

The Planck Mass Particle Finally Discovered!

The True God Particle!

Good bye to the Point Particle Hypothesis!

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Abstract

In this paper we suggest that one single fundamental particle exists behind all matter and energy. We claim that this particle has a spatial dimension and diameter equal to the Planck length and a mass equal to half of the Planck mass. Further, we will claim this particle is indivisible, that is it was never created and can never be destroyed. All other subatomic particles, in spite of having much lower masses than the Planck mass, are easily explained by the existence of such an indivisible particle. Isaac Newton stated that there had to be a fundamental particle, completely hard, that could not be broken down. He also claimed that light consisted of a stream of such particles. Newton's particle theory was very similar to that of the ancient atomists Democritus and Leucippus; see, for example, [1, 2]. However, the atomist view of an indivisible particle with spatial dimensions has generally been pushed aside by modern physics and replaced with hypothetical point particles and the mysterious wave-particle duality.

Although the Planck mass is enormous compared to any known subatomic particles, including the Higgs particle, we will explain how all known subatomic particles contain and are created from the Planck mass. In this paper we will show that the Planck mass is found everywhere at the subatomic level and that the Planck mass probably consists of two indivisible particles. There are good reasons to believe that the Planck mass can only exist for an instant equal to a Planck second. We show that what modern physics considers a rest-mass is, in reality, "objects" rapidly fluctuating between their mass state and an energy state.

Our new view of matter and energy seems to address a series of unsolved problems in modern physics, including the question of why we have not observed a particle with a mass close to the Planck mass, despite the fact that the Planck mass plays an important role in certain aspects of theoretical physics. We also show how our view of matter and energy is consistent with Heisenberg's Uncertainty principle, but gives a different and more logical interpretation than the interpretation given by modern quantum mechanics. Further, our theory offers a completely new interpretation of the so-called Schwarzschild radius at the subatomic scale. In the last section we provide a new solution to Einstein's infinite mass problem. As we show, all elementary particles will turn into energy just before they reach the speed of light. In other words, there is no need for infinite energy to accelerate a mass to the speed of light. This does not replace Einstein's relativistic mass formula, which we claim is correct; it only gives additional insight on how it should be used based on new perspective on what mass truly is.

Key words: Planck mass, Planck particle, Motz particle, indivisible particle, energy, mass, spatial dimension, Heisenberg's Uncertainty principle .

1 Introduction

Isaac Newton assumed that everything, including light, consists of solid, hard, impenetrable moving particles or, in Newton's own words, [3]:

All these things being consider'd it seems probable to me, that God in the Beginning form'd Matter in solid, massy, hard, impenetrable, movable Particles, of such Sizes and Figures, and in such Proportion to Space, as most conduce to the End for which he form'd them; and that these

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primitive Particles being Solids, are incomparably harder than any porous Bodies compounded of them; even so very hard, as never to wear or break in pieces; no ordinary Power being able to divide what God himself made one in the first Creation. While the Particles continue entire, they may compose bodies of one and the same Nature and Texture in all Ages; But should they wear away, or break in pieces, the Nature of Things depending on them, would be changed. Those minute rondures, swimming in space, from the stuff of the world: the solid, coloured table I write on, no, less than the thin invisible air I breathe, is constructed out of small colourless corpuscles; the world at close quarters looks like the night sky – a few dots of stuff, scattered sporadically through and empty vastness. Such is modern corpuscularianism.

The corpuscular particles of Newton were very similar to the ancient atomist view of matter: that everything consisted of indivisible particles moving in the void. The void can be imagined as empty space, but it is more than that, as all observable subatomic particles consist of indivisible particles and void; see [4] for an in-depth discussion on this. In this paper we will suggest that by reintroducing an indivisible particle we will be able to tackle some of the unsolved problems in modern physics. We suggest that the modern hypothesis of point particles, rather than a fundamental indivisible particle with spatial dimensions, is one of the main causes of much of the non-intuitive interpretations in some areas of modern physics.

Before we reunite the Newton corpuscular God particle, which is rooted in ancient atomism, with modern physics we will briefly discuss the Planck mass and the Planck particle. The Planck mass and a series of Planck units play an important role in modern physics. And yet even physicists involved with the Large Hadron Collider have not observed a subatomic particle with a mass even close to the Planck mass.

In 1906, Max Planck introduced the following mass $m_p = \sqrt{\frac{\hbar c}{G}} \approx 2.17651 \times 10^{-8}$ kg, see [5]. This is an extremely large mass compared to the mass of all known subatomic particles. The Planck mass is about the same as that of a flea egg; to put it in context – the mass is so large that we can relate it to something macroscopic. The Planck mass is equal to 1.3×10^{19} the proton masses and about 2.4×10^{22} the electron masses. Its mass is enormous compared to any subatomic particle and even to the mass of the heaviest atoms. Table 1 list the mass as well as the reduced Compton wavelength of some elementary particles. As we can see from the table, even the large Higgs particle mass is incredibly small compared to the Planck mass. While the Planck mass is very large, its reduced Compton wavelength: $\frac{\hbar}{m_p c}$ is equal to the Planck length $l_p \approx 1.6162 \times 10^{-35}$ meter, and this is incredibly small compared to the reduced Compton wavelength of all known particles in present day particle physics.

Particle	Mass	Particles per Planck mass	Reduced Compton Wavelength
Planck mass	2.177E-08	1	1.616E-35
Higgs particle	2.230E-25	9.760E+16	1.577E-18
Neutron	1.675E-27	1.299E+19	2.100E-16
Proton	1.673E-27	1.301E+19	2.103E-16
Electron	9.109E-31	2.389E+22	3.862E-13

Table 1: The mass and reduced Compton wavelength of some particles.

Lloyd Motz, while working at the Rutherford Laboratory, [6, 7, 8] suggested that there was probably a very fundamental particle with a mass equal to the Planck mass. Motz named this particle the *uniton*.¹ Motz suggested that the uniton could be the most fundamental of all particles and that all other particles were initially made of unitons. Motz acknowledged that his unitons (Planck mass particle) had far too much mass compared to known subatomic masses. He tried to get around this issue by claiming the unitons had radiated most of their energy away:

According to this point of view electrons and nucleons are the lowest bound states of two or more unitons that have collapsed down to the appropriate dimensions gravitationally and radiated away most of their energy in the process. – Lloyd Motz

Others have suggested that there were plenty of Planck mass type particles around just after the Big Bang, see [10], but that most of the mass of these super heavy particles has radiated away. Modern physics has also suggested a hypothetical Planck particle that has $\sqrt{\pi}$ more mass than the uniton suggested by Motz. Some physicists including Motz and Hawking has suggested such particles could be micro-black-holes [11, 12, 13]. Planck mass particles has even been suggested as a candidate for cosmological

¹See also [9] that introduces a similar particle that he calls maximons.

dark matter, [14, 15]. Others again, like Crothers and Dunning-Davies [16], have strongly criticized the black-hole interpretation of the Planck particle and have even questioned the existence of the Planck particle. Even the existence of Planck mass size particles reminds a unsolved mystery. We think current interpretations of the Planck mass and Planck type particles do not make much sense and instead we offer a fresh alternative based on an ancient way of looking at matter and energy. In the final section of the paper we will even give a new interpretation of so called mini-black holes.

