{\hbar}M_i$
$G = \frac{\hbar c}{m_p^2}$	$\nabla^2\phi = 4\pi\frac{\hbar c}{m_p^2}\rho$	$\oint_{\partial V} \boldsymbol{g}\cdot d\boldsymbol{A} = -4\pi\frac{\hbar c}{m_p^2}M_i$
$G = \frac{\hbar c^5}{E_p^2}$	$\nabla^2\phi = 4\pi\frac{\hbar c^5}{E_p^2}\rho$	$\oint_{\partial V} \boldsymbol{g}\cdot d\boldsymbol{A} = -4\pi\frac{\hbar c^5}{E_p^2}M_i$
Collision space-time	$\nabla^2\phi = 4\pi c^3\rho_c$	$\oint_{\partial V} \boldsymbol{g}\cdot d\boldsymbol{A} = -4\pi c^3\bar{M}_i$

Table 1: The table shows the different field equations we have discussed, based on the Gaussian law.

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 and gravity. 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 [9, 13].

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