Contribution ID: **673** Type: **Rapporteured**

Overview of Globus-M2 spherical tokamak results at the enhanced values of magnetic field and plasma current.

Tuesday 11 May 2021 15:24 (21 minutes)

The report provides an overview of the results obtained at the upgraded Globus-M2 spherical tokamak 1 since the last IAEA conference. The tokamak was designed to reach the toroidal magnetic field as high as BT =1 T and the plasma current Ip = 0.5 MA having a small plasma minor radius a = 0.22-0.23 m. Currently 80% of highest magnetic field and plasma current value are reached, so during the reported period the experiments were performed with the toroidal magnetic field up to 0.8 T and plasma current up to 0.4 MA. The plasma breakdown conditions were improved noticeably with regard to the Globus-M ones, 30% breakdown loop voltage decreasing was achieved. The discharge duration was increased due to higher central solenoid volt-second consumption. The plasma column magnetic configuration explored was the divertor lower null with the aspect ratio A = R/a = 1.5-1.6, triangularity up to δ~0.35 and elongation up to κ~2.2.
The first neutral beam heating experiments on Globus-M2 have demonstrated an increased efficiency, comparing with the Globus-M ones, at the same NBI parameters (deuterium beam with particle energy 28 keV and the heating power 0.8 MW). The electron and ion central plasma temperatures exceeded 1 keV at the central density as high as 1×10^20 m-3. The diamagnetically measured plasma thermal energy increased up to 10 kJ, which is nearly triple as high as in Globus-M (BT =0.4, Ip = 0.2 MA). NPA spectra demonstrating improved fast particle confinement are presented. The energy confinement time increased more than two times that is significantly higher than the IPB98(y,2) scaling predicts. The effect is due to the strong dependence of the energy confinement time on the toroidal magnetic field in accordance with the Globus-M experimental scaling that is found to be valid for a wider range of BT. The regression fit of the Globus-M/Globus-M2 data yields the following scaling for energy confinement time:
τE ~ Ip^(0.58)BT^(1.23)Pabs^(-0.66)ne^(0.63)
where Pabs is the absorbed heating power and ne is the line average density. The scaling confirms weak τE dependence on Ip that emphasizes the major role of BT on heat perpendicular transport in spherical tokamaks, Enhanced plasma parameters allowed us to obtain regimes with much lower collisionality. That make possible investigation of dependence of the normalized energy confinement time (BTτE) on collsionality (ν~*ne/T^2) in the wide range of plasma collisionalities 0.018<ν<* 0.23. This dependence turned out to be rather strong BTτE ~ ν*^(-0.8) for a fixed values of safety factor q ~ BT/Ip, normalized ion gyroradius ρ* ~ T^(0.5)/BT and parameter βT ~ W/BT^2. The power balance analysis carried out using ASTRA transport code indicates the reduction of both electron and ion heat diffusivity with collisionality decrease while the ion heat diffusivity remains near the neoclassical level.
Important results are related to non-inductive current drive. About 30% of the loop voltage drop was recorded during the NB injection, which indicates a noticeable amount of non-inductively (mainly bootstrap) driven current. For the first time in spherical tokamaks a non-inductively driven current was recorded during the launch of the electromagnetic waves of the lower hybrid (LH) range (2.45 GHz) with the help of toroidally oriented grill. The fraction of noninductively driven current has exceeded 30% in the discharge with the total current of 0.2 MA. The modelling results of the experimental data by means of the ASTRA transport code and Fast Ray Tracing Code incorporated to ASTRA 2 are presented.
Plasma scrape of layer (SOL) and divertor characteristics were investigated in new experimental conditions of enhanced magnetic field and plasma current. Heat and particle fluxes together with currents and potentials in SOL and divertor plate vicinity were measured with a divertor Langmuir probe array and movable Langmuir probe. The plasma parameters in SOL were also modelled with the fluid version of the SOLPS-ITER code. Currents and drifts were included in the simulations. Comparison of experimental and simulated heat flux power density decay length (λqt) in SOL with the well-known scalings is presented.
The study of Alfvén modes (AM) was continued during the reported period. An increase in plasma parameters led to a change in the nature of AM and the expansion of their frequency spectrum (50–300 kHz). Together with the toroidal Alfvén eigenmodes (TAE), observed earlier on Globus-M, the so-called Alfvén cascades (AC or RSAE) were identified. Observation of ACs made it possible to apply the method of MHD spectroscopy to determine the evolution of qmin in a discharge. In experiments on current drive by the LH waves, modes with a frequency of about 1 MHz, excited by fast electrons, were detected. To study the spatial structure of AM, Doppler backscattering diagnostics was used [3] with application of a multi-channel microwave scheme. Using the neutral particle analyzer and a neutron detector, we studied the dependence of fast particle losses initiated by TAEs on the magnetic field and plasma current. It was shown that losses decrease significantly with increasing field and current, demonstrating dependence favorable for compact neutron sources.

