EFDA

EUROPEAN FUSION DEVELOPMENT AGREEMENT

Task Force
INTEGRATED TOKAMAK MODELLING

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IMP5: Energetic Particles

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HMGC-GW

- Quantities read from equilibrium and coreprof CPOs, in order to generate simple $O(\varepsilon^3)$ equilibria required by HMGC and eXtended HMGC (XHMGC)

- eqe3aaab_gw.o is able to read the equilibrium CPOs, in particular it read:
  - equilibrium_in(it)%profiles_1d%rho_tor,
  - equilibrium_in(it)%profiles_1d%q,
  - equilibrium_in(it)%eqgeometry%a_minor,
  - equilibrium_in(it)%eqgeometry%geom_axis%r,
  - equilibrium_in(it)%global_param%toroid_field%b0,
  - equilibrium_in(it)%global_param%i_plasma,
  - coreprof_in(it)%rho_tor,
  - coreprof_in(it)%psi%value(i),
  - coreprof_in(it)%composition%amn(j),
  - coreprof_in(it)%ni%value(i,j),
  - coreprof_in(it)%ti%value(i,j),

New developments in XHMGC

Two species treated kinetically:

•electrons described using strongly anisotropic Maxwellian

•(bulk) ions described using isotropic Maxwellian

Energetic electrons

•Energetic electrons treated kinetically to describe resonant excitation
•strongly anisotropic Maxwellian (as, e.g., produced by Lower Hybrid heating)

$$f_{\text{electrons}} \propto \frac{\hat{n}_{Ee}(\psi)}{\tau_{Ee}(\psi)^{3/2}} \Theta(\alpha;\alpha_0,\Delta) e^{-E/T_{Ee}(\psi)} \equiv \frac{\hat{n}_{Ee}(\psi)}{\tau_{Ee}(\psi)^{3/2}} \hat{f}_{\text{electrons}}$$

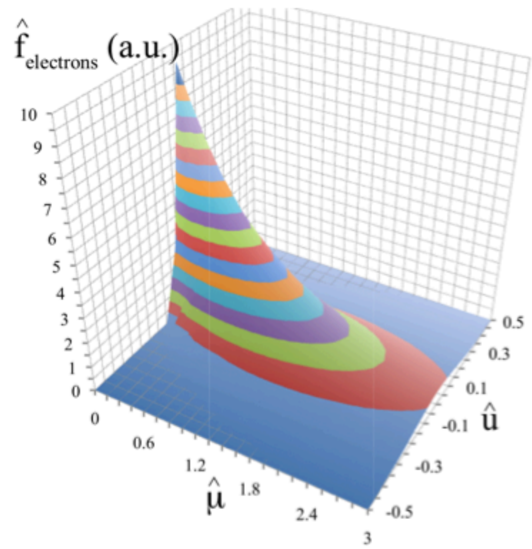
$$\Theta(\alpha;\alpha_0,\Delta) \equiv \frac{4}{\Delta\sqrt{\pi}} \frac{\exp\left[-\left(\frac{\cos\alpha-\cos\alpha_0}{\Delta}\right)^2\right]}{\text{erf}\left(\frac{1-\cos\alpha_0}{\Delta}\right)+\text{erf}\left(\frac{1+\cos\alpha_0}{\Delta}\right)}$$

