A Minimum Rindler Horizon When Accelerating?

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Abstract

When a particle is in constant acceleration, it has been suggested it has a Rindler horizon given by $\frac{c^2}{a}$, where a is the proper acceleration. The Rindler event horizon tells us that we cannot receive information outside the horizon during the time period in which we are accelerating at this uniform rate. If we accelerate uniformly, sooner or later we will reach the speed of light, or at least very close to it. In this paper, we will look more closely at the Rindler horizon in relation to Haug's newly-suggested maximum velocity for matter and see that there likely is a minimum Rindler horizon for a particle with mass that is accelerating; this minimum Rindler horizon may, in fact, be the Planck length.

1 Minimum Rindler Horizon?

The Rindler horizon relates to concept that if one accelerates a particle or object away from an area, beyond a certain distance light itself will not be able to catch up to it. This means the accelerating particle or object cannot get information beyond that Rindler horizon while it is undergoing this acceleration. It is also important to understand that the Rindler event horizon is asymmetrical; it only refers to the side we are accelerating away from. Here we will here at the Rindler horizon in relation to maximum acceleration.

The Planck acceleration is known to be

$$a_p = \frac{m_p c^3}{\hbar} = \frac{c}{t_p} = \frac{c^2}{l_p} \approx 5.56092 \times 10^{51}\ m/s^2 \tag{1}$$

where l_p is the Planck length and t_p is the Planck second; see [1] and [2]. In 1984, Scarpetta had already predicted this as the maximum acceleration possible, [3], something also suggested by [4]:

> *"the 'Planck acceleration' is both the maximum acceleration for an elementary particle in free space and also the surface gravity of a black hole with minimum mass m_p" – Falla and Landsberg, 1994*

However, as pointed out by [5], for example, this enormous acceleration means that one will reach the speed of light after one Planck second, $a_p t_p = c$. Yet nothing with mass can travel at the speed of light, so nothing that still has mass after acceleration can undergo such rapid acceleration. However, in previous work we have suggested that a Planck mass particle dissolves into energy within one Planck second, and this is why we can have Planck acceleration. The Rindler horizon for a Planck mass particle is therefore

$$\frac{c^2}{a_p} = \frac{c^2}{\frac{c^2}{l_p}} = l_p \tag{2}$$

Haug [6, 7, 8] has recently suggested there is a maximum velocity of anything with rest-mass given by

$$v_{max} = c\sqrt{1 - \frac{l_p^2}{\bar{\lambda}^2}} \tag{3}$$

Based on this, Haug has suggested that the maximum acceleration for an elementary particle with mass (excluding the Planck mass particle) is

$$a_{max} = \left(\frac{c^2}{l_p} - \frac{c^2}{\bar{\lambda}}\right)\sqrt{1 - \frac{l_p^2}{\bar{\lambda}^2}} \tag{4}$$

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This would mean the minimum Rindler horizon related to mass is

$$\frac{c^2}{a_{max}} = \frac{c^2}{\left(\frac{c^2}{l_p} - \frac{c^2}{\bar{\lambda}}\right)\sqrt{1 - \frac{l_p^2}{\bar{\lambda}^2}}} = \frac{l_p\bar{\lambda}}{(l_p + \bar{\lambda})\sqrt{1 - \frac{l_p^2}{\bar{\lambda}^2}}} \tag{5}$$

As long as $\bar{\lambda} >> l_p$, this is approximately equal to

$$\frac{c^2}{a_{max}} \approx \frac{l_p\bar{\lambda}}{l_p + \bar{\lambda}} \approx \frac{l_p\bar{\lambda}}{\bar{\lambda}} = l_p \tag{6}$$

the Planck length. This means the minimum Rindler horizon for elementary particles is always the Planck length. It is worth mentioning that the Planck length is also the smallest possible Schwarzschild radius (with non-probabilistic meaning). For composite masses, we therefore wonder if the minimum Rindler horizon could also be related to the Schwarzschild radius of that object. See also [9, 10] who discuss an interesting idea of modified inertial mass related to the Rindler horizon, where they also touch upon the idea that the amount of information is related to the number of Planck areas that are on the closest event horizon, as seen by the object. McCulloch's and Giné's idea and insight are related to the concept that the Rindler horizon likely causes asymmetric radiation preassure from any object accelerating that will show up again as inertial mass. This would require a modification of standard inertial mass. Whether or not this paper is relevant to gaining further insight on their analysis (for example if there is a limit on inertia) will require considerable further investigation.

One important consideration is the fact that the Rindler horizon is asymmetric and only refers to the side from which we are accelerating. Further study is merited of this phenomenon and possible extensions into other areas of particle physics.

2 Conclusion

We have shown that the minimum Rindler horizon for any elementary particle accelerating likely is the Planck length.

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