Double photoionization in vicinity of K-shell resonances and direct double Auger decay of K-shell excited states of O^{+}-O^{4+} ions

Jiaolong Zeng* [1], **Yongjun Li***, **Liping Liu***, **Pengfei Liu***, **Cheng Gao***, **and Jianmin Yuan***

* College of Science, National University of Defense Technology, Changsha Hunan 410073, P. R. China

Synopsis The direct double Auger decay of K-shell excited states of singly to four times ionized oxygen ions are investigated for the first time. The data are utilized to interpret recent experiments on the double photoionization.

The observations from x-ray satellites like Chandra and XMM Newton identified a number of intense lines originating from the 1s-2p transitions in different ionization stages of light elements, in particular oxygen. Oxygen is the third most abundant element in the astrophysical plasmas and it is also abundant in the Earth's atmosphere. The x-ray photoabsorption in the KLL resonances of O^{5+} was first detected by the Chandra X-ray Observatory [1]. Up to now the K-shell absorption lines of oxygen and its ions have been observed in various astrophysical objects.

Absolute K-shell photoionization cross sections for boron-like O^{3+} ions were measured by McLaughlin et al. [2] employing the ion-photon merged beam technique at the SOLEIL synchrotron-radiation facility in the photon energy range from 540 to 600 eV with a resolving power ~5000. The key parameters including the resonance energies, natural line widths and and resonance strengths of the strong 1s-2p and the weaker 1s-3p resonances were determined from the observed K-shell spectra of this ion. All the above theoretical and experimental investigations are devoted to the single PI or single Auger decay processes. Very recently, Bizau et al. [3] experimentally measured the absolute cross sections for the single and double K-shell PI of O^{+} and O^{2+} ions in the 526-620 eV photon energy range by employing the ion-photon merged-beam technique with a high-resolution of resolving power ~5300 at the SOLEIL synchrotron-radiation facility. To the best of our knowledge, however, no theoretical efforts was devoted to the double Auger decay [4,5] and double PI of the oxygen ions.

In this work, single and double photoionization cross sections in the 1s-2p resonance energy range are investigated theoretically for the quantum states of the ground and first excited configurations of O^{+}-O^{4+}. By analyzing all possible double ionization pathways, we conclude that the double photoionization originates solely from the direct double Auger decay of the K-shell resonance states. R-matrix method has been utilized to obtain the single ionization cross section, whereas the double ionization cross sections are obtained by multiplying the single photoionization cross sections by the branching ratios of the direct double Auger decay to the total Auger decay. Our theoretical work diagnose the population fractions prepared in a recent experiment work [3] and successfully interpreted it.

References

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[1] E-mail: jlzeng@nudt.edu.cn