Global gyrokinetic simulations of electromagnetic turbulence in stellarator plasmas

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Turbulence plays an important role in stellarators, particularly if the neoclassical losses have been reduced by optimization of the magnetic field. Confinement has been studied in Wendelstein 7-X experiments, and these have been accompanied by nonlinear gyrokinetic simulations, but most of the latter have been performed in a flux tube. However, other than in an ideally axisymmetric tokamak, stellarator flux tubes are not equivalent to each other, there is no good way to incorporate the ambient radial electric field, and simulations of the Kinetic Ballooning Mode (KBM) turbulence can be problematic in a flux tube. To resolve these issues, a global approach is needed. Simulations in the electromagnetic regime which are mandatory for the KBM problem represent a particular challenge. In this presentation, global electromagnetic turbulence is addressed in stellarator geometry using the gyrokinetic particle-in-cell code EUTERPE. The evolution of the turbulent electromagnetic field and the plasma profiles is considered at different plasma beta and for different magnetic configurations of Wendelstein 7-X. It is found that turbulence is linearly driven at relatively high toroidal mode numbers. In the nonlinear regime, lower toroidal mode numbers, including zonal flows, are excited resulting in a quench of the linear instability drive. The turbulent heat flux is outward and leads to the nonlinear relaxation of the plasma temperature profile. The particle flux is inward for the parameters considered. The effect of the parallel perturbation of the magnetic field on the stellarator turbulence is addressed.