Newton's $E = mc^2$ Two Hundred Years Before Einstein? Newton = Einstein at the Quantum Scale

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Abstract

The most famous Einstein formula is $E = mc^2$, while Newton's most famous formula is $F = G\frac{mm}{r^2}$. Here we will show the existence of a simple relationship between Einstein's and Newton's formulas. They are closely connected in terms of fundamental particles. Without knowing so, Newton indirectly conceptualized $E = mc^2$ two hundred years before Einstein.

Key words: $E = mc^2$, energy, kinetic energy, mass, gravity, relativity, Newton and Einstein.

1 Did Newton "Discover" $E = mc^2$ Two Hundred Years Before Einstein?

The Italian geologist and industrialist, Olinto de Pretto, speculated three years before Einstein that the old, well-known[1] formula $E = mv^2$ had to be equal to $E = mc^2$ when something moved at the speed of light, where v is the object's speed, c is the speed of light, m is the mass, and E is the energy. In his 1904 book "Electricity and Matter", Thomson [1] presented what he called a kinetic energy formula for light, which he described[2] as $E = \frac{1}{2}mc^2$.

Einstein [2] is still likely the first to mathematically "prove" the $E = mc^2$ relationship between energy and mass. Here, however, we will show that Newton basically conceived the same mathematical relationship between energy and matter, as hidden in his gravity formula (see [3]) two hundred years before Einstein; if he had simply known the "radius" and mass of a fundamental particle.

The rest-mass of any fundamental particle can be written as

$$m = \frac{\hbar}{\bar{\lambda}}\frac{1}{c}, \tag{1}$$

where $\bar{\lambda}$ is the reduced Compton wavelength. For example, the rest mass of an electron is given by

$$m_e = \frac{\hbar}{\bar{\lambda}_e}\frac{1}{c} \approx 9.10938 \times 10^{-31} \text{ kg}. \tag{2}$$

On this basis, we obtain the following relationship between energy mass:

$$E = mc^2 = G\frac{m_p m_p}{\bar{\lambda}}, \tag{3}$$

where m_p is the Planck mass (see [4]) and $\bar{\lambda}$ is the reduced Compton wavelength of the fundamental particle m (this is actually the "extended radius" of the particle, see [5, 7]). That is, the rest energy embedded in any fundamental particle is equal to the gravity (energy) between two Planck masses separated by the reduced Compton wavelength of the fundamental particle of interest.

Moreover, the kinetic energy of a fundamental particle is given by

$$E_k = \frac{mc^2}{\sqrt{1-\frac{v^2}{c^2}}} - mc^2 = G\frac{m_p m_p}{\bar{\lambda}\sqrt{1-\frac{v^2}{c^2}}} - G\frac{m_p m_p}{\bar{\lambda}}. \tag{4}$$

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[1] $E = mv^2$ was suggested by Gottfried Leibniz in the period 1676–1689.

[2] In the original formula he used notation $E = \frac{1}{2}MV^2$, but Thomson clearly stated "where V is velocity with which light travels through the medium...".

And when $v << c$, we can use the first term of a series expansion and closely approximate the kinetic energy by

$$E_k \approx \frac{1}{2}mv^2 = \frac{1}{2}G\frac{m_p m_p}{\bar{\lambda}}\frac{v^2}{c^2}. \tag{5}$$

Furthermore, we must have

$$\begin{aligned} \frac{mc^2}{c^2} &= G\frac{m_p m_p}{c^2\bar{\lambda}} \\ m &= G\frac{m_p m_p}{c^2\bar{\lambda}}. \end{aligned} \tag{6}$$

And what we can call the rest-force of a fundamental particle is given by

$$F = \frac{mc^2}{\bar{\lambda}} = G\frac{m_p m_p}{\bar{\lambda}^2} \tag{7}$$

In other words,

$$Newton = \frac{Einstein}{r},$$

where r is the extended radius of the fundamental particle in question (the reduced Compton wavelength of that particle).

