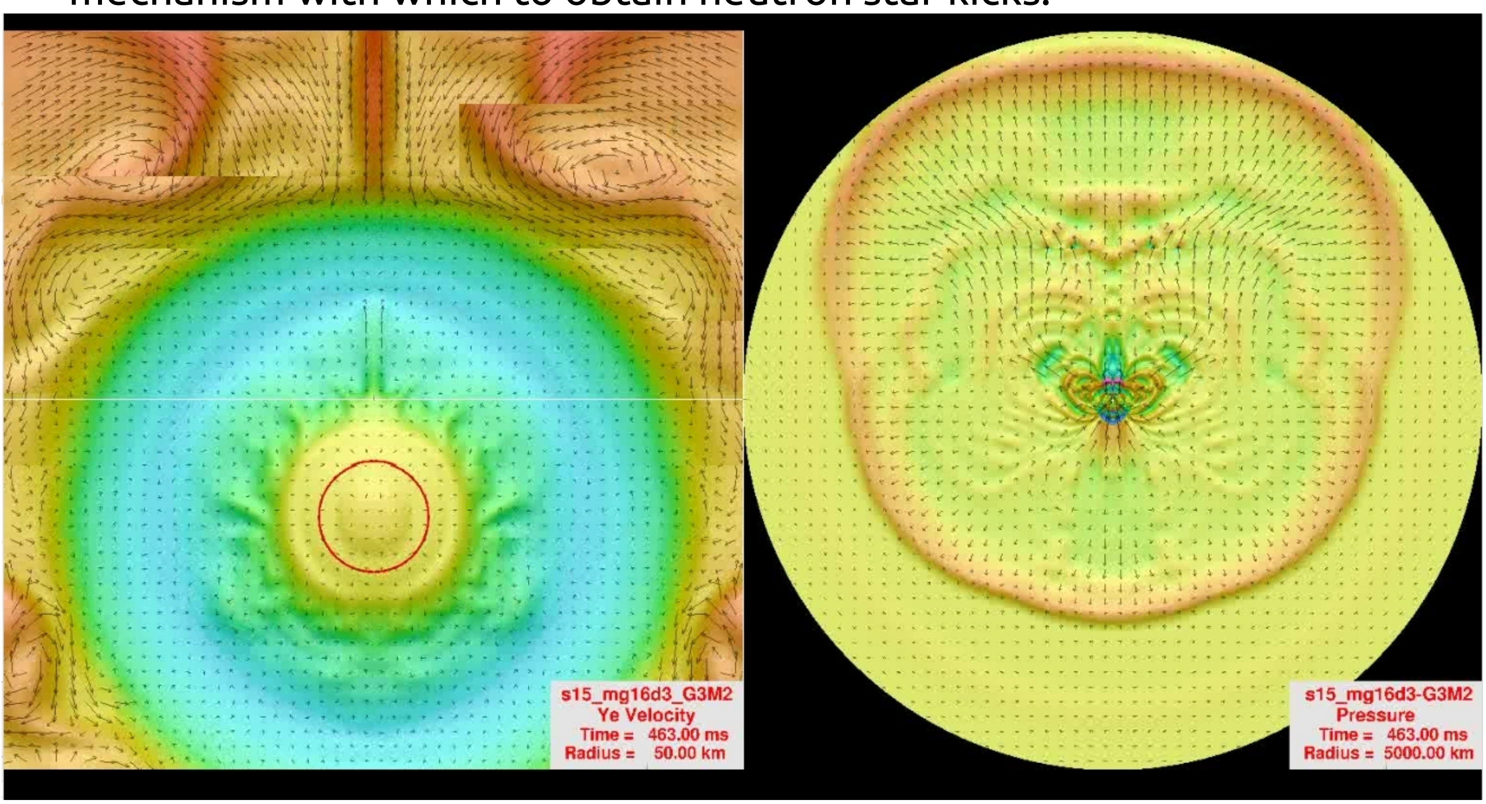
Joint Institute for Nuclear Astrophysics

Theoretical Support for the Hydrodynamic Mechanism of Pulsar Kicks

The collapse of a massive star core, followed by a neutrino-driven, asymmetric supernova explosion, can naturally lead to pulsar recoils and neutron star kicks. Nordhaus et al. (2010b) presented a two-dimensional, radiation-hydrodynamic simulation in which core-collapse leads to significant acceleration of a fully-formed, nascent neutron star (NS). During the explosion, anisotropic low-mass, high-velocity ejecta leads to recoil of the high-mass neutron star, albeit at lower velocity. At the end of their simulation, the NS achieved a velocity of ~150 km s^{-1}, is accelerating at ~350 km s^{-2}, but had yet to reach the ballistic regime. The recoil is due almost entirely to hydrodynamical processes, with anisotropic neutrino emission contributing less than 2% to the overall kick magnitude. Since the observed distribution of neutron star kick velocities peaks at ~300-400 km s^{-1}, recoil due to anisotropic core-collapse supernovae provides a natural, non-exotic mechanism with which to obtain neutron star kicks.



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