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A Study of Core Thomson Scattering Measurements in ITER Using a Multi-Laser Approach

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The electron component is the main channel for anomalous power loss, and the main indicator of transient processes in the tokamak plasma, thus electron temperature and density profiles mainly define the operational mode of the machine. All these things impose high requirements on precision, spatial and temporal resolution of the Thomson Scattering (TS) measurements. Future tokamak-reactors will be equipped with high power heating complexes including neutral beam injection, electron and ion cyclotron resonance heating (ERCH and ICRH) providing the temperatures as high as 40 keV both for electrons and ions. Pronounced relativistic effects in the TS spectra are expected in such plasma, and the complexity of TS measurement interpretation in tokamak reactors is associated with the deviation of electron velocity distribution (EVD) from a Maxwellian that can take place under a strong ECRH/ECCD. The ill-posed inverse problem of reconstructing the EVD parameters from the measured TS spectra can be solved by assuming moderate anisotropy of the EVD in electron pitch angles in the thermal and weakly/moderate super-thermal energy range and giving more freedom for a strongly non-Maxwellian, more energetic component of the super-thermal EVD.

The second problem is concerned with restrictions on the spectral window for TS spectra measurements. The blue boundary is determined by the possible strong background line radiation of Be (<550 nm). In addition, the range shorter than 450 nm is forbidden because of glass darkness due to intensive neutron/gamma irradiation effects and W and He lines. Thus, high temperature measurements are impossible for 1064 nm probing wavelength since the TS signal in the frame of the operational window weakly depends on Te. The analyses of the expected errors demonstrate that the proposed multiple probing wavelengths of Nd:YAG lasers, 1320 nm, 1064 nm, and 946 nm allow to cover a wide electron temperature range 0.5-40 keV.

Such an approach is essential in the presence of inaccessible optical components on the large fusion machines where spectral characteristics may change with time, posing a problem for the calibration of the TS diagnostic. In this paper, a particular example of the ITER core plasma TS system design is considered, and a comparative analysis of conservative and advanced approaches is given.

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