32nd EPS Conference on Plasma Phys. Tarragona, 27 June - 1 July 2005 ECA Vol.**29C**, P-2.088 (2005)

Influence of the stray light upon TJ-II Thomson scattering profiles measured in different magnetic configurations

J. Herranz, I. Pastor, and D. López-Bruna

Laboratorio Nacional de Fusión, CIEMAT, Madrid, Spain

I. Introduction. In Thomson scattering diagnostics, one must have a very intense laser radiation source in order to provide an acceptable signal level. In TJ-II stellarator [1], the input laser beam of the diagnostic [2] passes through vacuum windows at its entrance and exit of the vacuum vessel (Ref. 2, Fig. 1). At these surfaces, scattering of the laser beam occurs and despite all kinds of precautions, like light baffles, viewing dumps, high rejection spectral notch filters or even removing the windows far away from the collection area, the intensity of the stray light can be comparable to plasma scattering signal [3]. Along its trajectory across the vacuum vessel, the intense ruby laser intersects the plasma next to the hard-core surface, where it is not possible to install a proper viewing dump as a black background (see Fig. 1). Moreover, the spectrometer and laser branch are mounted on a 10 m height structure. The C-frame allows a radial movement of the laser chord (Ref. 2, Fig. 1), making it possible for it to

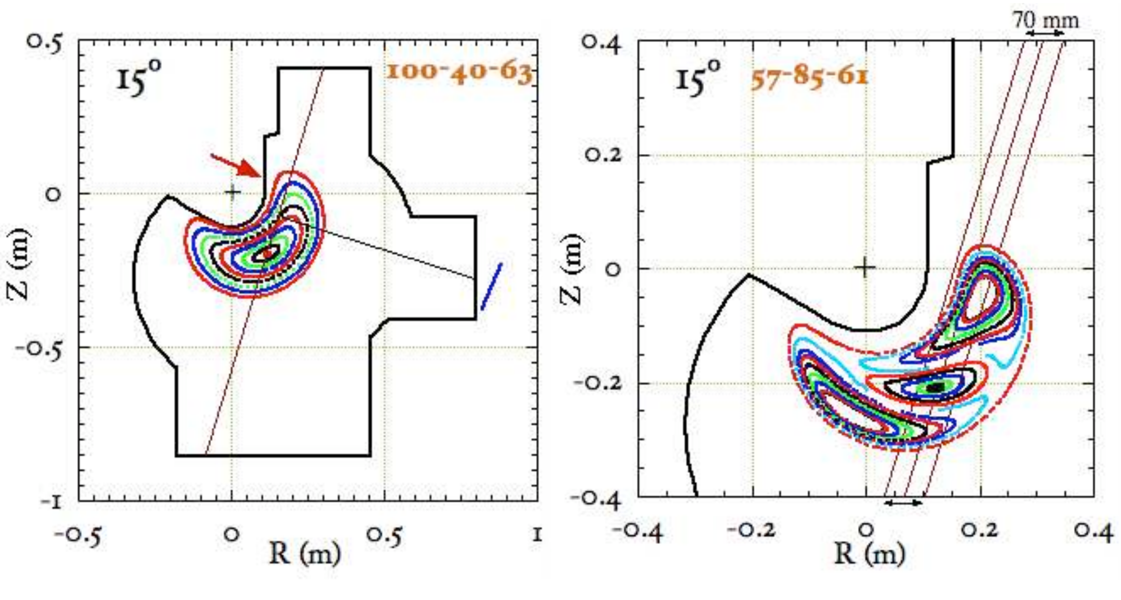

Fig. 1: TJ-II toroidal cross section (15°) showing the vacuum vessel, hard-core area (red arrow), two different magnetic configurations (100-40-60 and 57-85-61), laser path (red), optical axis (black), and notch filter (blue).

pass through the magnetic axis of the different TJ-II magnetic configurations (see Fig. 1). In those magnetic configurations where the magnetic centre is close to the hard core, this shift of the laser path provokes that the laser distance to the vacuum vessel is as short as ~4 cm, reflecting a parasitic intense stray light, which is collected by the viewing triplet and that eventually enters into the spectrometer.

The influence of this particular noise in the recorded electronic distribution function has been analysed. This let us determine and correct the level of distortion introduced in the electron temperature and density profiles measured by the TS system. Different deformations brought on the electronic profiles by this unwanted signal have been evaluated as a function of the varied TJ-II magnetic configurations, or laser path position, that impose constrained conditions of measurements. In certain magnetic configurations and under low plasma density conditions (ne ~0.5×10^{19} m^{-3}) the stray light signal can increase the density values up to 90%, whereas the measured temperatures (Te ~1 keV) might drop ~35% once the stray light has been subtracted.

