Project Summary—*Using Generalized Adversarial Networks to ensure trusted science results and maximize science reach within the dark matter community*

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Background and Objective: The objective of the proposed work is to develop a method for measuring analysis bias that also allows analysis of the full dataset for next-generation dark matter experiments.

Direct-detection dark matter experiments face unprecedented challenges in interpreting their data as we move into the next generation. Little is known about dark matter and therefore the energy spectrum of the expected signal is unknown. The field therefore uses a single set of data to look for many different types of signals: low-mass dark matter, high-mass dark matter, axion-like dark matter, and modulation signals. *The objective of the proposed work is to develop trust in these diverse analysis efforts and ensure maximum science reach.*

Project Description: The proposed work will use Generative Adversarial Networks (GANs) to make a promising blinding technique feasible for use with dark matter data. The technique, "salting," adds simulated signal to a data set they and GANs are ideally suited for this task: they specialize in learning to generate new data that is indistinguishable from the training set in terms of data distribution and behavior. GANs may offer a way to address the unique data quality issues of upcoming dark matter epxeriments: salting data allows analyzers to look at the full data set, which has been necessary in previous SuperCDMS experiments because detector response is so uncertain. Currently, creating realistic simulated signal takes years. GANs have the potential to create realistic simulated signal within weeks.

PIs Roberts (Physics) and Banaei-Kashani (Computer Science) propose to apply change detection methods to known - and possibly unknown - SuperCDMS data quality issues and to implement automated, intelligent testing on SuperCDMS sensors. Building tests by hand for all the SuperCDMS sensors is not feasible, but intelligent change detection algorithms may make it possible to build tests that can be automatically applied to SuperCDMS sensors at scale. This will significantly improve livetime: knowing about changes in the experiment within days — as opposed to months later during science analysis — will allow us to act to maintain data quality.

The requested funding would support students from both Amy Roberts' and Farnoush Banaei-Kashani's groups. Amy Roberts is a long-time member of CDMS and her students work primarily on projects that directly support the CDMS project. Farnoush Banaei-Kashani has extensive experience in applying pattern recognition and analysis methods such as change detection to a diverse problem set. Funding students from both groups will enable rapid progress that would not be possible without collaboration between these PIs.

Impacts: The requested funding would directly support the science goals of the SuperCDMS-SNOLAB experiment, which focuses on sensitivity to low-mass dark matter. Specifically, the work will ensure data quality that allows SuperCDMS-SNOLAB to meet their science goals during Operations, especially in terms of an annual modulation analysis that has the most stringent data quality requirements. However, developing methods to rapidly create fake signal data to use as "salt" would impact any direct-detection dark matter experiment with similar data.

The methods developed also have the potential to impact experiments that record multi-sensor, time-series data; this category includes medical data like EKGs, brain-imaging methods like MEG and EEG, and environmental monitoring systems like seismic monitoring.