Exploring the Relativistic Transient Universe with Gravitational Waves

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The long-anticipated birth of gravitational-wave astronomy will occur in the next few years with the advent of the Advanced LIGO and Advanced Virgo gravitational-wave detectors. These instruments will open a new channel for studying the most extreme phenomena and environments found in nature, including gamma-ray bursts, core-collapse supernovae, and black-hole mergers. The inner engines of these systems are either obscured or inherently invisible to electromagnetic observations. Furthermore, the associated gravitational-wave emission typically depends on poorly understood physics, such as the equation-of-state of matter at supra-nuclear densities. Gravitational waves will therefore provide an exciting new probe of these astrophysical systems, for example constraining the neutron star equation-of-state, and providing laboratories for tests of fundamental physics and cosmology. However, realising the potential of gravitational waves poses a significant challenge: state-of-the-art techniques for detecting and interpreting gravitational waves require precise theoretical models of the gravitational-wave emission, and hence are not applicable to most gravitational-wave sources. This project aims at maximising the scientific exploitation of gravitational waves through advancements beyond current state-of-the-art in rapid automated analyses, advanced signal/background discrimination, and waveform reconstruction. The goals of this project are: *(i)* to develop the model-independent techniques needed to robustly detect gravitational waves from relativistic transient events, and determine the signal structure; *(ii)* to apply these to data from the Advanced LIGO / Advanced Virgo network to detect GWs; and *(iii)* to use detected GWs as probes of relativistic systems and fundamental physics.

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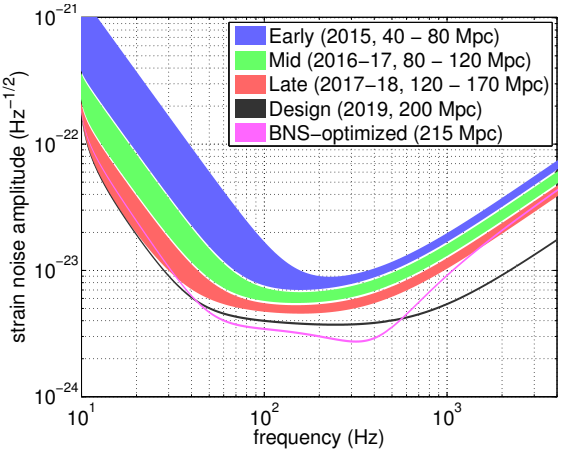
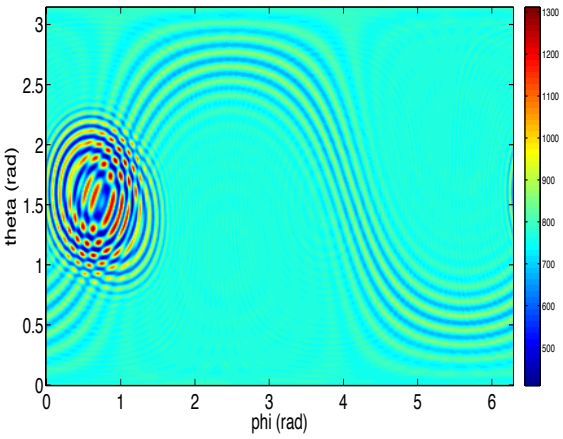


Projected evolution of Advanced LIGO sensitivity [Abadie et al., 1304.0670]. The average distance to which binary neutron star signals could be seen is given in Mpc.



Sky map for a simulated gravitational wave transient in the LIGO-Virgo network [Edwards & Sutton (2012)]. The colour indicates the relative probability of a gravitational wave from that direction.