Nonlinear Gyrokinetic Theory and its Applications to Kinetic Alfvén Waves

Liu Chen[1,2,3], Fulvio Zonca[3,1] and Yu Lin[4]

[1]Institute for Fusion Theory and Simulation, Department of Physics, Zhejiang University, Hangzhou, China

[2]Deptartment of Physics and Astronomy, University of California, Irvine, USA

[3]Center for Nonlinear Plasma Science and C.R. ENEA Frascati, C.P. 65, Frascati, Italy

[4]Physics Department, Auburn University, Auburn, AL 36849-5311, USA

e-mail (speaker): liuchen@zju.edu.cn

In realistic inhomogeneous magnetized plasmas, due to the existence of the shear Alfvén wave (SAW) continuous spectrum, finite-amplitude kinetic wave Alfvén (KAW) with perpendicular wavelength in the order of ion Larmor radius can be readily excited either externally or spontaneously. Since KAWs carry finite electric field parallel to the confining magnetic field, they are expected to play crucial roles in the heating, acceleration and cross-field transport of plasmas. In order to delineate and understand the above nonlinear phase-space dynamics of charged particles, we need to explore and develop physical insights on the nonlinear dynamics of KAWs. A powerful analytical as well as computational tool for such studies is the nonlinear gyrokinetic theory. In this talk, we will first give a brief review on the formalism of the nonlinear gyrokinetic equation and then apply it to the KAWs. Specifically, we will present both analytical and simulation studies on (i) KAW parametric decay instability, and (ii) spontaneous excitation of convective cells by KAW. Both studies demonstrate, in contrast to simplified dynamic descriptions, the crucial qualitative and quantitative roles kinetic effects play in the nonlinear processes. If time allows, we will also discuss a new low-frequency simulation model based on the nonlinear gyrokinetic theory; which is applicable to simulating KAW physics in realistic plasma geometries.

References

[1] L. Chen, F. Zonca and Y. Lin, Rev. Mod. Plasma Phys. **5**, 1 (2021)

[2] L. Chen, H.T. Chen, F. Zonca and Y. Lin, Science China Physics, Mechanics and Astronomy, **64**, 245211 (2021)