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The Low Threshold Parametric Decay Instabilities Leading to Anomalous Absorption at ECRH in Toroidal Devices

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In the paper the universal scenarios of the low-threshold parametric decay instabilities (PDIs), explaining the anomalous phenomena being already observed [1,2] and potentially important for the energy budget in the future ECRH experiments, are treated.

We investigate the scenario of a low-threshold absorptive PDI [3] based on the parametric excitation of the electron Bernstein wave 3D trapped in the drift wave eddies, filaments or blobs possessing density maximum and aligned with the magnetic field. The nonlinear excitation of this wave and the heavily damped low frequency oscillations manifests itself as the low-threshold absolute PDI resulting in anomalous absorption of the part of the microwave power by ions and electrons. In particular, this instability can be responsible for fast ion production often observed in 2nd harmonic ECRH experiments in toroidal plasmas [1]. We consider the anomalous backscattering reported in [2] as a secondary nonlinear process, which accompanies a primary low-threshold PDI [4]. The effect of the parametric decay of the 2nd harmonic extraordinary (X)-mode wave into two short wave-length upper hybrid (UH) plasmons, propagating in opposite directions, is considered. The radial localization of both the UH plasmons can be achieved in a vicinity of the density profile local maximum corresponding to either the discharge axis for the peaked profile, or the O-point of the magnetic island, or the presence of a blob. On the other hand, when the UH plasmons propagate oppositely and the pump microwave beam has the finite size, the absolute two - plasmon PDI of the X wave is possible, the power threshold of which, being derived explicitly, is two orders of magnitude smaller than the one derived in the case of a monotonous density profile.

The estimations of the threshold for the ordinary wave parametric decay into the 2D trapped UH plasmon and an ion Bernstein wave for the projected ITER conditions are presented as well.

[1] D. Rapisarda et al., Plasma Phys. Control. Fusion 49, 309 (2007).

[2] S.K. Nielsen et al., Plasma Phys. Control. Fusion 55, 115003 (2013).

[3] E.Gusakov, A.Popov, A. Saveliev, Plasma Phys. Control. Fusion 56, 015010 (2014).

[4] E. Gusakov, A. Popov, EPJ Web of Conferences 32, 01007 (2012).

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