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Tidal response from scattering and the role of analytic continuation

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The tidal response of a compact object is a key gravitational-wave observable encoding information about its interior. This link is subtle due to the nonlinearities of general relativity. We show that considering a scattering process bypasses challenges with potential ambiguities, as the tidal response is determined by the asymptotic in- and outgoing waves at null infinity. As an application of the general method, we analyze scalar waves scattering off a nonspinning black hole and demonstrate that the low-frequency expansion of the tidal response reproduces known results for the Love number and absorption. In addition, we discuss the definition of the response based on gauge-invariant observables obtained from an effective action description, and clarify the role of analytic continuation for robustly (i) extracting the response and the physical information it contains, and (ii) distinguishing high-order post-Newtonian corrections from finite-size effects in a binary system. Our work is important for interpreting upcoming gravitational-wave data for subatomic physics of ultradense matter in neutron stars, probing black holes and gravity, and looking for beyond-standard-model fields.

Primary authors: CRECI, Gastón (Utrecht University); Dr STEINHOFF, Jan (Max-Planck-Institute for Gravitational Physics (Albert-Einstein-Institute)); HINDERER, Tanja (Utrecht University)

Presenter: CRECI, Gastón (Utrecht University)

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