Here we will assume there ultimately is only one fundamental particle and this particle makes up all other particles, as well as energy. We will assume that this particle has the following properties:

1. Indivisible particle with a diameter of l_p and a “rest” mass equal to half that of the Planck mass.
2. This indivisible particle is always traveling at the speed of light, c as measured with Einstein-Poincaré synchronized clocks.
3. This particle travels in the void (“empty space”). This is necessary, so the particles have something to travel in.

In other words, our indivisible particle has half the mass of the uniton particle suggested by Motz in 1962 (Planck mass size particle). In 1979, Motz and Epstein [12] suggested there likely existed a fundamental particle with half the Planck mass, that is exactly the same mass as in the particle suggested here². Still they did not have a good explanations for why this particle was so much larger than all existing subatomic particles, what this “particle” truly was, and if it was indivisible or not. Instead of assuming that most of this super heavy particle mass has radiated away, we will suggest that all mass (and energy) of the indivisible particle “hides” inside each known subatomic particle and even inside energy. To get this to work we will have to understand energy and mass from a new perspective, that is from a much simpler and more logical perspective than given by modern particle physics.

If the indivisible particles make up both energy and matter, then how can energy and matter appear to be so different? As first explained by Haug [4] based on atomism, the only difference between energy and matter is how the indivisible particles move relative to each other. Energy is simply indivisible particles moving in the same direction (at the speed of light) after each other, while matter is indivisible particles moving back and forth at the round-trip speed of light and counter-striking with each other.

Haug [4] has shown how this view of matter and energy leads to all of the well known formulas of special relativity theory, including $E = mc^2$ and $E = \frac{mc^2}{\sqrt{1-\frac{v^2}{c^2}}}$, as well as relativistic Doppler shift and

more. For example, length contraction has to do with a reduction in the void-distance between a group of indivisible particles. Still, Haug [4] has not shown before how his theory directly can be linked to the Planck mass, as well as known subatomic particles such as the electron. That is what I will show here. We will define mass as existing only at the instant when two indivisible particles collide, what we will call a counter-strike. At a typical collision, there is normally some damage, but as the indivisible particles are indivisible and have no parts, they are unchanged after collision, so counter-strike is a better word to describe such an event. All they do at counter-strike is to change the direction of movement. What two fully hard bodies do when they collide was one of the most difficult and significant questions during the 16th century; giants like Newton and Descartes attempted to answer this question, but it was not resolved at that time, see [3].

As shown by [18, 17] the Planck mass can also be rewritten (without changing its value) as

$$m_p = \sqrt{\frac{\hbar c}{G}} = \frac{\hbar}{l_p} \frac{1}{c} \approx 2.17651 \times 10^{-8} \text{kg} \quad (1)$$

We will assume that the indivisible particle (the sole fundamental particle) has a mass of half the Planck mass, that is:

$$m_i = \frac{1}{2} m_p = \frac{1}{2} \frac{\hbar}{l_p} \frac{1}{c} = \frac{1}{2} \sqrt{\frac{\hbar c}{G}} \quad (2)$$

We use the notation m_i as mathematical symbol for the indivisible particle mass. Still, at all instants when an indivisible particle does not collide it is energy and this is then its potential mass. More precisely, indivisible particles that are, at any instant, not counter-striking (colliding) are what can be considered as pure energy. When they are counter-striking, we can consider them as half the Planck mass.

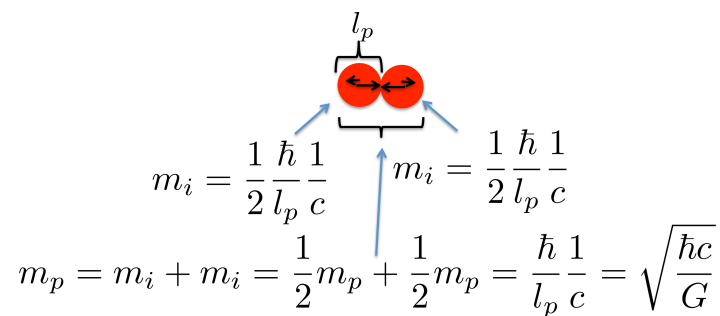
Even if this counter-strike collision only lasts for an instant, we will claim for hypothetical observable purposes that it lasts for one Planck second, that is $t_p = \frac{l_p}{c}$. This is because if we have a zero time interval, then how could we talk about mass or even observe any mass? Observations require time and due to the diameter of the indivisible particle, the minimum time interval we can measure hypothetically

²I discovered this 1979 paper of Motz and Epstein first after putting out version 2 of this paper on Vixra. They are, from what I have found out so far, the first ones that have suggested a fundamental particle with this mass.

is the Planck time. With the caveat hypothetically, I am simply thinking that even if we had the most advanced equipment available, this is something that possibly only can be done in a thought experiment at this time. Even so, experimental physics and logic strongly point towards the atomist view of matter and energy. Later we will look at mass in a slightly different view that involves continuous time.

Based on Einstein's formula $E = mc^2$ we know that a mass at rest contains a large energy potential [19, 20, 21]. We will here claim that energy (photons, electromagnetism) also has built-in mass potential. This lies in contradiction with modern physics interpretations that claim photons have absolutely zero mass, that they are massless. In our view, photons have zero rest-mass as long as they are not counter-striking; in this case, the photons have only potential mass. The photons are nothing other than indivisible particles moving after each other in the same direction (similar to the Newton model of light). Some will possibly immediately claim this is invalid based on the modern wave particle view. We will however claim that the experiments used to support the wave-particle duality stand on thin ground. We are not the first ones questioning the wave-particle hypothesis, see for example [22, 23, 24, 25, 26].

Only the counter-striking between indivisible particles produces what we can call mass, or rather lies at the origin of what we call mass. Just at the instant two indivisible particles counter-strike, they are combined a Planck mass, as illustrated in this figure 1



$$m_i = \frac{1}{2} \frac{\hbar}{l_p} \frac{1}{c}$$

$$m_i = \frac{1}{2} \frac{\hbar}{l_p} \frac{1}{c}$$

$$m_p = m_i + m_i = \frac{1}{2} m_p + \frac{1}{2} m_p = \frac{\hbar}{l_p} \frac{1}{c} = \sqrt{\frac{\hbar c}{G}}$$

Figure 1: Illustration of Planck mass. A Planck mass exists in the moment two indivisible particles counter-strike. Each indivisible particle has a mass of half the Planck mass.

