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Atomic parity violation and the caesium polarisability puzzle: A possible solution from inseparable contributions to perturbative expansions

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The measurement of atomic parity violation in Cs currently provides the most precise test of electroweak theory at low energies. High precision calculations of the Stark-induced 6S-7S vector transition polarisability are required to interpret this measurement and determine the level of agreement with the Standard Model prediction. However, there is currently a 2.8σ discrepancy between values obtained for this quantity using two different semi-empirical approaches and the subsequent “polarisability puzzle” is a major source of uncertainty. In this work we propose that the disagreement may be explained by a specific subset of contributions to the relevant perturbation expansion which have thus far been neglected in calculations.

For heavy atoms, the precision of *ab initio* calculations is primarily determined by the perturbative treatment of many-body electron correlation effects. An important class of correlation corrections to valence electron wavefunctions arise due to the presence of additional external fields. Indeed, one must account for the shift in valence-core interactions resulting from the polarisation of the atomic core by the external field.

Stark-induced transition polarisabilities parameterise E1 amplitudes induced when both a static and oscillating electric (laser) field are present. When including core polarisation corrections to second-order amplitudes of this nature, a subset of potentially non-negligible contributions to the perturbation expansion are often neglected in calculations due to their inherently inseparable nature. These corrections correspond to the simultaneous action of both fields in the atomic core.

This so-called double core polarisation has only been considered explicitly for second-order E1 amplitudes induced by the weak interaction. In this presentation, I will outline how one can generalise this formalism to include inseparable contributions for second order amplitudes involving arbitrary fields. In particular, we show that this correction may be large enough to resolve the disagreement between semi-empirical calculations of the 6S-7S vector transition polarisability in Cs.

Authors: ROBERTS, Benjamin; EASTON, Jack (University of Queensland)

Presenter: EASTON, Jack (University of Queensland)

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