A Inconsistency in Modern Physics and a Simple Solution

Espen Gaarder Haug
Norwegian University of Life Sciences
e-mail espenhaug@mac.com

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Abstract

In this paper, we will point out an important inconsistency in modern physics. When relativistic momentum and relativistic energy are combined with key concepts around Planck momentum and Planck energy, we find an inconsistency that has not been shown before. The inconsistency seems to be rooted in the fact that momentum as defined today is linked to the de Broglie wavelength. By rewriting the momentum equation in the form of the Compton wavelength instead, we get a consistent theory. This has a series of implications for physics and cosmology.

Key words: Special relativity theory, length contraction, Planck length, Planck time, trans-Planck.

1 Introduction

In 1899, Max Planck [1, 2] assumed there were three essential and universal constants: the Planck constant, the speed of light, and the gravitational constant. By using dimensional analysis, he then derived what he considered to be some very fundamental units, namely, length, time, mass, and energy. Today these are known as the Planck units.

The Planck mass is given by

$$m_p = \sqrt{\frac{\hbar c}{G}} \tag{1}$$

The Planck mass can also be found independent of any knowledge of Newton's gravitational constant, as shown in other work [3, 4]. Max Planck himself was not completely clear about the nature of the Planck mass. This mass is very large compared to the rest-mass of any observed elementary particle and has generated consideration speculation over the years. Lloyd Motz was likely the first to suggest there could be a Planck mass particles, see [5–7]. He thought that the Planck mass particle was truly essential, but he was also well aware that the Planck mass (about 10^{-8} kg) was substantially larger than any observed fundamental particle. Therefore, he suggested the Planck mass particle had existed just after the Big Bang and then disintegrated into all of the much smaller particles observed today. Others, like Hawking, have suggested that the Planck mass particle is linked to micro black holes, see [8–10]. We will return to this later and show that there is a much simpler solution for the missing Planck mass particle, but first we will evaluate Planck energy and Planck momentum.

The Planck energy is given by

$$E_p = m_p c^2 \tag{2}$$

and the Planck momentum [11] is given by

$$p_p = m_p c \tag{3}$$

Einstein's theory of special relativity plays a role here and the relativistic momentum in modern physics is given by

$$p = \frac{mv}{\sqrt{1-\frac{v^2}{c^2}}} \tag{4}$$

and, finally, the relativistic total energy is given by

$$E = \frac{mc^2}{\sqrt{1-\frac{v^2}{c^2}}} \tag{5}$$

2 The Inconsistency

Assume we have an elementary mass, m, that after acceleration has a total relativistic energy equal to the Planck energy

$$m_p c^2 = \frac{mc^2}{\sqrt{1-\frac{v^2}{c^2}}} \tag{6}$$

Next we solve this with respect to v and we get

$$v = c\sqrt{1-\frac{m^2}{m_p^2}} < c \tag{7}$$

This velocity is always smaller than the speed of light in vacuum and this is the same velocity that we have described as an exact upper maximum velocity for elementary particles in a series of papers, see [3, 12, 13].

However, whether this is a new maximum velocity or not is worth further study, although that is not the main point here. However, a very interesting feature of this velocity formula is that if $m = m_p$, then in order to have Planck mass energy, the the velocity of the Planck mass particle must be zero. This is no surprise, as $m_p c^2$ can indeed be seen as the rest-mass energy. Moving to the Planck momentum, we find that $p_p = m_p c$, and we can set up the following relation

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

solved with respect to v this gives

$$v = \frac{c}{\sqrt{1+\frac{m^2}{m_p^2}}} \tag{9}$$

We naturally see this is different than the velocity formula 7. Assume that the mass m is a Planck mass particle with mass m_p. It must move at the following velocity to have Planck mass momentum

$$v = \frac{c}{\sqrt{1+\frac{m_p^2}{m_p^2}}} = \frac{c}{\sqrt{2}} \tag{10}$$

Now this is beginning to sound a bit strange, or we could say inconsistent. On one hand, the Planck mass particle must be standing still in order to have the Planck energy. This seems logical enough as $m_p c^2$ does look like a rest-mass in terms of special relativity. But this also means that a Planck mass particle that has Planck energy cannot have Planck momentum at the same time. Further, why would an almost magical speed of $\frac{c}{\sqrt{2}}$ be required for the Planck mass particle to reach Planck momentum? This indicates that the Planck mass momentum is not a special momentum for the Planck mass particle, because what strange mechanism would limit such a particle to stay below $\frac{c}{\sqrt{2}} \approx 0.7c$? We have not heard of any such mechanism, but it could be an open question.

