A novel strong gravitational lensing feature from wormholes

Rajibul Shaikh, Pritam Banerjee, **Suvankar Paul**, and Tapobrata Sarkar

Department of Physics,
Indian Institute of Technology,
Kanpur 208016, India

Abstract

In general relativity, we encounter different kind of celestial objects which can be broadly categorized into two types: Objects with horizons, i.e., black holes and objects without horizons, such as wormholes, naked singularities etc. Horizonless compact objects are becoming increasingly popular in recent years for several reasons. In this regard, it is a genuine question to ask about how to distinguish these two category of objects based on their own characteristic signatures. To this end, we study gravitational lensing by a class of wormholes and compare our results with those of black holes. For a black hole, there exist an unstable light ring (or photon sphere) outside its event horizon which plays a pivotal role in the formation of its shadow. It produces a set of relativistic Einstein rings which forms the outer bright edge of the shadow. Wheres, for horizonless ultra-compact objects, additional relativistic images and rings may also form. In particular, we show that a horizonless object such as a wormhole of Morris-Thorne type can have two photon spheres. In addition to the one present outside a wormhole throat, the throat can itself act as an effective photon sphere. Such wormholes exhibit two sets of relativistic Einstein ring systems formed due to strong gravitational lensing. If such type of wormhole casts a shadow at all, then the inner set of the relativistic Einstein rings will form the outer bright edge of the shadow. Such a novel strong lensing behavior might serve as a distinguishing feature between wormholes and black holes as far as gravitational lensing is concerned.

References

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