GLOBAL SOUND MODE IN A TRAP WITH SLOSHING IONS

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In recent experiments on GDT, as well as in earlier experiments on the GOL-3 device, a new and interesting class of oscillations was observed. Its mode structure and frequency resembles that of a sound wave trapped in the mirror cell as a resonator. Such modes can strongly interact with the bounce motion of ions and thus affect the axial confinement in mirror traps. The modes are probably similar to the global acoustic modes (GAM) in tokamaks. However, there are significant difficulties in reconciling existence of such modes with conventional theory of plasma waves. Both in GOL-3 and in GDT in relevant regimes the electron temperature is far below the theoretical limit for existence (let alone weak Landau damping) of ion-sound waves in homogeneous plasma. We explore different models of inhomogeneous anisotropic non-maxwellian plasma of a mirror trap in search for possible explanations of the observed phenomena.

Global sound mode was observed on GDT via its effect on diamagnetic signals in standard regimes [1] as well as in recent experiments at much higher electron temperature and lower density (with auxiliary ECRH). Its structure resembles that of a sound wave trapped in the mirror cell. The phases of pressure perturbation at ends of the trap are opposite while the most common azimuthal mode number is zero. There is no direct information about the radial structure of the modes. However, the signals are observed on external (nonlocal) diagnostics, averaging over plasma cross-section, which means that the oscillation phases are radially correlated. The plasma in GDT has two components: the warm collisional component and the hot anisotropic population of sloshing ions with mean energy of about 8 keV. The frequency of the mode is close to the bounce frequency of fast ions with mean energy, thus enabling its strong interaction with the sloshing ions.

Similar longitudinal sound modes were found in GOL-3 experiments [2]. They are supposed to scatter passing ions and could strongly affect the axial confinement [3,4], thus playing an important role in the conceptual design of the GDMT trap [5]. Typical plasma parameters in relevant regimes range from n=1...5x1021m-3, Ti=1...2 keV, Te~150eV in GOL-3, to n=1...3x1019m-3, Ti~5keV, Te=150...650eV in GDT. The frequency spectrum is sharply peaked, essentially discreet. The new important feature of oscillations registered in GDT regimes with auxiliary heating is their high amplitude. It exceeds the maximum amplitude of the mode in regimes without heating by a factor of 2 or 3 (according to the longitudinal set of LF magnetic probes), and by more than an order of magnitude on average. Rough estimates show that the amplitude of plasma pressure oscillations in turning points of the hot ions exceeds 1-2% of its full value.

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