The small arrows illustrate that the indivisible particles will immediately move in opposite directions after a counter-strike. So even if the Planck mass is incredibly large compared to known subatomic particles, it only lasts for an instant before being dissolved into energy (non-colliding indivisible particles) again. The shortest time (the instant) we hypothetically can measure the existence of a Planck mass is likely to be a Planck second $t_p = \frac{l_p}{c}$, which is simply the diameter of the indivisible particle divided by the speed of light. We can say that the Planck mass lasts only a Planck second. Just after the instant of the counter-strike (the creation of mass), the two indivisible particles separate and are no longer a mass; they are now energy again. Each indivisible particle, when not counter-striking, only has potential mass, but no rest-mass. Each indivisible particle then has potential mass equal to half the Planck mass. Only at counter-strike the indivisible particles are at rest for an instant, so they have rest-mass, but only for a Planck second from an observable point of view.

Interesting to note in this context is that the Larmor radiation formula [27], when working with the charge of Planck masses, will radiate into energy within a Planck second, see [28]. However, the interpretation of radiation from Planck masses will be very different here than in modern physics. Despite their many very accurate formulas for energy, it is important to note that modern physics actually has no deep explanation of what energy is exactly; as Richard Feynman once said:

It is important to realize that in physics today, we have no knowledge what energy is.

Radiation into energy from a modern atomist point of view simply means the two indivisible particles have left their counter-striking state; this likely happens in an instant, but from an observer's point of view it will take a Planck second to see this change, even in the best possible thought experiment set-up. The Larmor formula further indirectly predicts that the Planck acceleration is from zero to the speed of light in a Planck second. The interpretation of this from the atomist point of view is simply that the indivisible particle, upon a counter-strike with another indivisible particle, changes its course of direction instantaneously and continues at the speed of light, but now it is moving in the opposite direction from its original path. Even if at the deepest level this happens instantaneously, it would theoretically take a minimum of one Planck second to measure this acceleration. In atomism the only things that exist at the depth of reality are indivisible particles and void, and the only thing we can observe is counter-strikes

between indivisible particles. The diameter of an indivisible particle is, in our theory, equal to the Planck length l_p and since the indivisible particles always moves with speed of light c , it would take a Planck second to see an indivisible particle leave or arrive. Even the most precise measuring device would have to be constructed of indivisible particles with diameter l_p .

So far we have discussed what we assume the Planck mass particle is, but nobody has ever observed a Planck particle and it is fair to ask how is all this related to our modern observed particles that are so much smaller than the Planck mass. One can think of an electron as two indivisible particles moving back and forth over a distance equal to the twice the reduced Compton wavelength of the electron (each moving the reduced Compton wavelength for each counter-strike). That is to say, each indivisible particle will counter-strike every time it has moved a distance equal to the reduced Compton wavelength.³

The indivisible particle is moving along reduced Compton wavelength at the speed of light. Because the reduced Compton wavelength of the electron is much longer than the diameter of the indivisible particle, this means there are only $\frac{c}{\lambda_e}$ counter-strikes per second. If we assume the hypothetical time to observe the counter-strike between two indivisible particles is $\frac{l_p}{c}$, then the amount of counter-strikes in a electron can be seen as a fraction of $\frac{l_p}{\lambda_e}$ relative to a Planck mass, even if the electron consists of a Planck mass (counter-strikes).

It is very important that the round-trip speed of the indivisible particle is c . If the speed was slower or faster than this, then the indivisible particle model explaining mass as counter-strikes would not have worked to describe such things as the mass of the electron. One should also see this paper in connection with the many derivations done by Haug 2014 showing that special relativity can be derived directly from indivisible particles and void.

Each time each the indivisible particles that make up the electron have traveled the reduced Compton wavelength of the electron, they counter-strike. In other words, the electron is in reality in a mass state only a fraction of the time. This is why the Planck mass can be so enormous compared to the electron rest-mass and still make up the electron as well as any other subatomic particle. The number of transitions between mass and energy for example for an electron is 7.76×10^{20} times per second.

We can say the electron is $\frac{l_p}{\lambda_e}$ fraction of a Planck mass. This means the electron must have a mass as a function of the Planck mass equal to the well known

$$m_e = \frac{l_p}{\lambda_e} m_p = \frac{1.6162 \times 10^{-35}}{3.86159 \times 10^{-13}} \times 2.17651 \times 10^{-8} \approx 9.1094 \times 10^{-31} \text{kg} \quad (3)$$

One could even say that all detected particles with so called rest-mass never, even when at so called rest, are constantly in a mass state, but rapidly are going between being in a mass state when their indivisible particles are counter-striking and in an energy state when they are not counter-striking. This naturally means matter and energy are almost the same and it explains why we can turn mass into energy and energy into mass. We can say the energy in a rest-mass is used to maintain the mass and the potential mass is used to maintain the energy. The shorter the reduced Compton wavelength, the more frequent will the indivisibles making up the mass counter-strike and the more mass the particle will contain. With a very short Compton wavelength, the mass will approach the Planck mass, because it then will counter-strike very frequently. Further, we can say that an indivisible particle is matter-like when it travels back and forth in a “stable” pattern, counter striking with other indivisible particles, and it is energy-like when it is freed from this pattern.

Figure 2 illustrates an electron

Every observable particle mass can mathematically be described as

$$m = \frac{l_p}{\lambda} m_p = \frac{l_p}{\lambda} \frac{\hbar}{l_p} \frac{1}{c} \quad (4)$$

where λ is the reduced Compton wavelength of the particle of interest. The factor $\frac{l_p}{\lambda}$ is the factor deciding how often the particular particle ticks (counter-strikes) compared to the maximum mass of a subatomic particle, which is the Planck mass. Each so-called elementary particle is nothing more than (minimum) two indivisible particles moving back and forth over a distance and counter-striking. What we consider particles are in reality not constantly in a mass state, that is they do not have continuously internal counter-strikes between the indivisible particles making them up. Particles are like discrete ticking clocks and at each tick they are a Planck mass. The shorter the reduced Compton wavelength is, the more frequent the counter-strikes (ticks) will be and therefore the larger the mass of the particle is. In practice things are more complicated; one would also need to take into account surrounding indivisible particles entering and leaving the mass (space) of interest.

³Bear in mind that the mutual velocity (also known as the closing speed) as observed from a reference frame different than the two indivisible particles $2c$ even under Einstein’s special relativity theory, see [29] for a historical overview

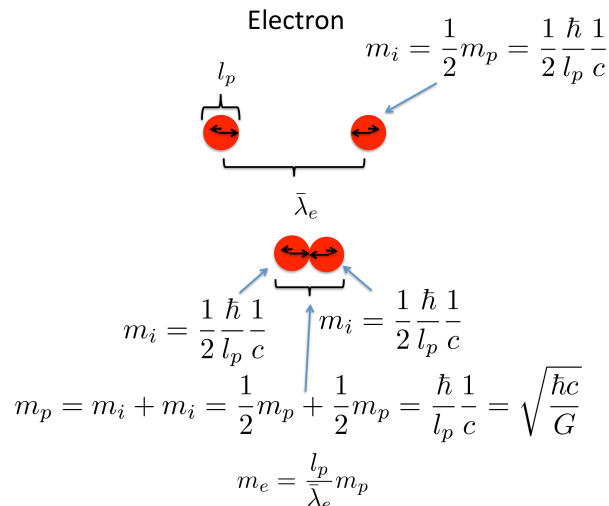


Figure 2: Illustration of Electron mass. An Electron is much smaller than the Planck mass as the mass event only takes up $\frac{l_p}{\lambda_e}$ of the size (length) of the electron.

