§39. Application of the Zeeman Patterns to the Local Plasma Diagnostics in the TRIAM-1M Tokamak (NIFS04KUTR001)

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Standard passive spectroscopy yields only a line-integrated emission along the viewing chord. In order to obtain the local plasma parameters, active methods such as the charge exchange spectroscopy, which makes use of a neutral beam injection, have been applied for highly-charged (usually hydrogenic) ions in core region.

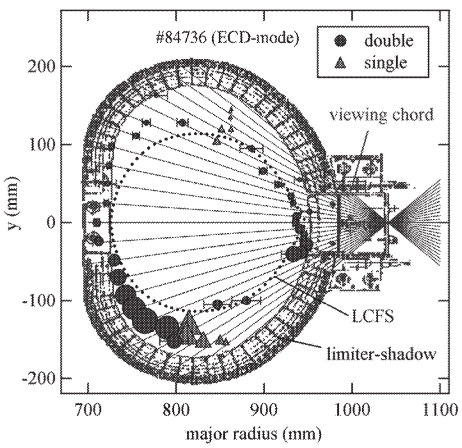
We have been developed a method in which local information can be obtained from the Zeeman patterns even in the device without NBI.1) In principle, this method can be applied both to the core and the boundary region. We have shown that the radial position of emission, temperature and the flow velocity in the position can be determined from the best-fit of the spectral line shape calculated by taking into account the Zeeman profile, the Doppler broadening and the Doppler shift. 2)

The experiments are performed in the TRIAM-1M super-conducting tokamak under the condition of 8.2 GHz lower hybrid current driven discharge. The magnetic field strength of about 7 T at the plasma center is generated using 16 Nb_3Sn super-conducting toroidal field coils. The plasma boundary shape is restricted by three D-shaped poloidal limiters and one vertically movable limiter installed in the upper port of the vacuum vessel. All plasma-facing components are made of molybdenum.

The emission from the plasma is observed using fan-shaped 25 viewing chords in the poloidal section. In front of the object lenses, a linear polarizer is attached with its polarization axis perpendicular to the toroidal field direction for the observation of the σ components. The collected emission is dispersed using a spectrometer (Acton Research AM-510) having a focal length of 1 m and equipped with a 1800 grooves/mm ruled grating. This fiscal year, we replaced the image-intensified CCD (ICCD) detectors 62 μm in the MCP resolution with the electrically cooled back-illuminated CCD (Andor DU440-BU2). The dimension of the CCD chip is 2048 x 512 pixels and each pixel size is 13.5 x 13.5 μm^2. This replacement improved the effective image resolution and lowered the noise to a great extent.

The H_α spectrum consists of seven transitions due to the fine structure splitting. In the external magnetic field, these seven components split into totally eighteen π and thirty σ components. When analyzing the emission from low temperature neutrals, one should estimate the shape of H_α spectrum containing these transitions, because the shape of the spectrum is strongly affected by the fine structure. In the fitting procedure, the thirty σ components are calculated based on the quantum mechanical method. 2) In addition, three temperature components: cold (<1eV), warm (1~10eV), and hot (~100eV) are assumed for the fitting procedure, since hydrogen atoms usually have multi-temperature components originated in the production processes, such as dissociations or charge-exchanges.

Fig.1(a) shows the separated positions of the emission. One can see that the spatial resolution of the measurement is much improved by installing the cooled-CCD detector compared to the former ICCD detector shown in Fig.1(b). Filled circles indicate the separated position of emission along the viewing chords and marker size represents the relative intensity of the cold components. The horizontal bar shown with the marker is the standard deviation of the fitting procedure. Filled triangles denote the positions obtained on the peripheral viewing chords assuming single magnetic field for checking the results. Emissions in the high-field side originate from the region between the vacuum vessel and the D-shaped poloidal limiter surface, namely so-called limiter shadow. The obtained positions of the emission are consistent with the bright positions in the visible image measured with the TV camera installed for the purpose of monitoring the plasma position. 3)



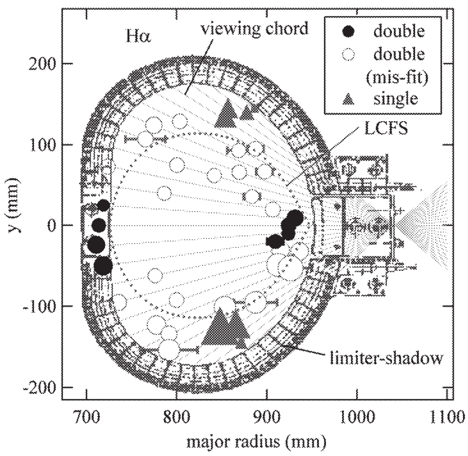


Fig.1: The measured position of Hα emission. (a: upper) The measured position using back-illuminated CCD detector (b : lower) The position measured using ICCD . 2)

Reference

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3) H. Zushi, et al. : Nucl. Fusion **43** (2003) 1600.