A comparative study on various General Relativity verification methods using LIGO

Abhinav Mallela, J Jerome Antony, Mohammed Suhayb, Rahul G

Team dhRuVa RVCE

Gravitational waves from binary black hole mergers have provided an opportunity to test general relativity in the strong-field regime. After the merger, the resultant black hole emits gravitational waves in the form of quasi-normal modes (QNMs), which are determined solely by the black hole's mass and spin according to the no-hair theorem. By observing these modes, we can directly test both the no-hair theorem and general relativity. In this study, four different QNM-based methods were investigated. The data was accessed using the Python library gwpy and processed with noise whitening, bandpass filtering, or a combination of both to enhance the signal-to-noise ratio. The single-mode consistency test compared parameters derived from the inspiral phase with those obtained from the fundamental (2,2,0) ringdown mode. A second method involved a direct curve fit of the first overtone (2,2,1), using the properties of the fundamental mode to test multimode consistency. The third approach used a theoretical overlay of the predicted (2,2,1) mode on the data to visually check frequency and damping time. Finally, a multi-mode superposition model represented the ringdown as a sum of QNMs and compared it with observations. The study outlines the advantages and challenges of these approaches in black hole spectroscopy.