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Tidal Deformability of Black Holes Immersed in Matter

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The tidal deformability of compact objects by an external field has a detectable imprint in the gravitational waves emitted by a binary system, which is encoded in the so-called Tidal Love Numbers (TLNs). For a particular theory of gravity, the TLNs depend solely on the object's internal structure and, remarkably, they vanish for black holes in general relativity. This fact has gathered attention recently since a non-zero measurement of the TLNs for a would-be black hole could provide evidence of new physics in the strong-field regime. However, in realistic astrophysical scenarios, a compact object will be surrounded by a non-vacuum environment. It is, therefore, crucial to evaluate if the effect on tidal deformability due to this environmental matter is comparable to the ones characterizing deviations to GR or exotic compact objects (ECOs), such as boson stars, gravastars, and wormholes. In this work, we compute the TLNs for model configurations of black holes immersed in matter and apply our results to astrophysically motivated black hole + accretion disk systems. Our results pose some questions regarding the possibility of testing strong-field gravity using TLNs.

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