Chirping comparison between HMGC and ORB5 simulations

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In collaboration with
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Motivation

- Nonlinear dynamics comparison between HMGC and ORB5.
- Extending the test-particle technique of HMGC to use in ORB5.
- Joint ATEP mission, phase space zonal structure calculation. (A. Bottino)

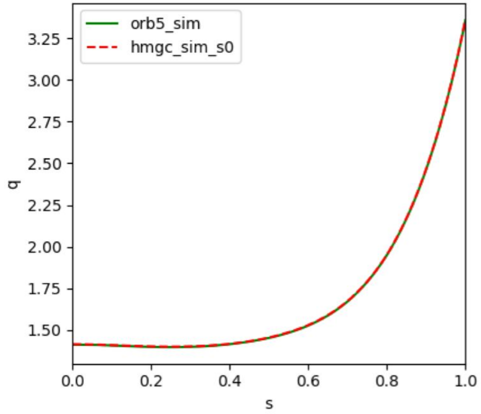
Steps

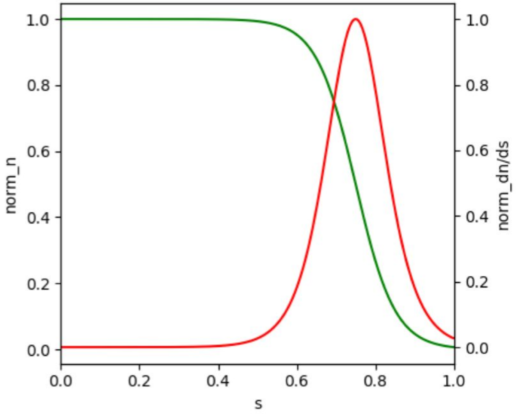
- HMGC has the shifted circular flux surfaces. CHEASE [1] is used to create the equilibrium for ORB5 based on the same q profile and uniform bulk plasmas.
- Looking for a qualitative agreement:
  - ➔ HMGC assumes bulk cold electrons. ORB5 must have finite electron temperature. Therefore Te/Ti = 1.0, 0.5, 0.1 are used.
  - ➔ EP density scan for each cases.
- Power exchange: preliminary solution, summing 2:4 terms in I. Novikau's [2] subroutine.
- Test particle analysis:
  - ➔ Small number of test particles: resonance structure
  - ➔ Large number of test particles: phase space dynamics, Hamiltonian mapping used in HMGC (in progress)

[1] https://crppwww.epfl.ch/~sauter/chease/
[2] I. Novikau et al, Computer Physics Communications Vol 262, 2021, 107032