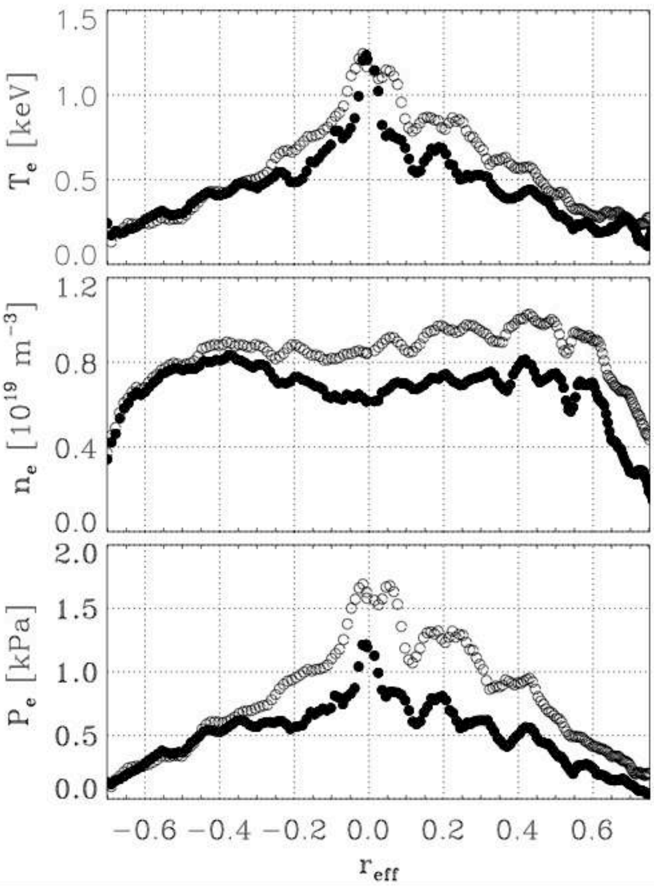

Fig. 2: Impact of the stray light signal on the Thomson profiles. Open circles: profiles with stray light in the spectra. Filled circles: Te, ne y Pe profiles with stray light subtracted in the recorded electronic distribution function.

II. Experiments and analysis. The importance of subtracting the stray light accurately, due to its relative intensity compared to the Thomson scattering signal, is shown in Fig. 2. In the TJ-II Thomson diagnostic operation, the stray light profile is determined triggering the laser in similar plasma operation conditions, but without any plasmas generating Thomson scattering signal. This process is repeated during normal plasma operation to check and record the variations in the stray light profile.

The influence of this noise on the temperature and density profiles has been determined experimentally [*i*] and numerically [*ii*].

[*i*]: Experimentally, subtracting the stray light signal in the recorded spectra and comparing the electronic temperature and density values obtained fitting the electronic distribution function without eliminating this parasitic signal. As shown in Fig. 2, the conclusion follows, from all the profiles and magnetic configurations analysed. The first conclusion is that the stray light impact created around the hard-core area is more significant for positive values of the effective radius. And secondly, the convolution with the Thomson scattering signal can be noticed in spatial positions as far as reff ~ -0.4.

[*ii*]: Numerically, introducing the recorded noise in a range of numerical Thomson spectra with different density (amplitude) and temperature (width) values. Some results of the analysis carried out can be observed in Fig. 3. As expected, the electronic density value increases in all the different levels of Thomson signal considered. Generally, the percentage increase varies from 40 % to 90 % in the lowest density values, i.e. $0.5x10^{19}/m^3$. It seems independent of the temperature value and, it is not negligible in NBI regime ($ne > 2x10^{19}/m^3$). As for the deviations introduced in the temperature values obtained fitting the spectra distorted by this superfluous intense light, they depend on

