The Planck Mass Must Always Have Zero Momentum Relativistic Energy-Momentum Relationship for the Planck Mass.

Espen Gaarder Haug*
Norwegian University of Life Sciences

January 16, 2017

Abstract

This is a short paper on the maximum possible momentum for subatomic particles, as well as on the relativistic energy-momentum relationship for a Planck mass. This paper builds significantly on the maximum velocity for subatomic particles introduced by [1, 2, 3] and I strongly recommend reading an earlier paper [1] before reading this paper.

It is important that we distinguish between Planck momentum and the momentum of a Planck mass. The Planck momentum can (almost) be reached for any subatomic particles with rest-mass lower than a Planck mass when accelerated to their maximum velocity, given by Haug. Just before the Planck momentum is reached, the mass will turn into a Planck mass. The Planck mass is surprisingly at rest for an instant, and then the mass will then burst into pure energy. This may sound illogical at first, but the Planck mass is the very turning point of the light particle (the indivisible particle) and it is the only mass that is at rest as observed from any reference frame.

That the Planck mass is at rest as observed from any reference frame could be as important as understanding that the speed of light is the same in every reference frame. The Planck mass seems to be as unique and special among masses (particles with mass) as the speed of light is among velocities. It is likely one of the big missing pieces towards a unified theory.

1 Maximum Momentum

Einstein's relativistic momentum is given by

$$p = \frac{mv}{\sqrt{1-\frac{v^2}{c^2}}} \tag{1}$$

This formula has some of the same challenges as the relativistic energy mass relationship formula recently discussed in great detail by [1] . If v approaches c the momentum goes towards infinite. Our maximum velocity formula for anything with mass, $v_{max} = c\sqrt{1-\frac{l_p^2}{\bar{\lambda}^2}}$, puts also a limitation on the maximum momentum that any subatomic particle can take. This means the maximum relativistic momentum for any particle is given by

*e-mail espenhaug@mac.com. Thanks to Victoria Terces for helping me edit this manuscript. Further, I would like to thank another anonymous associate editor for useful and constructive comments on one of my previous papers that lead to this note.

$$p_{max} = \frac{mv_{max}}{\sqrt{1-\frac{v_{max}^2}{c^2}}}$$
$$p_{max} = \frac{mv_{max}}{\sqrt{1-\frac{\left(c\sqrt{1-\frac{l_p^2}{\bar{\lambda}^2}}\right)^2}{c^2}}}$$
$$p_{max} = \frac{mv_{max}}{\sqrt{1-\frac{\left(c^2-c^2\frac{l_p^2}{\bar{\lambda}^2}\right)}{c^2}}}$$
$$p_{max} = \frac{mc\sqrt{1-\frac{l_p^2}{\bar{\lambda}^2}}}{\frac{l_p}{\bar{\lambda}}}$$
$$p_{max} = m_p c\sqrt{1-\frac{l_p^2}{\bar{\lambda}^2}} \tag{2}$$

Using series expansion when $\bar{\lambda} >> l_p$ we get: $c\sqrt{1-\frac{l_p^2}{\bar{\lambda}^2}} \approx c\left(1-\frac{1}{2}\frac{l_p^2}{\bar{\lambda}^2}\right)$, and this gives us the maximum momentum of a subatomic particle

$$p_{max} = m_p c\left(1-\frac{1}{2}\frac{l_p^2}{\bar{\lambda}^2}\right) < m_p c \tag{3}$$

Still $\frac{1}{2}\frac{l_p^2}{\bar{\lambda}^2} << 1$, which means the maximum momentum for any "fundamental" subatomic particle is approximately given by

$$p_{max} \approx m_p c \tag{4}$$

This is equal to the Planck momentum, see [5, 6]. We should here be very careful and distinguish between Planck momentum and the maximum momentum for a Planck mass [4], as these are not the same thing; this is something that has not been discussed in the literature before. Particles with a rest-mass less than a Planck mass can basically achieve the Planck momentum, or actually a momentum extremely close to the Planck momentum when moving at their maximum velocity. However, a particle with rest-mass equal to the Planck mass will surprisingly always have a maximum momentum equal to zero. This is because the maximum velocity of a Planck mass is

$$v_{max} = c\sqrt{1-\frac{l_p^2}{\bar{\lambda}^2}} = c\sqrt{1-\frac{l_p^2}{l_p^2}} = 0 \tag{5}$$