Equilibrium and other parameters

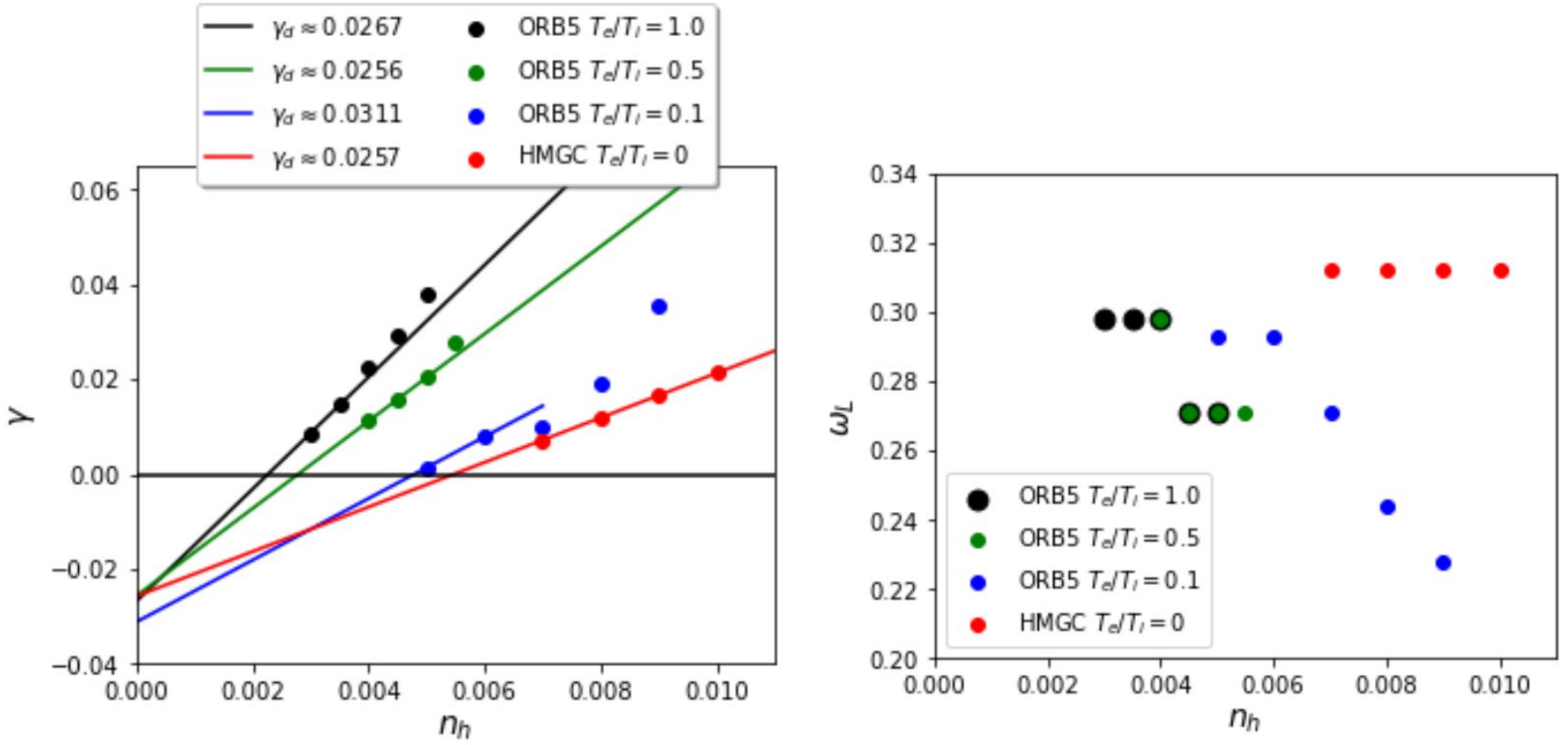
- a/R = 0.1
- The safety factor q profile is shown in left. HMGC q profile is plotted vs. sqrt(psi_0).
- For bulk plasmas, temperature and density for both electrons and bulk ions are uniform .
- ORB5, Te/Ti = 1, 0.5 and 0.1
- HMGC, Te=0





