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Tightly focused laser wake field acceleration to generate high field gradient for verification of the Unruh effect

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Quantum field theory predicts the Unruh effect [1], which states that a uniformly accelerated observer will see thermal radiation with a temperature proportional to the proper acceleration. The Unruh effect is connected to Hawking radiation by the equivalence principle. However, it is difficult to detect Hawking radiation generally because the radiation temperature is inversely proportional to the black hole mass. Since a typical black hole is more than the solar mass, the temperature is much less than the cosmic microwave background radiation of about 3 K. A very high acceleration is required to investigate the Unruh effect as well.

Laser wakefield acceleration (LWFA) is an attractive method with a high acceleration field gradient. The typical field gradient of a 100 GV/m is three orders of magnitude higher than that of conventional radio frequency (RF) electron accelerators. Recently, Aniculaesei *et al.* achieved 10 GeV of electron energy over a 10 cm scalelength using LWFA [2]. Practically, a long focus optic has been used for LWFA to obtain high energy electron beams. While in contrast, a high laser intensity and high electron density are essential for a high acceleration gradient. Here, we apply a tightly focused laser for LWFA with a realistic PW class laser system to show a field gradient beyond TV/m. This could be a potential experimental verification method for the Unruh effect.

References

[1] W.G. Unruh, Phys. Rev. D 14, 870 (1976).

[2] Constantin Aniculaesei *et al.*, Matter Radiat. Extremes 9, 014001 (2024).

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