Scrape-off-layer blob measurements using Hydrogen Beam Emission Spectroscopy on KSTAR

M. Lampert¹, Ö. Asztalos², G. I. Pokol², Y. U. Nam³ and S. Zoletnik¹

¹MTA Wigner RCP, Hungary, Budapest
²BME NTI, Hungary, Budapest
³NFRI, South-Korea, Daejeon

Corresponding author: Name: Mate Lampert  Email: lampert.mate@wigner.mta.hu

In magnetically confined toroidal plasma devices cross-field transport plays a key role in confinement and also effects the plasma – wall interaction. Scrape-off-layer (SOL) B┴ transport is dominated by filamentary structures called blobs [1] which carry a significant amount of energy and particles towards the wall due to their radial motion. Although the process of blob generation is qualitatively understood, open questions exist on their movement, their lifetime and the resulting wall load in ITER. Due to this need, SOL physics is studied extensively with all types of diagnostics on different tokamaks and with simulations, as well [1]. Most of the diagnostic results are obtained using probes which provide a few-point measurement or 1D arrays in some cases. Another excellent diagnostic is Gas Puff Imaging which provides a 2D picture of blobs but has some limitation to measure inside the separatrix. In this paper we are going to show that Hydrogen Beam Emission Spectroscopy (H-BES) is a capable tool for studying 2D SOL transport dynamics. First results of the blob dynamics investigation on KSTAR (Korean Superconducting Tokamak Advanced Research) will be presented as an example. KSTAR has a 2D BES 4x16 point observation system with 1 cm spatial resolution which can be freely moved to any location and direction in the whole radial range from the SOL to the core plasma [2].

H-BES measures the Hydrogen Balmer-alpha light emission by a heating or diagnostic Hydrogen (Deuterium) neutral beam resulting from plasma interaction. The measured signal is proportional to the product of plasma electron density and beam density. In the SOL beam attenuation is still low, therefore the BES light is related to electron density variations. With a proper observation geometry, a 2D picture can be obtained of electron density evolution from the SOL to the edge plasma. However, due to the finite life-time of the excitation states during the plasma – beam interaction, and some optical and geometrical smearing the fluctuation response is not local. The excited particles are emitting light as long as the excitation state exists, which can last as long as 10ns. This effect can introduce 40mm of spatial smearing in low density plasmas. Since the electron density is relatively low in the SOL, the spatial smearing becomes significant there. Hence, careful analysis is needed to study the local effects in the SOL with the use of BES.

After solving problems related to beam current modulation and background light we developed a method to eliminate the effects of spatial smearing. First we calculated the density – light fluctuation transfer function for a given plasma regime. This was done with the help of the RENATE beam emission spectroscopy simulation toolkit [3]. The transfer function is then inverted to get the local electron density, which is calculated with a method similar to the one described in [4]. We used this method to study the 2D blob dynamics on the KSTAR tokamak. After deconvolution of the spatial smearing, we found traces of individual blob-like phenomena with the use of conditional averaging. The analysis of skewness and kurtosis of the signal also supported the presence of blobs in the SOL. These results confirm, that Hydrogen Beam Emission Spectroscopy is a capable diagnostic to investigate SOL transport.