New Search for n-n' Regeneration at HFIR

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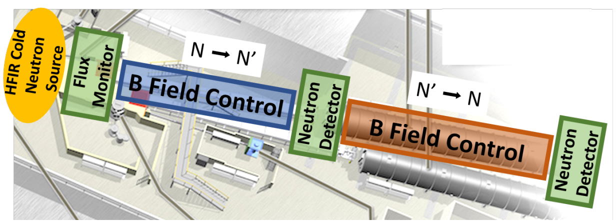
We introduce a novel experimental approach to search for neutron oscillations into a hidden sector. Mirror Matter theory postulates that there is a hidden sector which is a copy of the Standard Model (SM) with particle content and interactions described by (SM') [1]. The Mirror Matter paradigm is consistent with current cosmological observations [2, 3]. Experimental bounds on mirror neutron oscillations have thus far been studied using ultracold neutrons (UCN). Strong limits on the oscillation time of $\tau < 448$ s have been obtained by assuming the mirror sector's magnetic field (B') is negligible [4]. A reanalysis of [4] with proper consideration of B' yielded a 5.2 σ signal which could be interpreted as 2 s $< \tau <$ 10 s [5]. A later experiment which accounted for the presence of a mirror magnetic field yielded a constraint of $\tau > 12$ s [6], but the 25 mG scanning step size was too large to be sensitive to the narrow width in B of the resonance peak for UCN. A new, independent approach is needed to resolve this controversy.



To confirm or refute the anomalous result in the UCN storage measurement, a collaboration of ∼20 researchers at 6 institutions has recently formed to develop a new type of experiment using cold neutrons in a disappearance-regeneration style measurement. The method is described in detail in [7]. The existing General Purpose Small Angle Neutron Scattering (GP-SANS) instrument at the High Flux Isotope Reactor at Oak Ridge National Laboratory is an ideal location due to its high cold neutron flux ($\sim 10^{10}$ n/s) and long, large area guides (14 m for disappearance and 20 m for regeneration).

Currently, feasibility studies are ongoing to assess the sensitivity of the experiment to mirror neutron oscillations. Assuming the HFIR cold neutron spectrum, oscillation can occur when the magnitude of the magnetic field is within ∼10 mG of the mirror magnetic field, implying required magnitude field uniformity and control at the level of a few mG. Neutron flux monitors are available to measure the 10^{-6} level change in neutron transmission required for the disappearance experiment. Detection of regenerated neutrons is limited by backgrounds in the GP-SANS 1×1 m^2 position-sensitive detector, which should ideally reach < 0.1 cps to be sensitive to a ∼10 s oscillation time with short beamtime.

This experiment at HFIR GP-SANS will allow coverage of the full range of parameters of previous experiments using UCN and will either totally exclude the controversial results or discover a new phenomenon that will inform us about the nature of Dark Matter. A nominal 2 weeks of beamtime would exclude an oscillation time of $\tau < 12$ s (90% C.L.). The collaboration is currently at the proposal stage. R&D efforts will commence in a staged approach, where preparation for the the first stage, disappearance experiment is expected to take 1–2 years, and a further 1–2 years is required to implement a second stage, regeneration component. This experiment is expected to minimally impact the GP-SANS beamline, with modest additional costs for magnetic field control and shielding, and neutron flux monitor/detector, of ∼ \$0.5M. This project will be used to guide future experiments which can reach even higher sensitivies at the ORNL Second Target Station or the European Spallation Source.

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