That is to say the relativistic momentum of a Planck mass according to our theory must be zero

$$p = \frac{mv_{max}}{\sqrt{1-\frac{v_{max}^2}{c^2}}} = \frac{m\times 0}{1} = 0 \tag{6}$$

This is consistent with Haug's view that the Planck mass is at rest from any reference frame, but just for an instant. The Planck mass is very unique, it always has a momentum of zero as observed from any reference frame. This is because the Planck mass only lasts for an instant and can be seen as the very turning point of light particles, namely the very instant two indivisible particles collide.

Just after a non-Planck mass subatomic particle reaches its maximum velocity, its momentum goes from something extremely close to the Planck momentum to zero momentum. At the same instant it turns into a Planck mass and loses all of its momentum, this lasts for an instant before the mass bursts into energy. As we soon will see, understanding that the Planck mass momentum is zero is a key insight in understanding the relativistic energy-momentum relationship for the Planck mass itself.

2 Relativistic Energy-Momentum Relationship

Based on the well-known relativistic energy-momentum relationship, for a Planck Mass we would have a total energy of

$$E^2 = m_p^2 c^2 + p^2 c^2 \tag{7}$$

where p is the relativistic momentum

$$p = \frac{mv}{\sqrt{1-\frac{v^2}{c^2}}} \tag{8}$$

The half Planck mass particle always moves at the speed of light and has a suggested mass equal to half the Planck mass. At first sight, this makes it seem that the relativistic energy-momentum relationship should be a discrepancy in total energy. However, as we will see, the energy-momentum formula is fully consistent with what we have outlined about the indivisible particle (the uniton). Equation 7 can be rewritten as

$$\begin{aligned} E &= \sqrt{p^2c^2 + (m_pc^2)^2} \\ E &= \sqrt{\left(\frac{m_pv}{\sqrt{1-\frac{v^2}{c^2}}}\right)^2 c^2 + (m_pc^2)^2} \end{aligned} \tag{9}$$

The half Planck mass particle (the uniton) always travels at the speed of light. Still, there is an exception to this, namely at the very instant of counter-strike with another indivisible particle. Something that travels at the speed of light and suddenly is perfectly reflected must logically stand still in the very instant of the turning point. At this instant, the indivisible half Planck mass particle is at "rest" and creates the Planck mass, and its velocity in this instant is $v_{max} = c\sqrt{1-\frac{l_p^2}{\bar{\lambda}^2}} = 0$, as observed from any reference frame. The Planck mass total energy from the energy momentum formula is therefore

$$\begin{aligned} E &= \sqrt{\frac{m_p^2 \times 0^2 \times c^2}{1-\frac{0^2}{c^2}} + m_p^2c^4} \\ E &= m_p^2c^2 \end{aligned} \tag{10}$$

This is very unique, only for the Planck mass the momentum is always zero and all the energy is now only related to its rest-mass energy. And not only that, but as observed from any reference frame. It is important to be aware that this can only hold if the Planck mass only lasts for an instant. This instant, when measured with Einstein-Poincarè synchronized clocks, will be one Planck second. The union is very special, it's either 100% mass when counter-striking with another indivisible particle, or 100% energy. That is at the very depth of reality, energy and mass are ultimately binary. This fits very well within the model we have presented already.

The maximum velocity for a Planck mass is zero. Since the maximum speed of the Planck mass is zero, then naturally it can never move. The Planck mass has only one velocity, namely zero. All other particles can vary their mass from zero (rest-mass) to their maximum velocity given by v_{max}. The Planck mass is the collision point of two indivisible particles changing course of direction, it quickly goes from a Planck mass with speed zero to pure energy moving at the speed of light.

