Issues for Gyrokinetic Edge Turbulence

B. Scott

Max Planck Institut für Plasmaphysik
Euratom Association
D-85748 Garching, Germany

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Criteria for Edge Turbulence

- adiabatic response is present
  - ◦ required for correct representation of drift wave dynamics
  - ◦ automatic in a gyrokinetic model
  - ◦ note edge turbulence is not an MHD process; often does not follow strongest linear instability

- drift scale ρ_s is resolved
  - ◦ required to recover the drift wave nonlinear instability
  - ◦ issue of computation, independent of model
  - ◦ artificial diffusion coefficient no larger than 0.03 in gyro Bohm units
  - ◦ note that artificial diffusion will be required to recover a saturated state:
    a result of nonadiabatic density nonlinearity
    collisional dissipation not enough by itself unless ρ_e is resolved (not feasible present day)

- geodesic curvature mechanism is present
  - ◦ required for correct representation of zonal flow statistical equilibration
  - ◦ almost automatic in a fluid or gyrofluid model: curvature acts on zonal potential
  - ◦ very subtle in a gyrokinetic model:
    ExB velocity advecting background F must not be divergence free
    nonlinear trapping involving potential and curv drift required for phase space conservation

- note at present most models break energy conservation in basic formulation
  - ◦ conservation in geodesic transfer and other mechanisms
    very central to physics of zonal flow/turbulence interaction

What Gyrokinetic Equation Must Keep

- all species nonadiabatic
- parallel magnetic potential
- toroidal divergence of advecting ExB velocity
- phase space conservation
- energy conservation
  - fields plus particles, not just particles
  - i.e., not enough simply to have equation for f in divergence form
- energy conserving collisions
  - note simple formulations may not conserve energy
- recall resolution is a matter of ...
  - grid spacing, for continuum models
  - particle density, for discrete particle/cell models
- recall nonlinear cascade and hence dissipation goes through f, not fields
  - reason for requiring some form of high-$k_\perp$ entropy removal directly in f