§91. Calibration of SX-EUV Diagnostic Instruments Using LHD Plasma as a Standard Radiation Source

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The continuum radiation (bremsstrahlung emission) from high temperature plasma could be used as a standard source for calibration of spectroscopic instruments of soft x-ray and extreme ultraviolet (SX-EUV) radiation.[1, 2] In this work, the diagnostic instrument to be calibrated is a flat-field SX-EUV spectrograph with a varied spacing laminar-type holographic, aberration corrected concave grating, whose wavelength range is 6-40 nm.[2]

Observed spectral intensity, $I_{ob}(\lambda)$ [counts/s/Å], can be written as

$$I_{ob}(\lambda) = \frac{B(\lambda)}{1.60\times 10^{-19}\cdot h\nu}\cdot \Omega \cdot A \cdot C(\lambda)\cdot \eta_{CCD}(\lambda)\cdot \frac{h\nu}{3.65},$$

where B(λ) is the brightness from the plasma in W/cm^2/str/Å, $h\nu$ the photon energy in eV, Ω the solid angle viewed by the plasma at the entrance slit of the spectrograph, A the viewing area at the plasma in cm^2, $C(\lambda)$ the diffraction efficiency of the grating, η_{CCD} the quantum efficiency of CCD detector and 3.65 eV is the required energy to produce one CCD count. The brightness is denoted by using the spectral emissivity, ε(λ), as

$$B(\lambda) = \int \varepsilon(\lambda)\mathrm{d}x,$$

where $\varepsilon(\lambda)$ is the emissivity of the source in W/cm^3/str/Å and the integral is carried out along the line of sight within the plasma. Because the emissivity of bremsstrahlung emission can be predicted precisely when the electron temperature and density are given, one can determine the absolute sensitivity of the spectroscopic diagnostic system.

Recently, Morita et al. have determined the absolute intensity calibration factor of the mentioned SX-EUV spectrograph, observing radial profiles of bremsstrahlung continuum in LHD.[3] The measured calibration factor is shown in Fig. 1. The wavelength dependence of this factor comes from the reciprocal of $C(\lambda)\cdot\eta_{CCD}(\lambda)\cdot h\nu$. Diffraction efficiency of the laminar-type grating has been calculated by using the unified classical theory.[4] The result of calculation is shown in Fig. 2. The reciprocal of the product of grating efficiency and photon energy is shown in Fig. 3, where the plot is normalized by the value at 8 nm.

The wavelength dependence of the measured calibration factor can be explained as a whole by that of the product of the grating efficiency and photon energy as shown in Fig. 3. Detail investigations in quantitative comparison should be carried out talking into account the characteristics of the quantum efficiency of CCD detector.

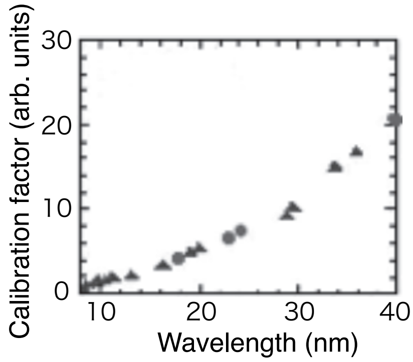

Fig. 1. Absolute intensity calibration factor of the SX-EUV spectrograph system as a function of wavelenghth.

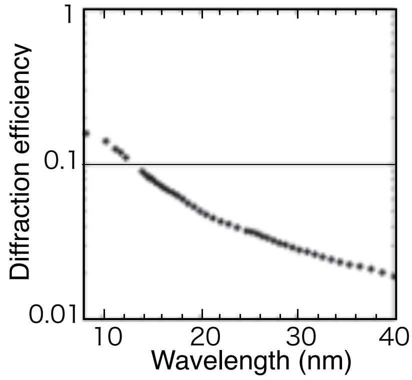

Fig. 2. Calculated diffraction efficiency for the laminar-type grating.

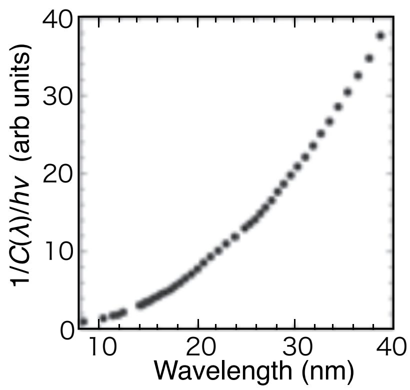

Fig. 3. The wavelength dependence of the reciprocal of $C(\lambda)\cdot h\nu$. Plots are normalized at 8 nm.

1) Feldman, U., et al.: Astron. Astrophys. **441** (2005) 1211.
2) Chowdhuri, M. B., et al.: Rev. Sci. Instrum. **78** (2007) 023501.
3) Dong, C., Morita, S., Goto, M., and Wang, E.: Rev. Sci Instrum. 82 (2011) 113102.
4) Maezawa, H. and Miyauchi, H.: J. Opt. Soc. Am. A **26** (2009) 330.