

Readme

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Supplementary data for “Extended electron tails in electrostatic microinstabilities and the nonadiabatic response of passing electrons, M. R. Hardman, F. I. Parra, C. Chong, T. Adkins, M. S. Anastopoulos-Tzanis, M. Barnes, D. Dickinson, J. F. Parisi, and H. Wilson. arXiv:2108.02822”

This repository contains `GS2` input files for section 6 of arXiv:2108.02822, as well as the necessary information to carry out the numerical calculations featured in appendices C and F.

1 Supplementary information for section 6

`GS2` input files for section 6 are contained in the folder `./input_files/`. The input files are organised according to the figures presented in section 6. For example, subfolders are `./input_files/figure5`, `./input_files/figure6-7`, etc. Some input files are duplicated where data is used from the same simulation in multiple figures. The structure of the input file names have the form:

```
rootname.vnewk.V.M.in,
```

where `rootname` is a string, `V` is a number referring the electron collision frequency in the field `vnewk` in the electron species namelist

```
&species_parameters_1  
  vnewk = 0.00692  
  type = 'electron'  
/
```

Note that for some input files, `V` is merely proportional to `vnewk`, rather than exactly equal. The other variable character `M` is a number that ranges from 0 to 24: 0 represents the Hydrogen mass ratio, whereas 24 represents the mass ratio with a very heavy ion species. Data from the simulations should be ordered with increasing `vnewk` in collisionality scans, and with increasing `M` in mass ratio scans.

All gyrokinetic simulations were performed using the gyrokinetic code `GS2`, found at <https://bitbucket.org/gyrokinetics/workspace/projects/GS2>. The simulations presented in this work used the branch https://bitbucket.org/gyrokinetics/gs2/branch/ms_pgelres, with the commit `ade5780`.

2 A note on converting between `GS2` and Braginskii collision frequencies.

As documented here https://bitbucket.org/gyrokinetics/gs2/wiki/Namelists/species_parameters.rst, the `GS2` collision frequency ν_{ss}^{GS2} is defined by

$$\nu_{ss}^{\text{GS2}} = \frac{\sqrt{2}\pi n_s Z_s^4 e^4 \ln \Lambda}{m_s^{1/2} T_s^{3/2}}, \quad (1)$$

meaning that the Braginskii collision frequencies are related to the `GS2` collision frequency by

$$\nu_{ee}^{\text{Brag}} = \frac{4}{3\sqrt{\pi}} \nu_{ee}^{\text{GS2}}, \quad (2)$$

and

$$\nu_{ii}^{\text{Brag}} = \frac{4}{3\sqrt{2\pi}} \nu_{ii}^{\text{GS2}}. \quad (3)$$

Hence, to compute ν_* from the `GS2` input files we must use the following formula

$$\nu_* = \frac{4}{3\sqrt{\pi}} \frac{qR_0}{\epsilon^{3/2}a} \left(\frac{m_e T_i}{m_i T_e} \right)^{1/2} \frac{a \nu_{ee}^{\text{GS2}}}{v_{\text{th},i}}, \quad (4)$$

where we have normalised ν_{ee}^{GS2} to the ions, as they are the reference species in the input files.

3 Supplementary information for appendices C and F

We supply codes used to calculate $C_{p,q}$ and $\mathcal{L}_{p,q}$ defined by equations (C.11) and (C.12), respectively, the trapped fraction f_{trap} defined by equation (F.22), and the matrix elements $D_{p,q}$ and $Q_{p,q}$, defined by equations (F.25) and (F.28), respectively.

The numerical calculation of $C_{p,q}$ and $\mathcal{L}_{p,q}$ is contained in the Wolfram Mathematica (v. 12.0) notebook

`genfuncs-eqns-C11-C12.nb`

and printout

`genfuncs-eqns-C11-C12.pdf`.

The numerical calculation of f_{trap} , $D_{p,q}$ and $Q_{p,q}$ is contained in the MATLAB R2019b (9.7.0.1190202) scripts

`trapped-fraction.m`,

`D-matrix-elements.m`,

and

`Q-matrix-elements.m`,

respectively. The screen printout of the MATLAB calculations are contained in

`matlab-output.txt`.

We use $C_{p,q}$ and $\mathcal{L}_{p,q}$ to calculate the coefficients a_n and c_n in the python script

`collisional-transport-coefficients.py`,

using Python 3.6.9 and the `numpy` library. The screen output from the Python calculation may be found in

`collisional-transport-coefficients-output.txt`.

The Python calculation also makes use of a_n , c_n , f_{trap} , $D_{p,q}$ and $Q_{p,q}$ to calculate the numerical coefficients appearing in E.28 and E.29, as well as F.24 and F.27.