Effects of Lorentz violation in the stochastic gravitational wave background

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The speed of propagation of gravitational waves (GWs) was measured with the joint detection of GW170817 and its several electromagnetic counterparts with extremely high precision. This was immediately used as an argument to disfavor a wide range of modified gravity theories that predict values different from the speed of light, notably several of the scalar-tensor theories [e.g. Creminelli et al. PRL (2017)]. However, the possibility of ruling out those theories with this LIGO detection was questioned [de Rham Melville PRL (2018)]. This is because even if in those models the GW speed only depends on cosmic time, these theories have problems of UV completion in the range of frequencies of the LIGO sensitivity.

This problem has motivated investigations of phenomenological models where the GW speed depends on frequency, $c_{\mathrm{gw}}(f)$ [Baker et al. (2022)]. In these models, one could be compatible with the LIGO observation and still see deviations from General Relativity with the future mission LISA, which will probe the mHz band. Different Lorentz invariance violation (LIV) assumptions can lead to a difference in the speed of light of GW. On phenomenological searches, these effects are modulated by a given LIV coefficient, δ, whose large phase space is explored by looking at effects at different energies and/or frequencies. The advent of the future mission LISA will allow probing a region of the phase space which was not accessible by LIGO measurements.

In that direction, an interesting calculation that has not been done yet is to see what happens with the stochastic GW background generated by weak astrophysical sources in these models. The idea here is to use our joint expertise in LIV (Rodrigo) and in predictions for the stochastic background (Isabela) to compute the observational effects of interesting fundamental models for $c_{\mathrm{gw}}(f)$ and check whether they could be measured in the future. This prediction will potentially have a future observational impact since LISA and other kinds of GW detectors will be sensitive to the spectral shape of the energy density of the stochastic GW background, an observable analogous to the cosmic microwave background that will bring a lot of information on various aspects of gravity and astrophysics.