If we shift the analysis from Planck mass particles and look only at observed particles, then there still cannot be a single type of particle that, when accelerated to any velocity $v < c$, will have Planck energy at the same time it has Planck momentum. We can see this by trying to solve the following relation with respect to v

$$\frac{E}{c} = p \tag{11}$$

$$\frac{mc^2}{c\sqrt{1-\frac{v^2}{c^2}}} = \frac{mv}{\sqrt{1-\frac{v^2}{c^2}}} \tag{12}$$

The only solution to this is when $v = c$, but then we would have infinite relativistic mass, which is impossible. One could naturally argue that Planck mass particles do not exist at all, and in fact, we have never observed any elementary particles with a mass anywhere close to the Planck mass.

This would also mean that if a Planck mass particle existed, then there cannot be a limit on momentum for elementary particles equal to the Planck mass momentum. Some physicists are fine with this, as special relativity technically allows the relativistic momentum of even the smallest elementary particle to approach but never reach infinity. This is because the only restriction is $v < c$ for anything with mass in SR. However, this is absurd, as it would lead theoretically to electrons that had a relativistic mass larger than the rest-mass of the Sun or even the entire Milky Way, see [14].

Again, we revisit the question posed earlier: Why should a Planck mass particle (if it exists) have a magical velocity equal to $\frac{c}{\sqrt{2}}$ in order to have Planck mass momentum? If this prediction on the need for such a velocity are correct (in theory) then it is very likely that the Planck mass particle does not actually exist. However, there is a much simpler solution to this puzzle.

3 The de Broglie Wave Length versus the Compton Wave

Around 1923, Louis de Broglie [15, 16] suggested that matter had wave-like properties. It has also been shown that the wavelength of a photon could be found using the following formula

$$\lambda = \frac{h}{p} \tag{13}$$

where p is the photon's momentum. A photon's momentum is therefore given by

$$p = \frac{\hbar}{\lambda} \tag{14}$$

Further, the energy of a photon is given by

$$E = \frac{\hbar}{\lambda}c \tag{15}$$

Even if modern physics cannot agree on whether a photon has mass or not, at least we can calculate its equivalent mass simply by dividing the energy by c^2. Thus the momentum of a photon can be written as

$$p = E/c^2 \times c = mc = \frac{\hbar}{\lambda} \tag{16}$$

However, for non-photons the momentum is given by the formula

$$p = \frac{mv}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{17}$$

When $v << c$, this can be approximated by the first term of a Taylor series expansion as the well-known $p \approx mv$.

There are several interesting things to notice here. The momentum formula for something with rest-mass is different than the momentum formula for photons. In other words, we appear to have a different theory for photons and matter. The fact that we use separate formulas for photons and matter indicates, in our view, that modern physics has not been completely successful at unifying matter and energy. Although we do have Einstein's $E = mc^2$ that gives a relation between rest-mass and energy.

In about the same year as de Broglie suggested his matter wave, Arthur Compton measured a wavelength from electron scattering; this was later known as the Compton wave, see [17]. While the previously mentioned de Broglie wave has never been measured, the Compton wavelength has been measured in a long series of experiments. The de Broglie wavelength is given by

$$\lambda_B = \frac{h}{\frac{mv}{\sqrt{1-\frac{v^2}{c^2}}}} \tag{18}$$

and from the formula we can see that the de Broglie wavelength is infinite if the particle stands still. Naturally, one could argue the particle cannot stand still. However, there are many interpretations in the modern physics literature with regard to the electron being everywhere in the universe until observed based on this property of the de Broglie wavelength. Such interpretations do not seem to make much sense though and may actually be based on a failure to understand what the de Broglie length truly represents.

