Development of main ion CXS for ion heat and momentum transport studies on JET-ILW

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The changeover to the Be/W wall on JET has resulted in a deterioration of the quality of the ion temperature and rotation data from intrinsic impurity based charge exchange spectroscopy [1]. Following promising results in fitting the main ion D_α CX spectrum as a byproduct of beam emission studies [2] and successes elsewhere [3], the use of this technique on JET was gradually further developed using the existing CXS spectrometers. Good results were obtained in a variety of scenarios using either beam blips or notches for background subtraction. The use of the existing hardware however meant that impurity and main ion CXS data could not be collected simultaneously along the same lines of sight, which has restricted routine use and hampered detailed validation. Therefore, a core CXS upgrade project with joint funding from ORNL (DOE) and EUROfusion was launched to install new spectrometers for impurity based CXS and dedicated main ion CXS spectrometers during the 2017 shutdown. This allows simultaneous main ion and impurity data collection along co- and counter-NBI sightlines using dichroic beam splitters with a cut-off around 600nm [4].

The scientific motivation for improving T_i data on JET is multiple: improving the empirical understanding of ion heat transport (with an emphasis on isotope effects), guiding scenario development towards higher ion temperatures and validating the performance of pulses during DTE2. In this poster, we outline the strategy for the use of main ion CXS for studying the isotope effect on heat transport, presenting data collected in previous campaigns along with first data from the upgraded diagnostic.

To answer the question if the reduction in global core confinement with lower isotope mass can be reconciled with local gyro-Bohm transport, highly accurate ion temperature gradient measurements are needed. Main ion CXS has first been applied to study the ion heat transport in a set of ohmic deuterium and hydrogen plasmas with a substantial difference between ion and electron temperatures [5]. The reduction in confinement in hydrogen could largely be attributed to the increased equipartition heat flux in a plasma dominated by ion heat transport due to the lower critical gradient for ion profile stiffness. Despite this accounting for most of the confinement drop in hydrogen, the local heat diffusivity from power balance was still larger in hydrogen than could be explained by modelling the effects of equipartition on the temperature profiles. Extending these studies to higher density and power is challenging due to a strong decrease in the electron and ion temperature difference, making a species resolved analysis more prone to uncertainties in the data. A systematic difference between the main ion and impurity T_i has so far prevented the use of main ion CXS for a species resolved analysis. A preliminary analysis using the main ion CXS data collected in hydrogen L- modes still shows that the heatflux is dominated by the ion channel. We aim to use the enhanced diagnostic capabilities to reduce the systematic uncertainties in the T_i profiles and collect the corresponding deuterium data with the upgraded diagnostic in the next campaign. Later, the studies will be extended to higher power scenarios with $T_i > T_e$ as equipartition changes sign and the electron heatflux is expected to become more dominant.

[1] S. Menmuir et al Rev. Sci. Instrum. 85, 11E412 (2014); [2] E. Delabie et al., Plasma Phys. Control. Fusion 52 (2010) 125008; [3] B. A. Grierson, et al Physics of Plasmas 19, 056107 (2012); [4] N. Hawkes et al., submitted to Rev. Sci. Instrum (HTPD 2018); [5] E. Delabie et al Proceedings of 44th EPS Conference on Plasma Physics, ECA, 41F P4.159 (2017)

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