Contribution ID: **104** Type: **Poster**

Resonant tidal excitation of superfluid neutron stars in coalescing binaries

We study the resonant tidal excitation of g-modes in coalescing superfluid neutron star (NS) binaries and investigate how such tidal driving impacts the gravitational-wave (GW) signal of the inspiral. Previous studies treated the NS core as a normal fluid and did not account for its superfluidity. The source of buoyancy that supports the g-modes is fundamentally different in the two cases: in a normal fluid core the buoyancy is due to gradients in the proton-to-neutron fraction whereas in a superfluid core it is due to gradients in the muon-to-electron (or hyperon) fraction. The latter yields a stronger stratification and a superfluid NS has a denser spectrum of g-modes. As a result, many more g-modes undergo resonant tidal excitation during the inspiral. We find that = 10 times more orbital energy is transferred into g-mode oscillations if the NS has a superfluid core rather than a normal fluid core. However, because this energy is transferred later in the inspiral when the orbital decay is faster, the accumulated phase error in the gravitational waveform is comparable for a superfluid and normal fluid NS (0.001 -0.01rad). A phase error of this magnitude is too small to be measured with the current generation of GW detectors. Nonetheless, by stacking events, third-generation GW detectors should be able to detect the phase shifts due to muonic modes.

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Session Classification: Poster session