Evaluation of the reliability of Rayleigh scattering as absolute calibration method for the Thomson scattering diagnostic at W7-X

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The spatially and temporally resolved measurement of plasma electron density and temperature is a key element in modern fusion experiments, and the Thomson scattering (TS) diagnostic is one of the most widespread diagnostics for this purpose. The reconstruction of the plasma parameters requires reliable and reproducible calibration factors. At Wendelstein 7-X (W7-X), two calibrations – a relative spectral calibration and an absolute calibration using anti-Stokes rotational Raman scattering of Nd:YAG laser pulses in nitrogen – are performed. The relative calibration, itself sufficient to determine electron temperature, is scaled by the separately measured absolute calibration factor to obtain the spectral absolute calibration needed for density reconstruction. Especially the relative spectral calibration, where a scattering disc and an optical fiber has to be moved in front of the observation optic, is not well suitable for remote measurements wanted for large fusion experiments like ITER. Already the W7-X project with restricted torus hall access during the experimental campaign would benefit from a remote calibration and is therefore ideally suited as a test environment.

A possible calibration candidate is the determination of the spectral response of the Thomson scattering diagnostic during Rayleigh scattering of laser pulses from a wavelength tunable optical parametric oscillator (OPO) in Argon. However, until now, only a proof-of-principle was shown [1], proposing that this remote calibration can serve for both, the relative spectral calibration and the absolute calibration. In addition, compared with the conventional calibration method, the spectral calibration using the OPO is taking into account the plasma facing optical window, which could be subject of coating during experimental campaigns – a part that is not included in the current spectral calibration.

In order to test the validity of both OPO-based calibrations, the measurements [1, 2] are repeated with improvements regarding the stability of the OPO source, the beam path and the energy measurement for all available scattering volumes of the Thomson scattering diagnostic.

[1] E. R. Scott, *et al.,* JINST 14 C10033 (2019).

[2] S. A. Bozhenkov, *et al.,* Rev. Sci. Instrum. 90 033505 (2019).

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