Diagnostics of the hot component of a dense nonequilibrium plasma of a continuous ECR discharge [[1]](#footnote-1)\*)

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1Kiseleva E., 1Viktorov M., 1Skalyga V., 1Izotov I., 2Bokhanov A.

1Lobachevsky State University of Nizhny Novgorod, Nizhny Novgorod, Russia, [unn@unn.ru](mailto:unn@unn.ru),,  
2Institute of Applied Physics RAS, Nizhny Novgorod, Russia, , [dir@ipfran.ru](mailto:%20dir@ipfran.ru)

The plasma of a discharge sustained under conditions of electron cyclotron resonance has been widely used in many fields of science and technology for recent decades. In particular, it is exploited in ion sources for accelerators, since the use of an ECR discharge plasma confined in open magnetic traps makes it possible to obtain ions with a high charge state. The increase in the efficiency of such sources is generally carried out by the improvement of the magnetic confinement systems and the parameters of the heating radiation sustaining the discharge. However, with the intention of further improvement in productivity and obtaining ions of higher charge, it is necessary to know and take into account the energy distribution of electrons in the plasma. Firstly, it determines the maximum ion charge in the plasma and makes it possible to estimate the ionization constants. Secondly, the electron energy distribution function (EEDF) is directly correlated with the onset of kinetic instabilities, which significantly affect plasma confinement [1], and, hence, the performance of ion sources.

In the present moment, the EEDF shape for an ECR discharge plasma still remains unknown, and the Maxwellian distribution is commonly used in simulations. There are various methods for indirect estimation of the energies in such a plasma: for example, local probe measurements or analysis of bremsstrahlung. In 2012, a method for measuring the energy distribution of electrons leaving the plasma was presented at the IAP RAS [2]. This method is ideologically a classical ion mass spectrometry with a magnetic analyzer, but with an inverted magnet polarity. It allows one to estimate the hot (from units of keV to units of MeV) electron component.

In this work, the distribution function of electrons lost from the ECR plasma of an ion source with a high specific energy input operating in a gas-dynamic (collisional) mode was experimentally investigated in a wide range the heating radiation powers and neutral gas pressures. Additionally, the diagnostics of radiation in the microwave and X-ray ranges, created by the same energetic electrons, was made. The optimal regimes for the development of kinetic instabilities in the plasma of an ECR discharge were found. The experimental results, taken into account along with theoretical works, will in future allow us to present a new and currently the only way to restore the real EEDF inside the plasma.

References

1. Tarvainen O et al. Beam current oscillations driven by cyclotron instabilities in a minimum-B electron cyclotron resonance ion source plasma. Plasma Sources Sci. Technol. 23 025020, 2014.
2. S.V. Golubev et al. Experimental electron energy distribution function investigation at initial stage of electron cyclotron resonance discharge. Review of Scientific Instruments. –– 2012. –– Vol. 83, no. 2. –– P. 02B504.

1. \*) [abstracts of this report in Russian](http://www.fpl.gpi.ru/Zvenigorod/XLIX/Lt/ru/EG-Kiseleva.docx) [↑](#footnote-ref-1)