Mass and Field Isotope Shift Parameters for the 2s - 2p Resonance Doublet of Lithium-like Ions

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Abstract. Dielectronic recombination measurements have been proven to be a sensitive tool for deducing changes in the nuclear mean-square charge radii of highly-charged lithium-like neodymium [1]. To make use of this method for other elements and isotopes, mass and field isotope shift calculations are required in order to derive information about the nuclear charge distributions. In this work, we estimate and discuss the relativistic mass and field isotope shift factors for the two 2s $^2S_{1/2}$ - 2p $^2P_{1/2,3/2}$ transitions along the lithium isoelectronic sequence. Using the grasp2K package based on the multi-configuration Dirac-Fock method, the electron correlation and the Breit interaction are taken systematically into account in all the calculations.

Adopting the calculated electronic parameters of isotope shifts, we qualitatively analyze the competition between the mass and field shift contributions for the 2s-2p resonance doublet along the isoelectronic sequence, with the assistance of some empirical relations between Z and the nuclear properties. It is found that the mass shifts and the field shifts possess similar orders of magnitude in the $Z < 40$ range, so that one should consider both of them for a relevant analysis of isotope shifts, especially for extracting the nuclear mean-square charge radii. The field shift contribution grows rapidly towards the high-Z region and becomes quickly dominant.

Quantitative discussions are also made for the 2s $^2S_{1/2}$ - 2p $^2P_{1/2,3/2}$ line isotope shifts in the case of $^{150,142}Nd^{57+}$ for which experimental values are available. The present results show that the higher-order nuclear moments often neglected in the calculation of the field shift should be considered for very highly charged ions in order to extract the $\delta\langle r^2\rangle$ values from experiments. The consistency between grasp2K and MCDF-gme results will be illustrated.

References:

[1] C. Brandau *et al.*, Phys. Rev. Lett. **100** (2008) 073201