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ANOMALOUS EMISSION AND ABSORPTION OF MICROWAVES IN ECRH EXPERIMENTS *)

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Electron cyclotron resonance heating (ECRH) and current drive is widely used in toroidal plasmas and is considered for application in ITER for heating and neoclassical tearing mode control. Nowadays an abrupt increase of the ECRH power from 20 MW up to 60 MW is under discussion by the ITER team. According to the predictions of the theory developed in 80th nonlinear effects and first of all parametric decay instabilities (PDIs), which can accompany the ECRH experiments, were believed to be deeply suppressed by huge energy loss of daughter waves from the decay region. However, during the last 15 years many experiments have demonstrated excitation of the anomalous nonlinear phenomena in the 1 MW level ECRH experiments. The clearest evidence of the nonlinear effects onset was obtained first at TEXTOR and then at ASDEX-UG and W-7X, where the strong microwave emission down–shifted in frequency was observed. Recently at ASDEX-UG the emission of the half harmonic of the pump wave was also observed. A convincing demonstration of the anomalous ion heating during the ECRH pulse under conditions when the energy exchange between the ion and electron components is negligible was obtained at TCV and TJ-II. Besides this a substantial broadening of the power deposition profile was reported at L-2M, T-10 and DIII-D in the second harmonic ECRH experiments.

In this talk we present a review of the anomalous phenomena experimental observations and develop a theoretical model taking into account, as distinct from the standard theory, trapping of the decay waves due to non-monotonous features of the density profile, which always exist on the discharge axis or may be present due to the magnetic island, the density pump-out effect or ELM filaments. We interpret the anomalous microwave emission and the ion heating, as a result of secondary nonlinear processes that accompany a primary low–threshold PDI leading to excitation of trapped waves. The primary PDI growth is saturated in our model due to both the secondary decays of the daughter waves and the pump wave depletion. The coupling of different daughter waves and the pump is responsible in the model for the microwave emission, which is a spurious signal for a tokamak microwave diagnostics. This mechanism appears capable of reproducing the fine details of the frequency spectrum and the absolute value of the emitted radiation. It also predicts substantial anomalous absorption in the range of 10% - 70% in the electron channel, which could be responsible for the broadening of the ECRH power deposition profile, and explains the anomalous ion heating by the generation of the secondary ion modes, which directly transfer the pump power to ions. Results of theoretical analysis of anomalous emission at TEXTOR and W-7X as well as of anomalous absorption reported by L-2M and T-10 where broadening of the power deposition profile was observed will be presented.

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