Extension of Drift Kinetic Hot Particles to Full Orbits in NIMROD

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Full Kinetic Equations

- for full kinetic equations use[a]

$$f_0 = f(\mathbf{x}, v^2) + \frac{1}{\omega}\left(\mathbf{v}\cdot\mathbf{b}\times\nabla f\right) \tag{1}$$

  to satisfy $\dot{\mathbf{z}}_0 \cdot \dfrac{\partial f_0}{\partial \mathbf{z}} = 0$

- R&R expand $f_0 = f + \lambda g$, take $f = f(\mathbf{x}, v^2)$, i.e. isotropic in $\mathbf{v}$
- then take $\mathbf{b}\cdot\nabla f = 0$
- weight equation is (mostly)

$$\dot{\delta f} = \frac{(\mathbf{v}\times\delta\mathbf{B} + \delta\mathbf{E})\cdot(\mathbf{B}\times\nabla f)}{B^2} + \frac{3}{2}\frac{e\varepsilon^{1/2}}{\varepsilon^{3/2} + \varepsilon_0^{3/2}}\mathbf{v}\cdot\mathbf{E} \tag{2}$$

[a] M. N. Rosenbluth and N. Rostoker "Theoretical Structure of Plasma Equations", Physics of Fluids vol**2** 23 (1959)

- this is satisfying in that it recovers most of drift kinetic weight equation

$$\dot{\delta f} = f_{eq}\left\{\frac{mg}{e\psi_0 B^3}\left[\left(v_\parallel^2+\frac{v_\perp^2}{2}\right)\delta\mathbf{B}\cdot\nabla B-\mu_0 v_\parallel \mathbf{J}\cdot\mathbf{E}\right]\right.$$
$$\left.+\frac{\delta\mathbf{v}\cdot\nabla\psi_p}{\psi_0}+\frac{3}{2}\frac{e\varepsilon^{1/2}}{\varepsilon^{3/2}+\varepsilon_0^{3/2}}\mathbf{v}_D\cdot\mathbf{E}\right\} \quad (3)$$

