Generator OF THz radiation based on intense beam-plasma interaction

A.V. Arzhannikov1,2, V.T. Astrelin1,2, A.V. Burdakov1,2,3, V.S. Burmasov1,2, L.N. Vyacheslavov1,2, I.A. Ivanov1,2, M.A. Makarov1, K.I. Mekler1, S.S. Popov1, V.V. Postupaev1,2, A.F. Roveskikh1, S.L. Sinitsky1,2, V.D. Stepanov1,2, V.F. Sklyarov1,2

1Budker Institute of Nuclear Physics, Siberian Branch, Russian Academy of Sciences, pr.
 Akademika Lavrent'eva 11, Novosibirsk, 630090 Russia
2Novosibirsk State University, ul. Pirogova 2, Novosibirsk, 630090 Russia
3Novosibirsk State Technical University, Novosibirsk, Russia, A.V.Arzhannikov@inp.nsk.su

Based on the theoretical concepts of the mechanisms of electromagnetic waves generation in a turbulent plasma, we can assume that the electromagnetic radiation in vicinity of the fundamental plasma frequency is generated either in weakly turbulent process of Langmuir oscillations scattering on ion sound waves, or in the process of their conversion on strong gradients of plasma density. Radiation at the double plasma frequency occurs in the merging process of two electron plasma waves of the same oscillation branch. In the theoretical analysis of the problem of electromagnetic wave generation in the system REB-plasma we have shown [1] that under the conditions which can be realized in a laboratory experiment, the electromagnetic emission with a frequency close to 1 THz and a specific power density of 100 kW/cm3 can be obtained at a plasma density above 1015 cm-3.

The first series of experiments [2] on the sub-millimeter wave generation in plasma with a density of about 2 × 1014 cm-3 was carried out at the GOL-3 facility. The operation of this facility was aimed to study the physics of collective relaxation of a relativistic electron beam in a plasma with respect to the preparation of plasma with thermonuclear parameters. The presented report provides a description of the specialized GOL-PET device intended for the generation of terahertz radiation during the high-current REB relaxation in the plasma with a density of (2 - 5) × 1015 cm-3. This device was created as results of the reconstruction of the GOL-3 facility which consisted of the U-2 accelerator and the device "Plasma". The U-2 accelerator is a source of 1 MeV beam with a current up to 30 kA and duration of about 10 microseconds. In accordance of the reconstruction, the magnetically insulated ribbon diode of the accelerator was remodeled to increase the REB current density injected into the plasma more than twofold. In turn, the length of a plasma column in the device "Plasma" was reduced from 12 down to 2.5 meters. This length allows creating by a high voltage discharge the plasma column with the density above 1015 cm-3. The diagnostic complex of the GOL-PET device gives possibility for measuring the parameters of the beam and plasma during the beam injection and for analyzing the frequency composition and polarization of the terahertz radiation emitted from the plasma.

The GOL-3 as part of the long open traps complex is one of the unique physical installations and stands of the Russian Federation. Studies on the generation of terahertz radiation in a plasma are carried out under the RSCF Project №14-12-00610. Spectral diagnostics are developed and manufactured under the State Assignment Contract No. #3002.

References

1. A. V. Arzhannikov and I. V. Timofeev // Plasma Phys. Controlled Fusion 54, 105004 (2012). http://dx.doi.org/10.1088/0741-3335/54/10/105004.
2. M.K.A. Thumm, A.V. Arzhannikov, V.T. Astrelin et al. “Generation of High-Power Sub-THz Waves in Magnetized Turbulent Electron Beam Plasmas”, Journal of Infrared, Millimeter and Terahertz Waves. Vol. 35, Iss. 1, 2014, pp. 81-90, DOI 10.1007/s10762-013-9969-3.