Fate of Extra Dimensions in Light of GW170817

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In this talk I will explore the consequences of the GW170817 event on the presence of extra dimensions. In particular, I will demonstrate the following results:

- I will present a calculation of the tidal Love numbers of black holes and neutron stars in the presence of higher dimensions. The perturbation equations around an arbitrary static and spherically symmetric metric for the even parity modes will be presented in the context of an *effective* four-dimensional theory on the brane. Surprisingly, even for black holes the tidal Love numbers are non-zero and, more importantly, negative. I will also discuss the tidal Love number of neutron stars in a spacetime inheriting extra dimensions and I will demonstrate that, in the context of effective gravitational theory on the brane, they are different from that in general relativity. Finally I will comment on possible constraints on the parameters inherited from higher dimensions from the GW170817 event as well [1, 2].

- I will also present the evolution equation for gravitational perturbation in four dimensional spacetime in presence of a spatial extra dimension. The evolution equation is derived by perturbing the *effective* gravitational field equations on the four dimensional spacetime, which inherits non-trivial higher dimensional effects. As I will demonstrate, this is *different* from the perturbation of the five dimensional gravitational field equations, existing in literature, and possess quantitatively new features. The gravitational perturbation has further been decomposed into a purely four dimensional part and another piece that depends on extra dimensions.

- I will further demonstrate that the four dimensional gravitational perturbation admits massive propagating degrees of freedom, owing to the existence of higher dimensions. The influence of these massive propagating modes on the quasi-normal mode frequencies have been presented, which have been contrasted with the massless modes in general relativity. Surprisingly, it turns out that the massive modes experience much smaller damping compared to the massless modes in general relativity and may even *dominate* over and above the general relativity contribution if one observes the ringdown phase of a black hole merger event at sufficiently late times. Furthermore, the whole analytical framework has been supplemented by the fully numerical Cauchy evolution problem as well. In this context I will comment on possible implications on observations of black holes with LIGO and proposed space missions like LISA [3–5].

These results again demonstrate that the presence of higher dimensions can non-trivially affect the gravitational waves, providing interesting playground to understand physics beyond general relativity.

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