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Modeling Athermal Phonons in Novel Materials using the G4CMP Simulation Toolkit

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The Geant4 Condensed Matter Physics (G4CMP) toolkit was designed to simulate the transport of charge and phonons in detectors made of Silicon and Germanium. Through these simulations, the toolkit effectively reproduces phenomena such as heat-pulse propagation times, average charge-carrier drift velocities, and phonon caustics. However, its limitation to Silicon and Germanium restricts its applicability to other fields such as material and quantum science research, as well as the exploration of new materials for Dark Matter detection. To address this, we expand the capabilities of G4CMP to include several novel materials like Sapphire (Al2O3), Gallium Arsenide (GaAs), Lithium Fluoride (LiF) and Calcium Fluoride (CaF2) . Specifically, we integrate parameters to facilitate the phonon kinematics simulations in G4CMP. We present various phonon caustic patterns for these materials and compare them with experimental phonon caustic images. Additionally, we create a comprehensive simulation framework, utilizing G4CMP, to assess the performance metrics of qubit chips operating in a gate-based "energy relaxation" readout scheme.

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