Performance of the Imaging Motional Stark Effect diagnostic at ASDEX Upgrade

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Motional Stark Effect (MSE) diagnostics provide important information on the safety factor in magnetically confined fusion plasmas. The method utilizes the polarisation of Stark-split D-alpha light emitted by injected neutral particles. In a traditional MSE system, the light, after being led through a set of two photo-elastic modulators that modulate its intensity in time, is collected via optical components defining individual lines of sight. Imaging MSE systems (IMSE), on the other hand, guide the light through a series of birefringent plates, combined with a linear polariser, before focusing it onto a camera without reducing the spatial resolution or coverage. This leads to a spatial modulation that takes the form of an interference pattern in the image, containing both spatial and polarisation information in each frame. While conventional MSE systems filter out the π- or σ-lines of the Stark spectrum, the IMSE approach utilizes all the lines, increasing the signal to noise ratio and eliminating the need for narrow-band filters. Furthermore, IMSE is not disturbed by polarized, broadband background light and provides a 2D image of the polarisation angle, significantly increasing the quality of the equilibrium reconstruction compared to 1D MSE systems.

The ASDEX Upgrade IMSE diagnostic has a wide field of view, extending from the outer separatrix across the magnetic axis. The optics are designed for low Faraday rotation, which is monitored, together with possible drifts, using in-vessel light sources with known polarisation. In the 2016 campaign a prototype “back-end”, which is the set of lenses and crystals creating the interference pattern, was mounted to the new in-vessel system. It was possible to resolve polarization changes of 0.1° with a time resolution of 5.6 ms, enabling the study of current redistribution during sawteeth. This prototype back-end was replaced by a fully optimized system at the start of the 2017 campaign. The new design features larger birefringent plates yielding a larger étendue, higher stability and improved calibration possibilities. The signal to noise level was significantly increased by the upgrade.

The details of the new IMSE back-end will be presented, together with a comparison with the conventional MSE system and the benefit of the IMSE data for the reconstruction of magnetic equilibria. Furthermore, a calibration method using specially designed forward and reversed magnetic field discharges will be described, as well as results from discharges with modified q-profiles.