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Complete measurements of anisotropic x-ray emission following recombination of highly charged ions

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Synopsis We report the first systematic measurement of x-ray emission anisotropies following dielectronic, trielectronic and quadroelectronic recombination into He-like through O-like iron and krypton ions. Using the experimental data we calculated the polarization of the Kα x rays in an anisotropic plasma as a function of the plasma temperature. Unexpectedly, we found that the degree of polarization is dominated by previously neglected trielectronic and quadroelectronic recombination resonances.

X-ray emission asymmetries following resonant recombination into highly charged ions were studied using an electron beam ion trap (EBIT) of Max Planck Institute for Nuclear Physics in Heidelberg. Iron and krypton ions in the He-like through O-like charge states were populated in an EBIT and the electron-ion collision energy was scanned over the region of the K-shell recombination resonances. With the help of the excellent electron energy resolution of 6.5 eV for iron ions and 11.5 eV for krypton ions the dielectronic, trielectronic and quadroelectronic recombination transitions were systematically investigated. The x rays emitted in the decays of resonantly excited states were observed by two germanium detectors aligned along and perpendicular to the electron beam propagation direction and the corresponding intensities of the K-shell x-ray transition were recorded as a function of the electron collision energy. The x-ray emission asymmetries reveal alignment of the intermediate excited states and, thus, the polarization of the emitted x rays. Except for a few transitions the experimental results are in excellent agreement with the theoretical calculations done with FAC and RATIP computer codes.

This measurement allows for a systematic modeling of the polarization of the prominent Kα radiation emitted by hot anisotropic plasmas. The measurement of its polarization gives access to the anisotropy of the electron momentum distribution in the plasma. Using the experimental data we calculated the maximum polarization of the Kα x rays emitted by an anisotropic plasma as a function of the plasma temperature, see Fig. 1. Surprisingly, we found that the degree of the x-ray polarization is dominated by trielectronic and quadroelectronic recombination transitions which were previously neglected. These experimental results should play an important role in diagnostics of hot astrophysical plasmas of solar flares and active galactic nuclei and laboratory fusion plasmas of tokamaks and stellarators.

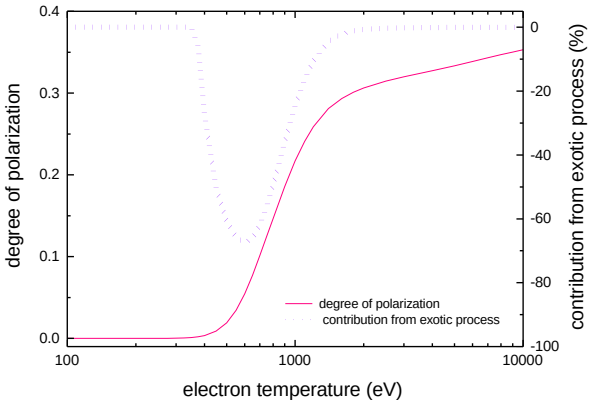

Figure 1. Maximum polarization of iron Kα x rays due to resonant recombination as a function of the plasma temperature. Exotic trielectronic and quadroelectronic recombination transitions dominate polarization in a broad range of temperatures.

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