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ORIGINAL ARTICLE

Is there lower limit to velocity or velocity change?

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Abstract Here we explore the possibility of a lower limit to velocity or velocity change which is 20 orders of magnitude smaller than the speed of light and explore the various observable signatures including those in cosmic rays and gamma ray bursts.

Keywords Special relativity · Planck scale · Limiting velocity

Special relativity implies an upper limit to velocity, i.e. that of light propagating in vacuum. This is well tested. Recent gamma ray bursts (Sivaram 2000; Tanvir 2009) with afterglows have enabled the independence of this upper limiting velocity with frequency in different parts of the electromagnetic spectrum from radio waves to gamma rays, and also in gamma rays of different energies. The fractional deviation (limit) is expressed as:

$$\frac{\Delta c}{c} < 10^{-18} \tag{1}$$

However special relativity is strictly valid only in inertial frames (in Euclidean flat space or absence of gravitational fields). Gravity by bending light causes light to propagate at lower speed (like a refracting medium) (Misner et al. 1973). It is not a priori evident that c should also be the limiting velocity in microscopic (subatomic) regions. Indeed for the highest energy cosmic rays observed ($\sim 10^{20}$ eV), the deviation from light velocity is $\sim 10^{-20}$.

In the micro-world (on the contrary) one would expect, especially around Fermi length scales or below, the existence of a lower limit to speed of propagation. These have been discussed in different contexts (deformed space-time, special relativity formulated with a minimal length scale, etc.; Sivaram 1993; Kloznaik 1999; Lukierski et al. 1995). Recently a suggestion (Sreenath 2012) was made that there could be a minimal velocity and its value was mentioned. Now arguing from the wavelength of de Broglie waves, i.e.:

$$\lambda = \frac{h}{mv} \quad (\text{say } v \sim c)$$

then for a change in velocity, we have:

$$d\lambda = \frac{h}{mv^2} dv \tag{2}$$

Now from various considerations, we may expect SR to become invalidated, at the Planck scale $\sim (\frac{\hbar G}{c^3})^{1/2} \sim 10^{-33}$ cm, when gravity and curvature effects become locally very important!

Thus the requirement that

$$d\lambda \geq \left(\frac{\hbar G}{c^3}\right)^{1/2} \tag{3}$$

implies from (2), that (for $m \sim m_e$ of electron mass)

$$dv \geq 10^{-11} \text{ cm/s} \tag{4}$$

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