Moving on, the relativistic force must be

$$F = \frac{mc^2}{\bar{\lambda}\left(1-\frac{v^2}{c^2}\right)} = G\frac{m_p m_p}{\bar{\lambda}^2\left(1-\frac{v^2}{c^2}\right)}. \tag{8}$$

Based on Haug's recent research, the maximum velocity of a Planck mass particle (mass gap particle) surprisingly is zero. The Planck mass particle is at rest in any reference frame and therefore the only invariant particle. This can only happen if the Planck mass particle only lasts an instant (see [6, 8]). The Planck mass particle is the collision point between two photons, and it only last for one Planck second as measured with Einstein-Poincare synchronized clocks. This means that the force for any particle moving at its maximum velocity must be

$$F = m_p a_p = m_p\frac{c^2}{l_p} = \frac{m_p c^2}{l_p} = G\frac{m_p m_p}{l_p^2}. \tag{9}$$

A Planck mass particle should not be confused with two Planck masses: we can have a heap of protons making up a Planck mass, yet this is not a Planck mass particle. A Planck mass particle has a reduced Compton wavelength of l_p. For non-Planck masses, it seems that one perhaps needs to perform a relativistic adjustment for gravity, but this is likely not the case for gravity between light particles (photons).

Furthermore, we must have the following relationship for relativistic momentum

$$p = \frac{mv}{\sqrt{1-\frac{v^2}{c^2}}} = G\frac{m_p m_p}{\bar{\lambda}\sqrt{1-\frac{v^2}{c^2}}}\frac{v}{c^2}. \tag{10}$$

Based on this the relativistic energy–momentum relation can then be written as

$$
\begin{aligned}
E^2 &= p^2c^2 + (mc^2)^2 \\
E &= \sqrt{p^2c^2 + (mc^2)^2} \\
E &= \sqrt{\left(G\frac{m_p m_p}{\bar{\lambda}\sqrt{1-\frac{v^2}{c^2}}}\frac{v}{c^2}\right)^2 c^2 + \left(G\frac{m_p m_p}{\bar{\lambda}}\right)^2} \\
E &= \sqrt{G^2\frac{m_p^2 m_p^2}{\bar{\lambda}^2\left(1-\frac{v^2}{c^2}\right)}\frac{v^2}{c^2} + G^2\frac{m_p^2 m_p^2}{\bar{\lambda}^2}} \\
E &= G\frac{m_p m_p}{\bar{\lambda}}\sqrt{\frac{1}{1-\frac{v^2}{c^2}}\frac{v^2}{c^2} + 1} \\
E &= G\frac{m_p m_p}{\bar{\lambda}\sqrt{1-\frac{v^2}{c^2}}}\sqrt{\frac{v^2}{c^2} + \left(1-\frac{v^2}{c^2}\right)} \\
E &= G\frac{m_p m_p}{\bar{\lambda}\sqrt{1-\frac{v^2}{c^2}}} = \frac{mc^2}{\sqrt{1-\frac{v^2}{c^2}}} \qquad (11)
\end{aligned}
$$

Table 1 summarizes the mathematical relationship between special relativity and Newtonian gravity (Newton-inspired formulas).

