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Cascades effects on the polarization properties of x-ray radiation emitted by electron-impact excitation of highly charged He-like Fe^{24+} ions

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Synopsis: Detailed calculations using a fully relativistic distorted-wave method are carried out for the electron-impact excitation cross sections from the ground state $1s^2$ (J= 0) to the individual magnetic sublevels of the excited state $1s2s_{1/2}$ (J= 1) of highly charged He-like Fe^{24+} ions. The cascades effects to the cross sections and the linear polarizations of the $1s2s_{1/2}(J=1)\rightarrow 1s^2$ (J=0) line are investigated systematically. Our results show that the 1s2p, 1s3l, and 1s4l (l = s, p, d) excited states have significant effects and make the cross sections increase. These influences also lead to a remarkable decrease in the linear polarization of subsequent x-ray radiation. The present results agree with the previous theoretical results and the polarization measurements very well.

The polarization of He-like ions is of importance for it provides diagnostics of the physical conditions in terrestrial magnetic and laser produced fusion plasmas. Such polarization may potentially be applied to future studies of solar flares and other exotic plasmas [1]. Several studies therefore have been carried out in the past to better understand the role of angular and polarization properties of x-rays emitted from highly charged He-like ions. However, the accuracy of these works is often suspect, different calculations using similar methods/codes sometimes differ so much due to the influence of the higher order effects [2, 3].

In this study, the electron-impact excitation cross sections from the ground state $1s^2(J=0)$ to the individual magnetic sublevels of the excited state $1s2s_{1/2}(J=1)$ of He-like Fe^{24+} ions are calculated using a fully relativistic distorted wave (RDW) method. Special attention is paid to the cascade contributions from high-lying levels 1s2p, 1snl (n= 3, 4, 5, 6; l= s, p, d) to the cross sections and the polarization properties of the $1s2s_{1/2}(J=1)\rightarrow 1s^2(J=0)$ transition line [1]. Our results show that radiative cascades have large effects and make the polarization decrease. For the cross sections, the contributions of the 1s2p, 1s3l, 1s4l, 1s5l and 1s6l (l = s, p, d) levels are 140%, 300%, 70%, 40%, and 20% to the $M_f = 0$ sublevel cross sections, and are 106%, 112%, 52%, 40%, and 15% to the $M_f = \pm 1$ sublevel cross sections, respectively. For the polarizations, the cascades effects causes a change of the sign of the linear polarization and decrease linear polarization from 0.004 to −0.08 and 0.003 to −0.268 at 6.8 and 8 keV, respectively. The present results agree very well with the previous theoretical results and polarization measurements.

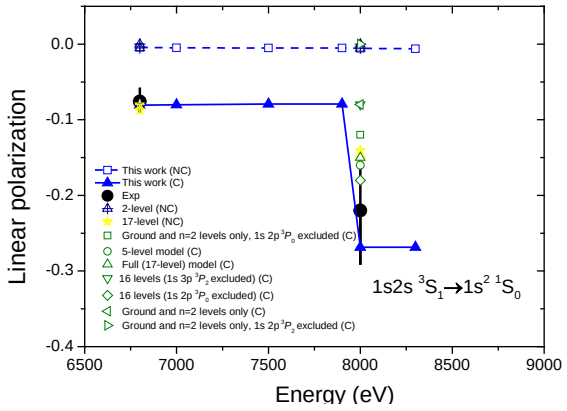

Figure 1. Calculated linear polarizations for the $1s2s_{1/2}(J=1)\rightarrow 1s^2(J=0)$ transition line of He-like Fe^{24+} ions, and comparison with the existing theoretical [5] and experimental values [4,5]. Here, NC represents the values without cascade contributions, and C represents the ones with cascade contributions included. The labeled '17-level' represent the results obtained from the full model [5] which included the 1s2, 1s2l (l = s, p), and 1s3l (l = s, p, d) configurations, the labeled '5-level' refer to separate calculations involving only the five configurations ($1s2\ ^1S_0$, $1s2s\ ^3S1$, $1s2p\ ^3P_0$, $1s2p\ ^3P_2$, and $1s3p\ ^3P_2$), and the labeled '2-level' refer to separate calculations involving only the two levels of each transition [5].

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