

Title: Neutron stars and gravitational waves in the context of modern nuclear physics theory.

Abstract:

Since the discovery of the atomic nucleus more than hundred years ago, the enigma of the force which holds the nucleus together remains unsolved. We are familiar with the utilization of nuclear phenomena in energy generation, industry, medicine and, unfortunately, in warfare. In academic research, the theory of nuclear forces evolved, starting from original ideas in 1930, to a large variety of empirical models, lacking fundamental insight. Increasing sophistication of data from terrestrial experiments, augmented by advanced astrophysical observations, including the discovery of gravitational waves, provides ever broadening evidence upon which any breakthrough in the quest for solving the nuclear force puzzle must be based. Yet today, despite novel mathematical techniques and computer power unimaginable a few decades ago, a plethora of models exist, dependent on a large number of variable correlated parameters which cannot be uniquely determined by the data.

In this talk I will concentrate on only one source of observational constraints on the nuclear force models, neutron stars. These densest objects in the Universe form an extremely rich laboratory for testing nuclear theories, encompassing a wide range of density, pressure and temperature, and containing an extensive spectrum of particles, possibly including quarks. I will outline basic ideas of the most modern nuclear theories, such as the Quark-Meson-Coupling model, one of the most promising current approaches to the nuclear force problem. The crucial role played by binary neutron star collisions, and hence the nuclear force, in the interpretation of gravitational waves will also be illustrated.