Atomic oxygen measurements with THz absorption spectroscopy, ps-TALIF, and CRDS: A comparison

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THz absorption spectroscopy with quantum cascade lasers (QCLs) has recently been developed and implemented as a novel diagnostic technique for determining atomic oxygen densities in plasmas [1,2]. It is based on the detection of the $^3P_1 \leftarrow {}^3P_2$ fine structure transition of ground-state atomic oxygen at approximately 4.75 THz (i.e., approximately 63 µm or 158 cm^{-1}). The experimental setup for THz absorption spectroscopy is relatively compact, especially compared to two-photon absorption laser induced fluorescence (TALIF) setups that typically involve bulky laser systems, and the requirements for the optical alignment are not as strict as for cavity ring-down spectroscopy (CRDS). These features make THz absorption spectroscopy an attractive diagnostic technique for atomic oxygen density measurements in plasmas. We present a comparison of THz absorption spectroscopy, picosecond-TALIF (ps-TALIF) [3] and CRDS measurements of atomic oxygen densities on the same capacitively coupled radio frequency (CCRF) oxygen discharge, for a variation of the applied RF power (20 W to 100 W) and the gas pressure (0.7 mbar and 1.3 mbar). TALIF is currently the most established method for determining atomic oxygen densities and is especially known for its high spatial and temporal resolution, while CRDS is an absorption technique that yields line-of-sight integrated densities in a similar manner as THz absorption spectroscopy. We will show that the obtained atomic oxygen densities are in good agreement with each other. This demonstrates that the three different diagnostic methods can be used interchangeably, provided that no spatial resolution is required.

[1] Wubs J. R., *et al.*, Plasma Source Sci. Technol. **32** (2023) 025006.
[2] Lü X., *et al.*, Semicond. Sci. Technol. **38** (2023) 035003.
[3] Wubs J. R., *et al.*, Appl. Phys. Lett. **123** (2023) 081107.

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