For indivisible particles traveling after one another in the same direction (energy) (and not back and forth), there will not be counter striking (as long as they are not colliding with other particles going in their way). This means that their equivalent matter distance (reduced Compton wavelength) is infinite $\bar{\lambda} \approx \infty$ and we can therefore say that a non-counter-striking indivisible particle must have the following rest-mass

$$m_i = \frac{1}{2} \frac{\hbar}{\infty} \frac{1}{c} = 0 \quad (5)$$

That the Compton wavelength is infinite for a photon is nothing new and has been pointed out by Hawking in 1971 [11], for example. Zero rest-mass simply means that even though it is not counter-striking, the indivisible particle still has a potential mass of half the Planck mass. The potential mass is turning into “rest-mass” when it is counter-striking another indivisible particle; this is the only moment during which it is at rest. More precisely, that is the only moment it changes its direction, and in the instant between changing direction we can say it is at “rest”. Rest-mass is related to the number of times indivisible particles are at rest (counter-striking), and this again is dependent on the so-called reduced Compton wavelength of the subatomic particle. Under atomism the reduced Compton wavelength has nothing to do with a wave, but has to do with the void distance between the indivisible particles making up the mass.

The void-distance between indivisible particles in a beam of energy, that is indivisible particles moving after each other will have very different implications than an identical reduced Compton wavelength. For example, two indivisible particles traveling after each other could have a void-distance (what modern physics think is a wavelength) equal to the reduced Compton wavelength of the electron. Still this would not be the matter length of the indivisibles, as a matter length (reduced Compton wavelength) is the length an indivisible particle travels back and forth in a stable pattern in between each counter-strike.

Table 2 illustrates how all masses theoretically can be constructed from two indivisible particles that together have a mass equal to the Planck mass.

Particle	Mass (kg)	Time-speed (s/m)
Indivisible particle	$m_i = 1.088\text{E-}08$	None
Planck mass particle (Motz)	$m_p = 2.177\text{E-}08$	3.34E-09
Higgs particle	$m_h = \frac{l_p}{\lambda_h} m_p = 2.230\text{E-}25$	3.42E-26
Neutron	$m_N = \frac{l_p}{\lambda_n} m_p = 1.675\text{E-}27$	2.57E-28
Proton	$m_P = \frac{l_p}{\lambda_p} m_p = 1.673\text{E-}27$	2.56E-28
Electron	$m_e = \frac{l_p}{\lambda_e} m_p = 9.109\text{E-}31$	1.40E-31

Table 2: The table shows the mass in kg and the mass in time-speed for some subatomic particles.

Table 3 lists a series of properties of the assumed indivisible particle. What is of great importance is that the indivisible particle must always travel with the speed⁴ of light c , its diameter must be l_p and its mass must be half the Planck mass, and the Planck mass last for a Planck second as seen from an observer. Like the atomist Giordano Bruno⁵, we are assuming that all indivisible particle are uniform and sphere shaped; this leads to a series of properties such as the circumference, surface area, and volume that also are listed in the table. To what degree these particular properties (below the line) potentially will have any importance in deriving useful physics formulas or to give us deeper insight in existing physics is unclear.

Property	SI Units	Dimensionless $l_p = 1, c = 1$
Diameter	$D_i = l_p \approx 1.616\text{E-}35$ m	1 (L)
Radius	$r_i = \frac{1}{2}l_p \approx 8.081\text{E-}36$ m	0.5 (L)
Schwarzschild radius	$r_s = l_p \approx 1.616\text{E-}35$ m	1 (L)
Round-trip speed	$c = 299,792,458$ m/s	1 (L/T)
Potential mass at hit	$m_i = \frac{1}{2}m_p = \frac{1}{2}\frac{\hbar}{l_p} \frac{1}{c} \approx 1.088\text{E-}08$ kg	3.2625...(M)
Potential mass at hit	$m_i = \frac{1}{2}m_p = \frac{1}{2}\frac{1}{c} \approx 1.668\text{E-}09$ time-speed	0.5 (T/L)
Energy	$E_i = \frac{1}{2}m_p c^2 = \frac{1}{2}\frac{\hbar}{l_p} c \approx 978,074,758$ J	3.2625... .
Potential charge	$q_i = \frac{1}{2}\sqrt{\frac{\hbar}{c}}\sqrt{10^7} \approx 9.38\text{E-}19$ C	4,038.88...
Other properties with potential future interest:		
Circumference	$C_i = \pi l_p \approx 5.077\text{E-}35$ m	π (L)
Sphere surface area	$A_i = \pi l_p^2 \approx 8.206\text{E-}70$ m ²	π (L ²)
Sphere volume	$V_i = \frac{1}{6}\pi l_p^3 \approx 2.210\text{E-}105$ m ³	$\frac{1}{6}\pi$ (L ³)
Equivalent square area	$l_p^2 = 2.612\text{E-}70$ m ²	1 (L ²)
Equivalent cube volume	$l_p^3 = 4.222\text{E-}105$ m ³	1 (L)

Table 3: The table shows the properties of the indivisible particle.

Based on the analysis above, the mass of this most fundamental particle is half the Planck mass and this also means its mass is related to half the reduced Planck constant, $\frac{1}{2}\hbar$, rather than \hbar . The constant $\frac{1}{2}\hbar$ has recently been described by [31] as the forgotten constant. We think indeed $\frac{1}{2}\hbar$ can be seen as an even more fundamental constant than \hbar , since the indivisible particle seems to be the only truly fundamental particle making up all energy and matter. D'Angelo also introduces the Planck circumference identical to the one listed in the table here and links it to atomism.⁶

2 Mass as kg and Mass as Time-Speed

In modern physics, mass is typically given in the notation of kg. For example, a Planck mass in kg is given by

$$m_p = \sqrt{\frac{\hbar c}{G}} = \frac{\hbar}{l_p} \frac{1}{c} \approx 2.17651 \times 10^{-8} \text{kg} \quad (6)$$

Further, an electron mass is given by

$$m_e = \frac{l_p}{\lambda_e} \sqrt{\frac{\hbar c}{2G}} = \frac{\hbar}{\lambda_e} \frac{1}{c} \approx 9.1094 \times 10^{-31} \text{kg} \quad (7)$$

Both G and \hbar are related to kg. In 2014, Haug has shown that mass also can be derived and analyzed from atomism without kg and without relation to G . Haug also introduced what he calls time-speed. As we have explained above, mass is actually related to counter-strikes between indivisible particles. Such counter-strikes are not only the foundation of mass, but they are also the foundation of time. Only counter-strikes can cause observable changes and time is change. Each counter-strike (mass event) can be seen as a tick of time. Every subatomic particle can be seen as a discrete clock with its own clock

⁴As measured with Einstein-Poincaré synchronized clocks.

