Observation of Two-Electron One-Photon X-ray transitions in collisions of slow Xe^{26+} ions with beryllium surface

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Synopsis Two-Electron One-Photon (TEOP) X-ray transitions were observed for the first time in collisions of highly charged Xe ions with metallic Be surface. The intensities of TEOP X-rays are well described by performed MCDF for one-electron one-photon (OEOP) dipole-allowed transition of Paschen and Brackett series assuming constant TEOP/OEOP branching ratio. The importance of the Internal Dielectronic Excitation (IDE) in relaxation of hollow Xe ions/atoms has been evidenced and discussed.

Slow highly charged ions (HCI) colliding with metal surface are rapidly neutralized forming highly excited Rydberg states, "hollow" atoms, which subsequently relax in a series of fast processes including Interatomic Coulombic Decay (ICD) [1] and X-ray andAuger electron emission cascade. It was evidenced the Internal Dielectronic Excitation (IDE) [2] contributes to relaxation of "hollow" atoms. We report here on the first observation of the TEOP X-ray transitions measured in interaction of slow Xe^{26+} ions with metallic beryllium surface. We show that TEOP process, predicted by Heisenberg in 1925 [3], contributes to X-ray emission from "hollow" atoms. In the present experiment the X-rays were emitted from 209 keV Xe^{26+} ions neutralized at metallic Be foil by capturing resonantly the electrons into Rydberg states with n≈25. The ion beam was produced by the EBIS-A facility [4]. For Xe^{26+} ions having filled M-shell the observed M-X-rays, which were excited by the IDE process, were measured with XFlash silicon drift detector (SDD). The measured M-X-rays were dominated by OEOP electric-dipole transitions (nf-3d) and reasonably well interpreted (Fig. 1)in terms of the MCDF calculations performed using GRASP2K code [5].

We have found that the high energy part of X-ray spectrum, extending roughly over doubled energy range of the OEOP transitions, can be explained by the TEOP transitions, having photon energies slightly bigger than doubled energy of the diagram M-X-ray transitions. Contribution of the TEOP transitions to the measured X-ray spectrum was calculated by assuming constant TEOP/OEOP ratio for these processes.

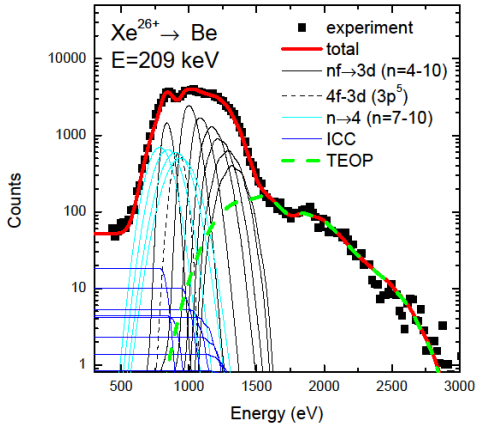

Figure 1. Measured spectrum of X-rays for 209 keV Xe^{26+} ions colliding with Be foil.

Consequently, the shape of TEOP was the same as for OEOP with stretched energy scale by a factor of about two.Despite of simplicity of the proposed approach, discussed OEOP and TEOP transitions reproduce reasonably well the measured X-rays. The results evidence importance of electron-electron correlations in relaxation of hollow atoms.

Acknowledgments

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References

[1] Wilhelm R *et al* 2017 *Phys. Rev. Lett.* **119** 103401
[2] Schuch R *et al* 1993 *Phys. Rev. Lett.* **70** 1073
[3] Heisenberg W 1925 *Z. Phys.* **32** 841
[4] Banaś D *et al* 2010 *J. Instrum.* **5** C09005
[5] Jönsson P *et al* 2013 *Comp. Phys. Comm.* **184** 2197

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