® PRINCETON PLASMA PHYSICS LABORATORY

LINEAR STABILITY COMPONENT DEMO*

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Introduction

- We have incorporated several MHD analysis codes into the SWIM framework.
- Initiated from time-slice-selectable equilibria generated in the Plasma State
  - JSOLVER. Equilibrium refinement ← [TSC]
  - MAPCK. Mapping for BALLOON ← [JSOLVER]
  - MAP2. Mapping for PEST2 ← [JSOLVER]
  - BALLOON. Ballooning stability ← [MAPCK]
  - PEST2. Low-n MHD stability ← [MAP2]
  - CAMINO*. Ballooning stability, 2nd region ← [MAPCK]
  - CHECKGS*. Grad-Shafranov checker ← [MAPCK]

  ∗ – not fully implemented.
- This is work in progress.

Drivers and Files

- Checkout files from the SWIM SVN repository.
  - Run **Make**
- Relevant stability component files:
  - `stability_driver.py`
  - `stability.py`
  - `sim_stability.conf`
- Make changes in `sim_stability.conf`
  - simulation name
  - time slice of the equilibrium
  - replay directory and runid

sim_stability.conf

Some relevant lines

```
IPS_ROOT = /p/swim/Chance/swim/jin_ips          # Root of IPS component and binary tree
SIM_NAME = S12346                               # Name of current simulation
SIM_ROOT = $IPS_ROOT/$SIM_NAME                  # Where to put results from this simulation
RUN_ID = $SIM_NAME

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OUTPUT_PREFIX =
CURRENT_STATE = ${RUN_ID}_ps.cdf
PRIOR_STATE = ${RUN_ID}_psp.cdf
CURRENT_EQDSK = ${RUN_ID}_ps.geq
CURRENT_EQJSO = ${RUN_ID}_ps.jso

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# Time loop sepecification (two modes for now) EXPLICIT | REGULAR
# For MODE = REGULAR, the framework uses the variables START, FINIS, and NSTEP
# For MODE = EXPLICIT, the frame work uses the variable VALUES (space separated list of time values)
[TIME_LOOP]
   MODE = EXPLICIT
   START  = 190 # 240  230.5
   FINISH = 280 # 240  230.5
   NSTEP  = 10
   VALUES = 240 #190 280 #

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```

sim_stability.conf , – *cont'd*

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```
[STABILITY]
    CLASS = stability
    SUB_CLASS =
    NAME = stability
    NPROC = 1
    BIN_PATH = $IPS_ROOT/bin
    INPUT_DIR = $IPS_ROOT/components/stability/input
    INPUT_RPS = # geqfile_210 got from this config file
    OUTPUT_RPS = cur_state.cdf log.rps eqdska  #_210
    INPUT_JSO = inequ # eqdska eqdskasci are binary/ascii-formated output from OUTPUT_RPS
    OUTPUT_JSO = eqrsou dbequs dbequp eqb1 eqdsk.cdf oust3 jso.cgm rzofq2 outequ fixed log.jso
    INPUT_MPK = maplst_mpk # eqb1 point to eqb1 in Jsolver
    OUTPUT_MPK = mapout mapdsk map.cgm sumout output_mpk log.mpk
    INPUT_MP2 = maplst_mp2 # fort.17 point to eqb1 in Jsolver
    OUTPUT_MP2 = fort.32 fort.31 map2.plt output_mp2 log.mp2 # pointed by mpout1/mapdsk
    INPUT_CHK = chklst # mpout1 mapdsk point to Mapck:mapout/mapdsk or map2:fort.32/fort.31
    OUTPUT_CHK = fort.18 fort.19 chek.cgm chkout log.chk # pointed by mpout1/mapdsk in Balloon
    INPUT_BAL = balin # mpout1 mapdsk point to mapout/mapdsk, fort.32/fort.31, fort.18/fort.19
    OUTPUT_BAL = lshr_dat dbbals bal.cgm balout log.bal
    INPUT_CAM = camlst # mpout1 mapdsk point to mapout/mapdsk, fort.32/fort.31, fort.18/fort.19
    OUTPUT_CAM = pqrdat camout cam.meta log.cam
    INPUT_PT2 = fort.20 fort.26 # fort.24
    OUTPUT_PT2 = dbkink pst.cgm fort.12 fort.21 fort.27 vector log.pt2 # eqjin eqjout matout outdsk1
    INPUT_FILES = $INPUT_RPS $INPUT_JSO $INPUT_MPK $INPUT_MP2 $INPUT_CHK $INPUT_BAL $INPUT_CAM $INPUT_PT2
    OUTPUT_FILES = $OUTPUT_RPS $OUTPUT_JSO $OUTPUT_MPK $OUTPUT_MP2 $OUTPUT_CHK $OUTPUT_BAL $OUTPUT_CAM $OUTPUT_PT2  # $PLASMA_STATE_FIL
    RUN_OPTION = pem2p2  # 1-pemkb: rps jso mpk, bal; 2-pem2p2: rps jso mp2 pt2
    SCRIPT = $BIN_PATH/stability.py
```

