ID de Contribution: **60** Type: **COSMOLOGIE**

Solving the Hubble tension with gravitational-wave standard sirens and electromagnetic counterparts

jeudi 15 octobre 2020 14:00 (15 minutes)

Compact object mergers offer a new and independent means of measuring the Hubble constant by combining the source's distance derived from the gravitational wave form with its redshift obtained from electromagnetic follow-up. It is expected that with a few tens of events, this multi-messenger method could reach a precision fit to resolve the pending tension between early- and late-Universe measurements of the Hubble constant. However, this method is limited by intrinsic degeneracies in the gravitational wave signal, especially between the system's distance and its orbital inclination. Fortunately, these degeneracies can be partially lifted by considering the merger's electromagnetic counterparts, which can independently constrain the inclination angle. This was done with the historic event GW170817, where the afterglow counterpart enabled a great improvement in the estimate of the inclination angle. Access to such counterparts is not guaranteed for all events because they are faint for distant or very inclined systems. We present models for emission and detection of multi-messenger radiation from binary neutron star mergers, as well as population models for these sources. Using these models, we quantify the benefit of including the inclination angle information from electromagnetic counterparts in obtaining a precise measurement of the Hubble constant. Though the information brought by the counterparts greatly improves the measurement for individual events, we find that the rareness of the electromagnetic counterparts disallows them to significantly contribute to the measurement of the Hubble constant in the long term, at least for the design-level LIGO-Virgo gravitational interferometers. We discuss these results under different source population hypotheses.

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Classification de Session: Groupe de travail: Cosmologie