Calculation of Inertial Masses Based on their Spacetime Curvature

Ivo Draschkow[1]

[1] Independent researcher

E-mail: ivo@draschkow.de

Received xxxxxx
Accepted for publication xxxxxx
Published xxxxxx

Abstract

This paper introduces a relativistic way to perform the calculation of inertial mass along with the purely mathematically derived gravitational constant $\boldsymbol{G}$, which has only been determined experimentally so far. The limits for a weak point mass are used to precisely calculate $\boldsymbol{G}$ without any further measurments. The accuracy of $\boldsymbol{G}$ depends only on the accuracy of the measurement of the speed of light. Mass is revealed not to be scalar, not invariant, and its units can be expressed in terms of time and space.

Keywords: Spacetime Flow Rate — Gravitational Constant — Lorentz Factor

1. Introduction and Preliminary Considerations

The relativistic nature of gravity has long been known but to date it has not impacted the understanding of inertial mass. The strict correlation of an object's size and gravity with its local relativistic transformations leads to the question, whether a supplementary gravitational component or constant is really necessary to determine the inertial mass of the object. If only a certain amount of inertial mass can result from a given mean radius paired with a given surface gravity, then the latter two components might suffice to determine it, just as they suffice to give us its whole profile of time dilation.

We need to go back to the basics of general relativity to find the overseen pieces. From the perspective of an observer within a gravitational field, everything outside the field would be moving faster because his own time is running out more slowly. However, since the speed of light must remain constant, the universe is going to have smaller dimensions from his vantage point than from the vantage point of an observer outside the field. What the observer gains in time, he thus loses in space: within a gravitational field his reality would be partially deflected from space to time. That deflection illustrates the gravitational contraction of length - one could say his surrounding universe is denser. I think that it makes sense, that this omnidirectional increase in density could represent the local phenomenon we call inertial mass.

Gravitational time dilation depicts how space curves into time, generating a maximum deflection at the center of mass and forming a corresponding volume within the curvature. The larger this volume is, the better the object eludes temporal progress. This drag may be the reason for its inertia and hence its inertial mass. My results will show that the specific amount of a relativistic gravitational contraction $\boldsymbol{L}$ with respect to the radius of a gravity-generating object is directly proportional to its mass. Its maximum value is known as the Schwarzschild radius $\boldsymbol{r_S}$ and is already accepted by science as being directly proportional to a Black Hole's mass. My derivation shows that not only that extreme case, but any gravitationally caused relativistic contraction of an object is directly proportional to its mass. $\boldsymbol{L}$ produces a mass-specific relativistic spectrum between $\boldsymbol{r_S}$ and a corresponding $\boldsymbol{r_{min}}$ for which the mass volume is large enough for gravity to tend to zero.

2. What is Moving - the Spacetime or the Object?

By common understanding, every object should be moving through spacetime at the speed of light. The main approach of this work is the assumption, that spacetime itself actively spreads with the speed of light in the form of a replicative expansion. Such a spacetime would have an accelerating flow rate $\boldsymbol{Q_S = c^3}$, since the volume of space created increases eightfold with each doubling of the directional distance with regard to a coordinate system.

3. Basic Derivation of Inertial Mass

If matter and thus inertial mass were the result of a condensed spacetime flow, the approach should be similar to how multiplying between material density, volumetric flow rate and time gives mass in a classic flow scenario:

$$\boldsymbol{M = \varrho \cdot Q \cdot t} \qquad (1)$$

For the density $\boldsymbol{\varrho}$ I assumed that it could be substituted by the relativistic contraction $\boldsymbol{L}$ since it should be directly proportional to mass and hence to $\boldsymbol{\varrho}$. Instead of an arbitrary period $\boldsymbol{t}$, I use a proportionality factor $\boldsymbol{k_M}$ to basically check for correlation:

$$\boldsymbol{M = L \cdot Q_S \cdot k = L \cdot c^3 \cdot k_M} \qquad (2)$$

4. Radial Gravitational Lorentz Contraction

Typically, to obtain the gravitational time dilation on a mass surface, the reciprocal Lorentz factor $\boldsymbol{\alpha}$ depending on the surface escape velocity $\boldsymbol{v_{Em}}$, which is expressed by the mean radius $\boldsymbol{r_m}$ and surface gravity $\boldsymbol{g_m}$, can be used to avoid $\boldsymbol{G}$.