Also presented are new diagnostics designed to fill in the missing data on plasma parameters and improve the quality of the simulation, such as: diagnostics Z eff, laser interferometer, charge-exchange resonance spectroscopy (CXRS), etc.

Indico rendering error

Could not include image: Problem downloading image (https://cdn3.savepice.ru/uploads/2020/3/13/5115b43

Indico rendering error

Could not include image: Problem downloading image (https://cdn3.savepice.ru/uploads/2020/3/13/2c73b78

1. V.B. Minaev et al 2017 Nucl. Fusion 57 066047
2. A.D. Piliya, A.N. Saveliev, JET Joint Undertakin Abingdon, Oxfordshire, OX14 3EA, 1998
3. V.V. Bulanin et al 2019 Tech. Phys. Lett., v.45, 11 p.p. 1107-1110

Country or International Organization

Russia

Affiliation

Ioffe Institute

Authors: PETROV, Yury (Ioffe Institute); GUSEV, Vasily (Ioffe Physical-Technical Institute); Dr SAKHAROV, Nikolay (Ioffe Insitute); MINAEV, Vladimir (Ioffe Institute); Dr VARFOLOMEEV, Vlsdimir (Ioffe Institute); DYACHENKO, Valeriy (Ioffe Physical-Tekhnical Institute); Mr BALACHENKOV, Ivan (Ioffe Insitute); BAKHAREV, Nikolai (Ioffe Institute); Mr BONDARCHUK, Eduard (JSC"NIIEFA"); Dr BULANIN, Viktor (Peter the Great St. Petersburg Polytechnic University); Dr CHERNYSHEV, Fedor (Ioffe Institute); Ms ILIASOVA, Margarita (Ioffe Insitute); KAVIN, Andrei (D.V.Efremov Institute of Electrophysical Apparatus); Mr KHILKEVITCH, Eugeny (Ioffe Institute); Dr KHROMOV, Nikolay (Ioffe Institute); Mr KISELEV, Eugeny (Ioffe Institute); Mr KONOVALOV, Alexey (Ioffe Institute); KORNEV, Vladimir (Ioffe Institute); Mr KRIKUNOV, Sergey (Ioffe Institute); KURSKIEV, Gleb (Ioffe Physical-Technical Institute of the Russian Academy of Sciences); Dr MELNIK, Andrey (Ioffe Institute); Dr MIRONOV, Maxim (Ioffe Institute); Mr MIROSHNIKOV, Igor (Ioffe Innstitute); NOVOKHATSKY, Alexandr (Ioffe Physical-Technical Institute of the Russian Academy of Sciences); Mr ZHILTSOV, Nikita (Ioffe Institute, 194021, St.Petersburg, Russia); MUKHIN, Eugene (Ioffe Institute); Dr PATROV, Michael (Ioffe Institute); Dr PETROV, Alexander (Peter the Great St. Petersburg Polytechnic University); ROZHANSKY, Vladimir (Peter the Great St. Petersburg Polytechnic University); SENICHENKOV, Ilya (Peter the Great Saint Petersburg Polytechnic University); Mr SHULYATIEV, Konstantin (Ioffe Institute); Mr SHCHEGOLEV, Petr (Ioffe Institute); SHEVELEV, Alexander (Ioffe Institute); Ms TELNOVA, Anna (Ioffe Institute); Dr TEPLOVA, Natalia (Ioffe Institute); Ms TUKHMENEVA, Ekaterina (Ioffe Institute); Mr TOKAREV, Vlentin (Ioffe Institute); Dr TOLSTYAKOV, Sergei (Ioffe Institute, 194021, St.Petersburg, Russia); Mr TROSHIN, Grigory (Ioffe Institute); Ms VEKSHINA, Elena (2Peter the Great St. Petersburg Polytechnic University); Dr VORONIN, Alexander (Ioffe Institute); YASHIN, Alexander (Peter the Great St.Petersburg Polytechnic University); BAGRYANSKY, Peter (Budker Institute of Nuclear Physics); Dr SOLOMATIN, Alexander (Budker Institute of Nuclear Physics); Mr ZHILIN, Eugeny (Ioffe Fusion Technology Ltd)

Presenter: PETROV, Yury (Ioffe Institute)

Session Classification: OV/4 Overview Magnetic Fusion

Track Classification: Overview