Recovery of hydrogen atoms INFLUX by the Hα-spectroscopy in ITER: comparison of Ballistic model and EIRENE code simulations

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Measurement of the influx of hydrogen isotopes atoms from the first wall into vacuum chamber is one of the key tasks of The ITER main chamber Hα and Visible Light Spectroscopy Diagnostics supplied to ITER by the Russian Federation. To recover the influx, it is proposed to use the Ballistic Model [1] for the recycling of neutral hydrogen isotopes (penetration of molecules and atoms from the wall into the plasma and return back), which allows one to calculate quickly, but not in real time, the velocity distribution functions of neutral atoms of hydrogen isotopes, using the known density and temperature profiles of electrons and ions in the scrape-off layer (SOL). The values of free parameters of the model may be recovered from the observed spectral intensity of the Balmer-alpha lines. To estimate the accuracy of the recovery, the approach [2] is used in the frame of the so-called synthetic diagnostics in which synthetic experimental data are generated using the results of predictive numerical simulation of main parameters of SOL&divertor plasma, in this case the numerical code SOLPS (B2-EIRENE) is used (see the references in [2]). The spectral line shape model and the inverse problems from [2] were tested in [3] on the tokamak JET experimental data to determine the isotopic ratio of hydrogen and deuterium.

In this work, the dependence of the detected signal on the density of the flux of neutral atomic and molecular deuterium from the first wall into the vacuum chamber was found in the basic operating scenarios of ITER SOL&divertor. It was shown that the Ballistic Model of penetration of hydrogen isotopes into the plasma from the wall can be used for solving the inverse problem of recovering the influx from the data of spectral measurements. In all considered scenarios differing from each other primarily by the plasma density near the wall (the density is varied within two orders of magnitude), the recovery of the density profile of deuterium atoms in the emitting layer is feasible with a 20% error while the error in recovering the density profile of deuterium molecules in some scenarios is much larger. The error in recovering the density of the flux of deuterium atoms on the emitting layer in all scenarios does not exceed 100%, that is a good accuracy for the inverse problem of such complexity. It is shown that there is a weak dependence of the signal, and of the recovered total influx of atomic and molecular deuterium, on the molecular density profile.

References

1. M.B. Kadomtsev, V. Kotov, V.S. Lisitsa, V.A. Shurygin. Proc. 39th EPS Conference & 16th Int. Congress on Plasma Physics, Stockholm, 2012, ECA, 36F, P4.093.
2. A.B. Kukushkin, V.S. Neverov, A.G. Alekseev, S.W. Lisgo, A.S. Kukushkin. Fusion Sci. Tech., 2016, 69(3), 628-642.
3. V.S. Neverov, A.B. Kukushkin, M.F. Stamp, et al. Nucl. Fusion, 2017, 57, 016031 (13pp).