§15. EUV Wavelength Calibration for SOXMOS Spectrometer

Obara, T., Kato, T., Sato, K.

Recently Xe spectrum from LHD were measured by Soft X-ray spectrometer(SOXMOS)[1]. Coverage of wavelength is from 116(Å) to 164 (Å), and central wavelength is 141.2(Å) in our measurement. In order to identify the measured wavelength of Xe ions, the wavelength calibration was performed.

Firstly, we derived coefficients b and a assuming $\lambda = b + a \times p$ by the least squares method where λ is wavelength and p is pixel number. We used six observed values for wavelengths of FeXXI(128.73 Å), FeXXII(135.774 Å), FeXXII(155.92 Å), FeXXIII(132.8 Å), CVI(134.9 Å), CrXXI(149.87 Å) ions as references. We obtained

$$\lambda(\text{Å}) = 0.0481458p + 118.259 \quad (1)$$

which is shown in Fig.2 as a solid line. The range of wavelength is from 118.308 to 167.682 and the central wavelength is 142.9(Å). This value is different from given the central wavelength(141.2(Å)).

To calibrate wavelength as a function of pixel theoretically, we calculated wavelength by using following two equations.

$$\pm m\lambda = d(\sin\alpha - \sin\beta) \quad (2)$$

where m is the diffraction order, 1,2,3,$\cdots$ and λ is wavelength(Å), d is the distance of the grating and is $10^7/N$ where N is the grating groove density per mm(600g/mm), α is the incidence angle, β is the diffraction angle[2] as shown in Fig.1.

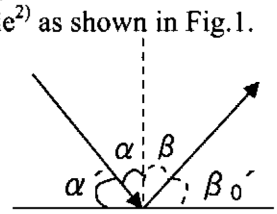

Fig.1 The incidence angle and the diffraction angle

$$k\lambda[\text{Å}] = \frac{10^7}{N}\left\{\cos\alpha' - \cos\left[\beta_0' + \cot^{-1}\times\left(\cot\beta_0' + \frac{Rn}{(p-p_0)M}\right)\right]\right\}$$

(3)

where $k = 1,2,3,\cdots\cdots$. R is the Rowland circle diameter(2m) , n is the number of pixel per unit length (40/mm), p is the pixel number(from 1 to 1024), p_0 is the central pixel(512), M is the fiber-optic taper magnification. We used the value M=2. In eq(2), the angle $\alpha' = \pi/2 - \alpha$ and $\beta' = \pi/2 - \beta$. β_0' is the diffraction angle for the central pixel p_0,

We have calculated the diffraction angle β in the case of both 141.2(Å) and 142.9(Å) by using eq.(2). For the central wavelength λ=141.2Å, β is derived as 82.386° for α=88.5°, and for λ=142.9 Å, β is 82.34°. Then $\beta_0' = 7.164°$ for β=82.386° and β_0'= 7.657° for β is 82.34°.

From eq.(3), for the central wavelength λ =141.2(Å), range of wavelength is from 114.456(Å) to 165.788(Å) when M=2 and R=2.2(m). For the central wavelength λ=142.9(Å), range of wavelength is from 116.007(Å) to 167.629Å when M=2 and R=2.2(m).

We show in Fig.2 the relation between wavelength and pixel calculated by eq.(3). We also plotted the measured wavelengths of six obserbed spectral lines in Fig.2. Comparing calculations by eq.(3) with experimental values, we find that the difference from the observed points becomes smaller towards long wavelength range. Finally we will use the derived relation eq.(1) in our spectral analysis.

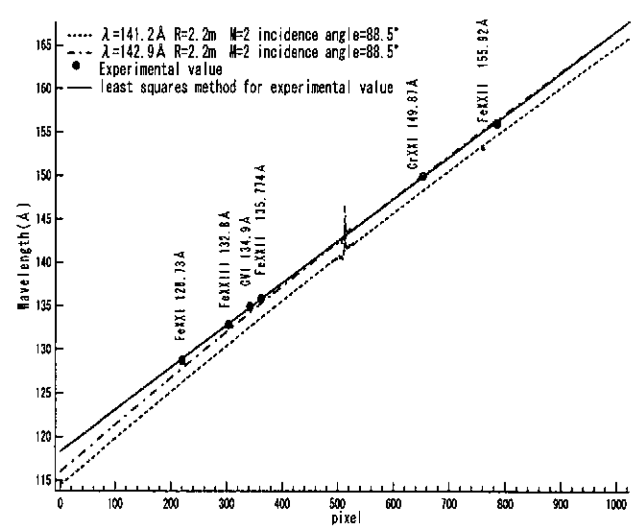

Fig.2 Theoretical wavelength calibration curve are measured wavelength

Reference

1) J.L.Schwob, A.W. Wouters, and S.Suckewer Rev. Sci. Instrum , 58 , 1601(1987)

2) JAMES A. R. SAMSON, Techniques of VACUUM ULTRAVIOLET SPECTROSCOPY, John Wiley & Sons, inc., NEW YORK(1967)