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Extended Bounce-Kinetic Model Turbulence Simulations with Trapped Particles

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Bounce-kinetic model based on the modern nonlinear bounce-kinetic equations[1] has been used for gKPSP[2] gyrokinetic simulations and produced useful and encouraging results[3]. However, magnetically trapped particles were treated as deeply trapped in those TEM and ITG simulations. This presentation reports on an extension including the barely trapped and barely passing particles. This will allow simulations addressing the precession reversed particles' effect, reversed shear plasmas, and more precise neoclassical polarization shielding[4,5]. Modern bounce-kinetic equation advances the bounce-center distribution function $\mathrm{F}(\bar{Y}_1, \bar{Y}_2, \bar{\mu}, \bar{J})$ according to

$$\frac{\partial}{\partial \mathrm{t}} F + \frac{d\bar{Y}_1}{dt}\frac{\partial \mathrm{F}}{\partial \bar{Y}_1} + \frac{d\bar{Y}_2}{dt}\frac{\partial \mathrm{F}}{\partial \bar{Y}_2} = 0, \qquad (1)$$

where $\bar{Y}_1$ and $\bar{Y}_2$ are bounce-averaged magnetic flux coordinates of gyrocenter, $\bar{\mu}$ and $\bar{J}$ are the first and the second adiabatic invariant respectively. With the total bounce-center Hamiltonian including the perturbation $\langle \mathrm{H} \rangle$, $\frac{\mathrm{d}\bar{Y}_1}{\mathrm{dt}} = \frac{c}{q}\frac{\partial \langle H \rangle}{\partial \bar{Y}_2}$ and $\frac{\mathrm{d}\bar{Y}_2}{\mathrm{dt}} = -\frac{c}{q}\frac{\partial \langle H \rangle}{\partial \bar{Y}_1}$ describe the motion of bounce-centers. While the expression of $\bar{J}$ in terms of particle's energy and pitch angle is well-known in terms of elliptic functions[6], their inversion is necessary to express Maxwellian distribution in terms of the action-angle variables. This is straight-forward for deeply trapped particles. We will present analytic expressions for barely trapped and barely passing particles in terms of Lambert function. Initial simulation results using this scheme will be reported.

References

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