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sim_stability.conf , – cont'd

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```
[STABILITY_DRIVER]
    CLASS = drivers
    SUB_CLASS = jchen # ku
    NAME = stabilityDriver
    NPROC = 1
    BIN_PATH = $IPS_ROOT/bin
        INPUT_DIR = $IPS_ROOT/components/$CLASS/$SUB_CLASS
        INPUT_FILES =
        OUTPUT_FILES =
    SCRIPT = $BIN_PATH/stability_driver.py

[TSC_REPLAY]
    CLASS = epa
    SUB_CLASS =
    NAME = tsc_replay
    NPROC = 1
    BIN_PATH = $IPS_ROOT/bin
    INPUT_DIR = $IPS_ROOT/components/epa/tsc_replay
    INPUT_FILES =
    OUTPUT_FILES = $PLASMA_STATE_FILES
    SCRIPT = $BIN_PATH/epa_tsc_replay.py
    REPLAY_DIR = /p/swim/lpku/IPS/my_ips/ITER_3
    REPLAY_RUNID = S12345
```

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Inputs

- Input files are in

```
 104 viz: ..... /ips/components/stability/input] ls
balin  camlst  chklst  fort.20  fort.26  inequ  maplst_mp2  maplst_mpk
```

- JSOLVER's input file, `inequ`, uses formatted ascii input.
  - Docmentation for `inequ` exists.
- The mapping and stability input files uses namelist inputs.
  - Example:

```
..........] more maplst_mpk
 &wdat nosuri=201, mthi=256, njacg=1, mjacx=1, ljacb = 0, nck=5
       lzio = 1  nout = 0,96,0 nout0 = 0 &end

..........] more balin
 &inp
      ndist=2,201,3, thpi=24., lzio=1, lljin=1, s=1.0
 &end
```

Inputs – pest2

