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Improved Treatment of Dark Matter Capture in Neutron Stars: Leptonic and Baryonic Targets

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The capture of Dark Matter in Neutron Stars has garnered considerable interest in recent years. This interest is driven by the prospect that the energy deposited by dark matter scattering can heat these objects to infrared temperatures, which may soon be within reach of observations. In order to obtain reliable results from these searches, proper incorporation of the physics of Neutron stars into the capture process is necessary. Key among these are gravitational focusing, relativistic kinematics, Pauli blocking, and multiple scattering. Additionally, we incorporate the internal structure of the Neutron star through the adoption of an equation of state coupled to the Tolman-Oppenheimer-Volkoff equations. In the case of hadronic targets, we must also account for strong interactions of the targets, which induce an effective mass, and that the momentum transfer is sufficiently large that hadrons cannot be treated as pointlike objects. Accounting for these effects allows us to project sensitivities for dark matter-lepton and nucleon cross sections using dimension-6 effective operators. In many cases, limits are potentially stronger than those obtained from direct detection searches.

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No

Primary authors: THOMAS, Anthony (University of Adelaide); VIRGATO, Michael (The University of Melbourne); BUSONI, Giorgio (Max-Planck-Institut für Kernphysik); BELL, Nicole (University of Melbourne); ROBLES, Sandra (The University of Melbourne)

Presenter: VIRGATO, Michael (The University of Melbourne)

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