Inferring the Neutron Star Maximum Mass and Lower Mass Gap in Neutron Star-Black Hole Systems With Spin

Ye, Christine (School: Eastlake High School)

Gravitational-wave (GW) detections of merging neutron star-black hole (NSBH) systems probe astrophysical neutron star (NS) and black hole (BH) mass distributions, especially at the transition between NS and BH masses. Of particular interest are the maximum NS mass, minimum BH mass, and potential mass gap between them. While previous GW population analyses assumed all NSs obey the same maximum mass, if rapidly spinning NSs exist, they can extend to larger maximum masses than nonspinning NSs. In fact, several authors have proposed that the 2.6Msol object in the event GW190814 -- either the most massive NS or least massive BH observed to date -- is a rapidly spinning NS. We therefore infer the NSBH mass distribution jointly with the NS spin distribution, modeling the NS maximum mass as a function of spin. Using 4 LIGO-Virgo NSBH events including GW190814, if we assume that the NS spin distribution is uniformly distributed up to the maximum (breakup) spin, we infer the maximum non-spinning NS mass is 2.7+0.5−0.4Msol (90\% credibility), while assuming only nonspinning NSs, the NS maximum mass must be >2.53Msol (90\% credibility). The data support the mass gap's existence, with a minimum BH mass at 5.4+0.7−1.0Msol. With future observations, under simplified assumptions, 150 NSBH events may constrain the maximum nonspinning NS mass to ±0.02Msol, and we may even measure the relation between the NS spin and maximum mass entirely from GW data. If rapidly rotating NSs exist, their spins and masses must be modeled simultaneously to avoid biasing the NS maximum mass.