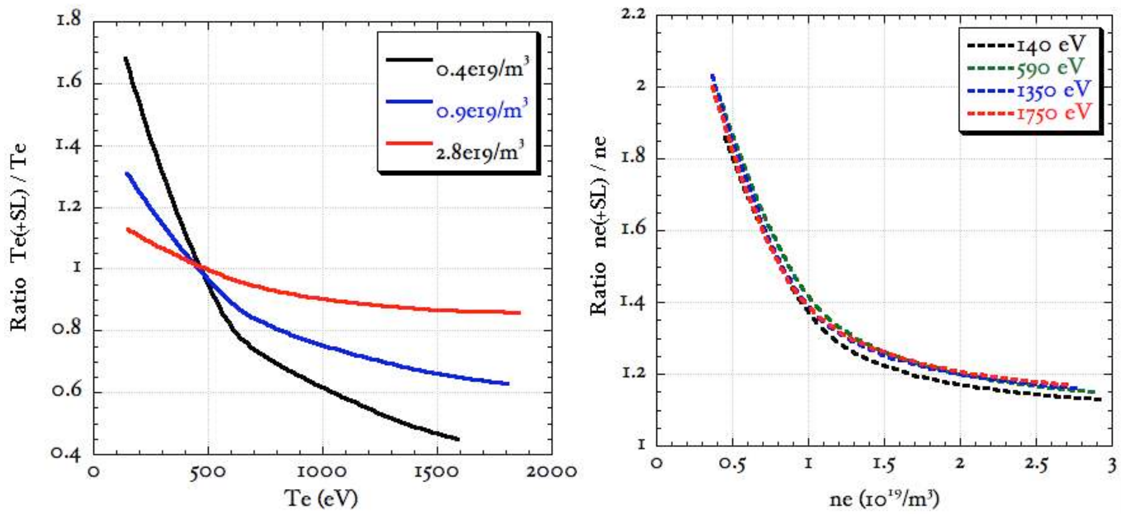

Fig. 3. Ratio between Te and ne obtained fitting spectra with (+SL) and without stray light.

both, density and temperature. In lower density and temperature regimes, ne $\sim 0.4x10^{19}/m^3$ and Te ~200 eV, the shape and intensity of the average noise pattern broaden artificially the spectra (see Fig. 3), while for electronic temperatures higher than 500 eV the spectra become narrower: the lower the density the bigger the distortion introduced in the recorded electronic distribution function.

III. Discussion. The stray light profiles analysed do not point out a clear relationship between, on one hand, the stray light intensity or particular pattern, and on the other hand, the heating system used (ECH, NBI) via mechanical stress brought on the laser entrance and exit tubes. Nor is there an unmistakable correlation with the C-frame position, as one could have expected. This is because the correct alignment of the laser path is fairly reproducible and has a stronger influence on the stray light than the mere nearness to the hard-core surface (see Fig. 1).

The best solution found for the specific geometry of TJ-II, where the plasma device is physically so restrictive, is to install a new notch filter with much better performance like higher rejection of the stray light wavelength, 694.3 nm. The new filter, manufactured by Tydex (Russia) is expected to decimate the stray light in the spectrometer virtually to zero. Around angles of incidence where the parasitic light is

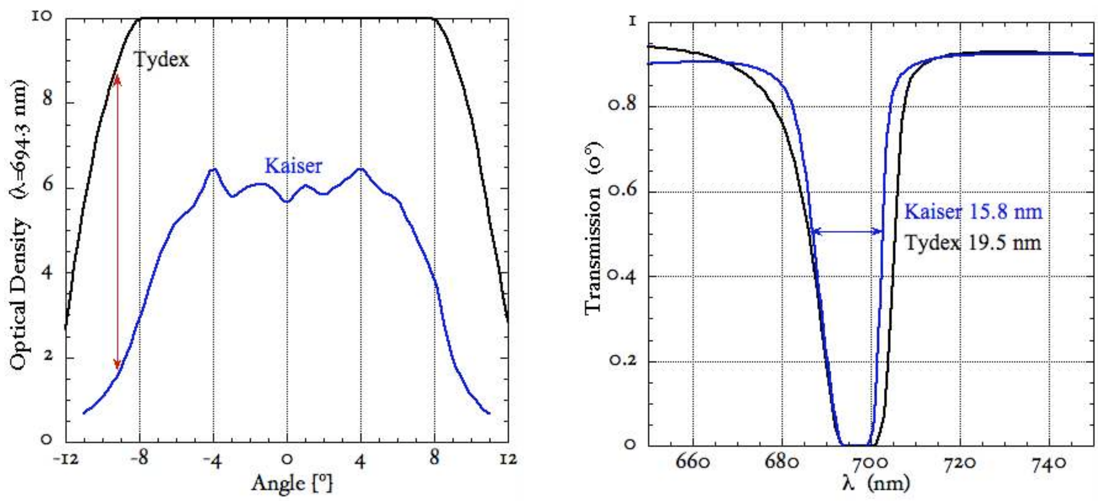

Fig. 4 (a): Optical density of both rejection filters. (b): Normalised transmission for an angle of incidence of 0º. The bandwidths suppressed are similar.

stronger, from 7 to 10 degrees, the measured optical density is seven orders of magnitude higher than the older one (Kaiser) installed in the diagnostic (see Fig. 4a). The dynamic range of the spectrophotometer (CARY 5E) used to characterise both filters, 10^{10}, also suggests a most favourable optical density from -8 to 8 degrees compared to the previous one.

[1] C. Alejaldre, *et al.*, *Plasma Phys. Control. Fusion* **41**, (1999) A539.
C. Alejaldre, *et al.*, *Nucl. Fusion* **41**, No. 10 (2001) 1449.
[2] J. Herranz, F. Castejón, I. Pastor y K.J. McCarthy, *Fusion Eng. Des.* **65**, 4 (2003) 525-536.
[3] J. Sheffield, *Plasma Scattering of Electromagnetic Radiation*, Academic Press.