Contribution ID: **54** Type: **Parallel talk**

Improved modeling of charge trapping and impact ionization in phonon-based crystal detectors used for dark matter searches

Tuesday, 9 July 2024 15:00 (20 minutes)

Various dark matter search experiments employ phonon-based crystal detectors operated at cryogenic temperatures. Some of these detectors, including HVeV detectors used by the SuperCDMS collaboration, are able to achieve single-charge sensitivity when a voltage bias is applied across the detector. The total amount of phonon energy measured by such a detector is proportional to the number of electron-hole pairs created by an interaction. However, crystal imperfections and surface effects can cause propagating charges to either trap inside the crystal or ionize additional charges, producing non-quantized measured energy as a result. Modeling these detector-response effects continues to be important for understanding and distinguishing between different sources of events, as well as for modeling the detector response of potential signals for dark matter searches. This presentation showcases an improved, more robust model of these detector-response effects that has fewer limitations and is capable of modeling more effects compared to previous models. This model allows for more accurate characterization of phonon-based crystal detectors and may facilitate discrimination between potential dark matter signals and background sources.

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Session Classification: Parallel 3

Track Classification: Parallel session: Light Dark Matter