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Towards a prototype paleo-detector for supernova neutrino and dark matter detection

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Using ancient minerals as paleo-detectors is a proposed experimental technique expected to transform supernova neutrino and dark matter detection. In this technique, minerals are processed and closely analyzed for nanometer scale damage track remnants from nuclear recoils caused by supernova neutrinos and possibly dark matter. These damage tracks present the opportunity to directly detect and characterize the core-collapse supernova rate of the Milky Way Galaxy as well as the presence of dark matter. Current literature presents theoretical estimates for these potential tracks, however, there is little research investigating the experimental feasibility of this technique. At the University of North Florida, we have contributed to the field by searching for and analyzing these damage tracks in prototype detectors constructed from selected minerals, including: halite, Muscovite mica, and Phlogopite mica. Our research characterizes the applicable backgrounds in these prototype detectors. We have employed non-destructive techniques, including laser confocal and atomic force microscopy to identify and characterize damage tracks in the minerals. Chemical etching and plasma etching of target minerals is used to enhance the detectability of these damage tracks at the expense of altering some of their geometrical attributes. With the use of an etching rate model and automatic track detection via Python, damage track lengths are reconstructed. Our data is compared to current theoretical predictions to pursue the practical implementation of paleo-detectors as local core-collapse supernova neutrino and dark matter detectors.

This research will be continued at the University of Michigan starting August 2024. Progress from the current Michigan team will be provided, as well as a discussion of the exciting next steps ahead.

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