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Measurement of Polarization of GWs by 3G Detectors as a Test of Gravity

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In this contribution I present the capabilities of ground-based third generation detectors to constrain the presence of non-tensor polarization modes in gravitational wave (GW) signals. These capabilities are assessed with mathematically simple figures of merit that discriminate between different theories of gravity. Different theories predict different polarization modes for GW emission by a Compact Binary Coalescence (CBC). In addition to the two tensor modes predicted by General Relativity, called $+$ and $\times$, several modified theories of gravity predict the existence of additional modes, that can be either vector or scalar. The formalism of null-streams can be used for the direct detection of such exotic polarization modes.

A null-stream is a linear combination of the measured signals, displayed as S_a for the a-th detector: $S_a = \sum_{\rm pol} F_a^{\rm pol}\, h_{\rm pol}$, where $F_a^{\rm pol}$ is the detector's antenna pattern for the pol polarization mode at the location of the source. A simple null-stream is, for instance: NS $= \epsilon^{lmn} F_m^+ F_n^\times S_l$, where the antenna patterns are now computed at the $estimated$ location of the source. One can easily prove that such a quantity is identically zero when only tensor modes are present, as in General Relativity, since it is given by the contraction of an antisymmetric tensor (the Levi Civita symbol) and a symmetric part; conversely, it can be non-zero when the detected strain contains non-tensor polarization modes.

We have tested the performance of the null stream as a figure of merit in the detection of non-tensor modes using a simulated population of 10^5 Binary Black Hole events. We compared the null-streams in the case of a completely GR-like signal (thus containing tensor modes only) and in the case of a deviation from GR (adding a scalar or vector mode contribution). This test has been performed both for a network of current detectors and for a network of third generation ground-based facilities, in order to investigate the enhancement future detectors would provide to this subject.

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