⁵Who was burnt by the stake for his view.

⁶I think D'Angelo has important points related to reintroducing $\frac{1}{2}\hbar$ and also the circumference of the indivisible particle. However, I doubt that the constant he calls the Democritean unit $Y' = 8.134865168 \times 10^{-54}$ has anything directly to do with the indivisible particles other than being another constant useful for some calculation purposes. Still, only time will tell if there is more to it.

frequency, that is number of ticks per second. With time-speed we simply think about the number times the indivisibles counter-strike compared to an ideal mass where there are continuous counter-strikes. We can think of an ideal fully solid mass where a series of Planck particles are laid out next to each (or approximately next to each other). The indivisible particles always move at the speed of light and if they are lying approximately side-by-side, then they will continuously counter-strike. This means the time-speed of a Planck mass can be described as simply

$$\hat{m}_p = \frac{l_p}{l_p} \frac{1}{c} = \frac{1}{c} = 3.33564095198152 \times 10^{-09} \text{ continuous seconds per meter} \quad (8)$$

That is to say, the dimension of a mass in the form of time-speed is $\frac{T}{L}$. Such an ideal mass is very useful for standardizing mass and comparing other masses to it. Continuously counter-striking can be seen as a continuous clock. For every meter an indivisible particle moves, it can maximum counter-strike an infinite number of times, or in other words it is can tick 3 continuous nano seconds for every meter it moves. Just as the Planck mass in kg 2.17651×10^{-8} can be seen as the most fundamental kg mass, then $\frac{1}{c} = 3.33564095198152 \times 10^{-09} \approx 3$ nano seconds per meter, can be seen as the equivalent continuous time-speed of a Planck mass. An electron does not have continuous counter-strikes; it is not a continuously ticking clock. An electron is equivalent to

$$\hat{m}_e = \frac{l_p}{\lambda_e} \frac{1}{c} \approx 1.396 \times 10^{-31} \text{ continuous seconds per meter}, \quad (9)$$

continuous seconds per meter the indivisible particles moves. Thus if we know the Planck length and the reduced Compton wavelength of the mass of interest, we can do without the Planck constant or the Newton gravitational constant when we work with any mass, as well as with gravity. For an indivisible particle, we have the potential mass in form of time-speed equal to

$$\hat{m}_i = \frac{1}{2} \frac{l_p}{l_p} \frac{1}{c} = \frac{1}{2} \frac{1}{c} = \frac{1}{2c}, \quad (10)$$

this is also the rest-mass when counter-striking. Further, its rest-mass when it is not counter-striking is

$$\hat{m}_i = \frac{1}{2} \frac{l_p}{\infty} \frac{1}{c} = 0. \quad (11)$$

That an indivisible particle has no rest-mass when not counter-striking does not mean that it does not have a potential mass. It is energy and has potential mass (time-speed) when not counter-striking, and it has rest-mass (time-speed) and potential energy when counter-striking. Again, this is a new way of looking at matter and energy. It is a logical way where energy and mass not are something undefined only described by mathematical formulas combined with a series of “buzz” words. By dressing up atomism in mathematics and combining it with insight from modern physics, then physics is again truly Physics. Math is extremely useful and necessary to add precision to the language and to calculate what a theory predicts; this can then be compared to experiments and the world around us. Still, mathematical physics alone, no matter how well it fit experiments, is no guarantee for acquiring an in-depth understanding of reality. Atomism seems to come handy in here.

3 Heisenberg’s Uncertainty Principle in a New Perspective

Our new atomist view of matter and energy also seems to provide a new interpretation of Heisenberg’s Uncertainty principle. Heisenberg’s Uncertainty principle [32] is given by

$$\sigma_x \sigma_p \geq \frac{\hbar}{2} \quad (12)$$

where σ_x is considered to be the uncertainty in the position, σ_p is the uncertainty in the momentum, and \hbar is the reduced Planck constant. For an indivisible particle we must have

$$\begin{aligned}
\sigma_x \sigma_p &\geq \frac{\hbar}{2} \\
\sigma_x &\geq \frac{\hbar}{2\sigma_p} \\
\sigma_x &\geq \frac{\hbar}{2m_i c} \\
\sigma_x &\geq \frac{\hbar}{2\frac{1}{2}m_p c} \\
\sigma_x &\geq \frac{\hbar}{2\frac{1}{2}\frac{\hbar}{l_p}\frac{1}{c}} \\
\sigma_x &\geq l_p
\end{aligned} \tag{13}$$

And this is no surprise; as the indivisible particle has a diameter of l_p , we cannot really say its location is inside or in a point inside its spatial dimension. The indivisible particle naturally covers its entire spatial dimension. So our minimum “uncertainty” concerning the exact position of the particle (in a one-dimensional analysis) must naturally be l_p . The word “uncertainty” is not a well-described term here, as this is simply the one-dimensional minimum length the particle always must occupy, see figure 3.⁷

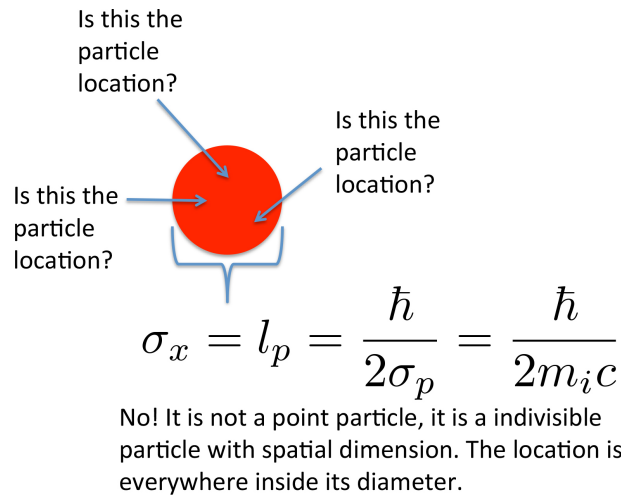


Figure 3: Illustration of Atomism interpretation of Heisenberg’s Uncertainty principle for an indivisible particle with mass equal to half the Planck mass.

This removes some of the mystery of Heisenberg Uncertainty principle. From an atomist point of view, the Heisenberg Uncertainty principle simply confirms that at the very depth of reality we have indivisible particles with spatial-dimension and a diameter of l_p , rather than the non-logical hypothetical point particles. Still, all observable subatomic particles, like electrons, for example, are neither point particles nor particles with a spatial dimension equal to their reduced Compton wavelength. All observable subatomic particles consist of indivisible particles and void, and the indivisible particles with spatial dimension are moving at the speed of light along the reduced Compton wavelength.

