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Implementation of Laser-induced Fluorescence Diagnostics in ITER

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A laser-induced fluorescence (LIF) diagnostic has been designed for measuring helium density (nHe) and ion temperature (Ti) in the outer leg of the ITER divertor. The LIF diagnostic is integrated with the divertor Thomson scattering (DTS) diagnostics via common injection and collection optics. Optimisation of previously proposed spectroscopic schemes, and lasers suitable for nHe and Ti measurements are the focus of this report.
The LIF method is based on laser pumping of transitions among excited states of atoms / ions and subsequent fluorescent signal processing. Optical parametric oscillators (OPO) or dye lasers with 5-10 ns pulse duration and repetition rate of ~ 1 kHz are suitable for nHe measurements. A set of spectroscopic schemes for He I detection requires the following wavelengths of laser radiation: 388.9, 501.7, 587.6 and / or 667.8 nm. Spectral coverage of OPO and dye lasers combined with currently available power spectral densities allow to achieve a saturation threshold in all the spectroscopic schemes under consideration.
Using time-modulated lasers (P ~ 20-50 W) for the Ti measurement is discussed in spectroscopic schemes with quenching excited states via pumping to higher excited levels. A tunable ytterbium fiber laser with 1012.3 nm wavelength can be used to quench the 468.6 nm line of He II. Spectral line scanning gives Ti from the absorption line contour Doppler broadening.
Optimization of the spectroscopic schemes and estimation of the required laser parameters have been performed using dynamic collisional-radiative models (CRMs). The schemes chosen were selected via comparing differences in measurement accuracy. The laser power spectral density has been estimated by calculating saturation threshold of the selected transitions in the ITER divertor plasma.

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