The challenge of auxiliary fast ion tail generation in Wendelstein 7-X

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Wendelstein 7-X (W7-X) is a large superconducting stellarator in Greifswald, Germany. This device is optimised for the confinement of fast particles and aims at demonstrating the quasi-isodynamic stellarator as a viable concept for a fusion reactor where good confinement of alpha particles is essential. In W7-X, fast ions will be generated either using Neutral Beam Injection (NBI) or Ion-Cyclotron Resonant Heating (ICRH). As shown in Refs. [1-2], and reviewed here, the current NBI design is not an optimal fast ion source because of its rather poor penetration and rapid loss of injected particles. In contrast, ICRH does not suffer from accessibility issues and can deposit power directly in the plasma centre and generate possibly generate confined fast particles. For modelling ICRH in strongly 3D plasmas, the SCENIC [3] modelling package consists of 3D codes capable of self-consistently calculating the fast ion tail generated by ICRH. The equilibrium code ANIMEC [4] computes W7-X anisotropic equilibria and inputs this into the 3D anisotropic full wave code LEMan [5-6], which calculates the wave field which propagates from a prescribed and realistic antenna excitation. The particle orbit solver VENUS-LEVIS [7] is used to solve for the particle trajectories in this equilibrium and applies Monte Carlo operators for the modelling of Coulomb collisions and ICRH wave-particle interactions. We apply this package to assess the capability of fundamental ICRH scenarios, such as minority heating or three-ion species scheme [8], to generate a significant fast ion population in W7-X. A detailed study into the physics of fast particle confinement in 3D fields enables further optimisation of the ICRH antenna and the plasma in order that a large fast ion tail can be generated.

References

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