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Gravitational Waves from Neutron Stars

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Neutron stars are the densest objects in the present Universe, attaining physical conditions of matter that cannot be replicated on Earth. These unique and irreproducible laboratories allow us to study physics in some of its most extreme regimes. More importantly, however, neutron stars allow us to formulate a number of fundamental questions that explore, in an intricate manner, the boundaries of our understanding of physics and of the Universe. The multifaceted nature of neutron stars involves a delicate interplay among astrophysics, gravitational physics, and nuclear physics. The research in the physics and astrophysics of neutron stars is expected to flourish and thrive in the next decade. The imminent direct detection of gravitational waves will turn gravitational physics into an observational science, and will provide us with a unique opportunity to make major breakthroughs in gravitational physics, in particle and high-energy astrophysics. These waves, which represent a basic prediction of Einstein's theory of general relativity but have yet to be detected directly, are produced in copious amounts, for instance, by tight binary neutron star and black hole systems, supernovae explosions, non-axisymmetric or unstable spinning neutron stars. The focus of the talk will be on the neutron star instabilities induced by rotation and the magnetic field. The conditions for the onset of these instabilities and their efficiency in gravitational waves will be presented. Finally, the dependence of the results and their impact on astrophysics and especially nuclear physics will be discussed.