S15-1

Atomic and radiation processes of multiple charged ions and their applications
多価電離イオンの原子過程と輻射の物理と応用の展開

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Atomic and radiation processes of multiple charged ions have been attracted attention. Spectroscopy of the emission from high-Z ions has been used as a useful diagnosing tool of the plasmas. In the magnetic fusion plasmas, the radiation loss from impurity ions are interested. In the indirect driven inertial fusion, high-Z ions are used to convert the energy of the laser to x-rays by to implode the target. Recently, EUV emission at λ=13.5nm using tin plasmas has been investigated, toward its application to microlithography.

6 papers will be presented in this symposium, including the spectroscopy of tungsten ions in magnetic fusion plasmas and collisional radiative (CR) modeling, atomic emission using the electron beam ion trap (EBIT), radiation hydrodynamics simulation of the laser produced plasmas, and investigation of the plasma EUV source.

The emission spectra from tungsten ions are complex, especially in the case of N-shell ions at low temperature (≈1keV). Recently, computational atomic codes have enabled us to develop collisional radiative (CR) model of such complex ions and allow us to calculate the emission spectra. In experiments, in the magnetic fusion devices, spectra from uniform and quasi-stationary plasma can be observed. Using EBIT, emission spectra from each charge state of tungsten ions can be observed separately, using which the emission lines observed in the fusion plasmas can be identified. By comparing calculations with experimental spectra, the atomic model is validated.

Figure 1 shows the mean charge of tungsten plasma as an example. At high temperature (T_e≈3keV) where Ni-like tungsten is dominant, results from different calculations agree well each other, which are also consistent with experiments. In contrast, at lower temperatures, disagreement between calculations is seen, and calculated mean charge is higher than experiment [4]. This suggests that accuracy of the atomic data especially collisional cross sections need improvement.

In laser produced plasmas, the radiation transport determines their temporal and spatial characteristics, which also decides the conversion efficiency of the EUV source. Accurate opacity data is required, and also novel methods to calculate frequency and angle dependent radiation transport, which is computationally intensive, are demanded. With further experimental and theoretical investigation of atomic and radiation processes in plasmas the model will be more useful for fusion and a variety of applications, and will also become useful in astrophysics.

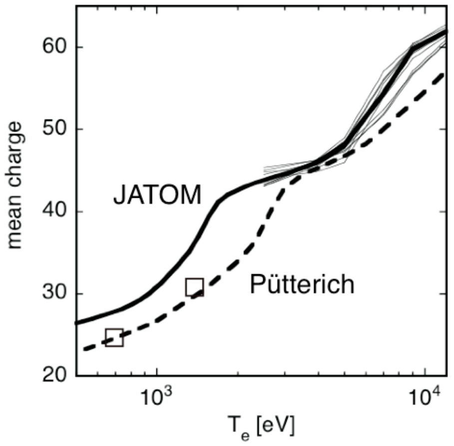

Fig.1. Mean charge of tungsten at $n_e=10^{14}/cm^3$. Lines are calculated result from this work (thick solid line) [1], from ref. 2 (thick dotted line), and from the codes presented at the NLTE7 kinetics workshop [3]. Squares show the result from the measurement at LHD.

References

[1] A. Sasaki and I. Murakami: J. Phys. B**96** (2014) 175701.
[2] T. Pütterich, et al.: Plasma Phys. Control. Fusion. **50** (2008) 085016.
[3] H.-K. Chung, et al.: High Energy Density Phys. **9** (2013) 645.
[4] I. Murakami et al., IAEA 25th Fusion Energy Conference (Oct.12-18, 2014, St. Petersburg、Russia), EX/P6-28.