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Ab-initio calculations of structure factors for dark matter searches

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We present the first ab-initio calculations of the structure factors for elastic spin-dependent WIMP scattering off ^{19}F, ^{27}Al, ^{23}Na, ^{27}Al, ^{29}Si, ^{73}Ge, ^{127}I and ^{129,131}Xe. A set of established two- (NN) and three-nucleon (3N) interactions derived from chiral effective field theory (EFT) are used for nuclear interaction, including N^{3}LO-level NN + N^{2}LO-level 3N, N^{4}LO-level NN + N^{2}LO-level 3N, and N^{2}LO-level NN+3N with the (1232)-isobar degrees of freedom. Within the same chiral EFT framework, we employ corresponding WIMP-nucleus currents at the one-body level and also include the effects from axial-vector two-body currents. We then apply the ab-initio in-medium similarity renormalization group to construct valence-space Hamiltonians and consistently transformed operators of nuclear responses. By combining the newly developed frameworks, natural orbitals and expressing the 3N force with a very large basis size, we obtain basis-space converged structure factors in heavy nuclei. This work paves the path toward a true first-principles calculation of the structure factor for WIMP scattering in all nuclei relevant for ongoing searches. All results are publicly available in a Jupyter notebook.

Author: Dr HU, Baishan (TRIUMF)

Co-authors: Prof. HOLT, Jason (TRIUMF and McGill University); Dr MIYAGI, Takayuki (TRIMUF); Mr PADUA, José (TRIUMF); Dr STROBERG, Ragnar (University of Washington)

Presenter: Dr HU, Baishan (TRIUMF)

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