## §2. Plasma Simulation Experiments Using Versatile Highly Charged Ion Sources

Nakamura, N. (Univ. Electro-Communications),
Sakaue, H.A., Kato, D., Murakami, I.,
Yamamoto, N. (Chubu Univ.)

Using highly charged ion (HCI) sources at the University of Electro-Communications (UEC) and NIFS, we have been obtaining atomic data of highly charged ions such as the cross sections of resonant recombination and ionization processes. Those data are important as fundamental atomic data in non-equilibrium plasmas such as the peripheral plasma in fusion devices and the transition region in the solar atmosphere. On the other hand, the purpose of the present study is to make more active contribution to the understanding of such non-equilibrium plasmas by obtaining experimental spectra from a well defined, controlled plasma.

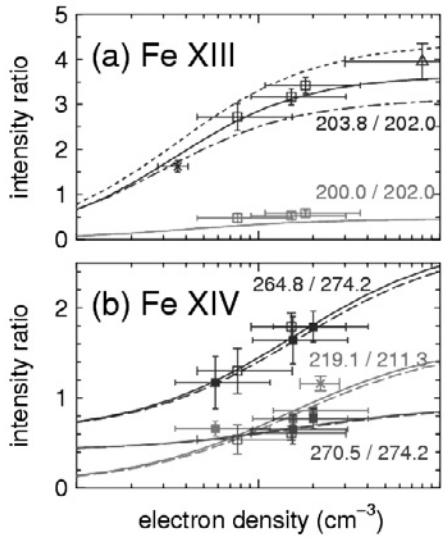


Fig. 1. Intensity ratio of density-sensitive lines of (a) Fe XIII, and (b) Fe XIV. The data obtained with electron beam energies of 400 and 500 eV are plotted as open and closed squares, respectively. The solid and long dashed lines represent the results of the present model calculation for 400 and 500 eV, respectively.

Figure 1 shows the intensity ratios obtained for several density sensitive lines of Fe XIII and XIV as a function of the electron density. In this measurement, a compact EBIT developed at UEC, called CoBIT,[1] was used. At the same time with the spectral observation, the electron beam profile was also measured with a pinhole-camera for obtaining the density of the beam electrons. A slit 0.2 mm wide was placed at 30 mm from the electron beam and the EUV photons passing though the slit were observed with a Peltier-cooled back-illuminated CCD placed at 320 mm from the slit. This arrangement enabled us to obtain the spatial distribution of the EUV emission with a magnification of about 10. The EUV emission distribution is considered to represent the electron density distribution since the lifetime of EUV transitions is as short as the order of $10^{-10}$ s. The electron density determined from the electron current and the electron beam profile observed with the pinhole EUV camera was used as a horizontal axis of the figure. As seen in the figure, overall good agreement is found between the present experiment and theoretical model.[2]

For actively simulating non-equilibrium plasmas with an EBIT, fast control of electron beam energy and current is needed. In order to achieve the fast control, the power supplies which are floated at a high voltage should be controlled from a PC at the ground potential. In this fiscal year, the insulated control system which enables the link between the power supplies and the PC was constructed. For testing the new control system, transition lifetime measurement was performed for the visible transition of highly charged iron which is of astrophysical interest.

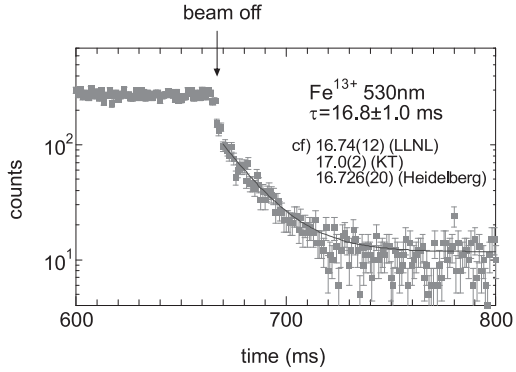


Fig. 2. Time variation of the line intensity of M1 transition in Fe XIV.

Figure 2 shows the results of the lifetime measurement for the magnetic dipole visible transition between the ground state fine structure levels of $^2P_{1/2}$ - $^2P_{3/2}$ of Fe XIV. The horizontal axis is the time since the electron beam was turned on with the control system, and the vertical axis is the intensity of the corresponding line observed with a photo-multiplier tube through an interference filter. The electron beam was turned off by the control system at $t$=665 ms when the line intensity reached the equilibrium. The trapped ions continued to be trapped without an electron beam because of the strong magnetic filed of the EBIT; and thus the ions which were excited by the electron beam continued to emit the corresponding line. Therefore the decay curve of the emission intensity gives the lifetime of the transition. The lifetime obtained in the present experiment is found to agree with the previously reported values. This proves the validity of the new control system.

1) N. Nakamura et al.: Rev. Sci. Instrum. 79 (2008) 063104.
2) N. Nakamura et al.: ApJ (2011) in press