Tidal Love numbers of Kerr black holes

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The open question of whether a black hole can become tidally deformed by an external gravitational field has profound implications for fundamental physics, astrophysics and gravitational-wave astronomy. Love numbers characterize the tidal deformability of compact objects such as astrophysical (Kerr) black holes. We prove that all Love numbers vanish identically for a Kerr black hole in the nonspinning limit or for an axisymmetric tidal perturbation. In contrast to this result, we show that Love numbers are generically nonzero for a spinning black hole. Specifically, to linear order in the black hole spin and the weak perturbing tidal field, we compute in closed form the Love numbers that couple the mass-type and current-type quadrupole moments to the electric-type and magnetic-type quadrupolar tidal fields. This tidal deformability is potentially observationally important through its contribution to the accumulated gravitational-wave phase of an inspiralling stellar-mass compact object into a massive black hole. We show that for a dimensionless black hole spin ~ 0.1, the nonvanishing quadrupolar Love numbers are ~ 0.002. This indicates that, despite black holes being particularly "rigid" compact objects, their nonvanishing tidal deformability could be detected by the future gravitational-wave interferometer LISA.