Further, the momentum of an indivisible particle is given by

$$\begin{aligned}
\sigma_x \sigma_p &= \frac{\hbar}{2} \\
\sigma_p &= \frac{\hbar}{2l_p} \\
\sigma_p &= \frac{1}{2} \frac{\hbar}{l_p}
\end{aligned} \tag{14}$$

⁷Based on special relativity theory we have length contraction and we should think this was frame dependent. As shown by Haug 2014, the length contraction is simply related to reduced void-distance between indivisible particles and the indivisible particles themselves cannot contract. But all masses consist of indivisible particles moving back and forth in the void.

which we already know, since the momentum of an indivisible particle must be

$$p_i = m_i c = \frac{1}{2} \frac{\hbar}{l_p} \frac{1}{c} c = \frac{1}{2} \frac{\hbar}{l_p} \quad (15)$$

We conclude that Heisenberg's Uncertainty principle formula makes logical sense for indivisible particles and opens up for a more logical interpretation based on an indivisible particle with spatial dimension and diameter l_p .

Next let us look at a subatomic particles with mass less than half the Planck mass, for example the electron, m_e . We claim the right interpretation here is given by using $m_e c$ as the momentum of the electron, this gives the "uncertainty" in the position of

$$\begin{aligned} \sigma_x &\geq \frac{\hbar}{2m_e c} \\ \sigma_x &\geq \frac{\hbar}{2 \frac{\hbar}{\lambda_e} \frac{1}{c} c} \\ \sigma_x &\geq \frac{\lambda_e}{2} \end{aligned} \quad (16)$$

This is fully consistent with atomism. The indivisible particle moves back and forth with the speed of light along the reduced Compton wavelength of the electron. And since the particle moves so fast, the best guess to minimize our error of where the indivisible particle relies on choosing the midpoint of the reduced Compton wavelength. Then we know it must be within half the reduced Compton wavelength of the electron. Similar can be done for any subatomic particles.

Modern physics is a top-down theory where one has tried to dig deeper and deeper with some wonderful success in formula derivations and predictions. However, modern physics is lost at understanding the depth of reality. Atomism on the other hand is mostly a bottom-up theory. This alone is not any guarantee for success, but the great progress in mathematical atomism in recent years is very promising. Based on atomism we "know" that an indivisible particle must take up a diameter of l_p . It is meaningless to try to pin point the location of the particle further, at least without talking about also the center of the particle and so on. Atomism does not need Heisenberg's Uncertainty principle to figure out the "uncertainty" (that is not really an uncertainty) in the particle extension. Still, atomism is fully consistent with the Heisenberg Uncertainty principle formula. Modern physics, with the hypothetical idea of point particles, often has the correct formulas but the interpretations seem to be far-fetched. In addition, their formulas can often be broken down into simpler formulas based on Planck quantization as recently shown by [17, 30]

4 Particle radius or Point particle?

Not so long ago it was assumed known subatomic particles such as the electron had a radius. The modern view is that subatomic particles are point particles with no spatial-dimension. From the modern atomist perspective, none of these views are correct. Observable subatomic particle, like the electron does not have a radius. The electron is not a sphere. Based on atomism the electron is also not a point particle. The electron consists of likely (minimum) two indivisible particles moving back and forth at the speed of light over a distance equal to twice the reduced Compton wavelength of the electron. Under atomism the only particle that has sphere shape and that does not consist of moving parts is the indivisible particle. It has a diameter equal to the Planck length and a radius equal to half the Planck length. Further, the indivisible particle is not a particle based on the criteria from modern physics, because it has no rest-mass, except when counter-striking; alone, when not counter-striking another indivisible particle, it only has potential mass (equal to half the Planck mass).

All known subatomic particles are not point particles, nor do they have a radius, but they consist of extremely small indivisible particles moving back and forth in a pattern at the speed of light counter-striking with each other. For modern physics this is a whole new way of thinking about matter and energy. Based on atomism matter is characterized by an indivisible-void duality rather than particle-wave duality. But under atomism this duality is nothing more mystical than indivisible particles always moving at the speed c in empty space (void).

5 Schwarzschild radius of the indivisible particle

The so called Schwarzschild radius is given by (see [33, 34, 35, 36, 37])

$$r_s = \frac{2Gm}{c^2} \quad (17)$$

The particle with half the Planck mass is the only particle where the Schwarzschild radius is equal to the Planck length:

$$r_s = \frac{2Gm_i}{c^2} = \frac{2G\frac{1}{2}m_p}{c^2} = l_p \approx 1.6162 \times 10^{-35} \quad (18)$$

One can input the standard values of G the Planck mass m_p and c to check that it gives a Schwarzschild radius of l_p , alternatively, based on recent findings by [17, 30, 38], it could also be written as

$$\begin{aligned} r_s &= \frac{2G\frac{1}{2}m_p}{c^2} \\ r_s &= \frac{2\frac{l_p^2 c^3}{\hbar} \frac{1}{2} \frac{\hbar}{l_p} \frac{1}{c}}{c^2} = l_p \end{aligned} \quad (19)$$

Most physicists assume that the Planck length plays an important role at the depth of reality. The indivisible particle is very unique; it must have a mass of half the Planck mass, its Schwarzschild “radius” is l_p , and furthermore, it is the only particle that has an escape velocity of c when we are operating all the way down to the Planck length l_p

$$v_e = \sqrt{\frac{2Gm_i}{r_s}} = \sqrt{\frac{2G\frac{1}{2}m_p}{l_p}} = c \quad (20)$$

In our view, the half a Planck mass particle is an indivisible particle, always moving with the speed of light, that makes up all other particles, and the fact that it is directly related to the escape velocity with $r = l_p$ simply confirms it. As we soon will see this gives also a new interpretation of so called mini-black holes. The idea of an escape velocity and black holes actually goes all the way back to 1784 when Michell, based on Newton mechanics, speculated on what he called “dark stars”, see [39, 40, 41].

There exists a somewhat “competing” particle that is often called the Planck particle; among many physicist it has been interpreted as a mini-black hole. This is a particle with mass $\sqrt{\pi}$ times the Planck mass. Its escape velocity is c , when using its Compton wavelength as the radius in the escape velocity formula. However, we do not think that this particle can exist and it is not as unique as some physicists might think, even from a mathematical point of view, see also [16]. Alternatively we can look at a mass with $\frac{1}{\sqrt{2}}$ times the Planck mass and when setting the reduced Compton wavelength (instead of the Compton wavelength) equal to the radius in the escape velocity formula, and we again get an escape velocity of c . So is this another mini-black hole? We doubt so.

On the other hand, the indivisible particle does have many similarities with the originally conception of the properties of a black hole. The indivisible particle is indivisible, that is unbreakable; it is fully contained inside a length equal to the Schwarzschild radius and therefore nothing can escape from it, because it is singular and indivisible. Nothing radiates out from it or into it. There is no Hawking radiation from an indivisible particle. The indivisible particle is in one instant, that is for one Planck second, part of a mass (counter-striking) and in the next instant it is energy again, so it is “radiating” into itself. However, the mass and radiation are nothing more than entering and leaving the counter-striking state.

