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New Understanding of Coherence in Bragg-Primakoff Axion Detection

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Axions and axion-like pseudoscalar particles with dimension-5 couplings to photons exhibit coherent Primakoff scattering with ordered crystals at keV energy scales, making for a natural detection technique in searches for solar axions. We find that there are large suppressive corrections, potentially greater than a factor of $\mathcal{O}(10^3)$, to the coherent enhancement when taking into account absorption of the final state photon. This effect has already been accounted for in light-shining-through-wall experiments through the language of Darwin classical diffraction, but is missing from the literature in the context of solar axion searches that use a matrix element approach. We extend the treatment of the event rate with a heuristic description of absorption effects to bridge the gap between these two languages. Furthermore, we explore the Borrmann effect of anomalous absorption in lifting some of the event rate suppression by increasing the coherence length of the conversion. We study this phenomenon in Ge, NaI, and CsI crystal experiments and its impact on the the projected sensitivities of SuperCDMS, LEGEND, and SABRE to the solar axion parameter space. Lastly, we comment on the reach of multi-tonne scale crystal detectors and strategies to maximize the discovery potential of experimental efforts in this vein.

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