The Gyrokinetic Regime
Geometry
Velocity Space
Linear How-To

Coordinates

- Recall GS2 uses energy E and pitch angle $\lambda = \mu/E$
- λ grid is divided into trapped and untrapped regions
- Untrapped pitch angle resolution determined by `ngauss`
- Select `ngauss` from this list:

$$1, 2, 3, 4, 5, 6, 8, 10, 12, 16, 20, 24, 32, 40, 48$$

Why Choices are Restricted

- E, λ grids used in collision operator & source integrals

- The energy grid and the untrapped component of the pitch angle grid are pseudo-spectral to improve accuracy

- Simpler rules like

$$\int_a^b f(x)\,dx = \sum_{i=1}^{N} f(x_i) w_i$$

integrate polynomial of degree $N+1$ accurately over finite domain with equally spaced grid points.

Pseudo-spectral grids (Gaussian quadrature)

- But, use freedom to choose x_i to minimize error; increases degree of polynomials that are exactly integrated to $2N+1$.
- No free lunch: x_i, w_i must be precomputed.
- Precomputed untrapped pitch angle grids hardwired.
- Upgrade expected soon, following Candy & Waltz
- Energy grid already upgraded...

Energy Grid

- Two choices for energy grid discretization available

- Namelist `le_grids_knobs`, `advanced_egrid = T` selects the Candy-Waltz algorithm and is the default. With this choice:

  1. Set `negrid > 1` (any integer)

  2. Set `ecut` $\sim$ `6.0`

- Otherwise (to compare with old results, mainly), consult website for guidance.

Energy Grid: Note for Developers

- Internally, the energy grid is normalized according to the definition $v_t \equiv \sqrt{2T/m}$ regardless of any choices in the input file.

- It is possible to turn off trapped particles, but this option is not fully supported yet and may not work.

Collision Operator

- Lorentz collision operator:

$$C(f) = \frac{\nu(E)}{2}\frac{\partial}{\partial\xi}(1-\xi^2)\frac{\partial f}{\partial\xi}$$

  with optional momentum-conserving terms allowed (but not recommended!)

- For example, for electron-ion collisions:

$$\nu(E) = \frac{\nu_{ei}}{(v/v_{te})^3}\left[Z_{\text{eff}} + \frac{v_{te}}{v\sqrt{\pi}}e^{-(\frac{v}{v_{te}})^2} + \left(1 - \frac{v_{te}}{2v^2}\right)\text{erf}(\frac{v}{v_{te}})\right]$$

  where

$$\nu_{ei} = \frac{4\pi n e^4 \ln\Lambda}{(2T_e)^{3/2}m_e^{1/2}}$$

Collision Operator Inputs

- Recommend collision_model = "default", (automatically selected if choice is left out of input file)
- Recommend conserve_momentum = F. The physics model isn't reliable, and the performance takes a big hit.
- Set collision frequency for each species in `species_knobs` namelist (variable `vnewk`)
- See detailed notes on website:
  http://gs2.sourceforge.net/collision_notes.ps

Adiabaticity

- Sometimes it is wise to make one species adiabatic:

  1. For ITG studies, might wish to use adiabatic electrons

  2. For ETG studies, might wish to use adiabatic ions

- If no species has type ='electron' an adiabatic species is automatically added.

- This feature can be used to simulate ETG modes with adiabatic ions, by pretending the electrons are ions with charge $Z = -1$

Adiabaticity Options

- The form of the adiabatic response can be chosen from:

  1. Namelist `dist_fn_knobs`, `adiabatic_option='default'`
     - Appropriate for adiabatic ions in an ETG simulation
  2. Namelist `dist_fn_knobs`, `adiabatic_option='field-line-average-term'`
     - Appropriate for adiabatic electrons in an ITG simulation

Beams and Impurities

- Okay to leave out charge from such species.

- Beams can be mocked up with high-temperature Maxwellian