# §89. Non-Equilibrium Plasma Diagnostics in Large Helical Device (LHD) and Hinode EUV Imaging Spectrometer (EIS)

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EUV Imaging Spectrometer (EIS) on board Hinode is observing numerous emission lines from iron ions at various ionization stages and the instrument tries to pin down the mechanism of coronal heating via spectroscopic observations. Atomic models and their atomic parameters used in the model could be improved via the experiments conducted for plasma produced in the Large Helical Device (LHD). The experiment through a compact EBIT (Electron Beam Ion Trap) instrument (CoBIT) is also carried out to check these parameters in different plasma conditions (excited mono-energetically and at lower electron densities). Iron ion most concerned this time is Ne-like FeXVII ion, emission lines of which are emerging in the EIS observing wavelengths.

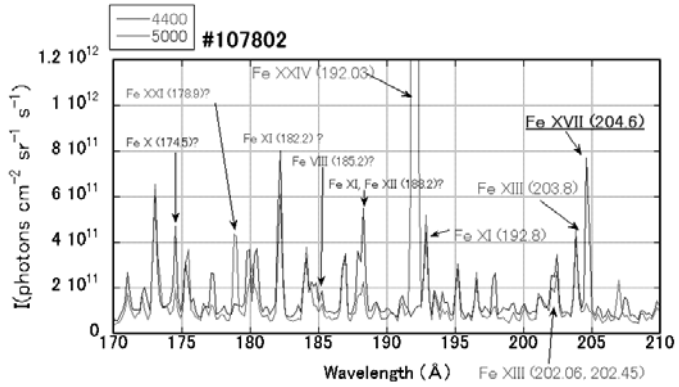


Fig. 1. Highly-Charged Iron Ion Spectra in the EUV wavelengths of 170 – 210 Å taken at LHD

EIS has been observing FeXVII lines formed in the core (high-temperature) region of active regions [1]. Ne-sequence iron ions, FeXVII, are formed around the temperature of log Te ~ 6.7, which nearly corresponds to the maximum temperature reached in solar active regions. EIS has detected several weak FeXVII emission lines appearing in its observing wavelengths (170 - 210 Å, 250 - 290 Å), and they are identified as those from the transitions between $2p^5$ 3s/3p - $2p^5$ 3p/3d. The observed line intensity ratios among them are compared with our theoretical calculations. We found that many of them were blended by lower-temperature weak coronal lines, and that the photon branching ratio of the $2p^5 3p\ ^3S_0$ level to the $2p^5 3s$ levels was wrong roughly by a factor of 2 [1]. Theoretical calculations are carefully investigated, as well. Significant enhancement of the EUV lines around 250 – 400 Å is demonstrated as the effect of resonance excitation, but no such large line intensity ratio is calculated [2].

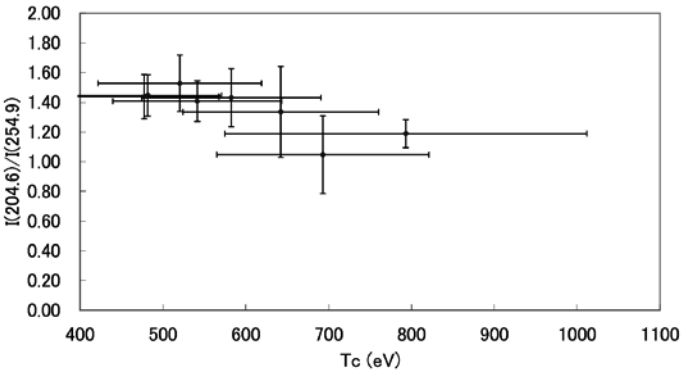


Fig. 2. Line intensity ratios of FeXVII λ204.6 Å /λ254.8 Å along with $T_e$

The intensity ratios of these lines were for the first time successfully measured in LHD at NIFS (see Fig. 1). EUV spectra were taken by injecting the iron TESPELs (Tracer Encapsulated Solid Pellets) into LHD. An Al filter properly blocked the contribution of the emission lines in the 2nd order wavelengths, and relatively cool plasma of $T_e$ ~ 700eV was created by NBI control. Quick look analysis reveals that the intensity ratios of FeXVII λ 204.6 Å / λ 254.8 Å are less than 1.4 (See Fig. 2). These line ratios could closely reach the theoretical value of ~ 1, if the contributions of FeXIII lines blending is considered in the FeXVII λ 204.6 Å line.

Encouraged by this experiment, we are now revisiting the solar active region data, assuming that even in small flare spectra unknown line originating from the transition region could be blended with FeXVII λ 204.6 Å.

CoBIT instrument has not been successful of detecting weak EUV FeXVII lines observed by the EIS instrument. Adjusting the CoBIT electron energy to excite FeXVII irons, we were successful in getting X-ray spectra of emission lines of the same ion, although we yet try to measure the EUV lines. Acording to the calculations of atomic data with the collisional-radiative model, intensities of the strongest EUV lines among them at 204.6 Å and 254.8 Å are found to be 2 orders of magnitude less intense than the X-ray lines at 15 Å and 17 Å, but we still think they are measureable in the CoBIT.

1) Watanabe, T., Yamamoto, N. Kato, D., Sakaue, H. A., Murakami, I.: 2010, presented at 38th COSPAR G.A. E25-0008-10.
2) P. Jönsson et al.: "Relativistic CI Calculation of Spectroscopic Data for the $2p^6$ and $2p^5 3l$ Configurations in Ne-like Ions between Mg III and Kr XXVII," 2011, Research Report NIFS-Data Ser., NIFS-DATA-113.