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Dark Matter Capture and Thermalization in Neutron Stars

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Neutron stars (NSs) are promising cosmic laboratories to test the nature of dark matter (DM). DM captured by the strong gravitational field of these stellar remnants transfers kinetic energy to the star during the collision. This can produce anomalous heating of old neutron stars. Further thermalization and DM annihilation can add an extra source of heating. We improve former calculations of the DM capture rate, thermalization, and capture-annihilation equilibrium timescales in NSs, which rely on approximations. We account for the stellar structure, gravitational focusing, relativistic kinematics, Pauli blocking, strong interactions and nucleon structure. In NSs, DM can be captured via collisions with strongly interacting baryons or relativistic leptons. We project the NS sensitivity to DM-nucleon and DM-lepton scattering cross sections which greatly exceeds that of direct detection experiments, especially for low mass DM. In addition, we determine the region of the DM parameter space where kinetic heating dominates over kinetic plus annihilation heating, for different DM interactions with NS constituents, in light of possible observations of local old NSs with infrared telescopes.

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