

Theoretical study of inner-shell electron-impact excitation of highly charged ions: Alignment and angular distribution of electron emission

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Synopsis The influence of the Breit interaction, typically appears as a relativistic correction to the Coulomb repulsion acting among the electrons, on the alignment (*i.e.* the population of the magnetic sublevels) and the angular distribution of electron emission from the excited state have been investigated systematically. Detailed calculations have been carried out for the electron-impact excitation cross sections from the ground state to the individual magnetic sublevels of highly charged beryllium-like ions by using a fully relativistic distorted-wave (RDW) method. A remarkable change in the alignment and the electron angular distribution due to the Breit interaction is found, especially for the cases with high-energetic incident electron and high-Z target ions.

An atomic autoionizing state created by a beam of electron is aligned in the direction of the incident beam if the total angular momentum of the excited state is greater than 1/2. The alignment results from the fact that the excitation cross section has different values for different projections of the total angular momentum of the ion on the beam direction and independent of the sign. The alignment of the ions can be revealed by studying its subsequent decay by ejection of the Auger electrons and characteristic x-ray emission. On the other hand, from the analysis of the Auger electron or photon, valuable information can be obtained for both the dynamical process and the magnetic sublevel population of the excited states, which is a very important supplement to the conventional observables [1].

In the present work, we calculated the electron-impact excitation cross sections from the ground state to the individual magnetic sublevels of the excited state $1s2s^22p_{3/2} J=2$ of highly charged beryllium-like ions by using a fully relativistic distorted-wave (RDW) code [2]. Then these cross sections have been used to obtain the alignment parameters of the excited state. Two kinds of calculations have been carried out: one is to include the only Coulomb repulsion term in excitation amplitude (labeled with “C”), and another is to take the magnetic and retardation contributions to the $e-e$ interaction into account (labeled with “C + B”), which is also known as the Breit interaction.

Figure 1 shows the alignment parameter A_{20} (upper panel: a, b, c) and A_{40} (lower panel: d, e, f) of the excited state $1s2s^22p_{3/2} J=2$ for highly charged beryllium-like Fe^{22+} , Xe^{50+} and W^{70+}

ions, respectively. It is found that the Breit interaction has a remarkable contribution to A_{20} for high-Z ions, especially at high incident electron energy. But for A_{40} , the contribution from the Breit interaction becomes significant for Fe^{22+} ion already, and the influence is quite different for different ions and energies. This evident change of the alignment parameters leads to a qualitative change in the electron angular distribution, which shows some very different pattern compared with the Coulomb excitation process [3].

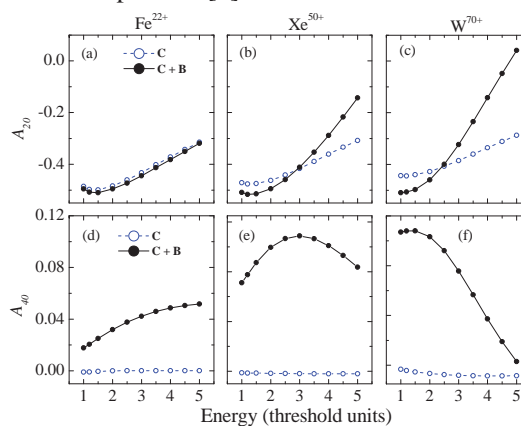


Figure 1. Alignment parameters for the excitation to the excited state $1s2s^22p_{3/2} J=2$ for the Fe^{22+} , Xe^{50+} and W^{70+} ions as functions of incident electron energy in threshold units.

References

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