Resonant excitation of highly charged Fe ions observed with a compact electron beam ion trap

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Synopsis We present extreme ultraviolet spectra of $n = 3$ –3 transitions in highly charged Fe ions excited by electron impact. The spectra has been obtained with an electron beam ion trap while sweeping the electron energy to study resonant excitation processes. Strong intensity enhancements at specific energies, which correspond to resonant excitation, are found for $3p - 3d$ transitions in Fe^{14+} and Fe^{15+}. The experimental results are compared with theoretical resonance strength calculated with the Flexible Atomic Code (FAC) and the Hebrew University Lawrence Livermore Atomic Code (HULLAC).

Resonant excitation of highly charged ions is one of the important processes in hot plasmas. The process has thus been investigated to date both experimentally and theoretically. An electron beam ion trap (EBIT) is a suitable device to study such resonant processes [1, 2]. However, since an ordinary EBIT is suitable for the operation with an electron energy of several keV or higher, very few experiments have been done so far for lower energy such as less than 1 keV. In this work, we present an experimental study of the resonant excitation of Fe ions observed in the electron energy range of 350 - 500 eV.

The present experiment was performed with a compact electron beam ion trap, called CoBIT [3]. Highly charged Fe ions were produced through successive ionization of iron injected as a vapor of ferrocene ($Fe(C_5H_5)_2$ by a 600 eV electron beam. After a "cooking" time of 1600 ms, the electron energy was swept between 350 and 500 eV for about 7 ms (probing time), and kept at 600 eV for about 13 ms (keeping time) for preserving the charge distribution. After the probing and keeping periods were repeated 100 times, the ions were dumped and the cycle was started again from the cooking time. The electron beam current was 10 mA throughout the measurement.

The EUV emission from the trapped Fe ions was observed with a grazing incidence flat field grating spectrometer [4] employing a 1200 gr/mm concave grating with 13450 mm radius of curvature (Hitachi 001-0660). The diffracted EUV photon was detected by a position sensitive detector (PSD) consisting of five micro channel plates (MCPs) and a resistive anode (Quantar 3391). The front of the MCP was coated by CsI for enhancing the sensitivity. When a photon was detected, the position on the PSD, pulse height, and the electron energy were recorded on PC in list mode.

Figure 1 shows the experimental result for Fe^{14+}, where intensity enhancements due to resonant excitation are confirmed. We also present comparison with the theoretical cross sections calculated with the Flexible Atomic Code (FAC) and the Hebrew University Lawrence Livermore Atomic Code (HULLAC).

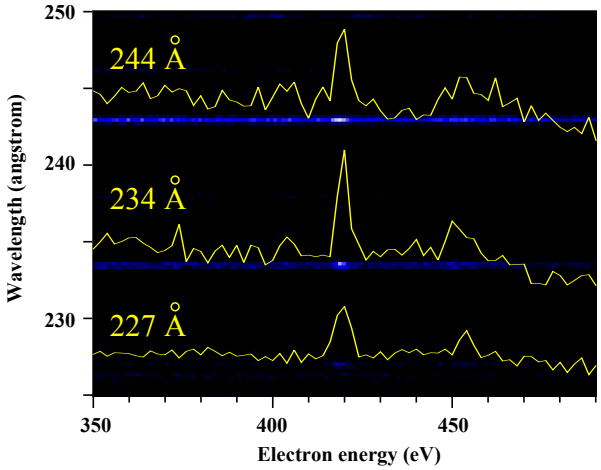

Figure 1. Electron energy dependence of $3s3p - 3s3d$ transitions in Fe^{14+} observed with CoBIT: $^3P_1$–$^3D_2$ (227 Å), $^3P_2$–$^3D_3$ (234 Å), and $^1P_1$–$^1D_2$ (244 Å).

References

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