Soft X-ray Spectroscopy of Rare-Earth Elements in LHD Plasmas

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Soft X-ray spectra from highly charged ions of high Z rare-earth elements (lanthanides) are of great interest in terms of atomic physics issues such as configuration mixing and relativistic effects. In addition, some of the elements are potentially important in plasma applications for short-wavelength light sources. Soft X-ray spectra from lanthanide elements have been studied so far using laser-produced plasmas (LPPs), magnetically confined fusion (MCF) plasmas and electron beam ion traps (EBITs). Nevertheless, experimental surveys of the spectra are still incomplete. Also, it is worthwhile to make comparisons among the spectra from different light sources.

For this reason, we have systematically investigated soft X-ray spectra from highly charged lanthanide ions in the Large Helical Device (LHD) plasmas. Because LHD is a large-scale facility for MCF research, spectra from high Z elements in a wide range of electron temperature (up to a few keV) can be observed in an optically thin condition. Until now, all lanthanide elements except for La and Pm have already been injected in LHD plasmas [1,2]. It has already been demonstrated that the discrete and quasicontinuum spectral features from lanthanide ions with outermost N shell electrons are observed in high and low temperature conditions, respectively [2]. The discrete spectra originate mainly from ions having 4s or 4p outermost orbitals, while the quasicontinuum spectra are generated from ions having 4d or 4f outermost orbitals.

The spectra have been analyzed by various methods: several different atomic codes and/or comparisons with existing experimental data taken in different light sources. Some of the isolated spectral lines have been newly identified for the first time in LHD. It would be more difficult to construct theoretical models for the quasicontinuum feature so as to reproduce correctly the measured spectra. Nevertheless, comparisons with theoretical calculations of wavelengths and oscillator strengths lead to the assignments of some of the spectral peaks.

References

[1] C. Suzuki et al., Plasma Phys. Control. Fusion **59**, 014009 (2017).
[2] C. Suzuki et al., Atoms **6**, 24 (2018).