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STATUS OF DEVELOPMENT OF PLASMA HEATING AND CURRENT GENERATION SYSTEMS BY ELECTROMAGNETIC WAVES OF INTERMEDIATE FREQUENCY RANGE FOR EXISTING AND PROSPECTIVE NATIONAL TOKAMAKS *)

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The development of non-inductive current generation systems utilizing radio-frequency electromagnetic waves is an important task in the implementation of the thermonuclear program in the Russian Federation. Methods based on the use of intermediate frequency waves, which are highly efficient, are of interest for both existing and prospective national tokamaks.

Current generation by a slow lower-hybrid (LH) wave is the most efficient method. To implement this approach, experimental modules of current generation systems with operating frequencies of 2.45 GHz and 4.6 GHz are being created and tested in the Ioffe Institute. To excite waves slowed down along a toroidal magnetic field and propagating in the direction of the electron current, multi-waveguide antennas of the "multijunction" type have been developed and tested, in which a certain phasing sequence between the waveguides is used. The start of work on the creation of LH current generation systems gave a pulse to the development of the necessary microwave path elements and devices, including high-power protective ferrite valves. The production of continuous-mode amplifying klystrons with an operating frequency of 2.45 GHz was resumed, and microwave devices new for Russia were developed for a frequency of 4.6 GHz.

Interest in low-frequency intermediate-range helicons in relation to solving current generation problems arose in connection with an understanding of the difficulties encountered by the LH method. Unlike the slow LH wave, the absorption of the fast mode, the helicon, and the electric current excited by it are not localized at the periphery of the plasma and have no limitations on its density. Due to the relatively weak absorption of the fast mode by the Landau mechanism, it can be considered as a promising option for maintaining the current in the central hot region of the tokamak discharge.

For the spherical tokamak Globus-M2 with a magnetic field of up to 1 T within the framework of the complex program "Development of technology, equipment and scientific research in the field of atomic energy use in the Russian Federation" of the federal project "Development of controlled thermonuclear fusion technologies and innovative plasma technologies" (U3), a prototype of an experimental system for heating plasma and generating current using helicons at a frequency of 200 MHz is being created. A multi-loop traveling wave antenna has been developed to excite the helicon, and an RF generator has been developed and created to ensure a probing level of 200 kW.

The development of plasma heating and current generation systems was carried out at the unique scientific facility "Spherical Tokamak Globus-M", which is part of the Federal Center for Collective Use "Materials Science and Diagnostics in Advanced Technologies" with the support by the State Assignment of the Ioffe Institute FFUG-2022-0002, and the numerical codes for calculating the propagation and absorption of intermediate-range waves – by FFUG-2022-0003.

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