de Broglie Wavelength For the Proton at a Very Low Velocity

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Abstract

In modern physics, the de Broglie wavelength is considered to be the matter wave. However, the de Broglie wave has a series of strange properties. It is not mathematically defined for a rest-mass particle, when $v = 0$. However, one can claim a particle never stands still and that the de Broglie wavelength only converges towards infinite when v converges to zero. An infinite matter wavelength would also be strange. We have good reasons to think that the de Broglie wavelength only is a mathematical derivative of the true matter wavelength, which we believe is the Compton wavelength. Although noted briefly here, this has already been described by Haug [1] and is a topic for another article. What we will focus on here is that the length of the de Broglie wavelength, if we use an observational window of one second and the minimum observable velocity, is the Planck length per second. Then the de Broglie wavelength for a proton actually has a length very close to the assumed radius of the observable universe. We think most likely this is a coincidence, particularly since one second is an arbitrarily chosen time unit, and not a fundamental time unit such as the Compton time, or the Planck time, for example. Still, we think this finding is worth mentioning and could be the basis for further discussion.

Key Words: De Broglie wavelength, diameter, observable universe, rest-mass particle.

1 The de Broglie wavelength when the mass is almost at rest

The relativistic de Broglie wavelength [2] is given by

$$\lambda_b = \frac{h}{mv\gamma} \tag{1}$$

where h is the Planck constant and v is the velocity of the mass in question. When $v << c$, this can be approximated as

$$\lambda_b = \frac{h}{mv} \tag{2}$$

We can see from both formulas that they are not valid when $v = 0$, as this would mean dividing by zero, which is, of course, considered undefined in mathematics. This means that rest-mass particles do not have a defined matter wavelength. However, based on Heisenberg's [3, 4] uncertainty principle, we could argue that no particle or mass can be at absolute rest. This might be an incorrect interpretation seen in contrast to recent developments in understanding the Heisenberg principle, as described in our earlier paper [1]. However, we will follow this standard view here.

Next we will assume minimum observable velocity (or minimum uncertainty in a velocity) for a given observational time window; this is to move the Planck length during the observational time-window. Assume that this observational time window lasts for one second. This would mean $v = \frac{l_p}{1second}$. And from this set-up, a proton would have a predicted de Broglie wavelength of

$$\lambda_b = \frac{h}{m_p v} = \frac{h}{m_p \frac{l_p}{1second}} \approx 2.4 \times 10^{28}\ m \tag{3}$$

The diameter of observable universe is assumed to be about 8.8×10^{26} meter. So, this is clearly above that scale.

What if we assume that the minimum velocity is $v = \frac{2\pi l_p}{1second}$ instead? Then we get

$$\lambda_b = \frac{h}{m_p v} = \frac{h}{m_p \frac{2\pi l_p}{1second}} \approx 3.8 \times 10^{27}\ m \tag{4}$$

and the reduced de Broglie wavelength at this velocity is given by

$$\bar{\lambda}_b = \frac{\lambda_b}{2\pi} \approx 6.2 \times 10^{26}\ m \tag{5}$$

This is not that far from the assumed diameter of the observable universe, 8.8×10^{26} m, although we think this is likely a coincidence, particularly since one second is an arbitrary human time window, and not a fundamental unit of time. It is an mathematical result from some given input and perhaps it has no deeper meaning, but it could be worth investigating further and is certainly worth mentioning.

No matter whether there is a minimum velocity or not, how should such a very long de Broglie wavelength be interpreted? Some would see this as showing that the proton is basically everywhere in the observable universe until we observe it. Such interpretations have serious flaws, in our opinion. We should consider what would be the case if the velocity was even lower, because we could still have a minimum velocity linked to the Planck length that was smaller simply by choosing a larger time-window. Then would the proton also be outside the observable universe until it was observed? Our point is simply that the de Broglie wavelength interpreted in such ways is absurd.

We think that the de Broglie wavelength is merely a mathematical derivative of the much more important Compton wavelength. The Compton wavelength is close to 1.32×10^{-15} m for a particle at rest or moving at such low speeds. The Compton wavelength is also well-defined for rest-mass particles. The de Broglie wavelength is always equal to the Compton wavelength multiplied by $\frac{c}{v}$.

It is also worth noting that we have the following interesting relation $\frac{M_u}{R_u} \approx \frac{m_{pl}}{2\pi l_p}$, see also [5, 6]

A deeper and still open question concerns whether or not the assumed diameter of the universe is simply linked to something that we have not yet understood about the Planck scale. In other words, does the diameter of the observable universe really represent such a diameter, or is it just a "number" linked to a restriction we indirectly get from something we have not fully grasped about the Planck scale? One should naturally be very careful not to step in the salad here. If we divide a series of well-known physical numbers on each other, we will, by pure coincidence, get some that looks like they are related, based on the number value. However, this basically means nothing on its own; nevertheless, if we can understand a casual relation here then it becomes very interesting indeed; further work should be done in this direction.

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