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Investigation of Te measurements discrepancies between ECE and Thomson diagnostics in high-performance plasmas in JET

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Accurate and consistent measurements of the electron temperature (Te) profile are paramount for current fusion experiments, like JET, and future devices, such as ITER. In high performance plasmas in JET and TFTR, electron cyclotron emission (ECE) measurements for central Te>5 keV were systematically found to be up to 20% higher than those taken with Thomson scattering (TS) [1, 2]. Conversely, in very high Te plasmas at FTU (Te>10 keV), TS measurements pointed to systematically higher Te values than determined with ECE [3,4]. Such differences in Te measurements could be caused by diagnostic issues (calibration, alignment), but their observation in different machines suggests the presence of an underlying physical reason. A possible cause for this discrepancy could be the presence of a sufficiently large non-Maxwellian feature in the electron energy distribution function (EDF) [5]. In fact, the two diagnostic principles probe different domains of the EDF and the ECE is sensitive to its derivative through the reabsorption term. Such non-Maxwellian features may result from the interaction of the electron population with fast ion tails which, in turn, can be caused by external heating (neutral beam injection, ion cyclotron heating), or fast alpha particles produced by fusion reactions. For recent JET discharges, central Te measurements, relying on LIDAR [6] and the X-mode ECE interferometer [7], both independently and absolutely calibrated, were studied in a large database, including DD, TT, and DT plasmas. Indeed, discrepancies could be observed outside of the experimental uncertainties for a set of high-performance discharges. ECE measurements at high Te were found to be higher or lower than those of LIDAR, depending on the specific plasma scenario. In addition, discrepancies between the peaks of the second and third harmonic ranges of the ECE spectrum, were interpreted as evidence for the presence of non-Maxwellian features, in agreement with previous results [8]. These comparisons seem to suggest that such features can be found in most of the high-performance scenarios selected in this database. The experimental observations are in good agreement with the predictions of an ad-hoc model which calculates ECE emission and absorption by an EDF perturbed with a small non-Maxwellian feature [9]. In addition, more accurate predictions with the SPECE code [10] are presented, showing the effects on the ECE spectra in more detail.

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