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ANALYSIS OF THE IMPLEMENTATION FEASIBILITY FOR MSE-LS DIAGNOSTICS ON T-15MD TOKAMAK *)

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The work is aimed at modeling the spectra of the Balmer series emission lines of fast hydrogen atoms injected into the plasma of the T-15MD tokamak. The analysis of the calculated spectra enables evaluating the feasibility of implementing active spectroscopic diagnostics based on the Motional Stark Effect (MSE). This diagnostic allows the reconstruction of the magnetic field, plasma current, and safety factor profiles [1].

The spectra were modeled with ray-tracing methods using the Cherab code [2]. The following emission models were considered: MSE and charge-exchange spectra for the Hα line for diagnostic and heating beams, passive emission spectra of the Hα line including Doppler and Stark broadening effects and Zeeman splitting, and bremsstrahlung continuum. Synthetic data were generated using the results of core plasma modeling with the ASTRA code [3] and edge plasma modeling with the SOLPS 4.3 code [4] for a scenario with 14 MW of additional heating, a central electron temperature of 4.3 keV, a density of 6×10^{19} m^{-3}, and a magnetic field of 2 T on the magnetic axis. Models of the diagnostic beam created by the DINA-KI60 injector and heating beams of 60 keV and 2 MW power were also considered. The beams composition, their divergence, and radial density distribution were accounted for. Light reflections from the plasma facing elements of the tokamak chamber and its first wall, as well as the shapes of lines of sight formed using a lens doublet with focal lengths of 200 mm and diameters of 75 mm.

The intensities obtained for different lines of sight were converted to detector signals, accounting for the spectrometer’s instrumental function. The overall transmission of the light collection system was set to be 7%, and the quantum efficiency of the detector was taken as 90%.

The calculation results indicated that the MSE-LS method is more suitable for the T-15MD compared to the polarization-based MSE, due to the relatively small splitting of the MSE-spectra. At the optimal cross-section for observing the diagnostic beam, the MSE spectrum splitting is sufficient for identifying the wavelengths of the π- and σ-component peaks. The spatial resolution in this case is 3 to 6 cm at a scale of 1:13 to 1:16. The blue shift of the MSE spectrum prevents overlap with bright impurity lines, emission from heating beams, and the plasma's passive Hα line.

The best cross-section for observing the heating beam is the one adjacent to the left of the injection. This cross-section provides high spatial resolution (2 to 4 cm) and a smaller scale of 1:8 to 1:11. However, the MSE spectrum splitting is quite small, complicating signal processing and plasma parameter determination, and significantly limiting the diagnostic's operational range.

References

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