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Gyrokinetic investigation of the nonlinear interplay of Alfvén instabilities and energetic particles in tokamaks

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Alfvén Eigenmodes (AE) are global instabilities excited by energetic particles (EP) in magnetic fusion devices. AE can redistribute the EP population across flux surfaces, making the plasma heating less effective, and leading to additional loads on the walls. The interplay of AEs and EPs is investigated by means of gyrokinetic particle-in-cell simulations, with a nonperturbative approach. The global nonlinear codes ORB5 and EUTERPE are used for such studies. Both wave-particle and wave-wave nonlinearities are considered and various aspects of the nonlinear dynamics are addressed separately, by artificially switching off other nonlinearities. When concentrating on the wave-particle nonlinearity, a detailed study of the saturation is performed, as a consequence of the redistribution of the EP population in phase-space. A comparison with GK-MHD hybrid codes is also presented. When allowing wave-wave nonlinearities to occur with a zonal structure, the saturation level of the AE is observed to be drastically reduced. As a consequence, a much lower redistribution of EP is observed with respect to the case where only the wave-particle nonlinearity is allowed. Finally, numerical simulations of multiple modes with different toroidal mode number are also presented.

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