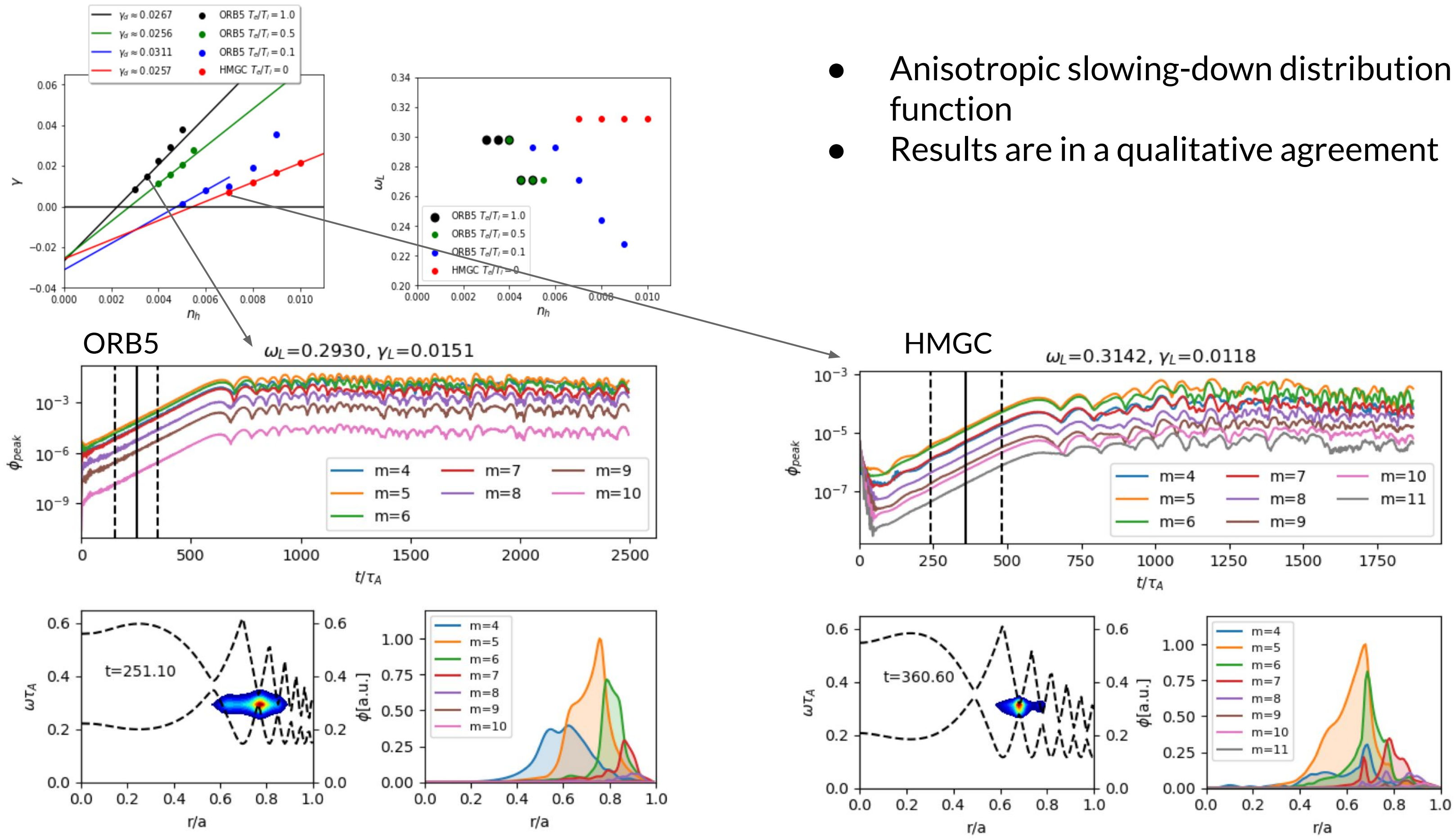
- Other parameters are listed in the appendix

Linear features



ORB5: single-n frequency chirping EPM

- Anisotropic slowing-down distribution function
- Results are in a qualitative agreement

