complex diagnostics of electron velocity distribution with thomson scattering and electron cyclotron emission in tokamak-reactors

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An increase of plasma auxiliary heating and neutron fluxes in the next, after ITER, generation of tokamak-reactors (DEMO) requires a more compact, and in some aspects more detailed, plasma diagnostics [1]. A new algorithm is suggested for diagnostics of electron velocity distribution function (VDF) under condition of the expected substantial deviation from equilibrium (Maxwellian) distribution in the frame of the general model of Thomson scattering in DEMO [2]. This is based on a complex diagnostics of electron VDF using Thomson scattering and electron cyclotron (EC) emission.

In the suggested algorithm the experimental Thomson scattering spectrum (multi-channel-spectrum measurement in a certain point) is fitted with theoretical spectrum. Mathematical optimization is used for solving an inverse problem of reconstruction of electron VDF with allowance for all the errors.

In the low-energy range the electron VDF is assumed to be Maxwellian with the temperature as a free parameter. In the moderate-energy range, which boundary should also be determined, the electron VDF is assumed to be close enough to equilibrium one. Here VDF is assumed to be an anisotropic Maxwellian with free effective temperature Te(θ) as a function of pitch angle. This choice is based on the numerical modeling results for the VDF in the case of EC heating and EC current drive (see, e.g., TCV tokamak experiment interpretation [3], using the CQL3D code [4], which has shown the possibility of evaluating the deviation of the VDF from a Maxwellian using the Thomson scattering diagnostics).

In the residual range – at high-energies where the most significant deviations from equilibrium are expected, and besides the Thomson scattering diagnostics becomes not so reliable as in the lower energy range -- the optimization should treat an arbitrary VDF in parallel and perpendicular (relative to magnetic field) components of velocity, and the formulation of the overall inverse problem includes the interpretation of experimental data for high-number harmonics of the EC radiation.

References

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