Edge density profile and turbulence measurements with an alkali beam diagnostic on Wendelstein 7-X

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The Alkali Beam Emission Spectroscopy (A-BES) system is a recently installed diagnostic instrument at the Wendelstein 7-X stellarator. In comparison to the conventional Lithium-based BES (Li-BES) systems, the shorter lifetime of the relevant excited state of the Na atoms facilitates a more localized analysis of the density profiles. This is a major advantage for the analysis of transport processes at the plasma edge, especially at the steep gradients expected at the banana-shaped cross section of the W7-X plasma.

The diagnostic consists of a 60 keV Sodium atomic beam injector [1] which can provide about 1 mA ion equivalent neutral current in a ~ 2 cm FWHM beam. The beam emission is observed from the poloidal direction with a high-etendue 40 channel optical system, where each channel collects light from a 4×0.5 cm (toroidal $\times$ radial) area of the beam. The light is detected by an Avalanche Photodiode (APD) system with 2 MHz sampling rate. Despite the 500 kHz analogue bandwidth the system has a peak signal-to-noise ratio up to 50, enabling the study of fast transients and turbulence. In addition to the CII background radiation, a considerable amount of light is also generated by Sodium gas originating from the beam neutraliser. The latter has a significant contribution to the detected light profiles inside the SOL. Resolving this necessitates the implementation of high-frequency modulation (chopping) of the atomic beam.

A-BES has been operational since December, 2017. The experimental data have been utilized for the reconstruction of electron density profiles near the LCFS of the plasma. The results imply A-BES to be robust, even at a time resolution of a few 10μs. The detected light profiles show evidence for turbulent transport at the location of the beam. Notably, there is also a clear indication of the presence of a magnetic island, according to expectations. The results have been compared with the available experimental data of various plasma diagnostic tools.

References

[1] Anda, G., Dunai, D., Lampert, M., Krizsanóczi, T., et al., *Review of Scientific Instruments*, **89**(1), 013503 (2018).