Problems of high-resolution spectroscopy of beryllium in ITER scrape-off layer

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Research for the capabilities of recovering the neutral atoms density of hydrogen isotopes from the measured spectral intensity of their lines in the visible light range has shown that under the condition of a strong background signal produced by the divertor stray light (DSL), only the high-resolution spectroscopy and the recently developed algorithms for interpreting the experimental data make it possible to attain the measurement accuracy, stipulated by the ITER Measurement Requirements, in a fairly wide range of ITER operation conditions. The new algorithms we have developed laid the basis of the ITER H-alpha synthetic diagnostics [1]. The essential novelty of the synthetic diagnostics [1] is the allowance for the DSL and for the non-Maxwellian effects in the kinetics of hydrogen isotopes neutral atoms in the scrape-off layer. Applying the developed algorithms to the data of Balmer-alpha emission of deuterium and hydrogen in the tokamak JET with ITER-like wall (JET-ILW) made it possible [2] to estimate the signal-to-background ratio for the Balmer-alpha lines and confirmed the expectation of a possible significant role of the DSL in ITER. The line shape model [3, 4] was used in [5] for the analysis of the spectral asymmetry of deuterium line observed in the JET-ILW divertor and for the analysis of the synthetic experimental data (including the transitions between highly excited atomic states).

In this paper, an extension of the methods of synthetic diagnostics of hydrogen isotopes to the diagnostics of beryllium in the ITER scrape-off layer is suggested. It is shown that the main problems are as follows: (a) the strong background signal (the beryllium spectral line DSL and the bremsstrahlung continuum), which complicates solving the inverse problem, (b) the lack of data for the fine structure of atomic levels in a strong magnetic field when the Zeeman splitting of atomic levels is comparable with the fine structure splitting, (c) complication of the atomic kinetics problem because of the metastable level in the neutral atom. The preliminary results of recovering the beryllium density in the ITER scrape-off layer from synthetic high-resolution spectra of beryllium lines are presented.

References

1. A.B. Kukushkin, V.S. Neverov, A.G. Alekseev, S.W. Lisgo, A.S. Kukushkin. Fusion Sci. Tech., 2016, 69, 628-642.
2. V.S. Neverov, A.B. Kukushkin, M.F. Stamp, A.G. Alekseev, S. Brezinsek, M. von Hellermann, and JET Contributors. "Determination of divertor stray light in high-resolution main chamber Hα spectroscopy in JET-ILW“, accepted in Nucl. Fusion, 2016.
3. V.S. Neverov, A.B. Kukushkin, S.W. Lisgo, A.S. Kukushkin, A.G. Alekseev. Plasma Phys. Rep., 2015, 41 (2), 103-111.
4. A.B. Kukushkin, V.S. Neverov, M.B. Kadomtsev, et al., Journal of Physics: Conference Series, 2014, 548, 012012.
5. Lomanowski B.A., et al., Nucl. Fusion, 2015, 55, 123028.