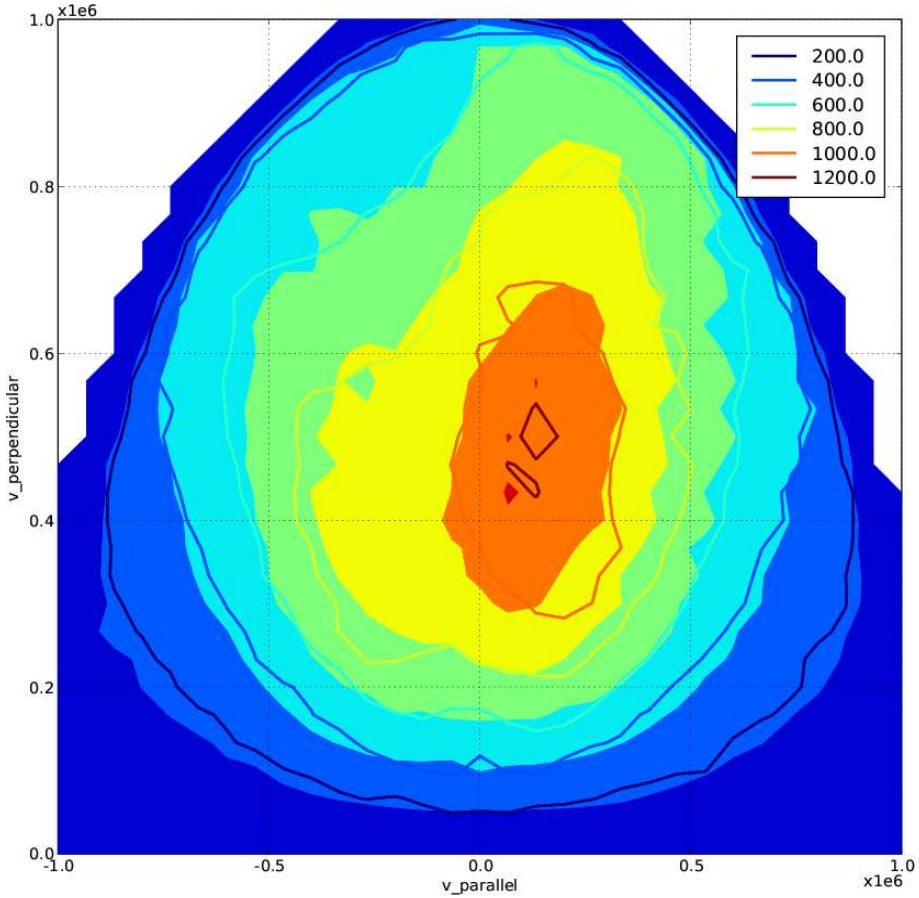
where

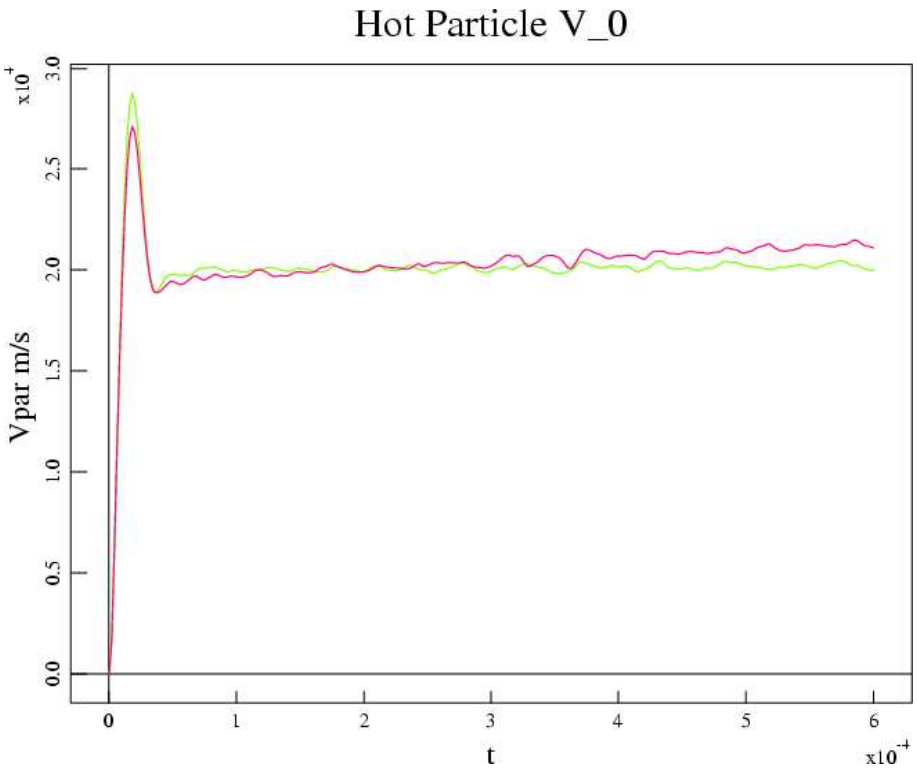
$$\mathbf{v}_D = \frac{m}{eB^3}\left(v_\parallel^2+\frac{v_\perp^2}{2}\right)(\mathbf{B}\times\nabla B)+\frac{\mu_0 m v_\parallel^2}{eB^2}\mathbf{J}_\perp \quad (4)$$

$$\delta\mathbf{v} = \frac{\mathbf{E}\times\mathbf{B}}{B^2}+\mathbf{v}_\parallel\cdot\frac{\delta\mathbf{B}}{B}. \quad (5)$$

Boris Algorithm nicely recovers Drift Kinetic results

- equilibrium evolution of particles well matched





- comparison of equilibrium phase space distribution and volume average $v_{||}$

$(1,1)$ **Benchmark**

- dt=1e-7, $\tau_A = 1.08e6$, Boris has been orbit averaged