High-energy particles in tokamak plasmas

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Physics of energetic particles in tokamak plasmas is subject of intensive studies in fusion oriented scientific centres. High priority of this area of high temperature plasma physics is due to approaching start of operation of first experimental reactor ITER, which should demonstrate self-sustained DT fusion reaction, critically dependent on high-energy alpha-particle (3.5 MeV) confinement [1].

Classical (collisional) slowing-down of energetic ions (EI), which provides target plasma heating, has been studied in detail. EI losses due to magnetic field ripples [2, 3], MHD instabilities causing EI anomalous transport: fishbone [4], ballooning modes [5], high-frequency Alfvenic modes (TAE) [6] are explored. Losses of EI caused by plasma turbulence have been observed [7].

In many papers excitation of Alfvenic modes (AM) by runaway electrons were predicted [8, 9]. The modes have been found in experiments on EC and LH heating [10, 11]. Since AM appearance in absence of auxiliary heating was not projected until recently, a theory of this phenomenon doesn’t exist. AM observations in ohmic regime are rare and contradictory [12, 13]. Model of AM excitation in presence of tearing-modes causing magnetic shear in vicinity of magnetic island separatrix is one of possible underlying mechanisms [14].

The paper presents results of the experimental study of AMs observed in the conditions of ohmically heated plasmas in the TUMAN-3M [15] and analysis of physics of their excitation. Oscillations are observed using magnetic probes sited inside vacuum vessel. Their frequency is in the range of 0.8 – 1.8 MHz. In shots with different working gases (H, D, He) linear dependence of oscillation frequency on Alfven speed was established. This allows identification of the oscillations as AMs. In many cases bursts of AMs coincide with crash phase of sawtooth oscillations. Excitation of AMs in ohmic regime in absence of energetic ions might be understood in frames of a model of magnetic perturbations caused by magnetic reconnection.

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