Microwave emission due to kinetic instabilities in an over-dense mirror-confined plasma

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The kinetic instabilities of a microwave plasma confined in an open magnetic trap are relevant to understanding various types of radio emission in space plasma, for example, in the magnetospheres of the Earth and the planets, the Sun, and certain types of stars. The high efficiency of the kinetic wave generation mechanism is due to the low group velocity of plasma waves (in comparison with electromagnetic waves), which ensures they enjoy an extended interaction time with nonequilibrium particles resulting in a high integral gain. Emission from the plasma is observed due to various mechanisms for the transformation of plasma waves into electromagnetic waves, for example, as a result of scattering by thermal ions. In view of the universality of the physical mechanisms of radiation generation, essential aspects of natural systems can be reproduced in laboratory magnetic traps under controlled and reproducible conditions. Hitherto the excitation of plasma waves in open magnetic traps has been carried out with the use of electron beams. The technique reported here exploits a plasma generated by irradiating a mirror confined plasma using mm-waves from a gyrotron under electron-cyclotron resonance conditions, a technique also potentially of interest for technological applications. In such a discharge, a two-component plasma is created with a dense cold (background) fraction with an isotropic particle velocity distribution and a less dense high-energy fraction of nonequilibrium electrons with an anisotropic distribution function. In these experiments, bursts of powerful electromagnetic radiation at a frequency close to the upper hybrid resonance and to the second harmonic of the electron gyrofrequency were observed for the first time, accompanied by synchronous precipitation of fast electrons from the trap. The observed bursts were associated with the instability of plasma waves under conditions of a double plasma resonance, with subsequent transformation of the plasma waves into electromagnetic waves.

This poster focusses on a theoretical and experimental study of wave generation in a dense magnetoactive plasma at the harmonics of the electron gyrofrequency. In the experiments at the IAP RAS, a detailed study of the fine structure of dynamic spectra using ultra-wideband oscilloscopes with a bandwidth of up to 59 GHz is reported. Theoretical and numerical analysis at relevant plasma parameters is underway at the University of Strathclyde. Comparison of experimental and theoretical data will lead to an understanding of the mechanisms of electromagnetic radiation generation in magnetic traps and the features of the radio emission spectra observed in natural conditions.

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