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Resonant electron ion recombinations: reliable atomic data for high temperature plasmas

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Resonant electron ion recombination is of vital importance in high temperature plasmas. Dielectronic recombination (DR) is the main resonant recombination process, in which a free electron is captured by the target ion, meanwhile the released energy is transferred to promote a bound electron forming an auto-ionization state. It is completed by subsequent photon emissions until the ion energy is below its ionization limit. It significantly affects the electron temperature, the charge state distribution, and the ion level population in the plasmas. The radiation often causes unresolvable satellites, disturbing the main line shape, line intensity and line width. Furthermore, DR of highly charged ions contributes significantly to radiation energy loss in fusion plasmas. Studies of the satellites distribution and the resonance strengths of the recombination help to advance the radiation loss mechanism of the fusion plasmas and also to the application of X-ray diagnostics.

In an electron beam ion trap (EBIT), highly charged ions with required charge states are created from sequentially collisional ionization by bombardment with a highly compressed energetic electron beam. The electron density is at the region of 10^{10}-10^{12} cm^{-3}, and the beam energy is tunable and monochromatic. This makes EBIT suitable for disentangling study the electron-ion collisional processes, especially for the resonant electron-ion recombinations, in complex plasmas, e.g. in magnetic confined fusion plasmas. The present work will show our resonant recombinaiton studies on argon, xenon, tungsten and other ions, measured at the Shanghai-EBIT [1], as shown in Fig. 1.

The dielectronic recombination resonant strength is necessary for predicting the charge state distribution in a plasma. The inner-shell excitation DR resonant strengths of open *L*-shell xenon [2, 3] and tungsten [4, 5] ions are carefully studied at the Shanghai-EBIT. The resonant strengths are measured at an accuracy level around 10%. In open M-shell ions, a large amount of metastable state population is observed via a resonant recombination measurement [6], which indicates the necessity of including metastable states population contribution in the plasma radiation calculations.

The Doppler width of the *w* line ($1s2p\ ^1P_1 - 1s^2\ ^1S_0$) is often used to diagnose the ion temperature in plasma. The $1s2pnl \rightarrow 1s^2nl$ (also known as $K\alpha$ satellites) transitions with spectator electron at high *n* levels may significantly affect the shape and width of the *w* line. In our work, $K\alpha$ satellite lines formed from resonant recombination of He-like argon ions are measured at a special electron energy scanning scheme. The satellites from different *KLn* manifolds are fully separated. The results show that $K\alpha$ satellites sit on the longer wavelength side of the *w* line. High-*n* satellites may fully blended with the *w* line. The effect should be well considered in temperature diagnostics using Doppler line width.

References
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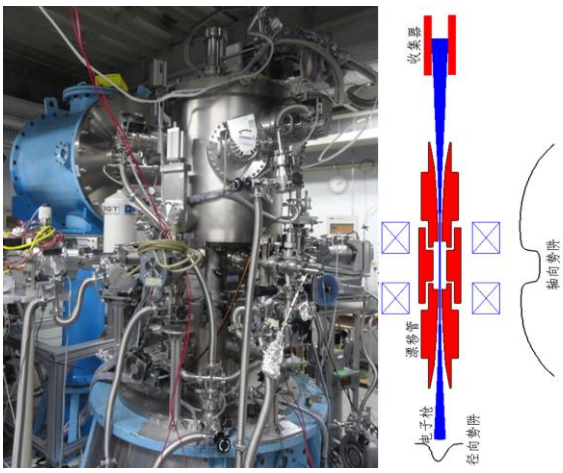

Figure 1. Shanghai-EBIT.