Divertor Stray Light Analysis in JET-ILW and Implications for the H-α Diagnostic in ITER

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The use of an all-metal first wall in future magnetic fusion reactors equipped with a divertor may impose severe limitations on the capabilities of optical diagnostics in the main chamber because of a divertor stray light (DSL) produced by multiple (diffusive and/or mirror) reflections of intense light emitted in divertor. For optical diagnosis of hydrogen, various neutral and low ionized impurities in the far scrape-off layer (SOL) of the main chamber one should expect strong contribution of the DSL in the same spectral lines. Preliminary analysis of the DSL problem for the H-alpha (and Visible Light) Spectroscopy Diagnostic in ITER suggested there may be a substantial dominance of Balmer-α DSL over the Balmer-α light emitted from the SOL (SOLL), up to two orders of magnitude for highly reflecting walls and high-power operation. To meet the ITER Measurement Requirements, one has to develop a detailed assessment of the measurement accuracy for the fuel ratio and the recycling flux from the first wall. First results [1] have shown that a test of the elaborated approach in the currently running machines with all-metal first wall is required to benchmark the analysis method.

Here, we report on the first results of the signal-to-background ratio (SOLL/DSL) for D-α light emitted from the far SOL and divertor in JET in the recent ITER-like wall (ILW) campaign. High-resolution spectrometer data on resolving power at D-α with direct observation of the divertor from the top (ten tracks with the filtered-out Zeeman σ-components) and with observation of the inner wall along tangential and radial lines-of-sight from equatorial ports (two tracks) are analyzed. The SOLL/DSL ratio is found via solving an inverse problem which uses semi-analytic models: a model [1] for the DSL spectral line shape and a model for the spectral line shape asymmetry caused by the inward flux of fast reflected atoms. The latter model is suggested by the results of the 1D model [2] for neutral atom velocity distribution function in the SOL, tested against simulations with the B2-EIRENE (SOLPS4.3) code. Here, the developed synthetic H-α diagnostic is tested on the example of data from predictive modeling of the flat-top of Q=10 inductive operation of ITER.

The results show the DSL/SOLL ratio for the Balmer-α light to vary from few to several units in moderate and high-power diverted discharges with the JET ILW, whereas without strong NBI this ratio is less than unity. The implications for the H-alpha (and Visible Light) Spectroscopy Diagnostic in ITER are discussed.

References

1. A.B. Kukushkin, V.S. Lisitsa, M.B. Kadomtsev, M.G. Levashova, V.S. Neverov, V.A. Shurygin, V. Kotov, A.S. Kukushkin, S. Lisgo, A.G. Alekseev, A.V. Gorshkov, D.K. Vukolov, K.Yu. Vukolov, E. Veshchev. Proc. 24th IAEA Fusion Energy Conference, San Diego, USA, 8-13 October 2012, ITR/P5-44.
2. M.B. Kadomtsev, V. Kotov, V.S. Lisitsa, V.A. Shurygin. Proc. 39th EPS Conf. & 16th Int. Congress on Plasma Phys., Stockholm, Sweden, 2012, P4.093.
1. *See the Appendix of F. Romanelli et al., Proceedings of the 24th IAEA Fusion Energy Conference 2012, San Diego, USA* [↑](#footnote-ref-1)