Light rings around exotic compact objects: Traversable wormholes

Sérgio V. M. C. B. Xavier and Luís C. B. Crispino
Universidade Federal do Pará, Brazil

Carlos A. R. Herdeiro
Universidade de Aveiro, Portugal

The standard astrophysical paradigm regarding dark and compact objects in the universe is that they are described by the Kerr metric of General Relativity (GR). In order to test this scenario, several horizonless exotic compact objects (ECOs) have been proposed. A class of ECOs particularly interesting is the one that presents light rings, the so-called ultracompact objects (UCOs). These UCOs could be black hole mimickers, concerning their strong gravity phenomenology. Some years ago, Cunha et al. established a theorem stating that, under general assumptions, UCOs formed from smooth, quasi-Minkowski initial data, must have at least a pair of light rings, one of which must be stable. These stable light rings are supposed to trigger a nonlinear instability in spacetime, potentially weakening UCOs' ability to replicate black hole phenomenology. This result strengthens the idea that the standard astrophysical description of dark and compact objects in the universe are characterized by black holes. However, this original light-ring theorem does not extend to wormholes, which represent topologically nontrivial spacetimes. We address the wormhole case by proving, using a topological technique, the following theorem: a stationary, axisymmetric, asymptotically flat, traversable wormhole in 1+3 dimensions, connecting two different asymptotic regions, has at least one standard light ring for each rotation sense. Thus, any (such) wormhole is an UCO. This result remains true across both static and rotating wormholes, whether symmetric or asymmetric relative to the throat. By filling this gap, our results not only broaden the horizon of knowledge on UCOs but also highlight their potential to closely mimic black hole phenomenology.