§32. Development of Three Dimensional Electron Temperature Measurements Using Multi-Layer Mirror Based Soft X-Ray Spectrometer

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A 20 channel fully calibrated multilayer mirror (MLM) based soft X-ray spectrometer was installed on CHS for central electron temperature measurement.[1)] Using the high throughput of the MLM and the fast time response of the PIN diodes, it is possible to measure the soft X-ray spectrum with a time resolution of 1ms. The slope of the spectrum gives us the electron temperature.

Analysis of the observed spectrum showed that the experimentally measured soft X-ray intensity was about 50 ~ 1000 times the theoretically calculated spectrum assuming free-free pure hydrogen bremsstrahlung using the temperature and density profiles from the Thomson scattering measurements for a single discharge (Fig.1.). Moreover the spectrum simulated with a software XSPEC [2)] showed that it is heavily contaminated by impurity lines in the energy range of the present measurements (640 eV ~ 1030eV). Figure 2 shows the simulated spectra 1) for a free-free pure hydrogen plasma and 2) the same spectra with contribution from impurities. The simulation was done with the following impurities (C (0.1%), N(0.1%), O(3%), Fe(0.02%), Ni(0.001%)) for a 1 keV plasma. These values are based on a earlier study of the soft X-ray spectrum from CHS plasmas.[3)] Also, the slope of the spectrum in the present range of measurement differs greatly from that of the free-free pure bremsstrahlung spectrum. Evidently, the slope of the observed spectrum wil not represent the electron temperature. It can thus be reasonably concluded that the soft x-ray spectrometer with its present setup cannot be used to measure the electron temperature of the CHS plasmas.

In order to explore the various ways that the soft X-ray spectrometer could be modified for temperature measurements leads to the following possibilities. The simplest is to change the range of measurement to a higher energy range (3 ~ 5keV) where there is little or no impurity radiation from the main impurities that are present in CHS plasmas. In this case, the spectrum is not sharply modified and the slope will represent the actual electron temperature. However, in this case the signal to noise (S/N) ratio may not be enough for a high time resolution for CHS plasmas (electron temperature < 2 keV) as the number of photons will be greatly reduced. This ratio can be increased by using the spectrometer to measure the spectrum of higher temperature plasmas like in LHD. Secondly, as the spectrometer is very compact with a size of about 280mm(w) x 480mm(l) x 95mm(h) (including pin hole, mirror, detectors) it is not difficult to install many systems for a large device. With the use of multi spectrometers viewing the plasma in both the toroidal and poloidal directions it would bepossible to measure the three dimensional electron temperature. These various options are presently under study.

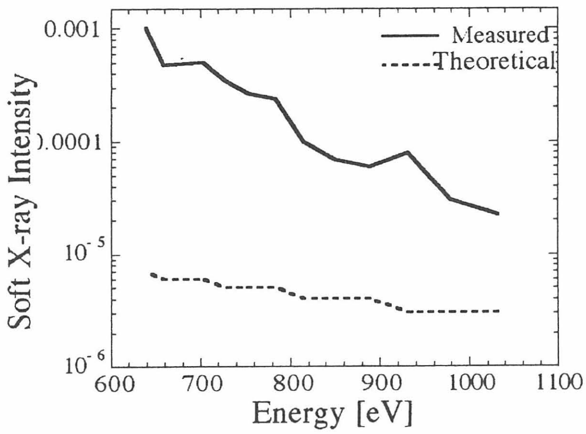

Fig.1. Comparison of the measured and theoretically calculated spectrum using the temperature and density profiles from Thomson scattering measurements.

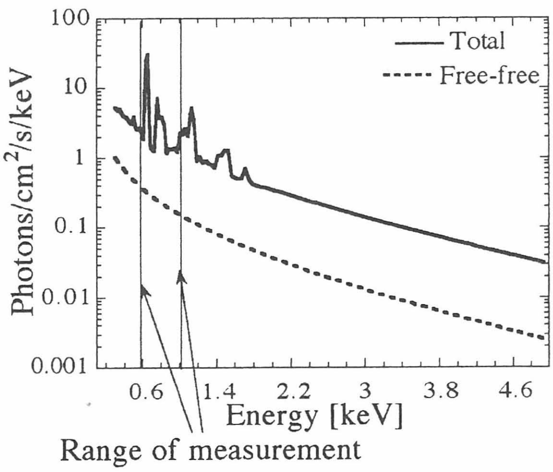

Fig.2. Simulated soft X-ray spectrum for a 1 keV plasma for free-free and total emission.

Reference

1) Ishiyama, E. Master Thesis. Univ. of Tokyo (1996)

2) Raymond, C.J. et al Astrophys. Journal Suppl. Vol. **35**, (1977) 419

3) Masai, K et al, IPP Ann. Rev. (April 1988 - May 1989) 20