Integrated Modeling of MHD Induced Alpha Particle Losses in JET DT Plasmas

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Alpha particle confinement is crucial for sustaining burning plasmas and designing future reactor concepts. Along with classical/prompt losses, various MHD instabilities can lead to wave-particle interactions which can transport alpha particles outward from the plasma. This can result in a reduction in plasma heating/performance, and, at worst, damage in-vessel components. JET's recent DT campaigns in 2021-2023 have produced numerous alpha particle loss measurements with its scintillator probe and Faraday cup array fast ion loss detectors (FILDs) [1]. This presentation will report on integrated transport modeling in support of these measurements. The modeling is accomplished with the TRANSP [2] and ORBIT-kick [3] codes with the use of recently developed reduced models [4] which calculate mode structure, amplitude, and the evolving dynamics. In particular, the ORBIT-kick model quantifies the resonant transport of the alphas. When possible, constraints and comparisons to experiment are conducted with some mode structures taken from analytic theory. Case studies are performed on a variety of MHD, including: fishbones, neoclassical tearing modes (NTMs), and sawtooth crashes. Additionally, a special case of an alpha-driven toroidal Alfvén eigenmode (TAE) [5] is briefly discussed, where modeling showed marginally weak alpha losses and was unable to support experimental observations. Coupled effects between a NTM and toroidal field ripple are presented and were unable to replicate the observations in lost particle pitch but did duplicate the localized flattening of the measured neutron profile [6]. Additional modeling results compare the spatial loss profile, magnitude of losses, and energy/velocity-space sensitivities against experimental observations/measurements for each scenario.

References

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