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Confinement modes and magnetic-island driven modes in the TJ-II stellarator

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Magneto-hydrodynamic (MHD) activity is ubiquitous in magnetic confinement plasmas and is related with confinement states. Particularly, confinement quality in TJ-II plasmas is intimately linked to the location and behaviour of magnetic resonances in the plasma column, which often manifest themselves as magnetic islands. Two main physical processes have been identified that relate confinement and magnetic-island driven modes, always in the low-frequency range of magnetic spectra: magnetic-island-induced Alfvén eigenmodes (MIAE) with frequencies normally below helicity-induced but above beta-induced eigenmodes (BAE, ˜20 kHz) under NBI heating; and island rotation yielding frequencies generally below 100 kHz in both ECR and NBI heated plasmas.

MIAEs behave like shear-Alfvén waves. They are identified under the hypothesis that non-rotating islands add well-defined helicities to the B-field spectrum and, in presence of rotating islands, new modes at composed frequencies are also excited. This is a first link between magnetic islands and AEs in stellarators [1]. Island-AE couplings open the possibility of energy channeling between MHD scales [2], with such consequences as bridging fast-particle energy towards dissipation scales through wave energy cascading.

Island rotation modes are normally seen when the main magnetic resonances are located in the outer half of the plasma. Stable rotation can be found in ECR and NBI L-mode plasmas, both at a frequency compatible with ExB rotation [3]. In H-mode plasmas the rotation speed tends to increase but the mode dims noticeably or becomes undetectable. Unstable rotation with chirping-down frequencies is found at the threshold between L- and H-modes of confinement and can be ascribed to the diamagnetic rotation of the same islands chain in the ExB frame [3]. The chirping is due to a repetitive breaking of a transport barrier located at or by the magnetically resonant region, and it provokes typical I-mode phenomenology [4].

[1] Sun B J et al. 2015 Nucl. Fusion 55 093023
[2] Chen W et al 2014 Europhys. Lett. 107 25001
[3] Sun B J et al., 41st EPS Conference Berlin, Germany, 2014, Vol, 38, P2.090
[4] Whyte D G et al 2010 Nucl. Fusion 50 105005

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Primary author: Dr LÓPEZ-BRUNA, Daniel (CIEMAT)

Co-authors: Mr SUN, Baojun (CIEMAT); Dr OCHANDO, M A (CIEMAT); Dr PEDROSA, M A (CIEMAT)

Presenter: Dr LÓPEZ-BRUNA, Daniel (CIEMAT)

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