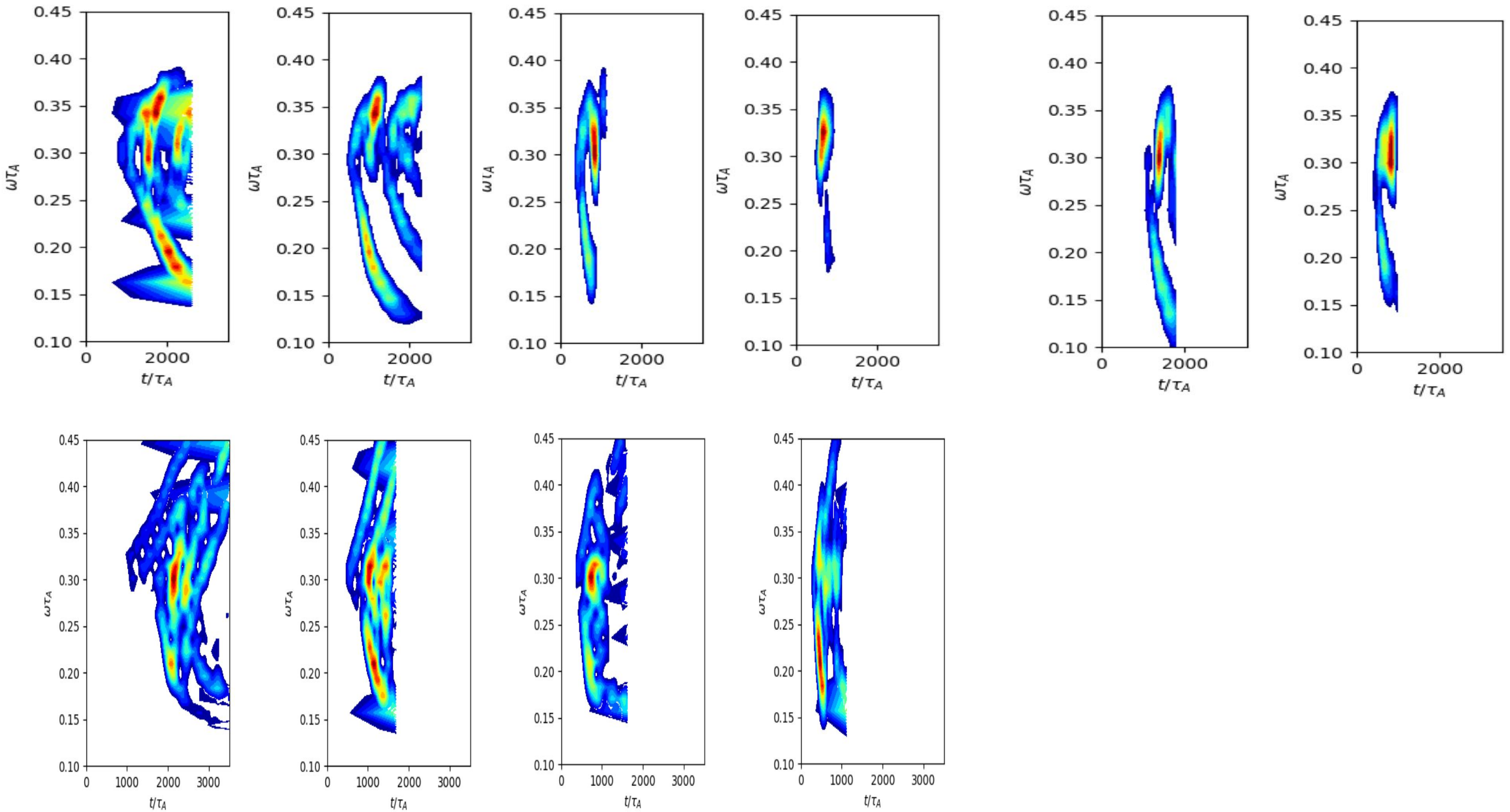


Frequency evolutions

Te/Ti = 1.0 Te/Ti = 0.1 Te/Ti = 0.5

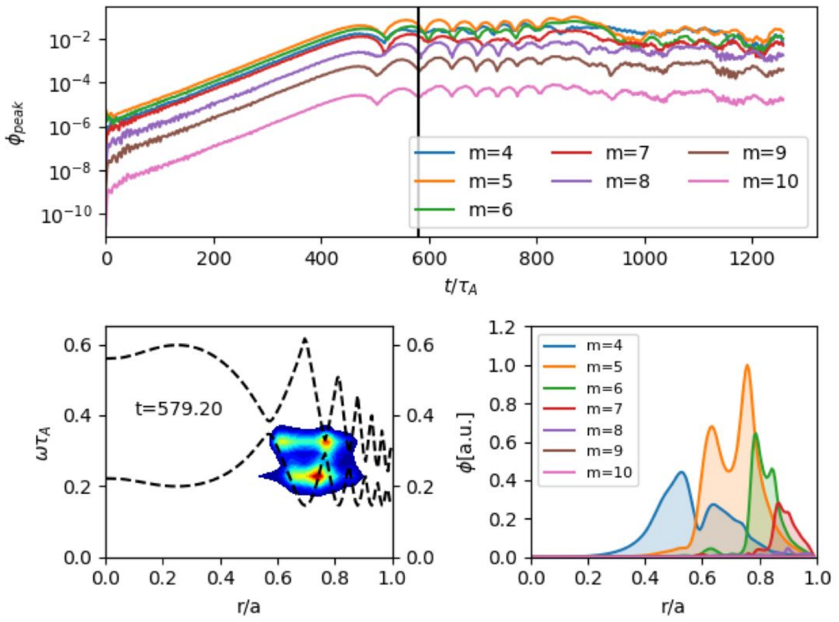
ORB5

HMGC
Te/Ti = 0.0

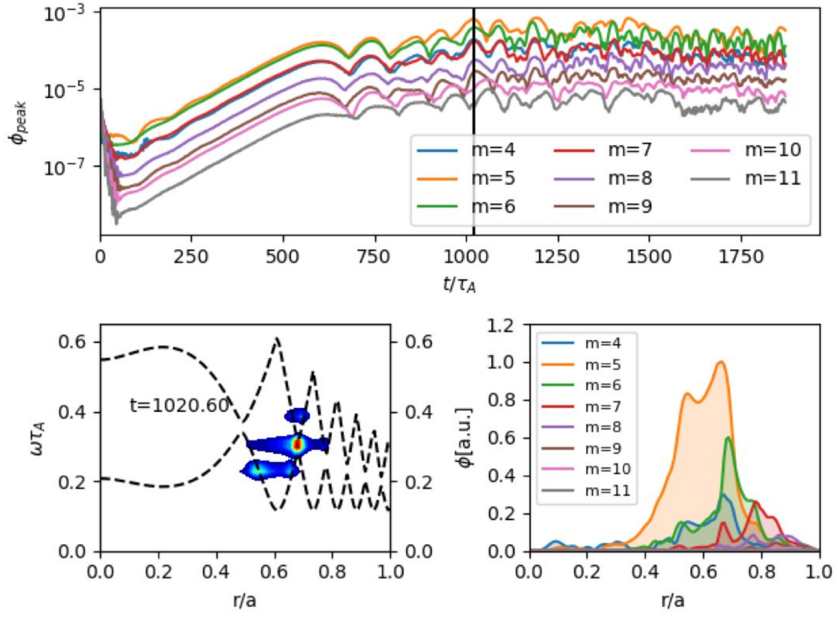


Frequency evolutions

ORB5

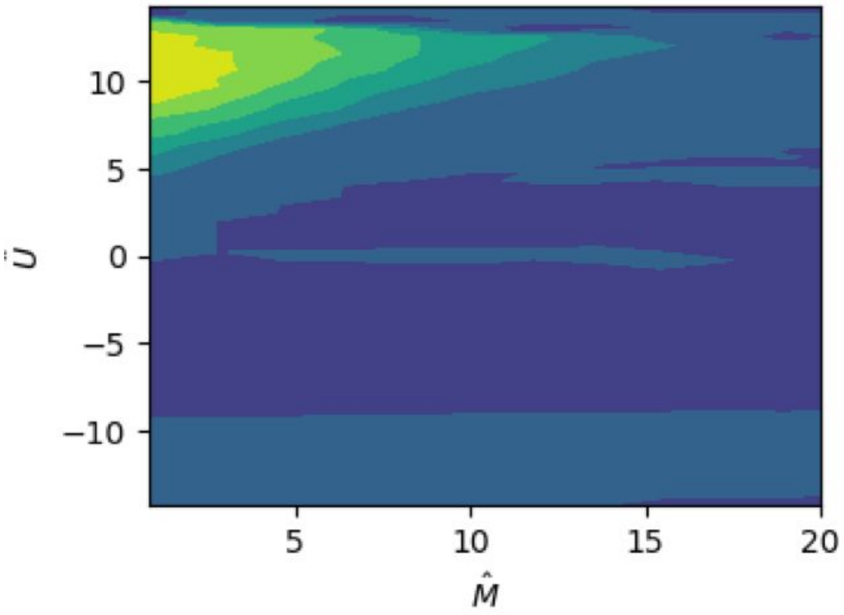


HMGC

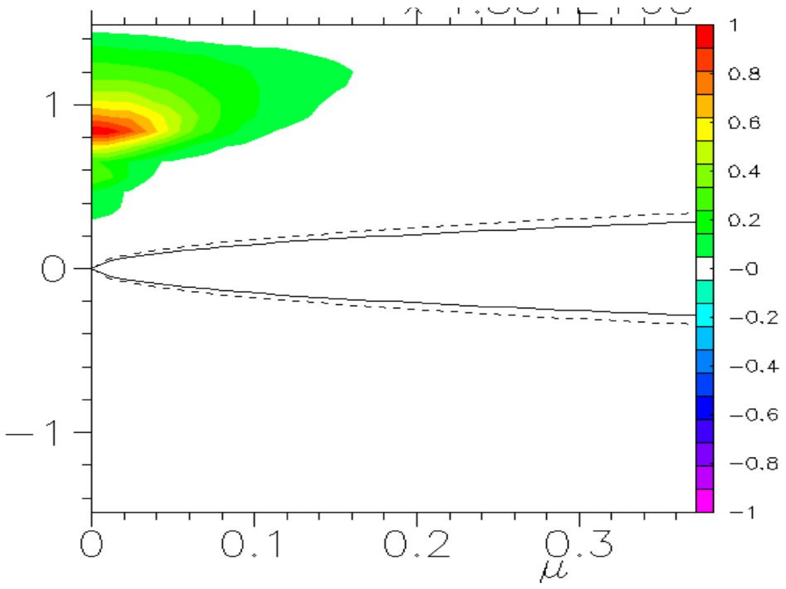