$$\boldsymbol{\alpha = \sqrt{1 - \frac{v_{Em}{}^2}{c^2}} = \sqrt{1 - \frac{2g_m r_m}{c^2}}} \qquad (3)$$

For time dilation states below the surface of the mass, the Lorentz factor must be adjusted according to the gravitational potential to provide correct data. Although the density distribution within a celestial body is individual, any mass of a body can be extrapolated using an idealized, average density or uniform distribution. Assuming direct proportionality to $\boldsymbol{\varrho}$, the same should hold for $\boldsymbol{L}$. With this in mind, we should be able to get correct masses based on a formula that assumes an uniformly dense body. At a corresponding radius $\boldsymbol{r_x}$

$$\boldsymbol{\alpha(r_x) = \sqrt{1 - \frac{g_m\,(3{r_m}^2 - {r_x}^2)}{r_m c^2}}} \qquad (4)$$

is going to deliver the locally appropriate Lorentz factor. We can use this optimized function to obtain the searched amount of relativistic contraction $\boldsymbol{L}$. To do this, we just need to integrate $\boldsymbol{1-\alpha(r_x)}$ from 0 to $\boldsymbol{r_m}$:

$$\boldsymbol{L} = [\boldsymbol{L(r_x)}]_{\boldsymbol{0}}^{r_m} = \boldsymbol{2} \cdot \int_{\boldsymbol{0}}^{r_m} \boldsymbol{(1-\alpha(r_x))dr_x}$$

$$= \int_{\boldsymbol{0}}^{r_m} \left(\boldsymbol{1 - \sqrt{1 - \frac{g_m\,(3{r_m}^2 - {r_x}^2)}{r_m c^2}}}\right)\boldsymbol{dr_x} \qquad (5)$$

For our earth $\boldsymbol{L}$ is ~**0.0059** m and for our sun ~**1971.02** m, which is not very far from their Schwarzschild radii $\boldsymbol{r_S}$. In the case of a Black Hole $\boldsymbol{L_{max} = r_m = r_S}$, because $\boldsymbol{\alpha(r_S) = 0}$ leads to $\boldsymbol{L_{max} = (1-\alpha(r_s)) \cdot r_m = r_S}$. The radius of the object would be completely contracted relativistically and therefore directly proportional to the Black Hole's mass.

$$\boldsymbol{M} = \int_{\boldsymbol{0}}^{r_m} \left(\boldsymbol{1 - \sqrt{1 - \frac{g_m\,(3{r_m}^2 - {r_x}^2)}{r_m c^2}}}\right)\boldsymbol{dr_x \cdot c^3 \cdot k_M} \qquad (6)$$

To determine $\boldsymbol{k}$ I divide the derived formula by the classic one eliminating the relativistic influence:

$$\boldsymbol{k_M} = \lim_{(g_m, r_m)\to(0,0)} \int_{\boldsymbol{0}}^{r_m} \boldsymbol{(1-\alpha(r_x))dr_x \cdot c^3 : \frac{g_m {r_m}^2}{G}} \qquad (7)$$

$$= \boldsymbol{37.5}\,\frac{m^4}{kg \cdot s^3}$$

It becomes obvious that $\boldsymbol{k_M}$ must contain the multipliers $\boldsymbol{G}$ and a speed, presumably $\boldsymbol{c}$. A remaining, purely numerical proportionality factor $\boldsymbol{k_{SI}}$ would establish the relationship between the SI unit $\boldsymbol{kg}$ and its spacetime expression.

