## 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 Te profiles, significant discrepancies often emerge in specific operational regimes, particularly in high-performance plasmas approaching reactor-relevant conditions. This work provides a comprehensive review of the underlying physics governing both diagnostics, focusing on their distinct mathematical and physical relationships with the electron velocity distribution function (EEDF) f(v). We highlight that while Thomson Scattering evaluates a global, isotropic projection of the bulk distribution through a logarithmic derivative formulation, remaining remarkably robust against localized kinetic perturbations, the ECE absorption and emission coefficients are intrinsically tied to the directional, perpendicular derivative integrated over momentum space. Consequently, ECE exhibits an extreme sensitivity to minor, anisotropic distortions in the perpendicular velocity space, such as those induced by bipolar kinetic perturbations. This not only amplifies the discrepancy between the two measurements but also leads to a severe 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. Finally, examples comparing modelling results with JET DTE3 data are presented, utilizing the latest version of the database, which includes a rigorous evaluation of ECE experimental errors.