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Integration of Thomson scattering and laser-induced fluorescence in ITER divertor: engineering and performance analysis

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This paper describes the benefits and challenges of divertor Thomson scattering 55.C4 (DTS) and laser-induced fluorescence 55.EA (LIF) integration in the divertor port #8 of ITER. One of the main challenges for the DTS system is to measure extremely low electron temperatures in the vicinity of the divertor plates. The cool and dense divertor plasma leads to pronounced collective effects and significant distortions of the TS spectra. Therefore, standard TS signal processing, valid for light scattering on a swarm of free electrons, is already not valid. To examine the real DTS performance, we apply a special simulation technique based on synthetic experiments. The estimated measurement accuracies of electron temperature and density are quite better than the specified technical requirements, in spite of the pronounced collective effects. On the contrary, in the case of low electron density, when the classical TS spectrum is expected, the diagnostics performance degrades significantly, though still satisfying the technical requirements. Currently, the LIF diagnostic is to measure density of Helium atoms with a collisional-radiative model (CRM) describing a relation between the fluorescence and plasma parameters. Required for CRM electron parameters are taken from DTS diagnostics. The temporal forms of the Helium fluorescence are dependent on electron parameters and the pumping laser pulse characteristics. Therefore, LIF can measure electron density in the range of 10^18 10^20 m^-3 analyzing the temporal behavior of Hellium fluorescence with the Helium CRM. This technique helps to expand the measurable range of electron density. The main advantage of this LIF measurements is that calibration of the collection system spectral and / or absolute sensitivity is not required, contrary to the DTS approach. Both DTS and LIF are laser aided diagnostics; hence, it seems attractive to develop universal laser and probing optics, which is the most sophisticated and expensive part of any ITER optical diagnostics. The engineering solutions discussed and challenges of the DTS and LIF integration includes collinear combination of DTS and LIF lasers, laser mirrors, collection mirrors, etc. Although the proposed solutions are considered in terms of ITER divertor compatibility, their use in currently operating magnetic confinement devices is also under discussion.

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