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Laboratory modeling of pulsed regimes of electron cyclotron instabilities

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One of the most interesting electron cyclotron resonance (ECR) manifestations is the generation of bursts of electromagnetic radiation that are related to the explosive growth of cyclotron instabilities of the magnetoactive plasma confined in magnetic traps of various kinds and that are accompanied by particle precipitations from the trap. Such phenomena are observed in a wide range of plasma parameters under various conditions: in the magnetospheres of the Earth and planets, in solar coronal loops, and in laboratory magnetic traps.
We demonstrate the use of a laboratory setup based on a magnetic mirror trap with plasma sustained by a gyrotron radiation under ECR conditions for investigation of the cyclotron instabilities similar to the ones which take place in space plasmas. Two regimes of the cyclotron instability are studied. In the first place, quasi-periodic pulsed precipitation of energetic electrons from the trap, accompanied by microwave bursts at frequencies below the electron gyrofrequency in the center of the trap, is detected. The study of the microwave plasma emission and the energetic electrons precipitated from the trap shows that the precipitation is related to the excitation of whistlers propagating nearly parallel to the trap axis. The observed instability has much in common with phenomena in space magnetic traps, such as radiation belts of magnetized planets and solar coronal loops. Such regimes have much in common with the quasi-periodic VLF radiation in the Earth's inner magnetosphere (with periods of T $\sim$ 100 s) and can also be met in solar flaring loops and at other space objects.
In the second place, we have detected and investigated quasi-periodic series of pulsed energetic electron precipitations in the decaying plasma of a pulsed ECR discharge in a mirror axisymmetric magnetic trap. The observed particle ejections from the trap are interpreted as the result of resonant interaction between energetic electrons and a slow extraordinary wave propagating in the rarefied plasma across the external magnetic field. We have been able to explain the generation mechanism of the sequences of pulsed precipitations at the nonlinear instability growth phase in terms of a cyclotron maser model in which the instability threshold is exceeded through a reduction in electromagnetic energy losses characteristic of the plasma decay. The conditions in the decaying plasma resemble those in auroral plasma cavities and similar systems, and in this case electromagnetic waves with quasi-perpendicular propagation direction are excited.