FORMATION OF SUPERTHERMAL ELECTRONS UNDER CONDITIONS OF ECRH AND ECCD IN ITER-LIKE TOKAMAK

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Fokker-Planck modeling of the electron velocity distribution for ECRH and ECCD showed the possibility of appreciable deviation from a Maxwellian for high enough intensity of the injected waves [1]. For hot ($\langle T_e \rangle > 10$ keV) plasmas in a strong toroidal magnetic field ($B > 5$ T), the superthermal electrons may influence the transport of electron cyclotron radiation (ECR) in the entire spectrum, not only at the low harmonic numbers of the fundamental frequency, which are directly involved in the ECRH and/or ECCD. These effects change the profile of the net ECR power loss, $P_{EC}(r)$ [2].

Here we evaluate the formation of ECCD/ECRH-produced superthermal electrons with the help of Fokker-Planck modeling of the electron distribution function (EDF) in parallel and perpendicular velocities on a given set of magnetic surfaces, via successive use of the numerical codes TORBEAM [3] and RELAX [4]. These data for the EDF are used in [5] for further evaluation, using the numerical code CYNEQ, of the impact of superthermal electrons on the transport of plasma's ECR and on the profile of $P_{EC}(r)$ for ITER-like conditions.

Our calculations are carried out for an ITER-like configuration, including the profiles of electron temperature and density, which are close to the ITER reference scenario 2 ($T_e(0) \sim 25$ keV), for various parameters of the EC wave beam (geometry, beam width, beam focusing etc.), allowing also for the presence of a toroidal electric field. The main results of calculations are as follows.

1. The EC absorbed power density may attain ~10 MW/m^3, for 20 MW total absorbed power and wave beam focusing in the plasma core.

2. For perpendicular launch (ECRH only), the deviation of the EDF from the Maxwellian is stronger for the thermal part ($E_{kin} < T_e$), with the effective temperature $T_{ef}(E_{kin})$ (defined as the exponential slope of the EDF with respect to energy for a given electron kinetic energy E_{kin}) exceeding T_e by 10-20%.

3. For oblique launch (ECCD/ECRH), with an injection angle $\beta \sim 20°$, T_{ef}/T_e is about twice smaller, but in a substantially broader energy range, up to $E_{kin}/m_ec^2 \sim 0.5$, producing thus a strong enough fraction of superthermal electrons. Also, formation of a plateau on the EDF at higher energies is found ($E_{kin}/m_ec^2 \sim 1$, $T_{ef}/T_e \sim 2$-5) for both launch geometries.

References

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