Overview of laser-aided plasma diagnostic developments at the Wendelstein 7-X stellarator

K. J. Brunner[1*], J.-P. Bähner[2], M. Beurskens[1], E. Edlund[3], G. Fuchert[1], D. Gradic[1], S. K. Hansen[2], J. Knauer[1], P. Kornejew[1], D. M. Kriete[4], M. Krychowiak[1], E. Pasch[1], A. v. Stechow[1], V. Perseo[1], M. Porkolab[2], Th. Wegner[1], R. C. Wolf[1]

[1]*Max-Planck-Institut f. Plasmaphysics, Wendelsteinstr. 1, 17491 Greifswald, Germany*
[2]*Plasma Science and Fusion Center, MIT, Cambridge, MA, USA*
[3]*SUNY Cortland, Cortland, NY, USA*
[4]*Auburn University, Auburn, AL, USA*

Wendelstein 7-X (W7-X) situated in Greifswald, Germany, is the largest stellarator-type fusion experiment operating today. It aims to demonstrate the quasi-isodynamic stellarator concept as a viable option for a future fusion power plant. With its plasma volume of 30 m^3, W7-X reached plasma densities beyond $2.4 \cdot 10^{20}\ m^{-3}$, as well as electron temperatures in excess of 5 keV. W7-X has recently finished its first experimental campaign with the new fully water cooled divertor, in which several record programs were conducted including an 8 min plasma with 1.3 GJ of injected energy. As such, W7-X has proven to be an exciting experiment to develop steady-state diagnostics for high-performance plasmas.

To fulfill its mission and measure its plasma's parameters W7-X is equipped with over 45 diagnostics and uses 69 lasers. Of these, 37 lasers are connected to measuring plasma parameters with 8 lasers in 4 laser-based diagnostics currently employed directly at the W7-X plasma. This includes laser blow-off in combination with spectroscopic diagnostics for impurity transport estimation, phase contrast imaging for characterization of poloidally resolved density fluctuations, Thomson scattering for core electron density and temperature profile measurement as well as dispersion interferometry for real-time density measurement and control.

In this presentation, we give an overview of the diagnostic developments conducted at W7-X in recent years as well as the work envisaged for the future. This includes developments towards real-time steady-state operation, in-situ or remote absolute calibration, high temporal resolution and even plasma actuation. We will go over the aforementioned laser-based diagnostics and their contribution to the broader plasma diagnostics community as well as some diagnostic techniques employing lasers for calibration purposes.