Two-dimensional n_e and T_e measurements of the edge plasma turbulence in TJ-II

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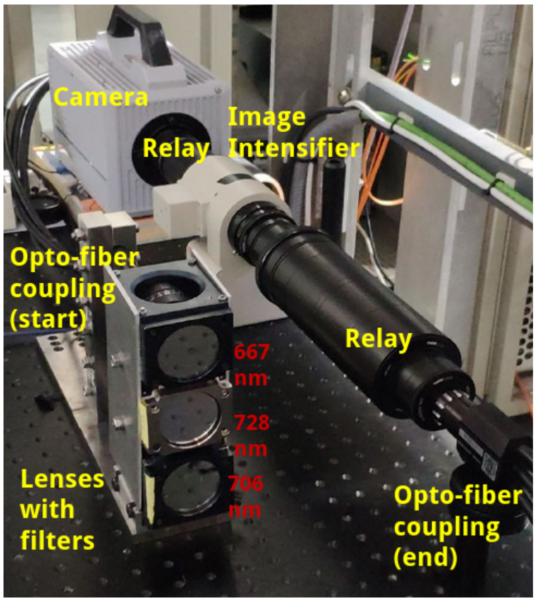
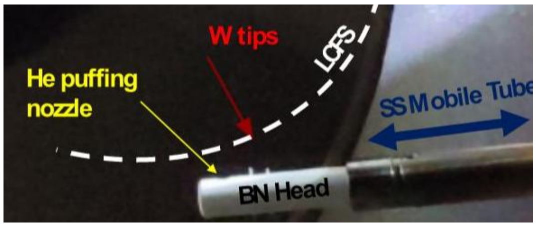
Introduction

The edge and SOL regions of fusion plasmas set the boundary condition for the core and, thus, determine the confinement. Recent advancements in simulations and limited experimental evidence seem to indicate not only complex spatio-temporal behaviour of fluctuations in theses regions, but, more importantly, the crucial role of their interaction (citations). This makes simultaneous experimental measurements of these turbulent fields very relevant. This contribution describes the most recent implementation of Spectrally resolved Gas Puff Imaging diagnostic installed in TJ-II heliac and presents first results of the measurement of n_e and T_e fluctuations in the edge plasma region.



(a) *Optical system of SGPI*



(b) *Movable puffing injector assembly*

Figure 1: Optical and puffing systems

Spectrally resolved Gas Puff Imaging

Common applications of the GPI technique that utilize a single spectrally filtered (bandpass) image are only able to recover an approximation of one 2-D field (e.g., the electron density). This does not allow studying the variation in neutral population or temperature, nor their interplay. In spectroscopic measurements this is usually addressed by application of line ratio techniques - the use of an additional measurement allows to further constrain the system. For example, using ratios of intensities measured at different wavelengths makes it possible cancel out the influence of the neutral population. Taking this method even further, 3 wavelengths allow the simultaneous determination of n_e, T_e. Moreover, potentially, n_n can be derived from the intensity and obtained plasma parameters.

The interpretation of the obtained line ratios is based on the so called collisional-radiative model (CRM) that estimates light emission spectra as a function of plasma electron temperature and density. The CRM therefore serves to map the line intensity ratios to plasma parameters and vice-versa. This method in fusion is usually referred to as the He-I line ratio technique [3].

The Spectrally resolved GPI (SGPI) presented here [1, 2] system uses the He-I line ratio technique applied to three spectrally filtered images of the same plasma region in combination with an intensified fast camera allowing for simultaneous continuous determination of the electron density, n_e, and temperature, T_e, with an exposure time as low as τ_{exp} 5μs.

Experimental set-up

SGPI consists of an optical and a puffing system: The optical system (Fig. 1a) collects light with three 50 mm lenses fitted with interference filters (667.8 nm, 706.5 nm and 728.2 nm, FWHM = 1 nm) stacked one on top of another. Three separate images are combined into a single image by the means of a triple opto-fiber bundle. This combined image is projected onto a 2-stage (GEN-II + GEN-I) image intensifier through a relay lens and after amplification the image is recorded by a fast camera. The puffing system is comprised of a retractable stainless steel tube with a Boron-Nitride injector head fitted additionally with tungsten pins (to aid spatial referencing), as shown in Fig.1b. The injection location of Helium was carefully chosen to minimise the angle α between the direction of the magnetic field and the line of sight (LoS) within injection volume (Fig. 2a). The purpose of this is to maximize spatial resolution: as the filamentary turbulent structures are extended mainly along the field lines, it is desirable to obtain a view tangential to the field lines - which in turn minimizes the uncertainty associated with integration along the LoS. The spatial resolution corresponding to a given LoS is then only limited, in

(a) *Angle α (colour coded) calculated in vicinity of chosen injection point with vacuum vessel of TJ-II*

(b) *Estimation of maximal potential spatial resolution from angle α, including difference in viewing angles of lenses*

Figure 2: Puffing system design