

Abstract

Assuming that general relativity is the correct theory of gravity in the strong field limit, can gravitational wave observations distinguish between black hole and other compact object sources? Alternatively, can gravitational wave observations provide a test of one of the fundamental predictions of general relativity? Here we describe a definitive test of the hypothesis that observations of damped, sinusoidal gravitational waves originated from a black hole or, alternatively, that nature respects the general relativistic no-hair theorem. For astrophysical black holes, which have a negligible charge-to-mass ratio, the black hole quasi-normal mode spectrum is characterized entirely by the black hole mass and angular momentum and is unique to black holes. In a different theory of gravity, or if the observed radiation arises from a different source (e.g., a neutron star, strange matter or boson star), the spectrum will be inconsistent with that predicted for general relativistic black holes. We give a statistical characterization of the consistency between the noisy observation and the theoretical predictions of general relativity, together with a numerical example.