Collective Thomson Scattering on Wendelstein 7-X

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Wendelstein 7-X (W7-X), the World's first so-called "optimized" stellarator, came into operation in 2016. The experiment is set out to show that the optimization has led to a fusion device with a confinement at least as good as in its competitor the tokamak. Plasma diagnostics play a crucial role in this endeavor. Here we present the work on the theory of an important diagnostic, collective Thomson scattering (CTS), which has been successfully brought into operation in the last experimental campaign [1]. CTS is a powerful microwave diagnostic, capable of measuring a number of plasma parameters such as: ion temperature, plasma composition, drift velocities, and fast ion population. The scattering is collective when the wavelength of the incident radiation os comparable to the Debye length. The incident radiation interacts with the fluctuations in the plasma and gives rise to a scattered wave which is picked up by a heterodyne receiver. What is finally obtained is a spectrum typically centered at the frequency of the incident wave. Spectra have been obtained from which the temperature is inferred by the use of a purpose-built forward model (eCTS) [2] and a Bayesian framework (Minerva) [3] which enables the inference of the parameter values from the data [4]. The forward model is further developed to enable the measurement of the radial electric field. We present the novel developments of the theory which were necessary in order to accommodate the inference of this parameter from the measured spectra. The theory is extended to non-axisymmetric plasmas and the results of a feasibility study of radial electric field measurements by CTS are presented.

References

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