Kinetic Mass

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Abstract

In this short note, we introduce the concept of kinetic mass. We have kinetic energy, but in standard theory there is only relativistic mass, and no kinetic mass. However, we think that kinetic mass is a useful addition to our physics toolbox. In our view, the kinetic mass is no less real than momentum, for example. In fact, it is arguably even more "real" than the concept of momentum, as we will discuss. Further, kinetic mass can be used to make wave equations with an operator on kinetic mass rather than on the momentum, as recently shown by Haug.

Key Words: rest-mass, kinetic-mass and total mass.

1 Kinetic mass

Einstein introduced the concept of relativistic mass. The relativistic mass (that we also can call total mass) is given by

$$m_t = \frac{m}{\sqrt{1-\frac{v^2}{c^2}}} = m\gamma \tag{1}$$

From relativistic kinetic energy, also first described by Einstein, we have

$$E_k = \frac{mc^2}{\sqrt{1-\frac{v^2}{c^2}}} - mc^2 = mc^2\gamma - mc^2 \tag{2}$$

if we divide by c^2 on both sides of the equation, we are left with what we will define as kinetic mass

$$m_k = \frac{m}{\sqrt{1-\frac{v^2}{c}}} - m = m\gamma - m \tag{3}$$

if $v << c$, we can approximate this very well with the first term of a Taylor series expansion.

$$m_k \approx \frac{1}{2}m\frac{v^2}{c^2} \tag{4}$$

In many ways, the kinetic mass is closer to what we can observe than momentum, for example. Assume I have a brass ball. I can find the mass of the brass ball relative to one kg by weighing it on a scale. I will then know the relative rest-mass of the brass ball in terms of one kg. Next, if I move the brass ball, I can measure its velocity with two time gates. So, I know the mass of the brass ball and I now know the velocity of the brass ball. Still, one can never observe the mass multiplied by the velocity; the standard momentum is a purely mathematical concept that contains important information about both the mass and the velocity of the object. What we can measure is the impact of the moving brass ball when it hits something. If we drop the brass ball on soft clay, then almost all the energy will be used to make an indentation in the clay. If we repeat the experiment and double the speed, then we will get an indentation that is not twice as deep, as one might expect, but rather four times as deep. That is, the directly observable impact is a function of v^2 and not v. As the kinetic mass is directly linked to v^2 (when $v << c$), we could say that it is almost directly observable. This is how Gravesande [1] first confirmed that kinetic energy was linked to v^2 and not v. Whether kinetic energy (back then known as "vis viva", living force) was linked to v or v^2 was a long theoretical debate, where Leibniz [2] and du Châtelet [3], for example, both argued that it was linked to v^2 and not v.

Actually, kinetic energy, kinetic mass, and what we have described in other articles as "Compton momentum" are all functions of v^2 (when $v << c$). They are also all more directly observable than standard momentum. As we have shown in several papers, the standard momentum is a pure mathematical derivative (artifact so to say) of the real Compton momentum.

What can kinetic mass be used for? In quantum mechanics, we can decide to use a mass operator instead of a momentum operator. The mass operator will, in general, be $-i\hbar\nabla$; that is, the kinetic mass is treated as a vector, see [4, 5]. There are other implications as well, which will be described in future notes and papers.

References

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