	Einstein = Newton
Mass	$m = G\frac{m_p m_p}{c^2\bar{\lambda}}$
Relativistic mass	$\frac{m}{\sqrt{1-\frac{v^2}{c^2}}} = G\frac{m_p m_p}{c^2\bar{\lambda}\sqrt{1-\frac{v^2}{c^2}}}$
Energy	$E = mc^2 = G\frac{m_p m_p}{\bar{\lambda}}$
Relativistic energy	$E = \frac{mc^2}{\sqrt{1-\frac{v^2}{c^2}}} = G\frac{m_p m_p}{\bar{\lambda}\sqrt{1-\frac{v^2}{c^2}}}$
Kinetic energy	$E_k = \frac{mc^2}{\sqrt{1-\frac{v^2}{c^2}}} - mc^2 = G\frac{m_p m_p}{\bar{\lambda}\sqrt{1-\frac{v^2}{c^2}}} - G\frac{m_p m_p}{\bar{\lambda}}$
Kinetic energy ($v << c$)	$E_k \approx \frac{1}{2}mv^2 = \frac{1}{2}G\frac{m_p m_p}{\bar{\lambda}}\frac{v^2}{c^2}$
Force	$F = \frac{mc^2}{\bar{\lambda}} = G\frac{m_p m_p}{\bar{\lambda}^2}$
Relativistic force	$F = \frac{mc^2}{\bar{\lambda}\left(1-\frac{v^2}{c^2}\right)} = G\frac{m_p m_p}{\bar{\lambda}^2\left(1-\frac{v^2}{c^2}\right)}$
Relativistic energy–momentum relation	$E = \sqrt{p^2c^2 + (mc^2)^2} = G\frac{m_p m_p}{\bar{\lambda}\sqrt{1-\frac{v^2}{c^2}}}$

Table 1: The table shows some simple mathematical relationships between the Einstein special relativity formulas and Newton-inspired formulas.

Table 2 illustrates the relativistic limit for the Einstein and Newtonian formulas. This is based on the maximum velocity for anything with rest-mass being $v_{max} = c\sqrt{1-\frac{l_p^2}{\bar{\lambda}^2}}$.

	Einstein = Newton
Relativistic mass	$m_{max} = \frac{m}{\sqrt{1-\frac{v_{max}^2}{c^2}}} = G\frac{m_p m_p}{c^2\bar{\lambda}\sqrt{1-\frac{v_{max}^2}{c^2}}} = G\frac{m_p m_p}{c^2 l_p} = m_p$
Relativistic energy	$E_{max} = \frac{mc^2}{\sqrt{1-\frac{v_{max}^2}{c^2}}} = G\frac{m_p m_p}{\bar{\lambda}\sqrt{1-\frac{v_{max}^2}{c^2}}} = G\frac{m_p m_p}{l_p} = m_p c^2$
Kinetic energy	$E_{k,max} = \frac{mc^2}{\sqrt{1-\frac{v_{max}^2}{c^2}}} - mc^2 = G\frac{m_p m_p}{\bar{\lambda}\sqrt{1-\frac{v_{max}^2}{c^2}}} - G\frac{m_p m_p}{\bar{\lambda}} = m_p c^2 - mc^2$
Relativistic momentum	$p = \frac{mv_{max}}{\sqrt{1-\frac{v_{max}^2}{c^2}}} = G\frac{m_p m_p}{\bar{\lambda}\sqrt{1-\frac{v^2}{c^2}}}\frac{v}{c^2}$
Relativistic force	$F_{max} = \frac{mc^2}{\bar{\lambda}\left(1-\frac{v_{max}^2}{c^2}\right)} = G\frac{m_p m_p}{\bar{\lambda}^2\left(1-\frac{v_{max}^2}{c^2}\right)} = G\frac{m_p m_p}{l_p^2} = \frac{m_p c^2}{l_p}$

Table 2: The table shows the relativistic maximum limit for energy, kinetic energy and force based on Haug's maximum velocity formula.

2 Conclusion

We have presented some interesting mathematical relationships between Einstein's special relativity formulas and Newton's formulas. It seems like the Newtonian gravity formulas are likely non-relativistic. Still, they are more than that, as they also seem to be the relativistic limit based on Haug's maximum velocity formula. We do not claim that Newton knew about $E = mc^2$ directly. But indirectly, Newton essentially had an energy-mass relationship formula that was valid for any fundamental particle. He merely lacked the concept of reduced Compton wavelength and the radius for fundamental particles.

References

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