$$\boldsymbol{M} = \int_{\boldsymbol{0}}^{r_m} \left(\boldsymbol{1 - \sqrt{1 - \frac{g_m\,(3{r_m}^2 - {r_x}^2)}{r_m c^2}}}\right)\boldsymbol{dr_x\, Gc^4 \cdot k_{SI}} \qquad (8)$$

$$\boldsymbol{k_{SI} = 1875} \qquad (9)$$

We can now determine the resulting units of my formula:

$$\boldsymbol{M} \rightarrow kg = m \cdot \frac{m^4}{s^4} \cdot \frac{m^3}{kg \cdot s^2} \rightarrow kg = \sqrt{\frac{m^8}{s^6}} = \frac{m^4}{s^3} \qquad (10)$$

That would lead to:

$$\boldsymbol{1}\,kg = \boldsymbol{1875}\,\frac{m^4}{s^3} \qquad (11)$$

We have proof that mass can be expressed in pure spacetime units. The integer value of $\boldsymbol{k_{SI}}$ can only be explained by the meter being derived from $\boldsymbol{c}$, which made $\boldsymbol{c}$ itself an integer. With these units the gravitational constant $\boldsymbol{G}$ would receive a very appropriate role as an expansion pace concerning the condensed spacetime propagation:

$$\boldsymbol{G} \rightarrow \frac{m^3}{kg \cdot s^2} = \frac{m^3 \cdot s^3}{m^4 \cdot s^2} = \frac{s}{m} \qquad \boldsymbol{1}\,\frac{m^3}{kg \cdot s^2} = \frac{s}{\boldsymbol{1875}\,m} \qquad (12)$$

If we look at the reciprocal of the speed of light, there might be a connection in this regard. Uncondensed spacetime would have a pace that equals $\boldsymbol{1/c}$ and would be a multiple of $\boldsymbol{G}$. Being a pace, $\boldsymbol{G}$ would express how much time is needed to generate one meter of condensed space. A multiplication between $\boldsymbol{c}$ and $\boldsymbol{G}$ gives a unitless factor, which means that $\boldsymbol{k_M}$ is ultimately also unitless:

$$\boldsymbol{k_M = 37.5} \qquad (13)$$

To work with my formula in pure spacetime units, $\boldsymbol{k_{SI}}$ has to be set to the power of three:

$$\boldsymbol{M = L \cdot c^4 \cdot G \cdot {k_{SI}}^3} \qquad (14)$$

It is time to do a quick check of the mass result for our Earth, still using the experimentally measured $\boldsymbol{G}$:

$$\boldsymbol{r_m} = 6371000\,m \qquad \boldsymbol{g_m} = 9.807\,\frac{m}{s^2}$$

M⊕ = 0.00590719828**299792458^4****6.6742*10^-11*****1875*

$\approx \boldsymbol{5.97 \cdot 10^{24}}\ \frac{m^4}{1875 s^3}\,(kg)$ → agrees with the NASA reference

Using the derived and fixed value for $\boldsymbol{k_{SI}}$, the results also do not differ from the NASA reference for any other celestial body in our solar system when using the correct mean values for $\boldsymbol{g_m}$ and $\boldsymbol{r_m}$.

5. Precise Calculation of the Gravitational Constant

With the classic formula

$$\boldsymbol{M} = \frac{\boldsymbol{g_m r_m}^2}{\boldsymbol{G}} \tag{15}$$

different $\boldsymbol{g_m}$ and $\boldsymbol{r_m}$ always lead to identical masses as long as the product $\boldsymbol{g_m r_m}^2$ is fixed. However, in my formula they do not provide a constant $\boldsymbol{L}$, but produce a relativistic spectrum. Dividing the limits of $\boldsymbol{L}$ depicts it:

$$\boldsymbol{L_{max}} = \boldsymbol{r_s}$$

$$\boldsymbol{L_{min}} = \int_0^{r_m} \frac{\boldsymbol{g_m}\,(3\boldsymbol{r_m}^2 - \boldsymbol{r_x}^2)}{2\boldsymbol{r_m c}^2}\, dr_x = \frac{4\boldsymbol{g_m r_m}^2}{3\boldsymbol{c}^2}$$

$$\frac{\boldsymbol{L_{max}}}{\boldsymbol{L_{min}}} = \frac{2\boldsymbol{g_m r_m}^2}{\boldsymbol{c}^2} : \frac{4\boldsymbol{g_m r_m}^2}{3\boldsymbol{c}^2} = \frac{\mathbf{1.5}}{\mathbf{1}} \tag{16}$$

It is evident that the relativistic spectrum of $\boldsymbol{L}$ closely follows the gravitational potential between the core and the surface. This also means that the mass and gravity of any object according to its classification within this spectrum would be higher compared to the classic calculation. This would particularly be noticeable for its upper limit and thus with Black Holes. Nevertheless, the relativistic effects for planets and pre-supernova stars are negligible and there is almost no relevant difference between the results of both formulas.

Despite the different assumptions on which both formulas are based, it should be possible to calculate $\boldsymbol{G}$ exactly by equating them. However, the equation would only be harmless for the limit value at which $(\boldsymbol{g_m}, \boldsymbol{r_m}) \rightarrow (\mathbf{0}, \mathbf{0})$. Since in this case $\boldsymbol{L}$ and thus also the relativistic effect itself tend to zero, both formulas should deliver identical results for the assumed point mass, from which $\boldsymbol{G}$ can be determined purely mathematically depending only on the accuracy of $\boldsymbol{c}$.

$$\boldsymbol{L} \cdot \boldsymbol{c}^4 \cdot \boldsymbol{G} \cdot \mathbf{1875} = \frac{\boldsymbol{g_m r_m}^2}{\boldsymbol{G}} \qquad \boldsymbol{G} = \sqrt{\frac{\boldsymbol{g_m r_m}^2}{\boldsymbol{L} \cdot \boldsymbol{c}^4 \cdot \mathbf{1875}}} \tag{17}$$

With the limit scenario we get:

$$\boldsymbol{G} = \lim_{(g_m, r_m)\rightarrow(0,0)} \sqrt{\frac{\boldsymbol{g_m r_m}^2}{\boldsymbol{L} \cdot \boldsymbol{c}^4 \cdot \mathbf{1875}}} = \frac{\mathbf{1}}{\mathbf{50} \cdot \boldsymbol{c}}\, \frac{m^4}{kg \cdot s^3} \tag{18}$$

$$\approx \mathbf{6.6712819} \cdot \mathbf{10^{-11}}\, \frac{m^3}{kg \cdot s^2} \approx \mathbf{3.5580170} \cdot \mathbf{10^{-14}}\, \frac{s}{m}$$

This exact result is very likely to be the true value of the gravitational constant. This does not mean that it cannot also show measurable evolutionary fluctuations.

6. Ready-to-Use Formula

As soon as we replace the variables $\boldsymbol{L}$ and $\boldsymbol{G}$ with their above derived data in my basic $\boldsymbol{M} = \boldsymbol{L} \cdot \boldsymbol{c}^4 \cdot \boldsymbol{G} \cdot \boldsymbol{k_{SI}}^3$, we get the finished formula:

$$\boldsymbol{M} = \boldsymbol{k_M} \cdot \boldsymbol{k_{SI}} \cdot \boldsymbol{L} \cdot \boldsymbol{c}^3 \tag{19}$$

$$= \boldsymbol{k_M} \cdot \boldsymbol{k_{SI}} \cdot \int_0^{r_m} \left(\mathbf{1} - \sqrt{\mathbf{1} - \frac{\boldsymbol{g_m}\,(3\boldsymbol{r_m}^2 - \boldsymbol{r_x}^2)}{\boldsymbol{r_m c}^2}} \right) \boldsymbol{dr_x} \cdot \boldsymbol{c}^3$$