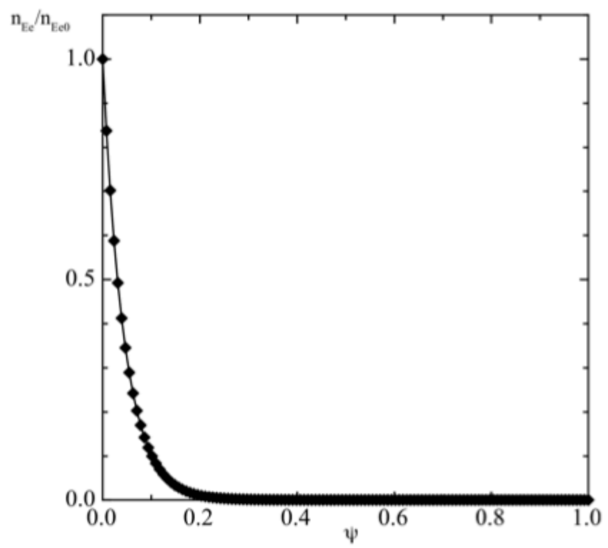
$$E = \frac{1}{2} m_e u^2 + \mu\Omega_{ce} \qquad \sin^2\alpha \equiv \frac{\mu\Omega_{ce}}{E} \qquad \cos\alpha \equiv \frac{u}{\sqrt{2E/m_e}}$$

$$\hat{u} \equiv u/v_{th0}\,, \quad v_{th0} = \sqrt{T_{Ee0}/m_e} \qquad \tau_{Ee}(\psi) \equiv T_{Ee}(\psi)/T_{Ee0}$$

$$\hat{\mu} \equiv \mu\Omega_{ce0}/T_{Ee0} \qquad T_{Ee} = T_{Ee0} = 50\,\text{keV}$$