Next the Compton wavelength of a rest-mass particle is given by

$$\lambda_c \approx \frac{\hbar}{mc} \tag{19}$$

notice that this would be identical to how one finds the wavelength of a photon, because the momentum of a photon is given by $mc = \frac{h}{\lambda}$. The relativistic version of the Compton wavelength must be

$$\lambda_c = \frac{\hbar}{\frac{mc}{\sqrt{1-\frac{v^2}{c^2}}}} \tag{20}$$

This means the de Broglie wavelength always is directly linked to the Compton wavelength through the following relation

$$\lambda_B = \lambda_c \frac{c}{v} \tag{21}$$

That is to say, the unobserved de Broglie wavelength is always a derivative of the observed Compton wavelength. One can also ask why we need two matter waves. Photons only have one photon wavelength, not one that is very long while the other is short. We think the de Broglie wavelength simply is a mathematical artifact that is not necessary and has actually caused a series of very strange and illogical interpretations. As a promising alternative, a full theory of quantum mechanics can be developed from the Compton wave rather than the de Broglie wave, see [18, 19].

4 Compton Momentum

The rest-mass of any mass can be found by the following formula

$$m = \frac{h}{\lambda_c}\frac{1}{c} \tag{22}$$

It has been shown experimentally that one can find the rest-mass of electrons by finding the Compton wavelength of the electron first. The same cannot be done from the de Broglie wavelength; the rest-mass formula from the de Broglie wavelength would be

$$m = \frac{h}{\lambda_c}\frac{1}{c} = \frac{h}{\lambda_B \frac{v}{c}}\frac{1}{c} = \frac{h}{\lambda_b}\frac{1}{v} \tag{23}$$

but again this leads to a inconsistency when $v = 0$, because we cannot divide by zero. For $v > 0$ and at the same time $v << c$, the formula above gives correct answers for masses of particles. However, formula 22 always gives the correct answer when $v << c$, and we can easily extend it to a relativistic mass as well.

$$\frac{m}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{\frac{h}{\lambda_c}\frac{1}{c}}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{h}{\lambda_c\sqrt{1-\frac{v^2}{c^2}}}\frac{1}{c} = \frac{h}{\lambda_c\sqrt{c^2-v^2}} \tag{24}$$

The interpretation should be that the when a mass is moving, the only thing that can undergo length contraction is the Compton wavelength. Similarly, if written in terms of the de Broglie wavelength, then this would be

$$\frac{m}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{\frac{h}{\lambda_b}\frac{1}{v}}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{h}{\lambda_b\sqrt{1-\frac{v^2}{c^2}}}\frac{1}{v} = \frac{h}{\lambda_b\sqrt{v^2-\frac{v^4}{c^2}}} \tag{25}$$

This formula works well as long as v not is equal to zero. However, when $v = 0$ the formula is not valid.

5 The Compton Momentum versus de Broglie Momentum

We have shown in the section above that the de Broglie wavelength (which has never been observed) is simply the observed Compton wavelength multiplied by $\frac{c}{v}$. We have also introduced a new momentum, namely what we will call the Compton momentum. The total Compton momentum is given by

$$p_c = \frac{mc}{\sqrt{1-\frac{v^2}{c^2}}} \tag{26}$$

while the de Broglie momentum, which is the standard momentum is given by

$$p_B = \frac{mv}{\sqrt{1-\frac{v^2}{c^2}}} \tag{27}$$

We see that the relation between these two momentums is identical to the relation between the de Broglie wavelength and the Compton wavelength. We have that

$$p_B = p_c\frac{c}{v}, \qquad \text{and} \qquad \lambda_B = \lambda_c\frac{c}{v} \tag{28}$$

Notice that when $v = 0$ we have no standard momentum (de Broglie momentum), while we still have Compton momentum. The Compton momentum is mathematically identical to a photon momentum when $v = 0$. That is to say, we suddenly have a rest-mass momentum in additional to moving momentum. We will claim we have three types of momentum: rest-mass momentum, kinetic momentum, and total momentum, just as we have three types of energy. The rest-mass momentum is given by

$$p_{c,r} = \frac{mc}{\sqrt{1-\frac{0^2}{c^2}}} = mc \tag{29}$$

The kinetic momentum is given by

$$p_{c,k} = \frac{mc}{\sqrt{1-\frac{v^2}{c^2}}} - mc \tag{30}$$

which, when $v << c$, is approximately equal to $p_{c,k} \approx \frac{1}{2}m\frac{v^2}{c}$. And the total momentum is given by

$$p_{c,t} = p_{c,r} + p_{c,k} = \frac{mc}{\sqrt{1-\frac{v^2}{c^2}}} \tag{31}$$

Recall that our maximum velocity formula $v = c\sqrt{1-\frac{l_p^2}{\bar{\lambda}^2}}$ is equal to zero when $\bar{\lambda} = l_p$. This means the Planck mass particle always has a rest-mass momentum equal to

$$p_{c,r} = \frac{mc}{\sqrt{1-\frac{0^2}{c^2}}} = m_p c \tag{32}$$

So, the rest-mass momentum of a Planck mass particle seems to be linked to the properties of photons. However, the Planck mass particle must always stand still. The interpretation should be that the Planck mass particle is, in fact, the collision point between photons.

