Gravitational waves, colliding neutron stars, and the nature of matter above nuclear density

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In the near future, gravitational-wave observatories are likely to detect (and may already have detected) waves from the inspiral and merger of neutron star–neutron star and neutron star–black hole systems.

A single event whose light and gravitational waves are simultaneously detected could resolve the 50-year mystery of the origin of short gamma-ray bursts; it might provide strong evidence for (or against) mergers as the main source of the universe's heaviest elements; and it could give an independent measurement of the Hubble constant. The closest events can also address a primary goal of gravitational-wave astronomy: From the imprint of tides on inspiral waveforms, observations can find the radius and tidal distortion of the inspiraling stars and infer the behavior of cold matter above nuclear density: Stiffer candidate equations of state lead to larger neutron-star radii, greater tidal deformation, and, as a result, more rapid inspiral and earlier merger. The accuracy with which electromagnetic and gravitational observations can measure radii should increase in tandem over the next decade, with the major advantage of gravitational observations lying in the model-independence of their interpretation.