§26. Poloidal Polarimetry for ITER

Pavlichenko, R., Kawahata, K.

Control of the current density profile becomes a paramount issue for the modern tokamak experiments. The polarimeter under study is based on the system that was originally proposed for ITER-98, ITER-FEAT designs[1-3]. The modified system featured a fan of chords viewing the plasma through an equatorial port. The updated system will be operating at a wavelength of 48 or 57 μm (instead of originally proposed 118 μm). This allow to increase the maximum number of chords via the equatorial port up to 12, which was limited to 9 (see Fig. 1), viewing the plasma via penetration through the blanket modules. For the best optimization of the plasma coverage up to six chords in vertical direction via an upper plug are proposed. The beams are reflected back along the same path through the plasma by means of 38 mm wide circular shaped retroreflectors indented about 25 cm deep at the bottom of remote handling grips in the blanket modules opposing the ports.
The base issue for the optical system design is the retroreflectors fault tolerance in respect to vignetting. This brings of the optical system starting point to comply the diameter limit of the retroreflectors with the well known formula: D_{min}>2.2d, where d the 1/e width of the laser Gaussian beam intensity distribution. This corresponds to a ~99% transmission (reflection) by (through) the optical system.
The basis of the method is the change of the polarization of electromagnetic wave passing magnetized plasma. The state of polarization can be described by the Stokes vector $s(z)$ [1]. The evolution along the line of sight (z direction) is given by $d\vec{s}(z)/dz = \vec{\Omega}(z)\times\vec{s}(z)$, where $\vec{\Omega}(z)$ is the vector describes the plasma wave interaction.

$$\begin{pmatrix}\Omega_1\\ \Omega_2\\ \Omega_3\end{pmatrix} = \frac{\omega_p^2}{2c\omega}\begin{pmatrix} e^2/m^2\left(B_x^2-B_y^2\right)\\ e^2/m^2\left(2B_xB_y\right)\\ e/m\left(2\omega B_z\right)\end{pmatrix}$$

The calculations of the *rotation angle* (related to the Faraday effect Ω_3) and the *ellipticity* (related to the Cotton–Mouton effect Ω_1,Ω_2) were done for 'thin plasma layer' approximation. The plasma was divided into 1cm slabs. For each layer the transformation matrices were derived. Then obtained matrices were applied these the electric field vector of the beams. Refraction in the plasma due to density gradients was excludes at the present time.
Here we will only present as example the calculations for a fan of beams through the equatorial port and for the flat density profile. The calculated values of the Faraday rotation angle are in the range of ±30° (see Fig. 2) and can be easily measured with high accuracy. Similar conclusions can be made for the upper chord and for the other plasma scenarios.

The data from the horizontal polarimeter fan give a substantial improvement of the *q*-profile determination in the plasma center. Including the chords via the upper port gives a further, but smaller, improvement.

References

1) DeMarco F., Segre S. E. : Plasma Phys. 14 (1972) 245.
2) A. J. H. Donné, A. J. H. et al. : Rev. Sci. Instrum. 70 (1999) 726.
3) A. J. H. Donné, A. J. H. et al. : Rev. Sci. Instrum. 75 (2004) 4694.

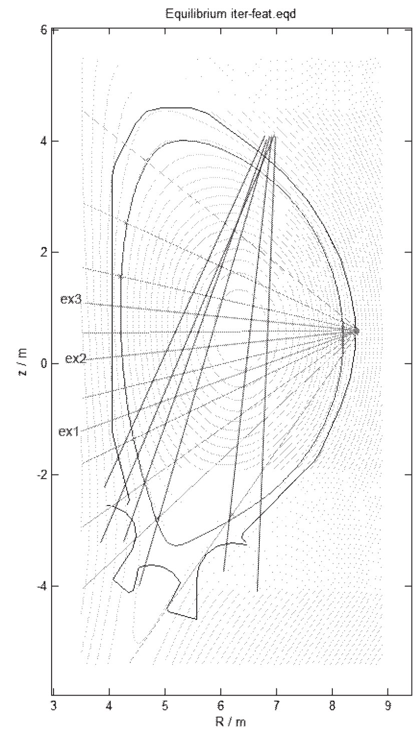

Fig.1. Schematic layout of the polarimeter chords in the poloidal cross-section of ITER; ex1, ex2, ex3 – are three additional chords.

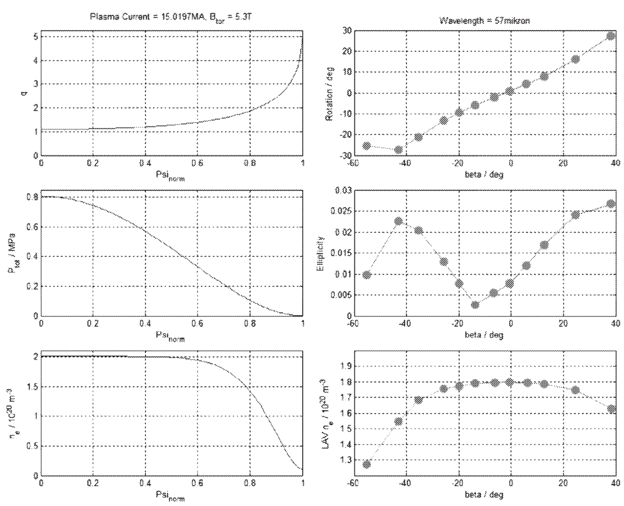

Fig.2. Calculated Faraday rotation angles for a horizontal fan of chords (right top) and the corresponding ellipticity values (right center).