Alpha channeling by inverse nonlinear damping of ion Bernstein waves

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Second harmonic cyclotron damping of mode-converted ion Bernstein waves on minority Tritium ions in D-H(T) tokamak plasma has been proposed as an efficient method to improve the fusion yield expected in thermal equilibrium [1]. Despite the dilution due to the presence of the Hydrogen, which is necessary to allow the mode conversion of the fast magnetosonic waves, the acceleration of T ions in the energy range of 50-100 keV, i.e. near the peak of DT fusion cross section, produces higher reactivity than the ideal isotopic blend DT at thermal equilibrium for the same kinetic profiles. In this scenario, IBW nonlinear inverse Landau damping on the fusion alpha particles might be observed at Doppler-shifted half-integer resonant layer $\omega = (3/2)\Omega_\alpha + k_\parallel v_\parallel$ (Fig. 1). The nonlinear RF-induced diffusion tensors in velocity and physical space are here derived in the frame of single-particle dynamics. We then discuss numerical solutions of the relevant Fokker-Planck equation, taking into account the collisions of the alpha particles with the plasma background as well as the source and sink terms. During the time evolution of the alpha particle distribution function towards the steady state, inverse nonlinear Landau damping might channel a fraction of the alpha power into the ion Bernstein wave power. This will provide a method for implementing the concept of alpha channeling [2].

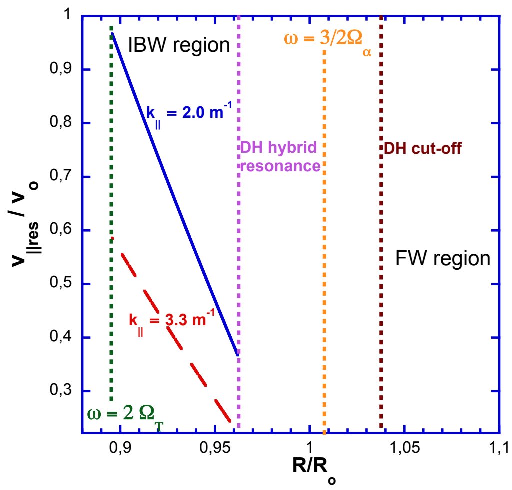

Fig. 1. Scheme of alpha power channeling in tokamak plasma with isotopic composition such that $n_H/n_D = 0.9$ and $n_T/n_e = 0.05$ and magnetic field on axis is $B_o = 2.8\,T$. The FW are coupled from the low field side, at the operating frequency $f_o = 32\,MHz$. The resonant parallel velocities $v_{\parallel,res}$, normalized to the velocity v_o at the peak (3.5 MeV) of the a source energy spectrum, are shown for parallel wavenumber $k_\parallel = 3.3\,m^{-1}$ (red, dashed line) and $k_\parallel = 2.0\,m^{-1}$ (blue, continuous line). Here R is the major radius coordinate and R_o is the position of the magnetic axis.

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