7. Exemplary Calculations on Celestial Bodies

According to my previous derivations, we observed that $\boldsymbol{L}$ is subject to a relativistic increase which mainly affects objects under extreme conditions. As a result, the mass of Black Holes with a Schwarzschild radius $\boldsymbol{r_s}$ would be

$$\boldsymbol{M_B} = \boldsymbol{k_M} \cdot \boldsymbol{k_{SI}} \cdot \boldsymbol{r_s} \cdot \boldsymbol{c}^3 = \mathbf{70312.5} \cdot \boldsymbol{r_s} \cdot \boldsymbol{c}^3 \tag{20}$$

To prove the accuracy of my formula, I provide the calculated masses of four celestial bodies in our solar system. Besides $\boldsymbol{c}$, $\boldsymbol{r_m}$ and $\boldsymbol{g_m}$ are the only inputs required, sourced from the referenced NASA and NIST websites.

Moon: $\boldsymbol{r_m} = 1737400\, m \qquad \boldsymbol{g_m} = 1.622\, \frac{m}{s^2}$

$\boldsymbol{M}_{☾}$ = *37.5****0.00007263531*****299792458^3*

$$\approx \mathbf{7.34} \cdot \mathbf{10^{22}}\ \frac{m^4}{1875\, s^3}\ (kg)$$

Venus: $\boldsymbol{r_m} = 6051800\, m \qquad \boldsymbol{g_m} = 8.87\, \frac{m}{s^2}$

$\boldsymbol{M}_{♀}$ = *37.5****0.00481936794*****299792458^3*

$$\approx \mathbf{4.87} \cdot \mathbf{10^{24}}\ \frac{m^4}{1875\, s^3}\ (kg)$$

Earth: $\boldsymbol{r_m} = 6371000\, m \qquad \boldsymbol{g_m} = 9.807\, \frac{m}{s^2}$

$\boldsymbol{M}_{\oplus}$ =*37.5****0.00590719828*****299792458^3*

$$\approx \mathbf{5.97} \cdot \mathbf{10^{24}}\ \frac{m^4}{1875\, s^3}\ (kg)$$

Sun: $\boldsymbol{r_m} = 695700000\, m \qquad \boldsymbol{g_m} = 274\, \frac{m}{s^2}$

$\boldsymbol{M}_{\odot}$ = *37.5****1967.39934309588*****299792458^3*

$$\approx \mathbf{1.99} \cdot \mathbf{10^{30}}\ \frac{m^4}{1875\, s^3}\ (kg)$$

The calculated results agree with the NASA reference values.

8. Conclusions

As initially assumed, inertial mass can be fully calculated by just knowing $\boldsymbol{r_m}$ and $\boldsymbol{g_m}$. The relevant variable in my basic formula is $\boldsymbol{L}$ and it determines the resulting masses entirely by itself. The defining effect of relativity could be the formation of inertial mass, which would thus be of relativistic origin. $\boldsymbol{L}$ ultimately yields the mass amounts by also being a relativistic slider that forms them according to their parameters between the limits described. Moreover, the assumption that mass experiences an additional more or less pronounced relativistic effect with increasing gravitational force is quite conclusive. This is where my results differ from the classic computational methods. A 1.5 times greater mass of a Black Hole compared to its former mass inside a star would be something that science would have to observe astronomically to fully prove my approach.

The values of $\boldsymbol{G}$ measured by science so far appear less accurate than assumed and generally too high.

Since $(\boldsymbol{3g_m r_m}) \rightarrow (\boldsymbol{c^2})$ determines the extreme case for time dilation, the singularity of a Black Hole and thus a complete standstill in time at the center of mass would occur before a mass implosion reaches the Schwarzschild radius. The singularity would begin forming at

$$\boldsymbol{r_{Si}} = \frac{\boldsymbol{3g_m r_m{}^2}}{\boldsymbol{c^2}} \qquad (21)$$

which is 1.5 times the Schwarzschild radius.

