New insights into cryogenic and TESPEL pellet physics in TJ-II

I. García-Cortés[1*], K. J. McCarthy[1], N. Tamura[2], A.V. Melnikov[3,4,5], N. Panadero[1], E. Ascasíbar[1], M. Drabinskiy[3], L. G. Eliseev[3], T. Estrada[1], J. Hernández-Sánchez[1], P. Khabanov[3], A. S. Kozachek[6], M. Liniers[1], S. E. Lysenko[3], D. Medina-Roque[1], P. Medina[1], M. A. Ochando[1], J. L. de Pablos[1], I. Pastor[1], C. Toledo[7], B. van Milligen[1] & TJ-II team[1]

[1]*Laboratorio Nacional de Fusión, CIEMAT, Madrid, Spain*
[2]*National Institute for Fusion Science, Toki, Japan*
[3]*National Research Centre 'Kurchatov Institute', Moscow, Russian Federation*
[4]*National Research Nuclear University 'MEPhI', Moscow, Russian Federation*
[5] *Moscow Institute of Physics and Technology, Dolgoprudny, Moscow region, Russian Federation*
[6]*Institute of Plasma Physics, NSC KIPT Kharkov, Ukraine*
[7]*Facultad de Ciencias Físicas, Universidad Complutense de Madrid, Madrid, Spain*

Pellet injectors (PI) are operated on many medium- and large-sized magnetic confinement devices. For instance, cryogenic PI is essential to achieving efficient plasma fuelling, in particular in large fusion devices. In contrast, tracer PI is used to investigate impurity transport and confinement, *e.g*., TESPEL [1]. Both types are used on W7-X, LHD and TJ-II as tools to study scenarios to achieve efficient core fuelling and avoid impurity accumulation in stellarators. Despite much progress, a complete comprehension of the physics involved in pellet ablation, particle drift and diffusion, as well as efficient fuelling remains outstanding. However, given the shared physics, comparative experiments using both pellet types can provide new insights and understanding into physics processes and plasma response.

A cryogenic PI is operated on TJ-II, a heliac-type stellarator. In parallel, a TESPEL system is piggybacked to its up-stream end to create a unique tool for pellet research in plasmas [2]. TJ-II is also fitted with a wide variety of diagnostics that can provide unique insights into pellet physics and post-injection plasma response, *e.g*., a dual HIBP system, magnetic-coil arrays, a 2-channel Doppler reflectometer, and a high-resolution Thomson scattering system [3]. Here, novel comparative experiments reveal strong plasmoid deceleration close to rational surfaces (inducing short-lived magnetic instabilities during ablation), show that post-injection reductions in broadband magnetic fluctuations can be associated with temperature gradient changes, and indicate that post-injection frequency jumps in NBI-driven Alfvén eigenmodes are dominated by plasma mass density changes. The analysis of density and potential fluctuations, measured simultaneously at 2 toroidal positions by the HIBP system, provides additional insights. Details of the experiments and findings, plus their implications for pellet injection physics, are presented and discussed.

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[2] K. J. McCarthy et al., Europhys. Lett. 120 (2017) 25001.
[3] K. J. McCarthy, J. Instrum. 16 (2021) C12026.