ORB5: preliminary power-exchange

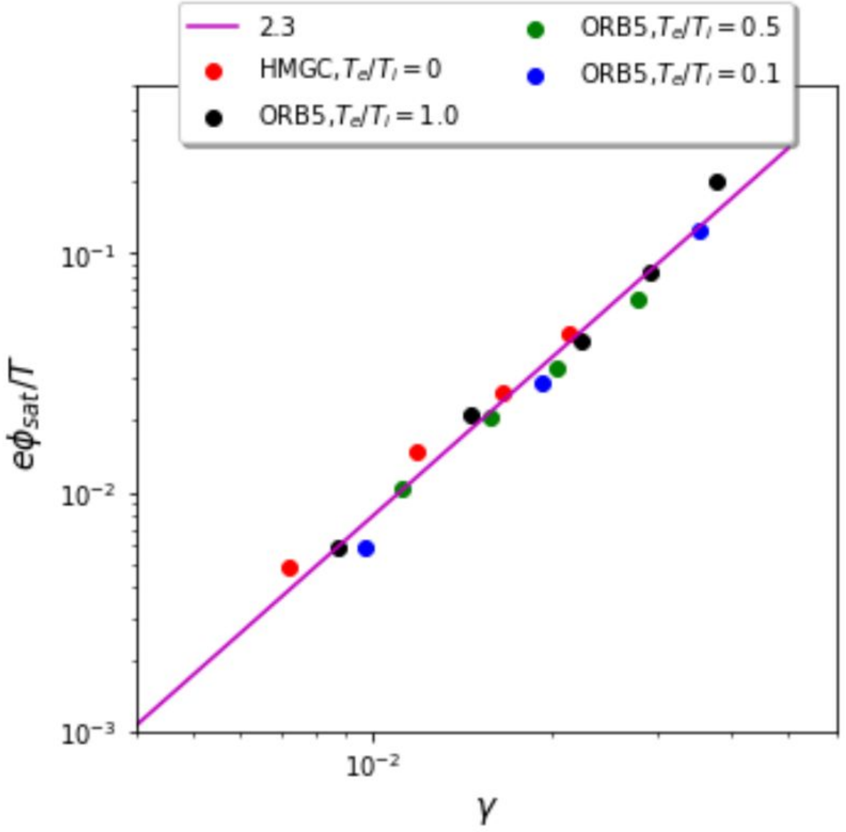
ORB5

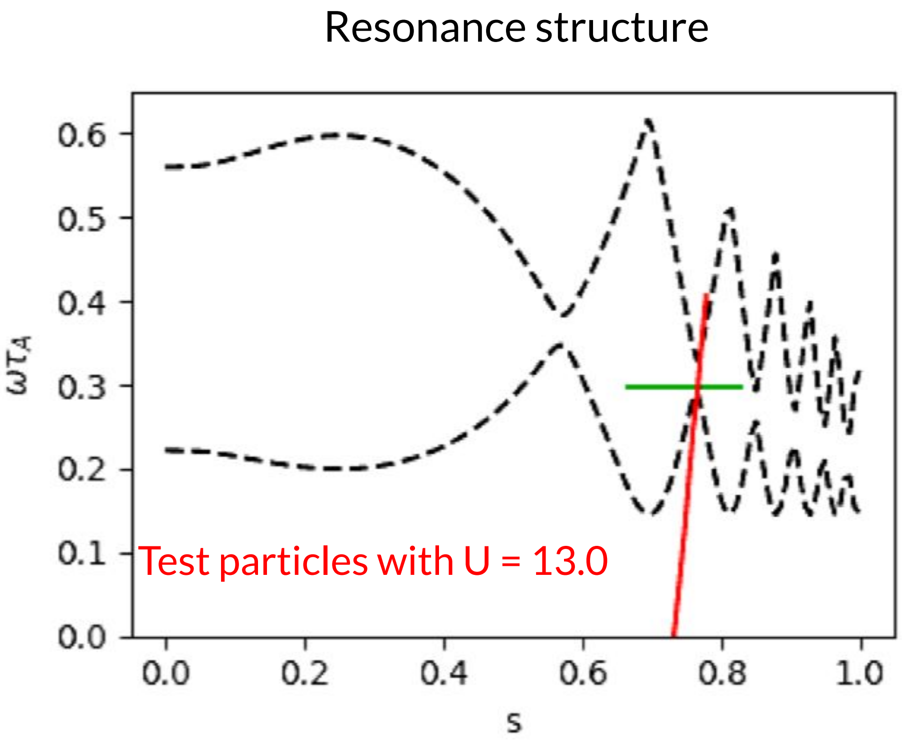


HMGC



Saturation amplitude scaling: resonance detuning





Appendix: parameter list

```
a_mid: 1.0
r_mid: 10.
B0: 1.4
zi: 1.0
mui: 2.0
muh: 2.0
ne_0: 2.5e19
nisne: 0.995
coef: 1.0
Te_in_ev: 1500.0
tau_i: 1.0
vthsva: 0.6
m_tor: 5
mi_me: 200
```

```
on-axis Alfven velocity: 4345122.37570 m/s
EP temperature: 140888.39606 ev
n_i: 2.488e+19
tau_f = tf/Te_in_ev: 93.92560
rho_ti: 0.00398 m
VTHSVA_b: 0.06191
rhosa_b: 0.00398
lx = 2a/rho_ti: 502.14374
rho_tf: 0.03860 m
VTHSVA: 0.60000
rhosa: 0.03860
lx_f = 2a/rho_tf: 51.81268
**Alfven frequency (VA0/R): 434512.23757 s^-1
cyclotron frequency (eB/m): 67539732.50966 s^-1
**cyclotron/Alfven frequency: 155.43804
dt_HMGC/cyclotron_time = 0.02*(wci0/wa0): 3.10876 tau_wci0
Beta in input of orb5: 0.00385208
kperp*rho_ti: 0.03319
kperp*rho_tf: 0.32167
mi/me = 200.00000
IMPORTANT: beta*m_i/(m_e*kperp^2rho_ti^2): 699.33305
```