Summary

Nonlinear effects are important to RF heating and current drive for tokamak. For example, 'Density limit' for LH waves has been observed in many experiments recently, which is believed to be related to nonlinear parametric decay instabilities.

Traditional simulation methods (WKB and full wave) can not address nonlinear physics. In this work, we develop global particle simulation approach to study nonlinear physics of RF waves (nonlinear wave-particle interaction, ponderomotive effects, parametric decay instabilities etc.)

- ✓ Particle simulations of LH waves have been developed in tokamak geometry for the first time, which has been verified for LH propagation and linear mode conversion. Linear simulations show that toroidal effects and wave diffractions cause upshift and broadening of the parallel spectrum of LH waves.
- ✓ Nonlinear simulations demonstrate that current can be driven by LH waves, that LH wave amplitude is locally enhanced due to the particle trapping, and that LH pump wave can decay into an ion plasma wave and a LH sideband wave.
- ✓ Fully kinetic (6-D Vlasov) ion orbit time-integrator is used for nonlinear simulation of ion Bernstein wave parametric decay instability, which is verified with theory.
- ✓ Electromagnetic theory for the parametric instability of the LH wave has been developed, which shows that the electromagnetic effects-induced nonlinearities can not be ignored in the SOL region. A series of theoretical studies of the electromagnetic effects on the LH-PDIs have been given for the first time.