

Abstract

Title: ECE and Thomson Scattering Diagnostics and their relation with the Electron Energy Distribution Function: Principles, Meanings, and Formulations.

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Abstract — Electron temperature (T_e) measurements in magnetized fusion plasmas rely heavily on Electron Cyclotron Emission (ECE) radiometry and High-Resolution Thomson Scattering (HRTS). While both diagnostics are routinely used to reconstruct T_e profiles, significant discrepancies often emerge in specific operational regimes, particularly in high-performance plasmas approaching reactor-relevant conditions. This work provides a focused review of the underlying physics governing both diagnostics, with emphasis on their distinct mathematical and physical relationships with the electron energy distribution function (EEDF) $f(p)$. We highlight that while TS measures a linear functional of f itself, the ECE absorption coefficient is a linear functional of $\partial f / \partial p_\perp$, and it enters the measurement through an exponential. A perturbation that is modest in amplitude but narrow in momentum therefore produces a much larger fractional change in the absorption coefficient α than in the distribution function f . ECE is thus sensitive to structure in the EEDF that leaves the Thomson spectrum essentially unchanged — such as the bipolar kinetic perturbations considered here. This not only amplifies the discrepancy between the two measurements but also leads to a misestimation of the core T_e . By examining the underlying principles, physical interpretations, and exact mathematical formulations of both diagnostics, this paper aims to contribute to identifying and interpreting cross-diagnostic discrepancies, thereby providing insight into the physics of the core plasma under these critical conditions of increasing interest towards future reactors such as ITER and in general for burning plasmas.