In our view, the interpretation is that there only exists one mass, it is the Planck mass, and it is directly linked to photons. In previous work, we have described the case where a Planck mass particle only exist for one Planck second before it dissolves into energy again. An electron, for example, is a Planck mass particle at its Compton frequency, so it is a Planck mass $\frac{c}{\bar{\lambda}}$ times per second, and each of these Planck mass events only lasts for one Planck second. This gives the correct electron mass. This is covered in much more detail in [19].

6 A Short History of Momentum

It is useful to see this topic in a historic perspective. Momentum, close to the sense in which the term is used in modern physics, was possibly first described mathematically by John Jennings in 1721. Jennings says that momentum is the quantity of matter multiplied by the velocity, which is the standard: $p = mv$ that we know today. However, we should keep in mind that momentum was defined before relativity theory had been developed and the scientists of the era also knew very little about the quantum world. Taking a fresh approach and redefining the momentum the way we have done above, e.g., the so-called Compton momentum, simplifies calculations and interpretations. The standard momentum is, as we have shown, rooted in the de Broglie wavelength, and we can also see the standard momentum as a derivative of the Compton momentum, where we have the standard momentum as the Compton momentum times v/c.

7 Summary of Key Findings

- The unobserved de Broglie wavelength is simply a mathematical derivative of the observable Compton wavelength. We always have the relation $\lambda_B = \lambda_c \frac{c}{v}$.
- The de Broglie wavelength is infinite for rest-mass particles. This is absurd and has been misinterpreted by modern physics. The solution is to switch to the Compton wavelength, which is the true matter wave.
- The momentum derived from the de Broglie wavelength, which is the standard momentum, will be zero for a rest-mass particle. On the other hand, the rest-mass momentum derived from the Compton wavelength is $p = mc$, which is the same as for photons. This indicates a relation between mass and photons, just like the rest-mass energy relation of Einstein: $E = mc^2$.
- In standard physics, one operates with different formulas for momentum for photons and matter. This is not necessary if one switches to Compton momentum.
- The de Broglie wavelength has, contrary to what many physicists assume, never been observed. On the other hand, the Compton wavelength has been observed very accurately many times. The misunderstandings that the de Broglie wavelength has been confirmed steam from observations showing matter has wave-like properties, but this is not because matter has a de Brogelie wave, it is because matter has a Compton wave.
- The rest-mass formula derived from the de Broglie wavelength blows up for a rest-mass particle, because we have division with zero. The rest-mass formula derived from the Compton wavelength get the correct rest-mass.
- Many of quantum mechanics absurd predictions are rooted in the fact that one has derived the theory from the unobservable de Broglie wavelength rather than the Compton wavelength.
- Only by deriving a theory from the Compton wavelength are we able to get a consistent theory, including a unified quantum gravity theory.

Summary in relation to relation to standard theory and the Planck scale

- If a Planck mass particle exists, then according to standard theory it must stand still to have Planck energy, and it must move at velocity $\frac{c}{\sqrt{2}}$ to have Planck momentum. It is strange that we should have a special velocity of $\frac{c}{\sqrt{2}}$. Under our modified theory, we find that the Planck mass energy and the Planck momentum only exist for Planck mass particles (two colliding light particles) when at rest; the collision point is at rest and only lasts for one Planck second.

- The Planck mass is, according to standard theory, massive compared to any observed elementary particle and even compared to protons. To explain its features, some have theorized that Planck mass particle only existed at the beginning of the Big Bang, or that such particles are hiding in micro black holes or in black holes. We think that this is attributable to problems with the model. In our theory, the Planck mass particle is a observational time window-dependent mass. It is only the Planck mass when observed over one Planck second. If observed over a second, it is about 10^{-51} kg.

8 Conclusion

In this paper, we have explained how there are inconsistencies in modern physics in relation to the Planck scale. Further, we have shown that several inconsistencies and strange interpretations disappear if we use a momentum rooted in the Compton wavelength rather than the de Broglie wavelength.

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