Anomalous absorption in ECRH experiments due to parametric excitation of localized UH waves

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Electron cyclotron resonance heating (ECRH) is widely used in toroidal plasmas and is considered for application in ITER for heating and neoclassical tearing mode control. In contradiction to the theory predictions [1] during the last decade many experiments have demonstrated excitation of the anomalous phenomena at the ECRH. The clearest evidence of the nonlinear effects was obtained at TEXTOR [2] where the strong backscattering signals down–shifted in frequency and amplitude modulated by the magnetic island were observed. A demonstration of the anomalous ion heating during the ECRH pulse was obtained at TCV [3].

In the present paper we develop further the theoretical model [4] taking into account, as distinct from the standard theory [1], the presence of a non-monotonous density profile, which always exists on the discharge axis or is often present due to the magnetic island or the density pump-out effect. The model interprets the generation of backscattering signal and the anomalous ion heating, as a result of secondary nonlinear processes that accompany a primary low – threshold two–upper-hybrid (UH) – plasmon PDI of the pump X mode. The threshold of the primary PDI is shown to be smaller than the one predicted in [1] due to the trapping of one UH wave in the presence of the non-monotonous density profile. The primary PDI is absolute due to the finite-size of the pump beam. Its growth enhancing the UH wave fluctuations from the thermal noise level is saturated in our theory due to both the pump wave depletion and the decay of the trapped daughter UH wave that leads to excitation of the secondary UH wave, which is also localized and ion Bernstein (IB) wave. The coupling of different daughter UH waves is responsible in the theory for generation of the backscattering signal. This mechanism appears capable of reproducing the fine details of the frequency spectrum of the anomalously reflected X wave and the absolute value of the observed backscattering signal in TEXTOR experiment. It also predicts substantial (up to 20%) anomalous absorption in the electron channel and explains the anomalous ion heating at TCV by the generation of the secondary IB waves which directly transfer the pump power to the ion component. The possibility of anomalous absorption of the O-mode pump in the ECRH experiment due to parametric excitation of the trapped UH wave is discussed as well.

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[3] A. N. Karpushov et al. 2013 33rd EPS Conference on Plasma Physics, 2006 **30I** P–1.152
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