Hawking [11] has expressed the opinion that a black hole cannot have a mass smaller than about 10^{-5} gram, which interestingly is the same as the mass of half the Planck mass. However, the interpretation given here is very different. The term black hole is misleading if the formulas are actually hinting at the existence of an indivisible particle. The black hole interpretation for a particle with escape velocity c is just a hypothesis. The indivisible particle theory seems more logical and it also solves the mystery of why do we not observe anything with a Planck mass or close to a Planck mass even when the Planck mass and the Planck length appear to be so important for certain parts of mathematical physics.

Hawking also interpreted such mini-black holes as collapsed objects shown in the form of very densely packed masses due to very strong gravitation and a type of gravitational collapse. Under atomism this, on the contrary, represent indivisible particles that not can collapse or get any smaller; it is simply a mathematical expression of their indivisibility. Further, it is important to note that the indivisible particle has a spatial dimension; it is not a point particle. Compared to other masses, such as an electron that mostly consist of void, an indivisible particle is indeed very dense. These particles when close to each other have an extremely strong force, namely the Planck force. However, this strong force only lasts for a Planck second from a observers perspective, when an indivisible particle counter-strikes with another

indivisible particle. It is correct that any mass in particles we can observe even in a though experiment set-up not can have a mass of less than the Planck mass. This could happen if we strip the particles such as an electron of their void, that is if we “pushed” the indivisible particles together. Alternatively, if we had equipment to observe the particles at close to a Planck second time interval we would likely have observed Planck mass objects already and almost everywhere. Unfortunately, our current technology is very far from being able to measure such short time windows. Again the atomism theory seems fully consistent with the idea that there is something very special for particles with escape velocity c ; namely that these are very likely to be indivisible particles always traveling at speed c .

Figure 4 gives an illustration of the atomism interpretation of Schwarzschild radius and escape velocity at the Planck scale.

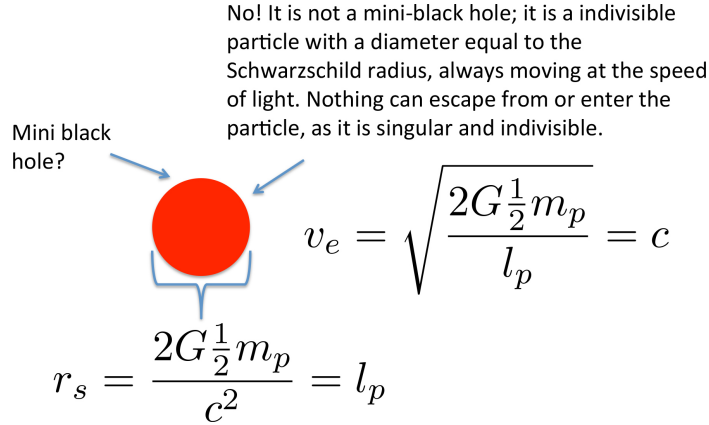


Figure 4: Illustration of Atomism interpretation of Schwarzschild radius and escape velocity at the Planck scale.

Four mathematically interesting Planck type particles, which are closely related to the Planck mass are listed in table 4. There are good reasons to think that only two of these particles actually represent something real: the Planck mass particle that consists of two indivisible particles and the most important of all particles, namely the indivisible particle, that has half the Planck mass.

Particle name	Mass in kg	Reduced Compton wavelength	Compton wavelength	Schwarzschild radius	Escape velocity ^a
	$m = \frac{l_p}{\lambda} \sqrt{\frac{\hbar c}{G}}$	$\bar{\lambda} = \frac{\hbar}{mc}$	$\lambda = \frac{\hbar}{mc} = \bar{\lambda} 2\pi$	$r_s = \frac{2Gm}{c^2}$	$v_e \sqrt{\frac{2Gm}{r}}$
Planck mass particle	$m_p \approx 2.177 \times 10^{-08}$	l_p	$l_p 2\pi$	$2l_p$	$\sqrt{2}c$ and $\frac{c}{\sqrt{\pi}}$
Planck type particle 1	$m_b = \sqrt{\pi} m_p$	$\frac{l_p}{\sqrt{\pi}}$	$2\sqrt{\pi} l_p$	$2\sqrt{\pi} l_p$	$\frac{c}{\sqrt{\pi}}$ and c
Planck type particle 2	$m_r = \frac{1}{\sqrt{2}} m_p$	$\sqrt{2} l_p$	$\sqrt{8\pi} l_p$	$\sqrt{2} l_p$	c and $\frac{c}{\sqrt{2\pi}}$
Indivisible particle	$m_i = \frac{1}{2} m_p$	l_p ^b	n/a	l_p	c

Table 4: Planck particles.

^aThe escape velocity is calculated twice, first by using the reduced Compton wavelength as the radius and second by using the Compton wavelength as the radius.

^bThis particle has per definition no Compton or reduced Compton wavelength on its own. This is the diameter of the particle, see comments below the table.

The indivisible particle has, by definition, no Compton or reduced Compton wavelength on its own. The indivisible particle does have an assumed diameter of l_p . In reality, to have a reduced Compton wavelength under our theory we need a minimum two indivisible particles, as the reduced Compton wavelength in this theory is the average distance between two indivisible particles making up a mass. In a Planck mass, for example, the reduced Compton wavelength is l_p . Bear in mind that the indivisible particle has no rest-mass except when counter-striking with another indivisible particle. When counter-striking with another indivisible particle, the two indivisible are combined the Planck mass and then this mass has a reduced Compton wavelength of l_p as also shown in the table. That is the distance center to center between two indivisible particles (that each has a diameter of l_p) lying next to each other (counter-striking). For an electron there is also on average void in between the indivisible particles as

they then travel over the reduced Compton wavelength of the electron that is extremely much longer than the Planck length.

6 A New Solution to Einstein's Infinite Mass Challenge

Let's look at relativistic masses next. Einstein [21, 42] gave the following relativistic mass formula:

$$\frac{mc^2}{\sqrt{1 - \frac{v^2}{c^2}}}. \quad (21)$$

Further, Einstein commented on his own formula

*This expression approaches infinity as the velocity v approaches the velocity of light c . The velocity must therefore always remain less than c , however great may be the energies used to produce the acceleration*⁸

We certainly agree on Einstein's formula; it is fully consistent and can also be derived from atomism, as shown by Haug in 2014. Einstein's argument is that the mass will become infinite as v approaches c and this would mean we would need infinite amount of energy to accelerate even an electron to the speed of light. However, the understanding of mass and energy in modern physics from a deeper fundamental point of view is still very limited. Based on a better understanding of quantization of mass and the Planck mass in particular, when rooted in atomism, we will show this leads to exact speed limit for any given fundamental particle as long as we know the particles rest-mass. At this maximum speed limit we will soon discuss, the subatomic particles will have reached a mass limit, which is the Planck mass. Next the Planck mass will dissolve basically instantaneously into energy. And energy is moving at the speed of light. We will not need infinite energy to move a mass to the speed of light.

