Shear Alfvén Waves In ITER Plasmas And The Ion-Ion Hybrid Resonator

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An investigation is made of the properties of shear Alfvén waves for burning plasma conditions in ITER to assess the possibility that an ion-ion hybrid resonator may be formed spontaneously. The presence of two ion species (Deuterium and Tritium) and the inherent longitudinal gradients in the total magnetic field provide the necessary elements for such a structure. The resonator concept is based on established observations. Experiments performed in a large, linear magnetic confinement device operating with two ion species have observed the reflection of shear Alfvén waves when the wave frequency matches the local ion-ion hybrid frequency [1]. In the same device, but operating with a magnetic well configuration, the formation of resonator modes has been demonstrated [2]. In a research tokamak, waves launched by a small antenna have been observed [3] to experience guided propagation along field lines, and to exhibit strong poloidal localization determined by the value of the ion-ion hybrid frequency. The present analytical and modeling study explores how the challenging environment of burning plasmas modify the trapping properties of such modes.

It is identified that the high ion temperatures introduce a dependence of the reflection points of the resonator modes on perpendicular wave number. A one-dimensional WKB analysis based on the kinetic dispersion relation is used to determine the eigenfrequencies of trapped modes. It is found that ion cyclotron damping limits the possible resonator modes to a narrow bandwidth (on the order of 500 kHz) above the local ion-ion hybrid frequency on the outboard side of a given magnetic surface. Within this bandwidth several weakly damped resonator modes can be found. The modes experience strong poloidal localization (ranging from 10 to 50 degrees) about the midplane. The interaction of fusion-born alpha particles with resonator modes results in roughly three e-foldings of amplification in one wave-transit through the resonator.

[1] S. T. Vincena, G. J. Morales, and J. E. Maggs, *Phys. Plasmas* **17**, 52106 (2010).
[2] S. T. Vincena, W. A. Farmer, J. E. Maggs, and G. J. Morales, *Phys. Plasmas* **20**, 012111 (2013).
[3] G. G. Borg and R. C. Cross, *Plasma Phys. Contr. F.* **29**, 681-696 (1987).