

## More on the tests of gravity using gravitational-waves data

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Despite that the parametrized post-Einstein (ppE) framework is a powerful tool to quantifiably investigate effects of modification of gravity theory [1], the current gravitational waveform in this framework is still extendable. In modified gravity such as Einstein-dilaton-Gauss-Bonnet (EdGB) theory, black holes may have a charge. Such a hairy black hole will emit dipole radiation. On the other hand, while spontaneous scalarization of a neutron star has been strongly constrained by the current binary pulsar observations for massless fields, massive fields are still allowed if their mass  $m$  is greater than  $10^{-16}$  eV [2]. The ground-based gravitational-wave detectors, LIGO, Virgo, and KAGRA, are sensitive to the mass range, say  $10^{-14}$  eV  $\lesssim m \lesssim 10^{-13}$  eV. However, the present gravitational waveform in the ppE framework does not incorporate such a modification due to massive fields. We then discuss a parametrized-test of the massive-field modification using the LIGO/Virgo's open data. In addition, assuming EdGB type coupling, we stack the results of the analysis of the binary black hole events and put a constraint on the “coupling parameter” [3].

Reference:

- [1] Nicolás Yunes, Frans Pretorius, Phys. Rev. D **80**, 122003 (2009).
- [2] Fethi M. Ramazanoğlu, Frans Pretorius, Phys. Rev. D **93**, 064005 (2016).
- [3] Kei Yamada, Tatsuya Narikawa, & Takahiro Tanaka, in preparation.

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