Strong higher-order resonant contribution to Fe K_α x-ray line polarization in hot anisotropic plasmas

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Synopsis We report the first systematic measurement of x-ray angular distribution and polarization following dielectronic, trielectronic and quadroelectronic recombination into He-like through O-like iron and krypton ions. The experimental data revealed that the the degree of polarization of x rays is dominated by relativistic Breit interaction and hitherto neglected higher-order trielectronic and quadroelectronic recombination resonances.

For a wide range of temperatures, resonantly captured electrons with energies below the excitation threshold are the strongest source of x-ray line excitation in hot plasmas containing highly charged Fe ions. The angular distribution and polarization of x rays emitted due to these processes were experimentally studied using an electron beam ion trap. The electron-ion collision energy was scanned over the *KLL* dielectronic, trielectronic and quadruelectronic recombination resonances of $Fe^{18+..24+}$ and $Kr^{28+..34+}$ with an excellent resolution of ~ 6 eV. The angular distribution of x rays was measured along and perpendicular to the electron beam propagation direction [1]. Subsequently, polarization due to dielectronic recombination of $Kr^{28+..34+}$ was measured using a novel Compton polarimetry as well [2, 3].

The experimental data reveal the alignment of the populated excited states and exhibit a high sensitivity of these parameters to the relativistic Breit interaction [2, 4]. We observed that most of the transitions lead to polarization, including hitherto neglected trielectronic and quadruelectronic resonances. Furthermore, these channels dominate the polarization of the prominent K_α x rays emitted by hot anisotropic plasmas in a broad temperature range, see Fig. 1. The present results comprehensively benchmark full-order atomic calculations carried out with the FAC [5] and RATIP [6] codes. We conclude that accurate polarization diagnostics of hot anisotropic plasmas, e. g., of solar flares and active galactic nuclei, and laboratory fusion plasmas of tokamaks can only be obtained under the premise of careful inclusion of relativistic effect and higher-order resonances which were most often neglected in previous works [1]. Furthermore, the present experiments also demonstrate the suitability for accurate directional diagnostics of electron or ion beams in the hot plasmas [7].

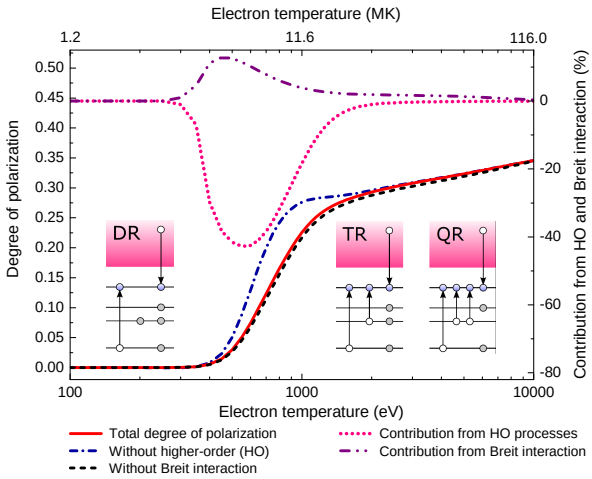

Figure 1. Maximum polarization of iron K_α x rays due to resonant recombination as a function of the plasma temperature.

References

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