DOI: 10.34854/ICPAF.52.2025.1.1.064

# SIMULATION OF AN ABSOLUTE SPECTRA OF BREMSSTRAHLUNGAND RECOMBINATION SOFT X-RAY RADIATION OF PLASMA IN COMPARISON WITH THE RESULTS OF MEASUREMENTS AT THE FT-2 TOKAMAK *)

Buts M.K., Kantor M.Yu., Altukhov A.B., Baranov Yu.F., Esipov L.A., Kouprienko D.V.

*Ioffe Institute, Saint-Petersburg, Russia, m.buts@mail.ioffe.ru*

Analysis of plasma emission spectra in the soft X-ray range allows one to obtain important information about the temperature, effective charge and other parameters of high-temperature plasma in magnetic confinement facilities. The spectrum of continuous plasma radiation consists of a bremsstrahlung and recombination parts. The recombination part the is usually neglected [1, 2], which leads to errors in the interpretation of radiation spectra at low electron temperatures. On a small tokamak FT-2 with a relatively low electron temperature ~300 eV an XR100-SDD X-ray spectrometer based on a silicon drift detector is installed. To analyze and interpret the spectra measured by the detector, absolute bremsstrahlung and recombination spectra reaching the detector were modeled in comparison with experimental plasma emission spectra.

To determine the spectrum of radiation reaching the the detector, it is necessary to know the radiation spectrum of the plasma at each point and the solid angle at which the detector is visible from this point. To simulate plasma radiation, the CHIANTI [3], AtomDB [4] databases were used, as well as the Aurora code [5], which uses the OPEN-ADAS database [6] to simulate recombination radiation. The input parameters for the calculation are the local values of electron temperature and density, as well as the elemental composition of impurity plasma ions, selected to match the experimental spectra. Electron temperature and density were determined by Thomson scattering diagnostics and a multichord microwave interferometer. The use of several databases makes it possible to verify their results, which is necessary for the correct interpretation of experimental results.

To consider the observation geometry and determine the solid angle of the detector, a software code has been developed that simulates the passage of radiation through the spectrometer diaphragms. The plasma column is divided into elementary volumes (voxels), and the detector into elementary areas. For each voxel, the total solid angle of the visible part of the detector is calculated as the sum of the solid angles of the elementary areas that are fully visible from this voxel. The spectrum of radiation reaching the detector is calculated the sum of the radiation of each voxel, taking into account the solid angle of visibility of the detector from the voxel position.

The calculated spectra are compared with experimental ones measured along different observation chords. This makes it possible to estimate the distribution of the impurity along the plasma radius.

Measurements of soft X-ray spectra in the FT-2 tokamak were supported by Ioffe Institute under State Contract No. FFUG-2022-0001. Data analysis was supported by Ioffe Institute under State Contract No. FFUG-2024-0028.

## References

[1]. Chen Y. et al., Rev. Sci. Instrum. 86, 023509 (2015)
[2]. Rathgeber S.K. et al,. Plasma Phys. Control. Fusion 52, 095008 (2010)
[3]. Dere et al., 2019; ApJS, 241, 22
[4]. Foster A.R., Heuer K., Atoms 2020, 8(3), 49
[5]. Sciortino F. et al 2021 Plasma Phys. Control. Fusion 63 112001
[6]. Summers H.P., O'Mullane M.G., AIP Conf. Proc. 1344, 179–187 (2011)

*) abstracts of this report in Russian