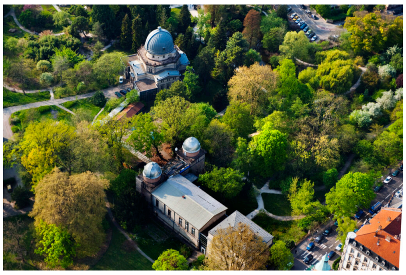

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Nonradial oscillations of stratified neutron stars with solid crusts: Mode characterization and tidal resonances in coalescing binaries

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Dynamical tides of neutron stars in the late stages of binary inspirals provide a viable probe into dense matter through gravitational waves, and potentially trigger electromagnetic precursors. We model the tidal response as a set of driven harmonic oscillators, where the natural frequencies are given by the quasinormal modes of a nonrotating neutron star. These modes are calculated in general relativity by applying linear perturbation theory to stellar models that include a solid crust and compositional stratification. For the mode spectrum, we find that the canonical interface mode associated with crust-core boundary vanishes in stratified neutron stars and is replaced by compositional gravity modes with mixed gravity–interfacial character, driven primarily by strong buoyancy in the outer core. We also find that fluid modes such as the core gravity mode and the fundamental mode can penetrate the crust, and we establish a criterion for such penetration. Regarding the tidal interaction, we find that transfer of binding energy to oscillations is dominated by the fundamental mode despite its frequency being too high to resonate with the tidal forcing. In general, we find that lower-frequency modes induce gravitational-wave phase shifts smaller than $\sim 10^{-3}$ rad for the equation of state we consider. We discover that nonresonant fundamental and crustal shear modes can trigger crust failure already near the first gravity-mode resonance, while gravity-mode resonance concentrates strain at the base of the crust and may marginally crack it. These results suggest that both resonant and nonresonant excitations can overstress the crust and may channel energy into the magnetosphere prior to merger, potentially powering electromagnetic precursors. Our work represents an important step toward realistic modeling of dynamical tides of neutron stars in multimessenger observations.

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