PHYSICS BASIS OF DISCREPANCIES BETWEEN TEMPERATURE MEASUREMENTS BY ECE AND THOMSON SCATTERING IN HIGH PERFORMANCE PLASMAS ON JET, EAST AND DIII-D

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1. INTRODUCTION

Discrepancies between the Electron Cyclotron Emission (T_ECE) and Thomson Scattering (T_TS) measurements of electron temperature were observed in plasmas heated by ECRH only (on FTU) and NBI (JET, TFTR) or NBI plus ICRH (JET) [1]. Models link these differences to the interaction of the heating systems with the electrons and then to the non-maxwellian nature of the electron velocity distribution function (EDF)[2,3]. **Studying these effects is important for ITER and for the reactor**: while the presently detected differences can be of the order of 10-20% for Te>6keV, they can increase significantly [2] for reactor plasmas where the temperature can be of the order of 30-50keV. **The need of defining the measurement of the electron temperature precisely is of highest relevance**. **Being so fundamental**, these themes are not new, the discussion started 30 years ago [3]. The radiation temperature T_r measured by ECE diagnostic systems can be extracted from the Kirchhoff theorem [4] linking T_r to the EDF and the electron emissivity $\boldsymbol{\eta_\omega}$:

$$k\,T_r = \frac{\int \eta_\omega(p)\, f(p)\, d^3p}{\int \eta_\omega(p)\,\left(\partial f(p)/\partial \varepsilon\right)\, d^3p}; \qquad S_\omega = \frac{\omega^2}{8\pi^3 c^2}\, k\,T_r \qquad (1)$$

where f(p) is the EDF (p electron momentum) and ε is the electron energy. The radiation flux S_ω, measured by the ECE diagnostics, is expressed by the Rayleigh-Jeans formula (1). Therefore, for maxwellian electrons, $\boldsymbol{T_r}$ is equal to T_e, and , for any η_ω , $\boldsymbol{T_r}$ depends on a balance between the emission and absorbtion, resulting in a dependence on the derivative of the EDF with respect to the electron energy . So the radiation temperature $\boldsymbol{T_r}$ measured by ECE is sensitive to the non-maxwellian EDF (NMEDF). On the other side the spectrum of the scattered light measured by TS is proportional to the EDF through a function of the light polarization and plasma density. The TS spectrum is fitted [5] using a relativistic maxwellian supposing that the deviation from maxwellian is small. In its essence, the difference of the temperature measurements T_ECE –T_TS is a measure of the non-maxwellian content of the EDF in the plasma. This paper presents for **the first time an intercomparison between devices**, made in the context of ITPA TG Diagnostics, of T_e measurements in JET DTE3 (third D-T campaign), DIIID and EAST pulses. Figure1a shows T_ECE vs T_TS(High Resolution TS) on JET-DTE3 campaign and Fig.1b the data, averaged on 'core channels',versus model of ECE radiation temperature using non-maxwellian bipolar perturbation: its parameters are p_0 where it is centred, δ the width in momentum space and f_0 the amplitude , p_{th} is the thermal momentum of the maxwellian EDF[2].

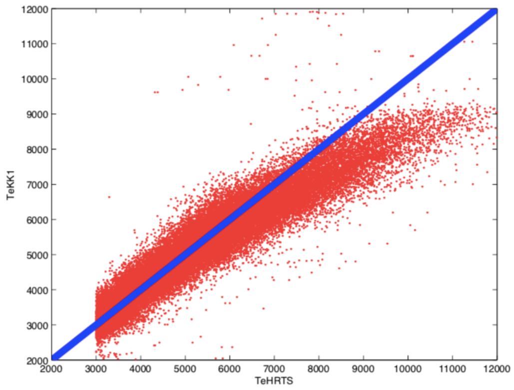

Fig.1a T_ECE(eV) vs T_TS(eV,HRTS) of DTE3

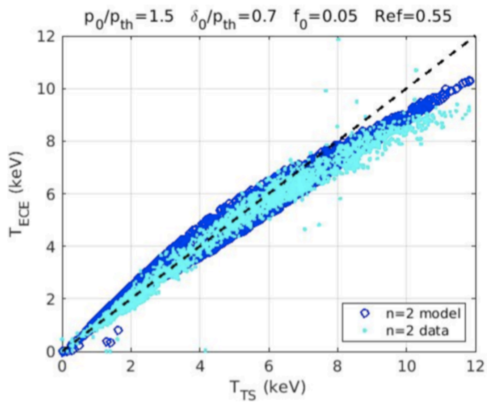

Fig.1b. DTE3 data(sky blue) vs non-maxwellian model (blue)

Comparison of TS/ECE for EAST pulses with different heating systems is shown in Fig. 2. A comparison of temperature spatial profiles is shown in Fig. 3 for a DIIID pulse #191947.

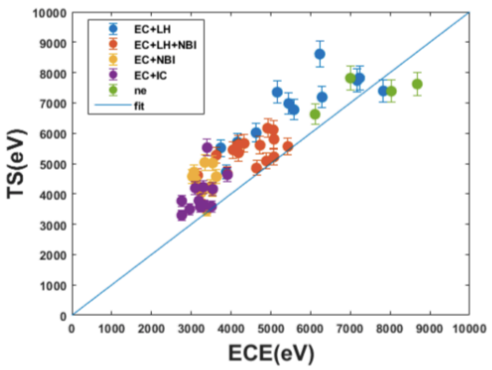

Fig.2 T_TS vs T_ECE in EAST

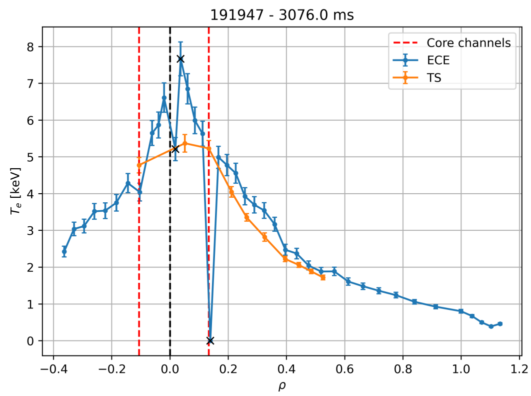

Fig.3 . T_ECE vs T_TS spatial profiles on DIIID

This paper reports **for the first time:** a comparison between T_ECE and T_TS made on i) JET DTE3 pulses ; ii) on EAST in pulses with different heating systems; iii) the spatial profile comparison on DIII-D . ITPA Activity on 'High Temperature measurements' is dedicated to comparative analysis of databases and testing on experiments the effects of heatings on EDF.

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