Physics of Energetic Particles and Alfvén Waves

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Hydromagnetic Alfvén waves are fundamental low-frequency electromagnetic oscillations in magnetized plasmas, which are found to be prevalent in nature and laboratory. For example, they are often found to be excited by energetic charged particles in space and fusion plasmas.

Due to their lower frequency and near incompressibility, shear Alfvén waves are generally easier to be excited than compressional Alfvén waves. Furthermore, due to their anisotropic nature, the linear wave propagation and dispersiveness of shear Alfvén waves are affected by plasma nonuniformities and magnetic field geometries, such as the existence of continuous spectrum, spectral gaps, and discrete eigenmodes in toroidal plasmas.

This work reviews linear as well as nonlinear physics of shear Alfvén waves and their self-consistent interaction with energetic particles in toroidal fusion devices. More specifically, the linear analysis focuses on wave spectral properties and collective excitations by energetic particles via wave-particle resonances. Meanwhile, the nonlinear physics deals with nonlinear wave-wave interactions as well as nonlinear wave-energetic particle interactions. These topics are presented within a single unified theoretical framework [1], where experimental observations and numerical simulation results are referred to elucidate concepts and physics processes [2].

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References

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