Bear in mind that a Planck mass comes into existence exactly in the instant when two indivisible particles collide. Even if the indivisible particles creating the Planck mass are moving at the speed of light just before and after they collide (counter-strike), they are standing still in the very instant they create the mass. The Planck mass is simply a collision. One collision between two indivisible particles is one collision no matter what frame it is observed from. That is to say, the Planck mass is actually very unique in that it always has the same mass no matter what frame it is observed from. This is a special case, as it only holds for the Planck mass (the Planck mass particle that exist in the instant of the collision between two indivisible particles) and for no other subatomic particles.

Not only is the Planck mass invariant to what frame it is observed from, in addition it must be largest possible mass that a subatomic particle can take. The Planck mass has also the shortest possible reduced Compton wavelength. Its reduced Compton wavelength is equal to the Planck length. It is actually impossible for two indivisible particles to come closer towards each other when they counter-strike. They are indivisible and fully hard just as the particles that Newton described. The indivisible particle has a diameter of l_p and the closest it can be between the two particles center to center is the Planck length, which again is the reduced Compton wavelength of the Planck mass, when the two indivisibles are lying side-by-side counter-striking. All known subatomic particles, such as an electron, have a much longer reduced Compton wavelength than the Planck mass. The indivisible particles making up an electron move back and forth along the reduced Compton wavelength of the electron. The shorter the reduced Compton wavelength of a particle, the larger the mass will be. The reduced Compton wavelength of any mass other than the Planck mass has mostly empty space (void) in the reduced Compton wavelength.

Assume two indivisible particles making up a rest-mass have a reduced Compton wavelength of $\bar{\lambda}$. Due to length contraction, when a mass is moving the reduced Compton wavelength of that mass will be observed as contracted from any other frame. At least as long as it is directly or indirectly measured with Einstein synchronized clocks; an extensive discussion and a series of derivations on this is given in [4]. When the speed of the subatomic particle is so large that the reduced Compton wavelength has length contracted to l_p , then the mass will simultaneously have reached its Planck mass. The Planck mass will however not be stable, but will within a Planck second burst into energy⁹. Well, the 'proof' is in the pudding, that is to say here, in the mathematical pudding¹⁰:

⁸This quote is taken from page 53 in the 1931 edition of Einstein's book *Relativity: The Special and General Theory*. English translation version of Einstein's book by Robert W. Lawson.

⁹Actually it will burst instantaneously into energy, but from an observer's perspective using Einstein-Poincaré synchronized clocks this would take place, under very idealized conditions, in one Planck second. This is actually due to a minimum synchronization error; see [4] for a discussion on clock synchronization errors.

¹⁰See an alternative derivation that gives the same end result in the Appendix.

is inversely related to the particle's rest-mass, and naturally because the maximum mass any subatomic "fundamental" particle can reach is the Planck mass. The energy needed to accelerate any mass to its maximum mass is the Planck mass energy, which is $E = m_p c^2 \approx 1.22 \times 10^{16}$ TeV. The LHC is currently operating at 13 TeV and it is therefore extremely unlikely we will see this theory verified experimentally, as it would require a much more powerful particle accelerator. Still, the main point is that we in no way need infinite energy for a mass to reach the speed of light. It will burst into energy when reaching its maximum speed, which is just below that of the speed of light, and we can calculate that speed accurately based on the atomist view of matter.

In reality, if a proton consists of a series of other subatomic particles, then the speed limit given above for a proton will not be very accurate. Alternatively, we could have looked at the reduced Compton wavelength of the quarks that the standard model claims is making up the proton. As the quarks in the proton have different reduced Compton wavelengths, then the proton could have several maximum speeds where parts of the proton mass turns into a Planck mass and then burst into energy.

7 Summary and Conclusion

The Planck mass plays an important role in a series of mathematical calculations and analysis in modern physics. The Planck mass is enormous compared to the mass of any known subatomic particle and still its reduced Compton wavelength is much smaller than any known subatomic particle. It has been speculated that Planck mass size particles are related to mini-black holes. Here we have introduced a totally new interpretation of matter and energy. In 2014, Haug has shown that all mathematical end results from special relativity can be derived from atomism. However, he had not shown how his theory could be linked to known subatomic particles.

Here we show that the indivisible particle, if having a potential mass equal to half the Planck mass, basically can explain the mass of any other subatomic particle. Based on this observation, we claim that we have found the Planck mass particle. We even claim that it cannot be found directly in a particle accelerator such as the Large Hadron Collider. The only way to find the Planck mass particle is through the intellect.

Atomism also provides a more logical interpretation of the Heisenberg Uncertainty principle than the interpretation given by modern quantum mechanics. Further, we develop a completely new interpretation of the Schwarzschild radius at the Planck scale. When the Schwarzschild radius is l_p , it fits the interpretation of an indivisible particle always traveling at the speed of light perfectly. In other words, there are really no mini-black holes. Still, the indivisible particle has many similarities with some of the ideas about black holes. Nothing can escape or enter an indivisible particle because it has no parts and is a singular particle with spatial-dimension. This new view of matter and energy also gives a new solution to Einstein's infinite mass problem. While Einstein solved it by assuming that no mass can be accelerated to the speed of light, as this would require infinite energy, we show that all subatomic particles have a maximum speed limit just below the speed of light where they will first turn into Planck masses. The Planck mass is extremely unstable and will instantaneously burst into energy. The amount of energy needed to accelerate any subatomic fundamental particle to its maximum speed is the Planck mass energy. This energy is substantially higher than what one is operating at with the Large Hadron Collider. So with today's particle accelerators we are far away from being able to test this out experimentally. Still, it gives a totally new and interesting view on matter and energy. It is high time to abandon the point-particle idea and to rethink the particle-wave duality – for this we must investigate atomism further.

8 Appendix

In this appendix we show a slightly different way of deriving the maximum speed for particles. The end result is the same as the derivation elsewhere in the paper.

$$\begin{aligned}
m_p &= \frac{m}{\sqrt{1 - \frac{v^2}{c^2}}} \\
\sqrt{1 - \frac{v^2}{c^2}} &= \frac{m}{m_p} \\
\sqrt{1 - \frac{v^2}{c^2}} &= \frac{\frac{l_p}{\lambda} \sqrt{\frac{\hbar c}{G}}}{\sqrt{\frac{\hbar c}{G}}} \\
1 - \frac{v^2}{c^2} &= \frac{\left(\frac{l_p}{\lambda} \sqrt{\frac{\hbar c}{G}}\right)^2}{\sqrt{\frac{\hbar c}{G}}^2} \\
1 - \frac{v^2}{c^2} &= \frac{\frac{l_p^2}{\lambda^2} \frac{\hbar c}{G}}{\frac{\hbar c}{G}} \\
v &= c \sqrt{1 - \frac{l_p^2}{\lambda^2}} \tag{23}
\end{aligned}$$

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