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"Exploring the physics of neutron star mergers with gravitational waves and gamma-ray bursts"

Abstract:

The GW170817 event provided the first observation of gravitational waves (GW) from a neutron star (NS) merger with associated transient counterparts across the entire electromagnetic spectrum. This discovery answered important open questions in modern astrophysics, notably demonstrating the long-hypothesized association between short gamma-ray bursts (GRB) and NS mergers. Despite the number of scientific results arisen from GW170817, we do not yet have a complete understanding of the complicated and violent physical processes that developed at the source. We also do not know if the properties of GW170817 are common to all NS mergers or represent an exceptional case. More joint detections are needed to explore the relation between the parameters inferred from the GW and the properties of the GRB signal, potentially ruling out some of the existing models of the physical processes responsible for these events.

For this purpose, we developed a joint multi-messenger analysis of LIGO, Virgo (the 2G detectors), and Fermi/GBM data designed for detecting weak GW transients associated with weak GRB. We take the full list of existing compact binary coalescence (CBC) triggers generated with the GW searches and reanalyze the entire set of public Fermi/GBM data covering the same observing run to generate a corresponding set of GRB candidate triggers in the hope to find more joint detections.

I also applied one of the search methods that produced the events reported in the GWTC catalog and worked on various projects aimed at improving the GW search's sensitivity. We set up, for instance, a new method aimed at discriminating between glitches from astrophysical signals.

These activities involved techniques such as signal detection with matched filtering, Bayesian parameter inference, template bank of waveform model generation, and scientific calculation on large computer clusters. Finally, I have been interested in the next generation of GW detectors, in particular Einstein Telescope (ET) which expects to detect more than 10000 binary neutron star (BNS) signals per year. We have started to think about how to analyze its data now, important differences with respect to 2G detectors will need to be considered, and we have decided to focus on the difference in the duration of BNS signals in the detector.