For any non-Planck mass, we note that at their maximum velocity, $v_{max} = c\sqrt{1-\frac{l_p^2}{\bar{\lambda}_e^2}}$, must always be larger than zero, and for any known subatomic particle we have observed so far $\bar{\lambda} >> l_p$, which means it is actually a maximum velocity that is very close to the speed of light. This gives us the following energy momentum relativistic relationship when a non-Planck mass is moving at its maximum velocity

$$\begin{aligned}
E &= \sqrt{p^2c^2 + (mc^2)^2} \\
E &= \sqrt{\left(\frac{mv_{max}}{\sqrt{1-\frac{v_{max}^2}{c^2}}}\right)^2 c^2 + (mc^2)^2} \\
E &= \sqrt{\frac{m^2 v_{max}^2 c^2}{1-\frac{v_{max}^2}{c^2}} + m^2c^4} \\
E &= \sqrt{\frac{m^2 \frac{v_{max}^2}{c^2} c^4}{1-\frac{v_{max}^2}{c^2}} + m^2c^4} \\
E &= \sqrt{\frac{m^2c^4\left(\frac{v_{max}^2}{c^2}-1\right)}{1-\frac{v_{max}^2}{c^2}} + \frac{m^2c^4}{1-\frac{v_{max}^2}{c^2}} + m^2c^4} \\
E &= \sqrt{-m^2c^4 + \frac{m^2c^4}{1-\frac{v_{max}^2}{c^2}} + m^2c^4} \\
E &= \sqrt{\frac{m^2c^4}{1-\frac{v_{max}^2}{c^2}}} \\
E &= \frac{mc^2}{\sqrt{1-\frac{v_{max}^2}{c^2}}}. \qquad (11)
\end{aligned}$$

which is the Einstein relativistic mass, and this we can further simplify be inputting the formula for v_{max}; this gives us

$$\begin{aligned}
E &= \frac{mc^2}{\sqrt{1-\frac{\left(c\sqrt{1-\frac{l_p^2}{\bar{\lambda}^2}}\right)^2}{c^2}}} \\
E &= \frac{mc^2}{\sqrt{1-\frac{\left(c^2-c^2\frac{l_p^2}{\bar{\lambda}^2}\right)}{c^2}}} \\
E &= \frac{\bar{\lambda}}{l_p}mc^2 = m_pc^2 \qquad (12)
\end{aligned}$$

In other words, the maximum energy for any particle according to the energy momentum relationship is the Planck energy. This is consistent with our earlier findings and also with the idea that the Planck mass is invariant from any reference frame, but this mass can only last for an instant and then turn into Planck energy.

We must conclude that only for a Planck mass, is the rest-mass energy equal to the relativistic energy.

$$m_pc^2 = \frac{m_pc^2}{\sqrt{1-\frac{v^2}{c^2}}} \qquad (13)$$

This because we always have $v = 0$ for a Planck mass. For all other fundamental non-Planck particle masses, when $v > 0$ we must have

$$mc^2 < \frac{mc^2}{\sqrt{1-\frac{v^2}{c^2}}} \leq m_pc^2, \qquad (14)$$

where m is the rest-mass of the particle in question. In other words, the rest-mass is, for all non-Planck masses, smaller than the relativistic mass, which will turn into a Planck mass at the speed limit for that mass.

That the Planck mass is the only mass that is at rest in every reference frame is in our view as great a breakthrough in our understanding of physics as the understanding that the speed of light is the same in every reference frame.[1] The indivisible half Plank mass particles are either only energy or only mass; they are not something in between, unlike every other particle that must be composite particles in our model, see [1].

References

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[1] More precisely, the round trip-speed of light is the same as observed from every reference frame, as is the one-way speed of light when measured with Einstein-Poincaré synchronized clocks.