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Rate-Equation -based model for describing the resonance laser ionization process

The nucleus perturbs the atomic energy levels of atoms and ions at the ppm level and although this is a small absolute effect it is readily probed and measured by modern laser spectroscopic methods. These methods are particularly suitable for the study of short-lived radionuclides with lifetimes as short as a few milliseconds and production rates often only a few isotopes/isomers per second in the case of resonance laser ionization spectroscopy (RIS)[1]. This ionization technique, which utilizes stepwise excitation of the unique atomic state of different elements, has been demonstrated to be a powerful tool for probing nuclei far from stability[2, 3].

The analysis of the RIS hyperfine spectra is typically performed with the help of relative intensities calculated using angular momentum coupling. The analysis yields the nuclear magnetic dipole and electric quadrupole moments and changes in mean-square charge radii in a model-independent manner. However, recent studies have observed that the relative intensities of the measured hyperfine transitions do not necessarily follow the calculated intensities. This has partially been attributed to optical pumping effects which are not addressed by the typical procedures. Due to this new methods, based on modeling the complete ionization process [4], are required to restrict the number of free parameters during analysis.

Here we present a model for resonance ionization process based on rate-equations as a stepping stone towards a density matrix -based model. The software is written in C++ utilizing Boost Odeint, Eigen and Sundials -libraries. In addition, the software facilitates parallel solving capabilities through the OpenMP library.

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[3] S. Rothe et al., Nat.Commun.4, (2013), 1835.

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