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M_F-Dependent Lifetimes Due to Hyperfine Induced Interference Effects

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We report on a theoretical investigation of M_F-dependent lifetimes due to interference between different types of multipole transitions, and in particular the $3d^{10}\ {}^1S_0 - 3d^9 4s\ {}^3D_3$ transition in Nickel-like ions. For pure states this decay is only allowed through a magnetic octupole (M3) transition, but in the presence of a nuclear spin an electric quadrupole (E2) transition is induced by the hyperfine interaction, and the interference between the two types of multipoles makes the lifetimes of the hyperfine levels M_F-dependent.

Extensive Multiconfiguration Dirac-Fock calculations were performed to calculate the $3d^{10}\ {}^1S_0 - 3d^9 4s\ {}^3D_3$ M3 transition element, the $3d^{10}\ {}^1S_0 - 3d^9 4s\ {}^3D_2$ E2 transition element and the hyperfine interaction matrix elements between ${}^3D_3$ and ${}^3D_2$. First order perturbation calculation were used to calculate the hyperfine induced E2 transition element and the M_F-dependent lifetimes.

Detailed results for Ni-like Xenon is presented. Xe consists of 9 different isotopes of which two have a nuclear spin (one with $I = 1/2$ and one with $I = 3/2$) resulting in 25 different lifetimes depending on isotope, F-value and M_F-value. [1] used a single exponential fit to experimentally determine the lifetime of the $3d^9 4s\ {}^3D_3$ state in Ni-like Xe. It is shown that a single exponential could be fitted to a theoretical decay curve, where each lifetime was weighted according to a gas of natural mixing of isotopes, with good accuracy. Depending on which interval the single exponential was fitted to, different lifetimes was obtained.

[1] E. Träbert, P. Beiersdorfer, G.V. Brown, K. Boyce, R.L. Kelley, C.A. Kilbourne, F.S. Porter and A. Szymkowiak, Phys. Rev. A **73**, 022508 (2006)