Modelling 3rd harmonic Ion Cyclotron acceleration of D beam for JET Fusion Product Studies experiments

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Fusion products will play a crucial role in future tokamak fusion devices: alpha particles are mainly aimed at sustaining fusion reactions and reach the ignition, while other fusion products are also used for diagnostic purposes. For this reason it is essential to fully understand their behaviour in present day tokamaks. To this prospect, 2014 JET fusion product studies experiments were based on ICRH 3rd harmonic heating of D beams in order to generate a MeV range D tail to enhance D-D and D-He3 fusion reactions and study confined and lost fusion products with dedicated diagnostics and modelling tools.

These experiments have demonstrated a clear production of fast ion D tail, visible from neutron [1] and gamma-ray [2] diagnostics. Proper modelling is required to ensure the correct interpretation of these data and to go beyond actual measurements by simulating the ion dynamics with time-evolving power references.

SPOT [3] is an orbit following Monte Carlo code recently extended with the RFOF [4] library for simulating the interaction between ions and ICRF waves in the context of the quasilinear theory. The SPOT/RFOF package has been run in association with the EVE full wave code for ICRF heating [5], and the NEMO beam deposition code [6] to simulate the relevant discharges including the NBI+ICRH synergy.

A comparison of the ion distribution and high energy cutoff between the SPOT/RFOF code and the neutron and gamma-ray spectroscopy is presented, showing an overall good agreement. Diagnostic sensitivity according to their line of sight is explored. PION [7] and SELFO-light [8] simulations are also included for comparison. In addition, the fast D tail decay/sustainment when switching off NBI and ICRF heating sources is presented. The ICRF heating efficiency according to the geometry of the beam injecting Positive Ions Neutral Injectors (PINIs) is analysed. Finally, a sawtooth activity has been observed in some discharges, which has been interpreted using SPOT/RFOF simulations in the framework of Porcelli’s theoretical model: NBI+ICRH accelerated ions have a strong stabilizing effect, yet sawtooth crashes occur, due in particular to tornado modes induced by fast ions [9].

* See the Appendix of F. Romanelli et al., Proceedings of the 25th IAEA Fusion Energy Conference 2014, Saint Petersburg, Russia 2.