The Breit interaction in dielectronic recombination transitions in Boron like ions

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Synopsis We calculated the transition rates of two $1s2s^22p_{1/2}2p_{3/2}$, $J^P=3/2^+$ upper levels to two $1s^22s^22p$,$J^P=1/2$, $3/2^-$ lower levels in Boron like ions from Ne^{5+} to Au^{74+}, respectively. The Breit interaction influence the transition rates greatly when the excitation energy change less than 0.5% in highly charge ions. Further analysing suggests the great influence is caused by the variation of the atomic state functions (ASFs) after considering the Breit interaction. We suggest a further experiment on the observable transition ratio of higher Z ions to observe the influence of the Breit interaction.

The collision of electrons with highly charged ions (HCIs) widely exists in warm plasmas. The dielectronic recombination (DR) are important processes in the collision of electrons with HCIs. With the advent of new experimental facilities of X-ray free electron laser (XFEL) and electron beam ion trap (EBIT), the intermediate levels of DR process with inner shell excitatio can be obtain now[1,2]. The measurement of this levels can provide information to diagnose warm astrophysical and laboratory plasma. And the important QED correction, the Breit interaction has been used to explain many deregulation phenomena in atomic and ionic level structure and dynamics[3].

The DR process in experiment can be divided into two steps. The first step a free electron is captured by an ions under the simultaneous excitation of a bound electron and form a double excitation intermediate state. Then the intermediate state emission a photon through the radiative decay process. In the present experiments on the influence of the Breit interaction in DR process mainly focus on the azimuthal distributions of emission photons[1,2]. In this work, we calculated the transition rate of two $1s2s^22p_{1/2}2p_{3/2}$, $J^P=3/2^+$ upper levels to two $1s^22s^22p$,$J^P=1/2$, $3/2^-$ lower levels in B like ions from Ne^{5+} to Au^{74+}, respectively.

For convenient, we define two upper levels the the level 1 and level 2 from low to high, the transition to $1s^22s^22p$,$J^P=1/2^-$ the trans 1 and the transition to $1s^22s^22p$,$J^P=3/2^-$ the trans 2. In Au^{79+}, the transition rate of level 1 trans 1 change from $9.92\times10^{13}s^{-1}$ to $3.71\times10^{15}s^{-1}$, which increase 37 times. The level 1 trans 2 increase 2.5 times, the ratio of level 2 trans 1 and trans 2 increase from 2.36 to 5.25 due to the large decrease of level 2 trans 2. Meanwhile the excitation energies of two level decrease 0.5% only.

Further works demonstrates, in high the nuclear charge number *Z*, the ASFs of two levels vary greatly with the effort of the Breit interaction. The Muti Configuration Dirac Fock (MCDF) method is used in this calculation. In MCDF, the ASF is expanded by a basis of Configuration states functions (CSF). Because the energy shifts of level 1 and level 2 are pretty small, a small correction of the Breit interaction lead to a result level 1 and level 2 great change of their ASF constitution of CSFs in highly charge ions. We also estimate the autoionization (inverse process of DR) rates of two levels in different Z. Because the autoionization rate of level 2 to ground state of Be like ions is several times of level 1, Be like ions in ground state can be easier to level 2 of B like ions through DR process, the ratio of two transitions of level 2 can be measured (which have been measured in lower Z)..

Our calculation shows the Breit interaction can dominate some physical transitions in inner excitation levels. We suggest a further experiment on the observable transition ratio of higher Z ions to observe the influence of the Breit interaction.

References

[1]C. Shah, et. al. 2015 Phys. Rev. A 92, 042702.

[2]H. Jörg, et. Al. 2015 Phys. Rev. A 91, 042705.

[3] G. Breit, 1930 Phys. Rev. 36383.

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