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

Jiguang Li^{*,*}, Huihui Kang^{*,*}, Chenzhong Dong^{*,*1}, Per Jönsson[†], Gediminas Gaigalas^{‡,§}

^{*}College of Physics and Electronic Engineering, Northwest Normal University, Lanzhou 730070, China

^{*}Joint Laboratory of Atomic and Molecular Physics, NWNLU & IMPCAS, Lanzhou 730070, China

[†]Nature, Environment, Society, Malmö University, Malmö S-20506, Sweden

[‡]Department 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 $1s2s\ ^1S_0 \rightarrow 1s^2\ ^1S_0$ M1 transition of He-like ions, $2s2p\ ^3P_0, ^3P_2 \rightarrow 2s^2\ ^1S_0$ E1 transition of Be-like ions and $3s3p\ ^3P_0 \rightarrow 3s^2\ ^1S_0$ 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 $1s2s\ ^1S_0 \rightarrow 1s^2\ ^1S_0$ M1 transition of He-like ions. A scaling law in Z was derived for the electronic quantities of this transition as follows [8],

$$A^{el} = 1.9728 \times 10^{-19} Z^{14.065}. \quad (1)$$

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 $2s2p\ ^3P_0 \rightarrow 2s^2\ ^1S_0$ 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 $2s2p\ ^3P_2 \rightarrow 2s^2\ ^1S_0$ transition [10]. It is worth noting that the trends of interference effects with atomic number Z in these two transitions are not monoto-

nous. The strongest interference effect occurs near $Z = 7$ for $2s2p\ ^3P_0 \rightarrow 2s^2\ ^1S_0$ E1 transition, and near $Z = 9$ for $2s2p\ ^3P_2 \rightarrow 2s^2\ ^1S_0$ 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.

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¹E-mail: Dongcz@nwnu.edu.cn