Modelling Hyperfine Interactions to Perform Picosecond-lifetime Nuclear g-factor Measurements

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The nuclear g factor is a useful metric for probing nuclear structure. This is because the g factor is sensitive to the angular momentum of unpaired nucleons. Particularly, in some regions of the nuclear chart $g(2_1^+)$ values in even-even nuclei can be used to probe sub-shell closures [1]. Therefore, comparisons between theoretical and experimental g factors are valuable. However, such states often have lifetimes in the picosecond range, making for challenging measurements. One technique for performing such measurements utilises the hyperfine field of recoiling ions in vacuum (RIV) [2]. While this technique has been successful in some cases, there are others in which complex atomic interactions complicate the measurement [3].

In order to utilise the RIV technique for such complex interactions the hyperfine interaction must be modelled. However, to model the interaction, detailed atomic-structure information must be known. Chen *et al.* developed a Monte-Carlo approach [4], with atomic structure information calculated using the General Relativistic Atomic Structure Package (GRASP) [5]. Considering nuclei recoiling out of a foil into vacuum, we know there exists a distribution of charge states and energies. The method is to allow for a number of atomic states, for each charge state, to be randomly populated. By treating decays in each state separately, their average interaction can be determined at a given time. This approach was found to agree with RIV data from ^{122,130,132}Te measurements and their reported $g(2_1^+)$ values [4].

In this work, a new approach similar to that of Chen *et al.* [4] will be presented. The new approach utilises a more realistic coupled-tensor evolution and allows for different types of atomic-state distribution. Additionally, atomic structure calculations have been performed using a more recent release of the GRASP [6], which utilises improved algorithms for wavefunction convergence. The effect of using the coupled-tensor approach, and also of the different atomic-state distributions, will be examined. Fits to experimental data will be presented, and the feasibility of determining g factors will be reviewed. Finally, the GRASP calculations will be scrutinised, in part to build confidence in their use, but also to identify uncertainties.

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