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Hyperfine induced transitions in He-like, Be-like and Mg-like ions

Jiguang Li∗⋆, Huihui Kang†‡, Chenzhong Dong∗†§, Per Jönsson1, Gediminas Gaigalas†§

∗College of Physics and Electronic Engineering, Northwest Normal University, Lanzhou 730070, China
†Joint Laboratory of Atomic and Molecular Physics, NWNU & IMPCAS, Lanzhou 730070, China
‡Nature, Environment, Society, Malmö University, Malmö S-20506, Sweden
1Department of Physics, Vilnius Pedagogical University, Studentu 39, Vilnius LT-08106, Lithuania
§Institute of Theoretical Physics and Astronomy, A. Gostauto 12, Vilnius LT-01108, Lithuania

Synopsis Hyperfine quenching rates for 1s2s 1S0 → 1s2 3S1 M1 transition of He-like ions, 2s2p 3P0, 3P2 → 2s2 1S0 E1 transition of Be-like ions and 3s3p 3P0 → 3s 3S1 E1 transition of Mg-like ions have been calculated from relativistic configuration interaction wavefunctions including the frequency independent Breit interaction and QED effects. The present study not only supply accurate theoretical values for developing atomic clocks, diagnosing low-density plasma, probing nuclear properties, exploring weak interaction beyond standard model, but also to analyze some characteristics in hyperfine induced transitions.

Hyperfine spectroscopy is a very important tool in the study of atomic and nuclear physics. Especially the investigation of hyperfine induced transition (or hyperfine quenching) attracts much attention due to the possibility to explore weak interaction in atoms [1], developing atomic clocks[2], analyzing spectra[3], determining isotopic ratios in stellar atmospheres and diagnosing low-density plasma[4]. Relevant data are however still insufficient and in response to this we have performed systematic investigations on hyperfine induced transitions for He-like, Be-like and Mg-like ions using GRASP2K [5] based on the multi-configuration Dirac-Hartree-Fock method and the HFST [6] package.

In order guide experiments on parity-violation effect through the mixed hyperfine- and weak-quenching[7], we have calculated hyperfine induced 1s2s 1S0 → 1s2 3S1 M1 transition of He-like ions. A scaling law in Z was derived for the electronic quantities of this transition as follows [8],

\[ A^{el} = 1.9728 \times 10^{-19} Z^{14.065} \]  \( (1) \)

The scaling law allows hyperfine induced transition probabilities to be estimated for any isotope.

For Be-like ions, although many studies have been performed[4, 9], it seems that characteristics about interference effects in hyperfine induced 2s2p 3P0 → 2s 1S0 transition of Be-like ions are still not very clear. Therefore, we further analysed the interference effects in this transition and compared to hyperfine induced 2s2p 3P2 → 2s 1S0 transition [10]. It is worth noting that the trends of interference effects with atomic number Z in these two transitions are not monotonous. The strongest interference effect occurs near Z = 7 for 2s2p 3P0 → 2s 1S0 E1 transition, and near Z = 9 for 2s2p 3P2 → 2s 1S0 E1 transition.

Recently, we have also finished calculations on hyperfine quenching rates of Mg-like[11]. These results are useful for seeking suitable transitions for atomic clocks and determining the physical parameters of low-density plasma.

References


1 E-mail: Dongcz@nwnu.edu.cn