Last but not least, the resulting spacetime units indicate the actual existance of the assumed spacetime flow and its possibly exciting consequences.

8.1 Hypotheses

My results could lead to the insight that spacetime has undergone an evolution leading to its condensed states (matter) and the Big Bang does not have to have happened. The universe may have come into being with the advent of quantum ability to systematically replicate and distribute similar states and events that depict time and space. It would be a holistic but open construct of evolving reference systems. Elementary space would be the primary quantum field, time its progression. These spatial fields of possible spacetime quanta would merge with one another and thereby allow the total amount of space and thus our universe to grow.

All of the energy in our universe could be the result of the ever self-expanding spacetime and it would keep increasing in total. The very similar behavior of the assumed density-stable dark energy with regard to the expansion of the universe is a further indication that my approach could be correct. Assuming that our universe simply possessed a definite and fixed amount of energy from the start does not make more sense than assuming that this energy could be due to external sources. We have abolished the static universe, but not yet its energetic static: this could change now.

There could even be a very interesting connection with the CMB if, contrary to current assumptions, the CMB were constant and not decreasing: the universe would be working like a sustained cavity resonator i.e. replicator. Being an open system, such a spacetime resonator would not deviate from the characteristics of a black body object: full absorption in its directions of expansion with the CMB temperature generating periodic, replicative vibrations representing an excitation frequency. After all, the classic formula describing damped natural frequencies

$$\boldsymbol{\omega_d = \omega_n \cdot \sqrt{1 - \zeta^2}} \qquad (22)$$

corresponds to the escape velocity resulting from the Lorentz factor:

$$\boldsymbol{v_{Em} = c \cdot \sqrt{1 - \alpha^2}} \qquad (23)$$

When comparing both formulas, there is a clear analogy: unattainable states for both, $\boldsymbol{\omega_d}$ and $\boldsymbol{v_{Em}}$, system predetermining constants and damping / contraction ratios. In such a scenario, $\boldsymbol{c}$ per distance could be playing the role of a natural, undamped diffusion frequency of spacetime, while the CMB would generate the excitation and thus spacetime replication frequencies.

Evolution may have elegantly misused this whole process for its main goal - quantum distribution and condensation. In this way it may have nested the diffusion strive energy by shaping it into higher complexity that we call matter. There is of course a catch with my calculation basis: should this primary form of replication ever end, spacetime would vanish instantaneously. In contrast, the universe of the Standard Model is a closed machine that consistently unfolds according to given design principles and is condemned to an immutable energy volume.

References

[1] NASA Space Science Data Coordinated Archive, Moon Fact Sheet. Retrieved from https://nssdc.gsfc.nasa.gov/planetary/factsheet/moonfact.html

[2] NASA Space Science Data Coordinated Archive,Venus Fact Sheet. Retrieved from https://nssdc.gsfc.nasa.gov/planetary/factsheet/venusfact.html

[3] NASA Space Science Data Coordinated Archive, Earth Fact Sheet. Retrieved from https://nssdc.gsfc.nasa.gov/planetary/factsheet/earthfact.html

[4] David B. Newell and Eite Tiesinga,Editors,NIST SP 330, 2019 edition,The International System of Units (SI),46. https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.330-2019.pdf

[5] NASA Space Science Data Coordinated Archive, Sun Fact Sheet. Retrieved from https://nssdc.gsfc.nasa.gov/planetary/factsheet/sunfact.html

[6] The NIST Reference on COnstants, Units, and Uncertainity, Newtonian constant of gravitation. Retrieved 17 January 2023 from https://physics.nist.gov/cgi-bin/cuu/Value?bg

[7] University of Washington Big G Measurement, Jens H. Gundlach and Stephen M. Merkowitz. Retrieved from https://asd.gsfc.nasa.gov/Stephen.Merkowitz/G/Big_G.html