STUDIES OF WAVE PROPAGATION IN MAGNETOACTIVE PLASMA IN THE VICINITY OF ELECTRON CYCLOTRON RESONANCE

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In our solar system, at least six sources of powerful radio wave radiation are known. The characteristic wavelengths of radiation from Earth, Jupiter, Saturn, Uranus, Neptune and the tube connecting Jupiter with its satellite IO, range from a few decimeters to several kilometers. This radiation is divided into two characteristic categories by the supposed mechanism of their generation. The first category includes high-power long-time radio wave radiation with a broad spectrum. The most characteristic representative is the auroral kilometer radio emission (AKR) generated in the Earth’s magnetosphere. AKR was first recorded by the “Electron” satellite [1]. To explain it, a mechanism was proposed associated with the development of a maser cyclotron instability in the auroral region of the magnetosphere with a low plasma concentration (Calvert cavern), where the condition is satisfied. Some of the results obtained with the help of a series of satellite missions are rather difficult to explain in the framework of this theory. Also very important are the issues of transformation and radiation emission from the planetary magnetosphere through a substantially inhomogeneous plasma containing structures with different spatial scales. In particular, recent satellite measurements indicate the fundamental role of inhomogeneities in the concentration of a magnetized plasma in the formation of an unusually narrow AKR directivity pattern relative to the local direction of the magnetic field in the source region (density cavities).

A research of wave propagation in the vicinity of electron cyclotron resonance (ECR) excited by various types of antennas in a magnetized plasma with density inhomogeneities of the cavern type and the plasma-vacuum boundary type was carried out on a large-scale laboratory plasma device "Ionosphere" (IAP RAS). A theoretical study of the radiation pattern of a point source in a magnetically active plasma based on the solution of the bicubic equation, which takes thermal corrections into account, was also conducted. On the basis of the experiments performed and the results of theoretical analysis, it was found that in the vicinity of the ECR, the radiation pattern of the emitting source is modified so that most of the excited waves are quasi-longitudinal, but their group velocity vectors are directed almost perpendicular to the magnetic field. Accordingly, the energy flux from the radiating source propagates across the magnetic field with a fairly narrow radiation pattern. It was also found that there is an optimal ratio of plasma and cyclotron frequencies, at which the signal amplitude becomes maximum. On the basis of these results, we propose one of the possible models for the formation of radio emission from the planetary magnetospheres, in which the source is the flux of charged particles in a dense plasma near the boundaries of the cavity.

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References

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