

Will Farr

SUNY Stony Brook

Cosmography and Black Hole Spectroscopy with Gravitational Waves

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MSI Conference Room • 3550 University

I will describe recent results in gravitational wave observations of binary black hole mergers. By tracking a feature in the binary black hole mass spectrum across cosmic time it will be possible for Advanced LIGO and Virgo to measure the expansion history of the universe to few-percent accuracy at redshifts $z \sim 0.7$. Measurements at these redshifts are particularly interesting because they correspond to the transition from a matter-dominated to dark-energy-dominated universe; in concert with other percent-level cosmographical measurements, binary black hole observations could constrain the dark energy equation of state parameter to better than 10%. Because binary black hole mergers are standard(izable) sirens, these measurements are independent of any of the other distance ladders or standard rulers employed for cosmography. Binary black hole mergers also enable precision tests of general relativity as a theory of gravity. One such test is black hole spectroscopy---measurement of the normal modes of the spacetime near a black hole horizon through their gravitational wave emission---which is analogous to the use of atomic spectral lines to test quantum mechanics. I will explain the first-ever measurement of multiple modes of oscillation from a black hole spacetime (the remnant black hole from the first binary black hole merger observed by LIGO, GW150914) and discuss the future of such measurements and the constraining power they have over general relativity. In both black hole cosmography and spectroscopy, advanced-era gravitational wave detectors are delivering precision and power at a level not anticipated until the next generation ("3G") of gravitational wave detectors.

