§8. VUV Telescope for the 2D Visualization of the Fluctuations

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This fiscal year, we have developed a VUV telescope[1] camera to study the fluctuations. The soft x–ray tangentially viewing camera we used so far had the advantage, that the photons it detects are in the same energy range as those emitted by the plasma. The drawback is, that no lenses are available in this energy range and we have to use a pinhole. Then the time and the space resolution are coupled. To improve the time resolution is then only possible if we increase the diameter of the pinhole and at the same time all sizes of the camera, i.e. also the size of the detector. The size of the detector is, however, limited by their availability; moreover, as the camera becomes larger it needs more space on the experiment.

If we go to longer wavelength, the first optical components we can use are mirrors made of Mo–Be layers, which can reflect photons of 13.5nm. The carbon VI line (13.5 nm) falls into this energy range. The reflectivity of the material is up to 65 % and the mirrors available are close to the theoretical limit. The CVI–line (n=4–2) has been observed by the VUV spectrometer on LHD. Therefore we may expect to observe with the camera patterns in the boundary of fusion devices.

If we want to look further into the plasma, we have to provide for radiation in the energy range in which the camera works. This could be achieved e.g. by doping the neutral beams with carbon and use the charge exchange emission ($H^0+C^{+6} \rightarrow H^{+}+\left(C^{+5}\right)^{*}$). The emission cross section of the CVI is even larger for higher energy transitions [2]. We expect to study the core fluctuations by the impurity radiation when the neutral beam is injected.

Here, VUV telescope system we are developing is briefly described. We took the inverse–Schwarzschild type mirror optical system with a magnification of 1/60. A schematic drawing of the system is shown in Fig.1. Ray–tracing of the sight lines is done with this mirror system(Fig. 2). The incident angle is calculated for the case where it is located at 7m away from the plasma. It is less than 10 degree in this design and satisfies the restrictions posed by the multi-layer mirror system. From the dispersion of the spot, the spatial resolution of the system is estimated. It is as small as $0.05\,\mathrm{mm} \times 60 = 3\,\mathrm{mm}$ in the middle of the viewing field. Thought, in the real experiment, the signal is a line integrated one, up to poloidal mode numbers m = 10 can be resolved in numerical simulations.

The effective brightness of the mirror system is also estimated. It is 10^4 times larger in the telescope system; we can expect a measurement with higher framing rate because we can collect more photons in the VUV telescope. For small-scale fluctuations, comparable to the spot size, the image far from the focal point is blurred by the finite depth of the focus. This is another advantage of the telescope system when we need to measure small–scale fluctuations. Together with good spatial resolution, we can expect to study the turbulence with scale lengths from several cm to several mm using this system.

[1] S. Ohdachi et al., Plasma and Fusion Research in press

[2] R. C. Isler, Plasma Phys. Control. Fusion, **36** 171 (1994)

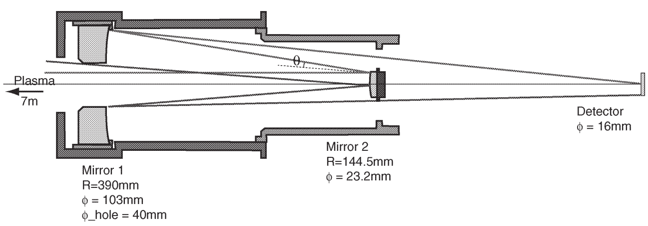

Fig.1: Schematic view of the tangentially viewing camera system.

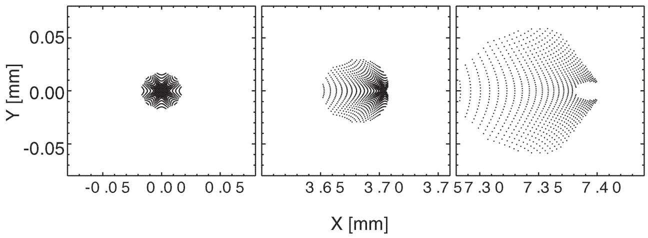

Fig.2: Spot diagram of the mirror system at three positions (center (A), 2cm and 4cm from the center at focal point of the detector) are shown.