```
........]  more fort.26
 ITER stability analysis JM
 &modes lmax1=   25 lmin1=  -5 m= 100 mth=256 n=1.0
   jmax2=83 lsymz=.t. lfunin=.f,lcirc=.f &end
 &torang lpmax=1, phi=39.0 &end
 &debugs check1=.f ,  checkd=.f,checki=.f,
   ldelta=.t. infwal=.t., wall=.f., lvacdsk= .f.
   ke=.t, fast=.t , symvac=.t   &end
 &vacdat  aw=00., bw=0.,nsing=500,epsq=1.e-5,nout=50 ,delg=1.0
           &end
 &shape a= -10.0 b=.50  gext=1.,f0=.008,r=100.   &end
 &scoeff alphar=0.,betar=0.,delr=1.,psi0r=1.,alphap=2.5,betap=4.,
   delp=1., psi0p=0.,p0=0.,gamma=0.0,    il=3 &end
 &vardat  scale=1.0 varmin=1.,varmax=3.6, nvar=1 &end
 &tcrit lscrit=.f iscalemax=6 scalemn=5.1 scalemx=7.1
         lscstep=.f scarray=3.1
         lbcrit=.t iwallmax=6  bstart=0.5 &end
 &resis psim(1)=2., lsing=.f,dlay=.0,nodchk=.false.,
   fracem=0.0,faclay=2.,lremap=.f.,lmapck=.false.,
   lpstps=.t ,  lmarg=.t. lcub=.t.
   zonew=0.3 0.7 1.0
   mzoned=20 10 5
   lmsin=.t ,msin= 3 4 , newm = 100, lsub=.f  &end
 &eigdat alam=0.0, dtry=0.1, nsteps=1, negtest=5000 nitmax=20, epscon=1.0e-3 &end
```

Execution and outputs

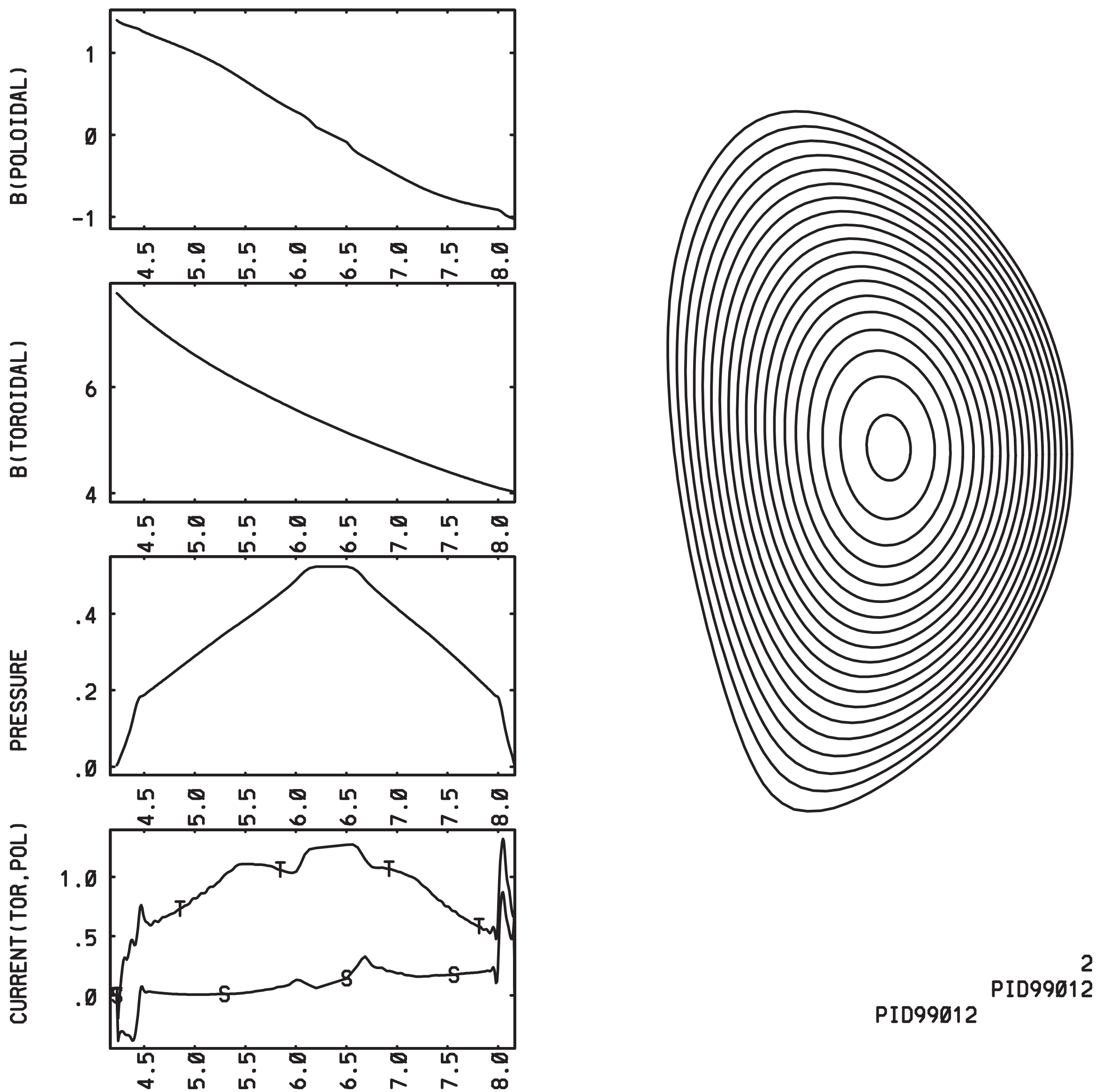
ips −−config = sim_stability.config

- Output files in:

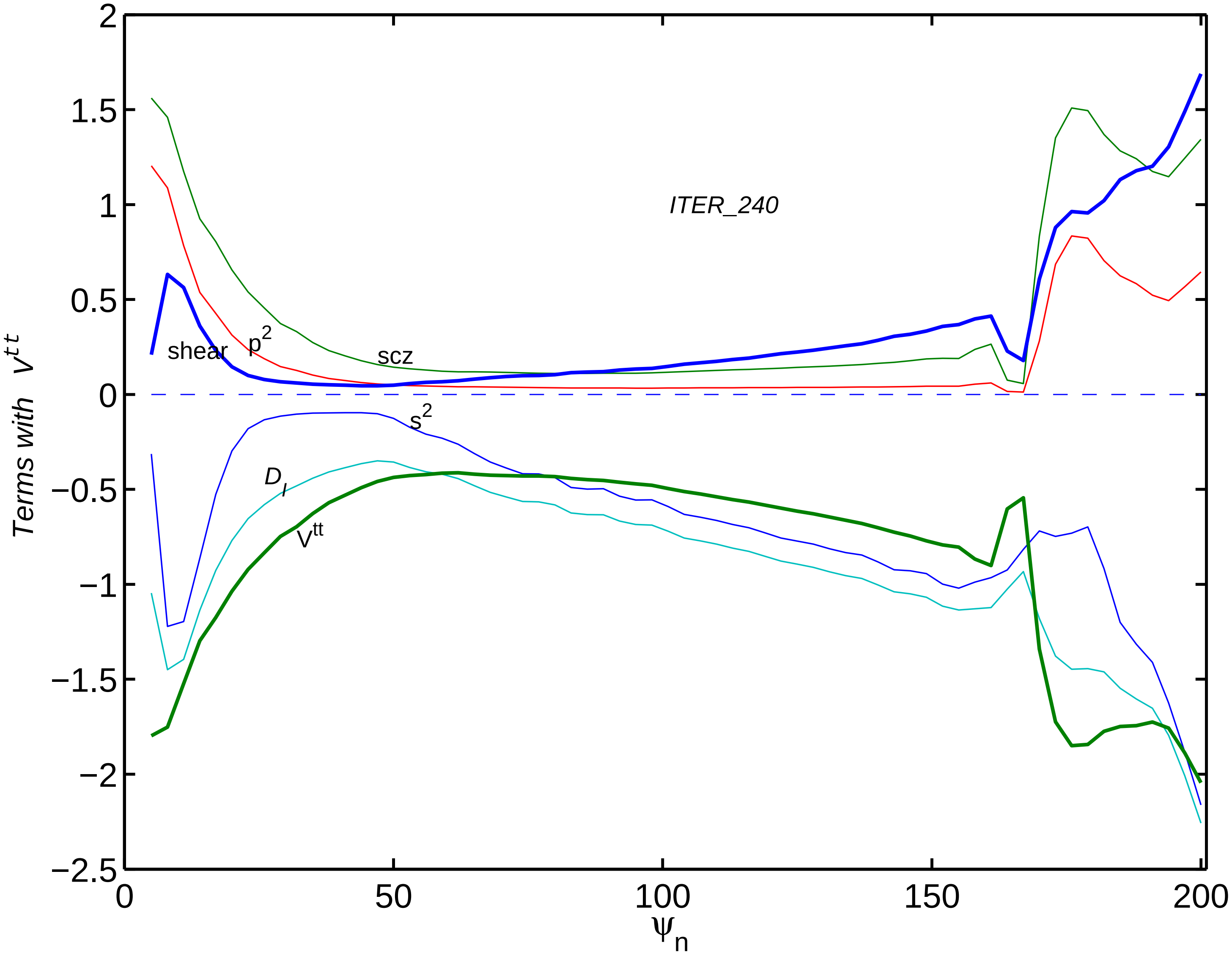
```
.......ips/S12346/simulation_results/history/240.000/components/stability/stability
```

