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Neutron stars: Promises and challenges from gravitational-wave astronomy

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Ground-based gravitational-wave observatories have detected more than three hundred gravitational-wave signals over the past decade. Most have been from binary black hole mergers, but the catalog of events also includes a handful of black-hole/neutron-star binaries and two or three double neutron star mergers. Observing these mergers is testing our understanding of gravity, revealing dense matter dynamics inside neutron-star cores, and tracing the endpoints of stellar evolution across cosmic time. They also tell us about the engines of transient astronomy and the sites where heavy elements are formed in our universe.

As observatory upgrades improve our sensitivity, and as new facilities come online, we expect both increased detection rates and higher-fidelity measurements of the loudest signals. The challenge of gravitational-wave astronomy is moving from detection to interpretation: understanding future observations will place stringent requirements on our modelling of the source systems and how well we understand the physics that describes them. In this talk, I'll outline gravitational-wave measurements of neutron star properties, in particular the nuclear equation of state, and their implications. I'll show how simplifying assumptions used to analyze the first signals will break down with future observations, and how bringing in information from nuclear science can improve our interpretations. Finally, I'll discuss how we can quantify and account for uncertainty in signal models in our analyses, reducing systematic biases and allowing unmodeled physics to be inferred from observational data.

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