Contribution ID: **541** Type: **Talk in a parallel session**

An Effective Field Theory Approach to Gravitational and Electromagnetic Love Numbers of Magnetars

Tuesday, 9 July 2024 16:00 (30 minutes)

Effective field theory methods have been used in a multitude of applications in gravitational theory, and recent efforts employ such techniques to study tidal interactions. The tidal deformability of stars presents exciting opportunities to analyze both nuclear and gravitational physics due to its dependence on the interior physics of stellar bodies. Information about tidal deformability is encoded in gravitational wave signals sourced by stars, so furthering our understanding of tidal interactions is crucial to probe the fundamental physics that can be observed from gravitational systems. Magnetar systems have been studied in a perturbative framework in general relativity, but the effects of coupled tidal field and magnetic field interactions have not been thoroughly explored. We employ the conventional neutron star perturbation techniques in conjunction with an effective action description of magnetized, tidally-deformed stars to study electromagnetic and gravitational Love numbers. We find that there are new Love numbers from the coupling of electromagnetic and gravitational fields, and this effective action approach can break ambiguities in Love number definitions. These interactions may have a measurable effect in double magnetar systems which could be observed with gravitational waves. This work studies tidal interactions of an Einstein-Maxwell system, and it can be extended to study other vector-tensor gravitational theories that are composed of less familiar fields.

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Session Classification: Astrophysics with gravitational waves

Track Classification: Gravitational Waves (GW): Astrophysics with gravitational waves