46th PLASMA PHYSICS Conference EPS 2019 Milan, Italy

Polychromator system for helium line ratio spectroscopy at ASDEX Upgrade

Line ratio spectroscopy on thermal helium provides the electron temperature and density with a high spatiotemporal resolution at the plasma edge region of the ASDEX Upgrade tokamak. For this purpose, the intensity of four different helium lines is measured simultaneously with the illustrated polychromator system and compared to a collisional radiative model.

Physical background In magnetic confinement fusion, a high temperature plasma is confined by a toroidally closed magnetic field in tokamaks or stellarators. In these devices, the plasma column outside the last closed magnetic flux surface features a rapid decay. This region of open field lines is called scrape-off layer. The plasma properites at the plasma edge influence the overall plasma confinement as well as the plasma wall interaction.
With the goal of gaining a better understanding of steady-state as well as fast transport processes *[1]*, a thermal helium beam is used as plasma edge diagnostic for the ASDEX Upgrade tokamak *[2]*. This diagnostic provides simultaneous measurements of electron density n_e and electron temperature T_e with high spatiotemporal resolution of 3 mm and 900 kHz.

Diagnostic description For thermal helium beam emission line ratio spectroscopy, neutral helium is locally injected into the plasma by an in-vessel piezo electric valve. Measured line ratios from He I lines can be used together with a collisional radiative model to reconstruct the underlying electron temperature and density.
The light emitted by the helium beam is collected with an optical head in the torus and transferred by 50 m long optical fibers to the polychromator system (fig. 1). It uses a telecentric lens (fig. 1, right) to focus the light of the single fibers to four 32-channel linear photomultiplier tube arrays. Each one is dedicated to measure the intensity of one of the 587, 667, 706 and 728 nm helium lines. To achieve the maximum transmission efficiency of the optical system, three dichroic mirrors (fig. 1, center) are used to separate four wavelength bands, covering one of the addressed He I lines, respectively. Small band interference filters with a full width at half maximum of 1.7 nm are placed directly in front of the sensitive areas of the photomultipliers to select the specific helium line.

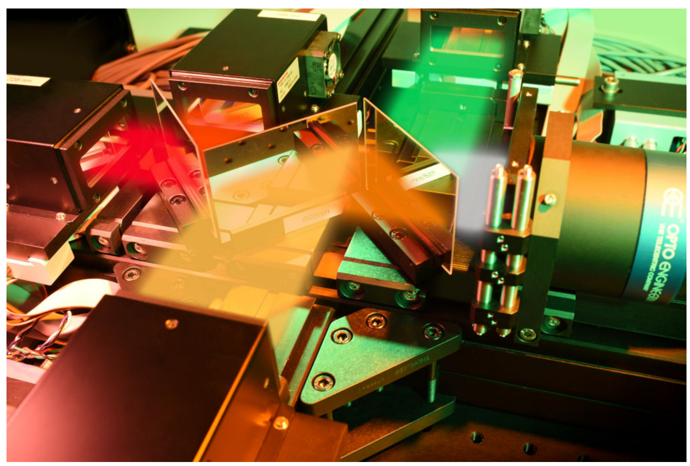

Figure 1: Polychromator system for helium line ration spectroscopy at ASDEX Upgrade. The functionality of the dichroic mirrors is illustrated in an artistic manner. They split the light into different components for a simultaneous intensity measurement of four selected helium lines.

Thus the polychromator system allows the simultaneous measurement of four helium lines at 32 optical channels, which correspond to different spatial positions in the plasma. The achieved high light throughput allows a measurement frequency of 900 kHz, making the diagnostic suitable for plasma turbulence studies.

REFERENCES

[1] M. Griener, et al. *„Investigation of intermittent and continuous transport in the scrape-off layer of ASDEX Upgrade"*, O2.105, EPS 2019
[2] M. Griener, et al., *„Helium line ratio spectroscopy for high spatiotemporal resolution plasma edge profile measurements at ASDEX Upgrade (invited)"*, Rev. Sci. Instrum. **89**, 10D102 (2018).

AUTHORS & CONTACT INFORMATION

Dr. Michael Griener
Max Planck Institute for Plasma Physics, Boltzmannstr. 2, 85748 Garching, Germany
michael.griener@ipp.mpg.de