Open Journal of Mathematics and Physics | Volume 1, Article 44, 2019 | ISSN: 2674-5747
https://doi.org/10.31219/osf.io/wru6z | published: 4 Sept 2019 | https://ojmp.wordpress.com
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The curvature of space due to one photon is inaccessible

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February 24, 2020

Abstract

We show that the curvature of space due to a single photon with $\lambda > l_p$ is less than the Planck length (l_p). Only a photon with precisely $\lambda = l_p$ curves space by Δl_g.

keywords: curvature, spacetime, photon, Planck scale, quantum gravity

Space curvature due to one photon

1. Consider one single photon traveling a distance l from A to B [1].
2. l is the distance in flat space.
3. The photon has energy $E = h\nu$, where ν is its frequency and h is the Planck constant.
4. Due to general relativity, the photon curves space and time.
5. The photon has velocity $c = \lambda\nu$.
6. $M = \frac{E}{c^2}$ is the equivalent of the photon's mass.

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7. The following calculations are approximate, but we'll use the symbol "=" for simplicity.

8. The Newtonian potential, having the photon as a source of gravity at a distance l, is
$$\phi = \frac{GM}{l},$$
where G is the Newtonian gravitational constant.

9. Inserting (3), (5) and (6) in (8),
$$\phi = \frac{G\hbar}{c\,l\lambda}.$$

10. The spatial distortion of l due to the photon's energy is [1]
$$\Delta l_g = l\frac{\phi}{c^2},$$
where ϕ is the Newtonian potential, and c is the speed of light.

11. The Planck length is given by
$$l_p = \sqrt{\frac{\hbar G}{c^3}}.$$

12. Inserting (9) in (10), and using (11),
$$\Delta l_g = \frac{l_p^2}{\lambda}.$$

Photon in the Planck scale

13. Conjecture: **The minimal length is the Planck length** [2].

14. So, by (13), $\lambda \geq l_p$.

15. First, let's suppose that $\lambda = l_p$.

16. From (12) and (15),
$$\Delta l_g = l_p.$$

17. *The result* (16) *means that a photon with* $\lambda = l_p$ *curves space by* λ.

18. Let's now suppose that $\lambda > l_p$.

19. From (18), $\lambda l_p > l_p^2$, then
$$\frac{l_p^2}{\lambda} < l_p.$$

20. From (12) and (19),
$$\Delta l_g = \frac{l_p^2}{\lambda} < l_p.$$

21. Therefore,
$$\Delta l_g < l_p.$$

22. From (13) and (21), *the curvature of space due to a single photon (with* $\lambda > l_p$*) is not accessible.*

Final Remarks

23. **A single photon** (with $\lambda > l_p$) **does NOT bend space**.

24. A photon with $\lambda = l_p$ has maximum energy and by extension (due to the principle of equivalence), maximum mass and acceleration [3–5].

25. **The minimum distortion in space is the Planck length, as we can see from** (16).

26. *If Planck length is the minimum discretized piece of space, then we should look towards a* **Discrete Riemannian Geometry** *in order to fully develop a quantum theory of gravity.*

Open Invitation

Review, *add* content, and **co-author** this article [6, 7]. *Join* the **Open Quantum Collaboration**. Send your contribution to mplobo@uft.edu.br.

Ethical conduct of research

This original work was pre-registered under the OSF Preprints [8], please cite it accordingly [9]. This will ensure that researches are conducted with integrity and intellectual honesty at all times and by all means.

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