ASSESSMENT OF LINE RADIATiON imprisonment EFFECTS during discharge quenching by intense argon injection in iter

1,2Kukushkin A.B., 1Sdvizhenskii P.A., 1Levashova M.G., 1Zhogolev V.E., 1Leonov V.M., 1,2Lisitsa V.S., 1Konovalov S.V.

1NRC “Kurchatov Institute”, Moscow, Russia, Sdvizgenskii\_PA@nrcki.ru
2National Research Nuclear University MEPhI, Moscow, Russia.

One of conditions of the experimental tokamak reactor ITER safe operation is the possibility of disruption instability mitigation by massive injection of inert gases, in particular, of argon and neon. Impurity radiation from the plasma periphery will allow to "reradiate" the considerable part of plasma thermal energy and to reduce the energy flux on the divertor plates. While modeling in [1] of Ar and Ne massive gas injection (MGI) in the 15 MA current basic scenario in ITER it was supposed that the MGI is carried out at the quasi-stationary stage of the discharge (flat-top of the current). For modeling of main plasma parameters, the ASTRA [2] transport code is used, which is integrated with the ZIMPUR [3] code describing the dynamics of charge states, radiation losses and transfer of impurity (description of radiation losses is carried out in [1] for optically thin coronal plasma). For calculation of the gas outflow from the MGI system, the phenomenological model [4] is used.

Here we present the results of assessment of line radiation imprisonment effects during discharge quenching by intense argon injection in ITER. Such problem is stimulated by the results [5] where the impact of plasma opacity effects on current quench mitigation by the MGI in tokamaks was shown. In [5] the "escape probability" model of line radiation escape from plasma (see surveys [6, 7]) and the coronal model for excited levels populations, averaged over multiplets, were used. In this paper the fine structure of levels and the non-coronal collisional-radiative kinetics for the radiating excited state are used (NIST, OPEN ADAS and ALADDIN databases are used). For the most strongly radiating ions at various stages of discharge quenching (e.g., Ar+15 ions, at the initial stage of penetration of impurity into plasma, and Ar+3, at the stage of impurity stirring practically in the whole plasma volume) it is shown that optical thickness for the ionic strongest lines appears to be about several units. However, it has no significant effect on the full radiation power losses of plasma in the quenching scenario simulated in [1]. Thus, the radiation losses calculation with account of radiation imprisonment in the model of the excited levels, averaged over multiplets, gives, as expected, an upper bound for estimation of the impact of opacity effects upon discharge quenching by the impurity injection.

References

1. Leonov V.M., Konovalov S.V., Zhogolev V.E., Modeling of pre-Thermal Quench and Thermal Quench stages of disruption induced by Massive Gas Injection in ITER, 27th IEEE Symposium on Fusion Engineering (SOFE 2017) Shanghai, China, 2017, W.POS.026.
2. Pereverzev G.V., Yushmanov P.N., Preprint IPP 5/98, 2002, Garching, Germany.
3. Leonov V.M., Zhogolev V.E., Plasma Phys. Control. Fusion, 2005, 47, 903.
4. Zhogolev V.E., Plasma Physics Reports, 2012, 38(10), 786-796.
5. Lukash V.E., Mineev A.B., Morozov D.Kh. Nucl. Fusion, 2007, 47, 1476–1484.
6. Kogan V.I., Encyclopedia of Low Temperature Plasma. Introduction Volume, ed. V.E. Fortov, Moscow: Nauka/Interperiodika, 2000, p. I-481.
7. Abramov V.A., Kogan V.I. and Lisitsa V.S. Reviews of Plasma Physics, ed. M.A. Leontovich and B.B. Kadomtsev, v. 12, New York: Consultants Bureau, 1987. p. 151.