§72. 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 mostly concerned this time is Ne-like FeXVII ion, emission lines of which are emerging in the EIS observing wavelengths.

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

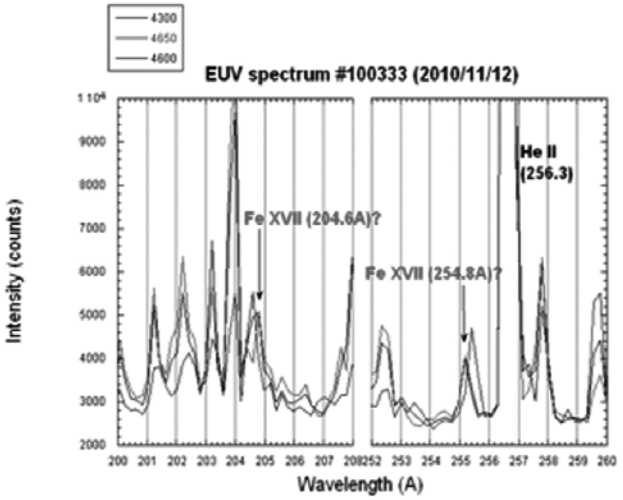

Fig. 1. Highly-Charged Iron Ion Spectra taken at LHD

ratios among them are compared with our theoretical calculations. We found that many of them are blended by lower-temperature weak coronal lines, and that the photon branching ratio of the $2p^53p\ ^3S_0$ level to the $2p^53s$ levels is wrong roughly by a factor of 2.

The intensity ratios of these lines measured in LHD at NIFS are also reported and try to be compared with the solar observations (see Fig. 1): The experiments were conducted on November 12, 2010 when the test measurement of EUV spectra was scheduled by injecting the iron TESPELs (Tracer Encapsulated Solid Pellets) into LHD, but actually it was not successful, because of the failure of the injection facility, and it was conducted on January 25, 2011, and we got a few spectra showing the FeXVII lines observed in the EIS spectral ranges. Quick look analysis suggests contradictory results against the solar observation.

CoBIT has been successfully observing the emission lines of iron ions appearing in the EUV wavelengths with a flat-field grazing incidence spectrometer [2]. The density dependence of line intensity ratios was investigated as cross checks of the measurement and the observation for FeXIII, XIV and XV. However, the 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.

Theoretical research is also addressed for the origin of discrepancy in the FeXVII line intensity ratio, particularly, of the 204.65.Å line to the 254.87 Å [3]. Calculations of atomic data and the collisional-radiative model, used to study population kinetics of $2p^53l$ levels of FeXVII, are considered. Intensities of the strongest EUV lines at 204.65 Å and 254.87 Å are found to be 2 orders of magnitude less intense than the X-ray lines at 15 Å and 17 Å. Significant enhancement of the EUV lines around 250 – 400 Å is demonstrated as the effect of resonance excitation.

1) Watanabe, T., Yamamoto, N. Kato, D., Sakaue, H. A., Murakami, I.: 2010, presented at 38th COSPAR G.A. E25-0008-10.
2) Nakamura, N., Watanabe, E., Sakaue, H. A., Kato, D., Murakami, I., Yamamoto, N., Hara, H., Watanabe, T.: 2011, accepted for publication in ApJ.
3) Kato, D., Sakaue, H. A., Murakami, I., Kato, T., Nakamura, N., Ohtani, S., Yamamoto, N., Watanabe, T.: 2009, Proc. 14th International Conference on the Physics of Highly Charged Ions, J. Phys. Conf. Ser., **163**, 012076.