Probing New Physics with Exotic Atoms

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High-precision atomic spectroscopy is a significant tool for determining fundamental constants, e.g., [1] as well as searching for new particles beyond the standard model (SM) e.g., [2]. New particles can be manifested as deviations from the SM prediction for transition energies and can be identified by meticulously comparing theory and experiment. In particular, heavy-nuclei exotic atoms in circular states offer a twofold advantage in a new particle search. First, as their reduced masses are larger than electronic atoms, the average distance between their constituents is smaller, resulting in sensitivity to particle masses $O\left(10^3\right)$ heavier. Second, their high angular momentum considerably suppresses contributions from the strong nuclear force and finite-size corrections, allowing the SM prediction to be calculated to a sub-ppm precision [3], above the estimated precision of upcoming experiments.

In this talk, I will present the results of a new physics search in such atomic systems including world-leading bounds for several benchmark models and near-future projections. I will distinguish between two scenarios. If the nuclei are not too heavy, bounds can be set directly by comparing the experimental and theoretical transition energies. On the other hand, heavy-nuclei atoms have a relevant nuclear polarizability contribution, which is poorly determined at present time [4]. Nevertheless, I will show that utilizing two energy transitions enables a novel probe of new physics and nuclear polarizabilities simultaneously, with minimal loss in sensitivity.

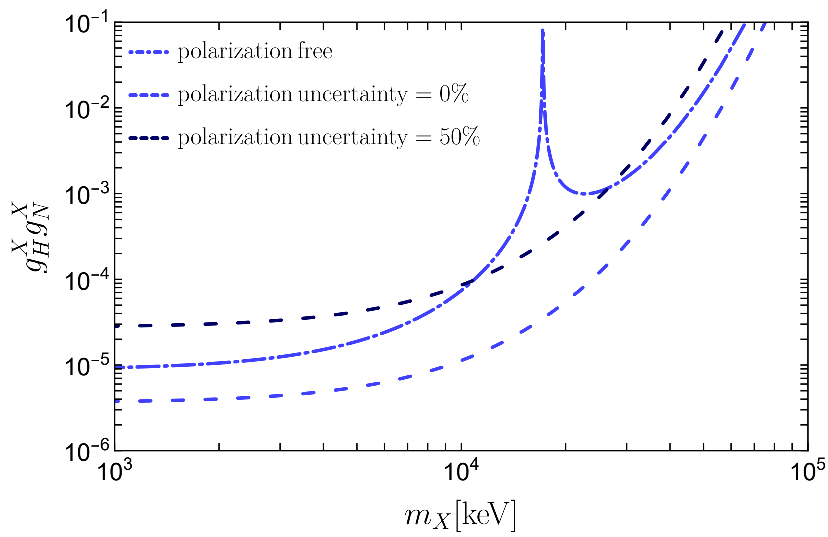

Figure 1: Projections of the $\bar{p}^{132}$Xe sensitivity to new particles. The dual-transition method removes the nuclear polarizability uncertainty with minimal loss in sensitivity.

References

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