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Intensity refractometry: choosing optimal diagnostic parameters and understanding distortion in experimental data

Wednesday 15 May 2024 09:00 (30 minutes)

Intensity refractometry is a recently developed technique for plasma density measurements in laboratory plasmas with large density gradient, such as in tokamaks or stellarators. It relies on measuring the change of both phase and amplitude of a microwave beam with the O-mode polarization passing through the plasma. The direction of the microwave beam propagation is perpendicular to the density gradient and perpendicular to the magnetic field. This ensures that different density profiles cause a large variation of the beam refraction. A broad phase-power parameter space is mapped to the density values. Dedicated numerical analysis based on 3D full-wave modelling allows interpreting the measured data [M.Usoltceva et al, Rev. Sci. Instrum. 93 (2022) 013502].

An optimization routine has been developed, which allows choosing optimal parameters of an intensity refractometer (including the number of the receivers) for a certain plasma device and for a target range of plasma density. This work has deepened the understanding of the influence of a density distribution on values measured by intensity refractometry and allowed improving the existing algorithm of density reconstruction. For any diagnostic, which relies on forward modelling for data interpretation, an optimization of the model selection approach is crucial. The developed routine is applied to optimize the configuration of Microwave Intensity refractometer in the Limiter Shadow (MILS), installed in ASDEX Upgrade, planned to have three receivers.

Experimental factors can influence the accuracy of measurements of the intensity refractometry and, therefore, the accuracy of density reconstruction. We have shown that the signal distortion is low enough to allow density reconstruction with accuracy better or comparable to other density diagnostics [M.Usoltseva et al, Fus. Eng. Des. 192 (2023) 113783]. This study has been expanded with a more detailed analysis of the experimental conditions and of ways to reduce errors.

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