

# On the vacuum topology of geometrical optics

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We propose there exists a topological structure (a knot) of geometrical optics in the most general vacuum space-time,  $R_{\mu\nu\rho\sigma} = 0$ .

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There exists a knot in Maxwell's gauge theory, a linear theory, in a vacuum (sourceless)<sup>1-4</sup>. The existence of geometrical optics knot in a 3-dimensional Euclidean flat space have been proposed<sup>5</sup>.

In gauge theory, classical fields of force are described in terms of curvature<sup>6</sup>. Gauge theories have global features which can be non-trivial even when all curvatures vanish<sup>6</sup>.

The true vacuum equation which describes the most general vacuum space-time can be written as<sup>7</sup>

$$R_{\mu\nu\rho\sigma} = 0 \quad (1)$$

where  $R_{\mu\nu\rho\sigma}$  denotes the Riemann curvature tensor. Here, the most general vacuum space-time is the vacuum space-time with source but this source does not disturb the vacuum space-time<sup>8</sup>.

The vacuum space-time can be classified by the knot topology was formulated<sup>7</sup>. In this article, we propose there exists a geometrical optics knot in the most general vacuum space-time,  $R_{\mu\nu\rho\sigma} = 0$ .

The work is still in progress.

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<sup>1</sup>Antonio F. Ranada, *Topological electromagnetism*, J. Phys. A: Math. Gen. **25** (1992) 1621-1641.

<sup>2</sup>Antonio F. Ranada, *A Topological Theory of the Electromagnetic Field*, Letters in Mathematical Physics **18**: 97-106, 1989.

<sup>3</sup>Antonio F. Ranada, *Knotted solutions of the Maxwell equations in vacuum*, J. Phys. A: Math. Gen. **23** (1990) L815-L820.

<sup>4</sup>Antonio F. Ranada, Jose L. Trueba, *Electromagnetic knot*, Physics Letters A **202** (1995) 337-342.

<sup>5</sup>Miftachul Hadi, *Knot in geometrical optics*, <https://vixra.org/abs/2207.0114>, 2022.

<sup>6</sup>Michael Atiyah, *The geometry and physics of knots*, Cambridge University Press, 1990.

<sup>7</sup>Y M Cho, Franklin H Cho, J H Yoon, *Vacuum decomposition of Einstein's theory and knot topology of vacuum space-time*, Class. Quantum Grav. **30** (2013) 055003 (17pp).

<sup>8</sup>P.A.M Dirac, *General Theory of Relativity*, John Wiley & Sons, 1975.