EFDA
EUROPEAN FUSION DEVELOPMENT AGREEMENT
JET

EFDA–JET–CP(02)07/03

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Improved Plasma Confinement by Ion Bernstein Waves (IBWs) Interacting with Ions in JET

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* *See annex of J. Pamela et al, "Overview of Recent JET Results and Future Perspectives", Fusion Energy 2000 (Proc. 18th Int. Conf. Sorrento, 2000), IAEA, Vienna (2001).*

Preprint of Paper to be submitted for publication in
Proceedings of the 19th IAEA Conference, (Lyon, France 14-19 October 2002)

For the first time a new scheme for excitation of ion Bernstein waves (IBW) by mode conversion (MC) of externally launched electromagnetic fast waves (FW) has been tested in a D-^{3}He plasma of the JET tokamak. Rather than aiming at localised electron heating close to the mode conversion layer as in standard mode conversion heating experiments [1], the present scheme aims at IBW power absorption by deuterons at the fundamental cyclotron resonant layer, located on the high field side near the plasma edge. This scheme allows to avoid, in principle, the non-linear interactions of the RF power with the plasma edge, typically present in the standard IBW coupling experiments by MC of externally launched slow electrostatic plasma waves [2]. The main goal of the experiment is to obtain an internal transport barrier, due to local IBW-induced ExB sheared plasma flows that, in turn, can suppress the ambient turbulence [3].

According to modeling result [4] and to indication of ion flux by Neutral particle Analyzer, 2MW of IBW power is available for damping on deuterons. A poloidal sheared flow with a peak rotation velocity of 80 km/s per MW of IBW coupled power should be produced, and turbulence suppression should be obtained. In the present experiment, an ExB shearing rate of 5MHz, exceeding the threshold expected for turbulence suppression (0.8MHz), is observed near the edge (see Fig.1). In the same region, transport analysis shows a reduction of the electron thermal diffusivity, and the plasma electron pressure increases in a wide plasma volume ($\rho \leq 0.8$) bounded by the region of transport reduction (see Fig. 2). An analogous behaviour is observed for the ion species, and suggests an improvement of the confinement similar to that observed in other regimes like internal transport barrier (ITB).

The improvement confinement regime persists during the whole FW power pulse (6s). The energy confinement time increases by 50%. inside the plasma the volume $\rho \leq 0.8$, which covers more than 80% of the overall plasma volume. The robustness of the improvement confinement achieved was tested in all the discharges obtained in the present new IBW launching scheme. The reference shot was performed in similar conditions, but with a central heating power density a factor 4 higher (provided by electron heating in the standard FW-MC scheme). The obtained plasma energy was 50% lower, confirming the better confinement achieved in the IBW scheme. The sheared plasma flows, related to transport reduction, seem saturate during the Ion cyclotron heating (ICRH) power ramp up at a power level of about 1MW. Therefore, higher plasma energy content might be obtained by devoting some of the installed ICRH power for plasma heating, and the remaining for the present FW-IBW MC scheme. Such scenario will be tested in the next experimental campaign of JET.

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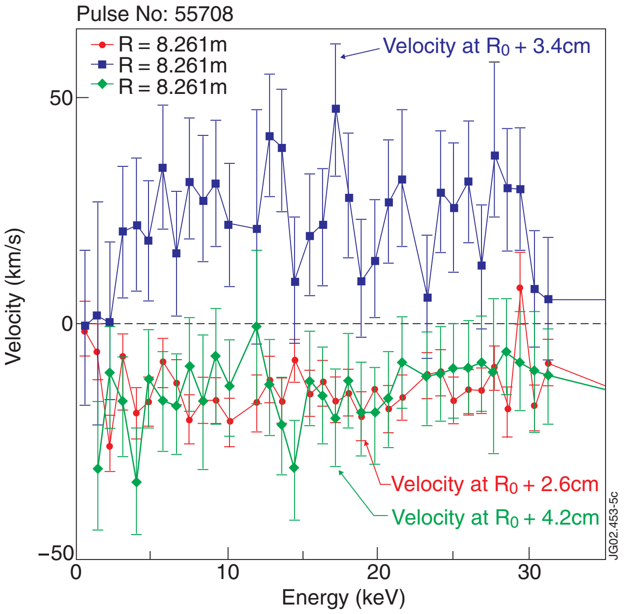

Figure 1: Time evolution of the line of sight impurity velocity measured by CXS diagnostics (shot 55708). A velocity of 35± 14 km/s is observed at the radial location R=3.834 m. Along the adjacent chords, at R=3.826 m and R=3.842 m, the velocity direction is opposite (16±5 km/s). The resulting velocity derivative (5 MHz) provides the main contribution to the shearing rate.

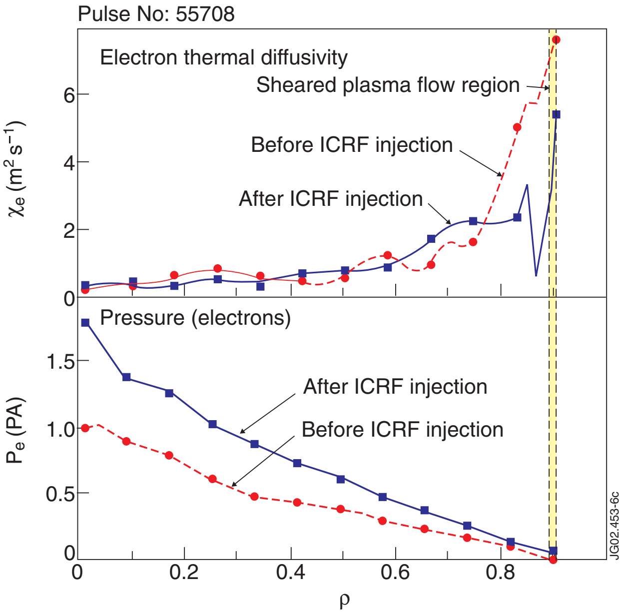

Figure 2: Profiles of the electron thermal diffusivity and electron plasma pressure before and during the IBW phase.