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Impact of shell model interactions on nuclear responses to WIMP elastic scattering

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Experimentalists strive to better analyse signals of dark matter direct detection at detectors. Thus, improved theoretical models are being developed to describe WIMP-nucleus elastic scattering, with one particular interest area focusing on enhanced study of the nuclear response functions associated with various target detector isotopes. We build on this by investigating the sensitivity of said nuclear responses to nuclear structure, considering a complete list of non-relativistic effective field theory (EFT) nuclear operators. We employ nuclear shell model interactions which differ from those used in previous literature, to facilitate comparison between different nuclear structure results.

We perform state-of-the-art nuclear shell model calculations for isotopes relevant to direct detection experiments: ^{19}F , ^{23}Na, $^{28-30}$Si, ^{40}Ar, ^{127}I, $^{70,72-74,76}$Ge and $^{128-132,134,136}$Xe. Our integrated nuclear response values sometimes exhibit large (up to orders-of-magnitude) factor differences compared to those in previous works for certain WIMP-nucleus interaction channels and their associated isotopes. We highlight the potential uncertainties that may arise from the nuclear components of WIMP-nucleus scattering amplitudes due to nuclear structure theory and modeling. This enables us to deduce the effect of these uncertainties on the scattering cross-section. In particular, we investigate the effect of nuclear structure on the scattering cross-sections associated with several dark matter direct detection experiments.

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