Laser-induced quenching diagnostics of hydrogen in tokamak plasma [[1]](#footnote-1)\*)

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Laser-induced quenching (LIQ) [1,2,3] technique is proposed for diagnostics of hydrogen atoms (deuterium, tritium) in tokamak and stellarator plasmas. LIQ combines benefits of both laser-induced fluorescence (LIQ) [4,5] and photoionization (LII) [6,7] used for hydrogen density measurements: the sensitivity of LIQ is comparable to laser fluorescence and due to the difference between pumping and viewing wavelengths as in LII laser stray-light can be easily reduced.

LIQ is based on partial decreasing the most intensive hydrogen line in the visible range *Hα* (656.3 nm, transition *n* = 3 → 2) by laser excitation in one of the Paschen series lines. Laser pumping in the transition *n* = 3 → *nUp* (*nUp* ≥ 4) reduces the population of *n* = 3 group of states and proportionally decreases the *Hα* intensity. The local density of hydrogen atoms can be calculated with collision-radiative model (CRM) from amplitude of the quenching signals.

100 Hz pulsed optical parametric oscillator based laser (OPO) used for the first tests in Globus-M tokamak plasma [3] pumped hydrogen line 1005 nm (*n* = 3 → 7). The experiments have confirmed the possibilities of diagnostic implementation in tokamak conditions.

The CRM calculations show that pumping the 1875 nm line (*n* = 3 → 4) requires minimum power spectral density of laser radiation (*PSat* < 1 W/cm2pm) to saturate the quenching signals comparing to other Paschen series lines. The low laser power required to quench the line allows using 1875 nm time-modulated thulium fiber laser (tunable range 1873-1877 nm) with peak power of 5 W. The first measurements with this laser were carried out in ohmic discharges in the equatorial plane near the inner wall of tokamak. The minimum measured hydrogen density was *na* ≈ 1015 m-3 averaging over 10 ms in steady state discharge stage. In case of higher density *na* > 1016 m-3 averaging over 1.0-2.5 ms was sufficient.

LIQ basics, experimental features in tokamak conditions are described. The experimental results of hydrogen density measurements in the scrape-of-layer Globus-M plasma are presented.

References

1. A. Gorbunov et al., Conference HTD-17, 2017, pp. 81-83
2. A. Gorbunov et al., Fusion Eng. Des., 2017, 123, pp. 695-698
3. E. Mukhin et al., Nucl. Fusion, 2019, 59, 086052
4. G. Razdobarin et al., Nucl. Fusion, 1979, 19, 1439
5. T. Kubach et al., 31st EPS Conference on Plasma Phys., ECA 28G, P-4.138 (2004)
6. V. Gladushchak, Nucl. Fusion, 1995, 35, 1385
7. M. Kantor, JINST, 2012, 7, C02017

1. \*) [abstracts of this report in Russian](http://www.fpl.gpi.ru/Zvenigorod/XLVIII/Mu/ru/AB-Gorbunov.docx) [↑](#footnote-ref-1)