```
..... ]  ips/S12346/simulation_results/history/240.000/components/stability/stability] ls
bal.cgm        dbbals     eqrsou     fort.27  log.jso   map2.ps      output_mpk
balout         dbequp     fixed      fort.31  log.mp2   map.cgm      pqrdat
cam.meta       dbequs     fort.12    fort.32  log.mpk   mapdsk       pst.cgm
camout         dbkink     fort.18    jso.cgm  log.pt2   mapout       rzofq2
chek.cgm       eqb1       fort.19    log.bal  log.rps   oust3        sumout
chkout         eqdska     #fort.21#  log.cam  lshr_dat  outequ       vector
cur_state.cdf  eqdsk.cdf  fort.21    log.chk  map2.plt  output_mp2
```

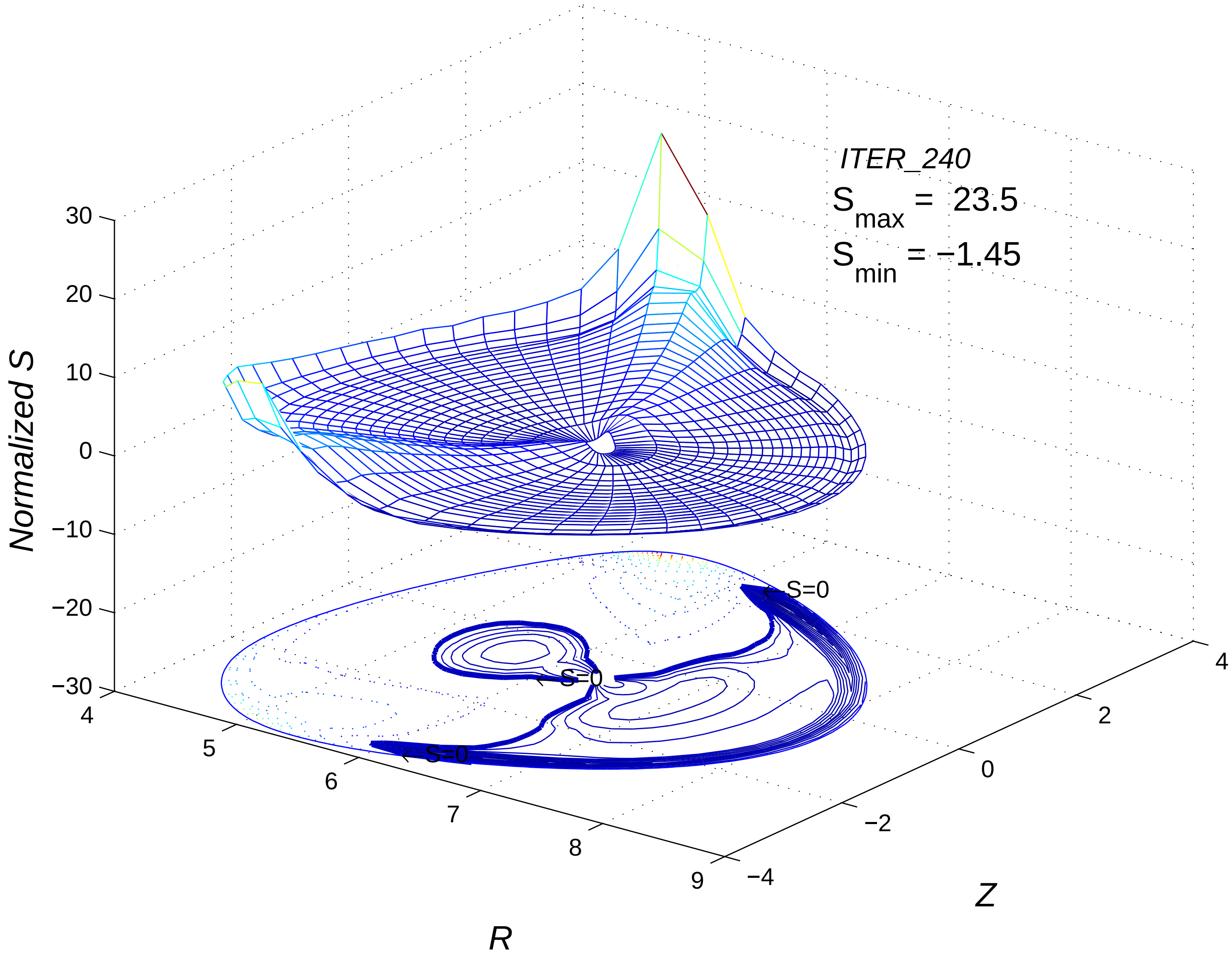
Profiles from JSOLVER



Mercier Criteria



Local Magnetic Shear



BALLOON Output

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```
no ballooning instability found
most unstable mode:
lambda = 1.00170E-04, at k/twopi = 0.00000E+00,
nsfrs =  197, q = 3.44452E+00
contribution from kappa-s term   =-1.00149E-02
contribution  from kappa-d term   =-1.04508E-02
contribution from kappa-psi term = 6.85682E-03
contribution from alpha term     = 3.25825E-03
```

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PEST2 Output

```
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           output quantities
          -------------------


            1 eigenvalues less than -0.11005E-01

            3 iterations done

         3162 vector components have converged


           eigenvalue from normalization -0.11436E-01

           rayleigh quotient             -0.11436E-01


           deltaw         (ala)    -0.14276E+00
           kinetic energy (alb)     0.12483E+02
1  there are   1 eigenvalues within the window,  1 were found
 the eigenvalues are :

               -0.1143562E-01

  **********************************************


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```

PEST2 Output