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Listening to the long ringdown: a novel way to pinpoint the equation of state in neutron-star cores

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Multimessenger signals from binary neutron star (BNS) mergers are promising tools to infer the largely unknown properties of nuclear matter at densities that are presently inac- cessible to laboratory experiments. The gravitational waves (GWs) emitted by BNS merger remnants, in particular, have the potential of setting tight constraints on the neutron- star equation of state (EOS) that would complement those coming from the late inspiral, direct mass-radius measurements, or ab-initio dense-matter calculations. To explore this possibility, we perform a representative series of general-relativistic simulations of BNS systems with EOSs carefully constructed so as to cover comprehensively the high-density regime of the EOS space. From these simulations, we identify a novel and tight correla- tion between the ratio of the energy and angular-momentum losses in the late-time portion of the post-merger signal, i.e., the "long ringdown", and the properties of the EOS at the highest pressures and densities in neutron-star cores. When applying this correlation to post-merger GW signals, we find a significant reduction of the EOS uncertainty at densities several times the nuclear saturation density, where no direct constraints are currently avail- able. Hence, the long ringdown has the potential of providing new and stringent constraints on the state of matter in neutron stars in general and, in particular, in their cores.

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