$$\cos\alpha_0 = 0\,, \quad \Delta = 0.1$$





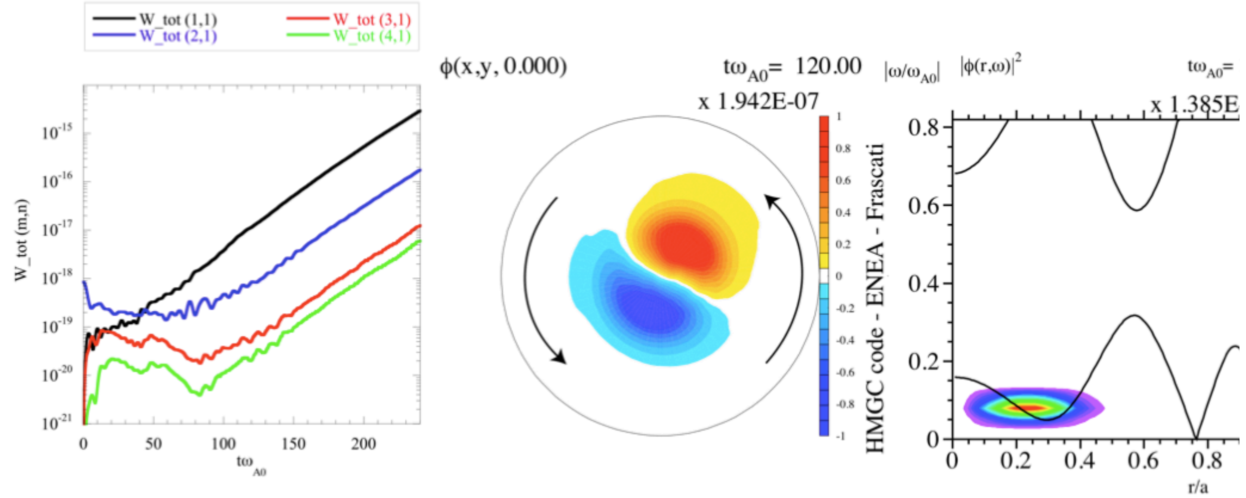
New developments in XHMGC

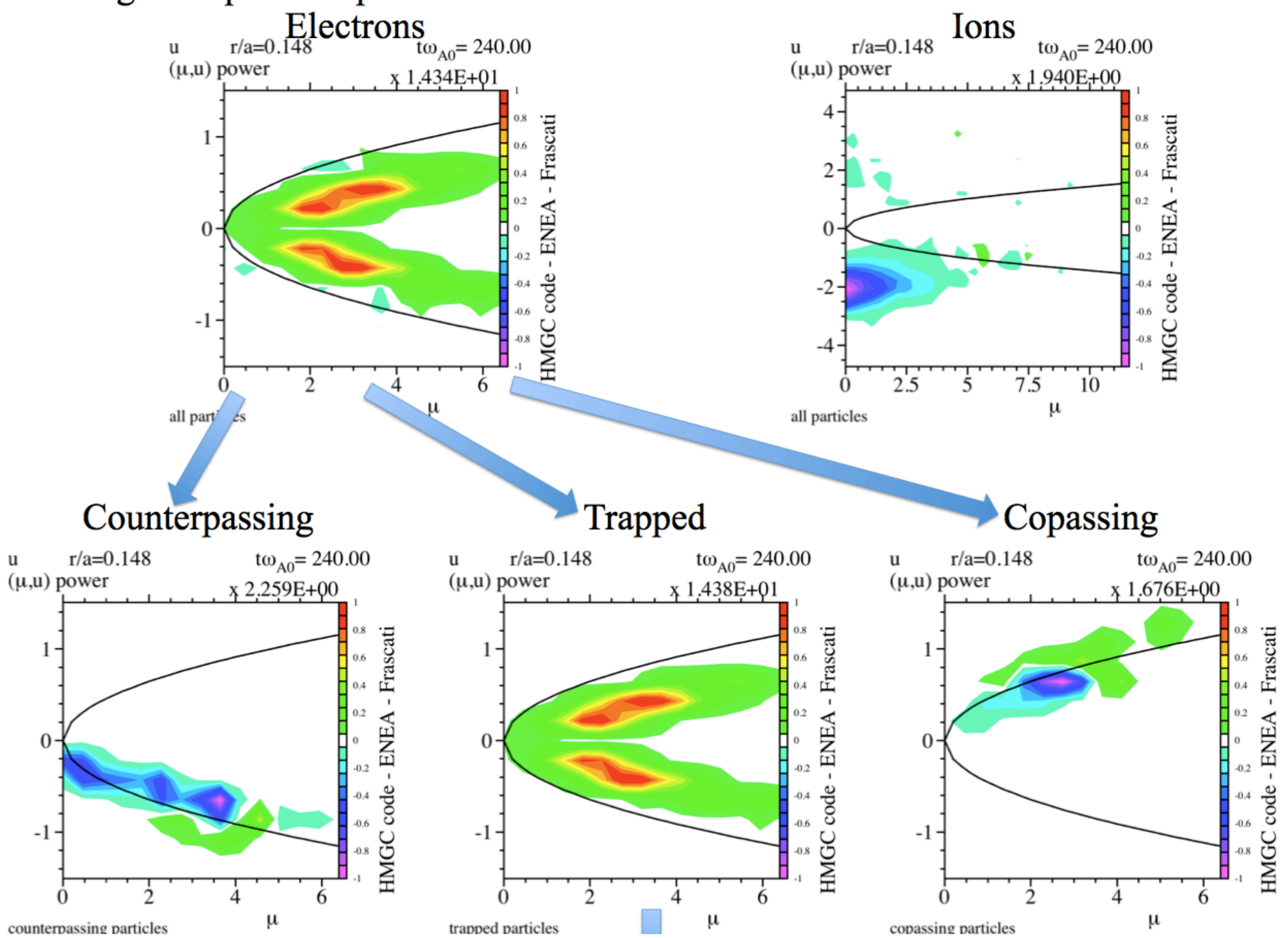
Electron fishbone case study (FTU like equilibria)

<u>Power transfer between particles and wave at the radial position where the power exchange is maximum ($r/a \approx 0.15$)</u>

- note: each particle contribution is referred to the value of *u* value of that particle when crossing the equatorial plane

- almost m=1 "step function"
- mode rotates in the direction of the diamagnetic velocity of the suprath electrons (counterclock-wise)
- $\omega/\omega_{A0} \approx -0.0815$, $\gamma/\omega_{A0} \approx 0.024$, $\gamma/|\omega| \approx 0.29$





Porting of MHD module (MARS) of HYMAGYC