§10. Atomic Data for Fe XVII Lines in EUV Spectra of the Solar Atmosphere and LHD

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Ne-like Fe (Fe XVII) is abundant in many astrophysical and laboratory plasmas because of its L-shell closed electronic configuration of the ground state. Fe XVII lines of extreme ultraviolet wavelengths (EUV) have been observed in solar flares and beam-foil spectra. The lines were identified as transitions among $2p^5 3l$ excited levels.

$2p^5 3p$ ($^1S_0$) → $2p^5 3s$ $(1/2, 1/2)_1$ transition is known as an electron-impact pumping scheme to produce soft x-ray or EUV lasers. Laboratory experiments with laser produce plasmas have, however, shown very small gain of this transition for Se XXV; other transitions in the $2p^5 3l$ levels exhibited the largest gain in the experiments. This result has been puzzling, since collisional excitation models predicted that the $2p^5 3p$ ($^1S_0$) → $2p^5 3s$ $(1/2, 1/2)_1$ line should have one of the highest intensities. Later, Doschek et al. reported that observed line intensities of Fe XVII in a solar flare were in good agreement with intensities calculated, taking account collisional excitations from the ground state of Fe XVII. In the both (observed and calculated) spectra, 204.6 Å and 254.8 Å lines, identified as $2p^5 3p$ ($^1S_0$) → $2p^5 3s$ $(3/2, 1/2)_1$ and → $2p^5 3s$ $(1/2, 1/2)_1$, respectively, had the strongest and almost the same intensities. They concluded therefore that inaccurate collision excitation rates in the model should not be the cause of the puzzle.

However, new observation of a solar flare by means of the EUV Imaging Spectrometer on *Hinode* satellite[1] has shown difficulty in reconciling observed Fe XVII line intensities with available atomic data. It was reported[2] that the observed intensity of the 254.8 Å line was factor of 2 smaller than that calculated by using CHIANTI code. Although the discrepancy may be ascribed partially to calibration issues, re-investigation of the relevant atomic data seems to be necessary for a better understanding.

In this work[3], we calculated excitation cross sections related to the Fe XVII lines by utilizing HULLAC code. From the calculated cross sections, resonance excitation effects and particularity of the $2p^5 3p$ ($^1S_0$) state were studied in details. To assess the calculations, we have undertaken R-matrix calculations through international collaboration with Dr. Norrington in QUB. To the best of our knowledge, the EUV line emission of Fe XVII has not been studied thoroughly with an electron-beam-ion-trap (EBIT), while there were studies on the x-ray lines at 15-17 Å. We, therefore, calculated line emissivity and intensity ratios for experimental conditions of an EBIT.

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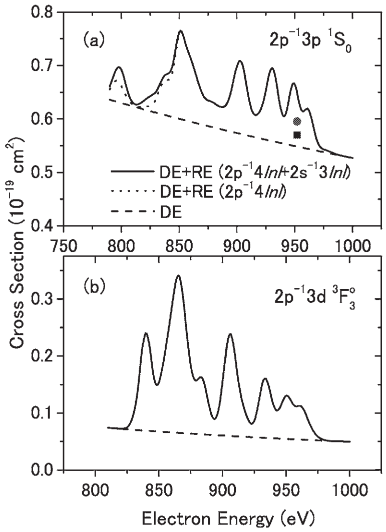

Fig. 1: Excitation cross sections of (a) $2p^5 3p$ $^1S_0$ and (b) $2p^5 3d$ $^3F_3$ from the ground state $2p^6$ of Fe XVII. Solid circle is relativistic R-matrix calculations and solid square relativistic distorted-wave calculations.

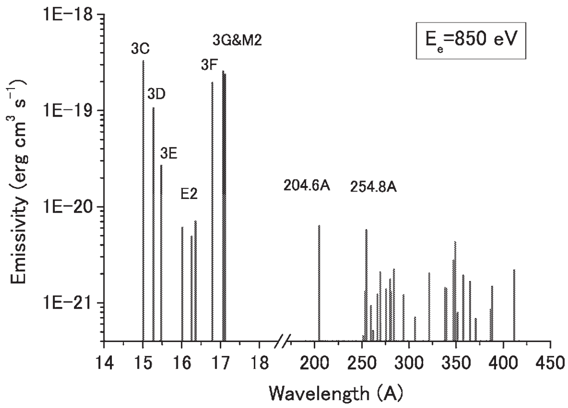

Fig. 2: Line emissivity of Fe XVII in EBIT at electron energy of 850 eV.

1) http://solar-b.nao.ac.jp/index_e.shtml.
2) Warren, H.P., Feldman, U., Brown, C.M.: Astrophys. J. 685 (2008) 1277-1285.
3) D. Kato et al.: J. Phys.: Conf. Ser. 163 (2009) 012076.