BOUT++ Results

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ABSTRACT

This document highlights some results from BOUT++ simulation

metadata

evolved: ['Ni' 'rho' 'jpar']

IC: [1.00000000e-08 0.00000000e+00 0.00000000e+00]

ZMAX: 0.01

TIMESTEP: 50.0

ZMIN: 0.0

ShiftXderivs: false

restart: false

grid: /home/cryosphere/BOUT/tools/cyl_and_helimak_grids/Helimak_11_1x32_140_lam_n.nc

MYG: 2.0

dump_format: nc

MXG: 2.0

TwistShift: false

NOUT: 100.0

MZ: 129.0

mxstep: 10000.0

RTOL: 1e-08

type: cvode

ATOL: 1e-12

AA: 2.0

estatic: true

nu_perp: 1e-20

phi_flags: 0.0

ZeroElMass: true

apar_flags: 0.0

ShearFactor: 0.0

ZZ: 1.0

Zeff: 4.0

ys_mode: 1.0

scale: 1e-08

zs_opt: 3.0

xs_opt: 0.0

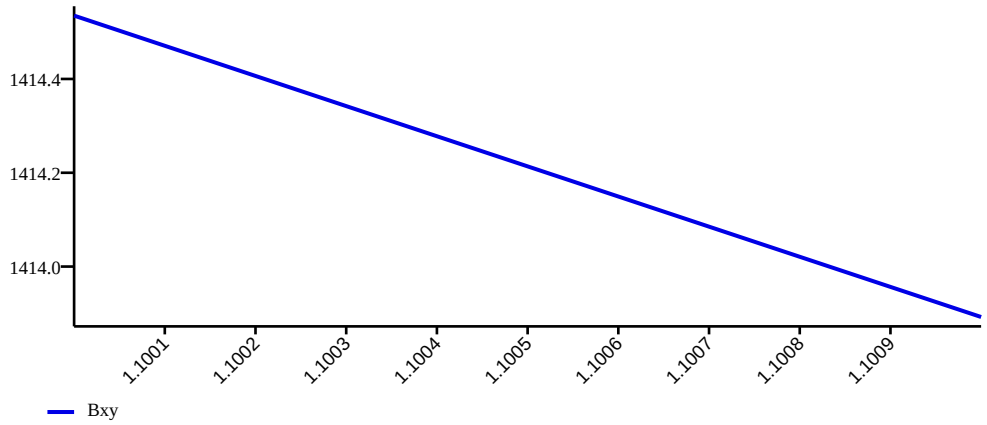
bndry_all: neumann

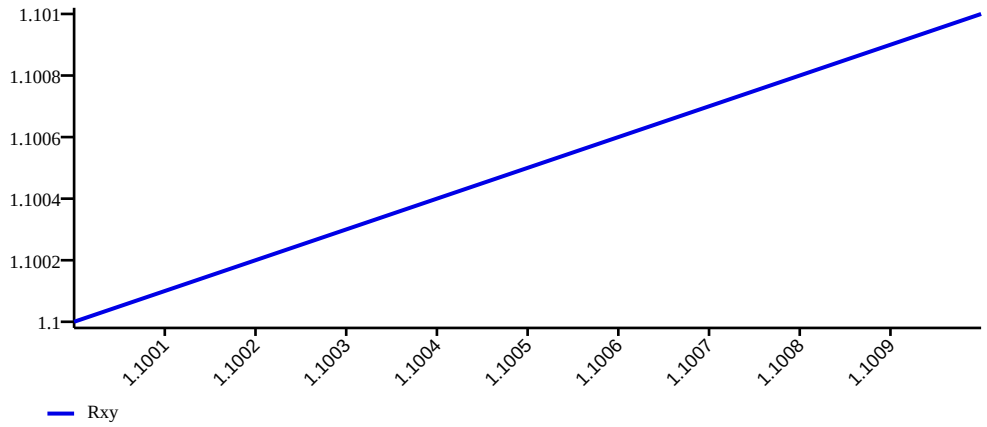
ys_opt: 2.0

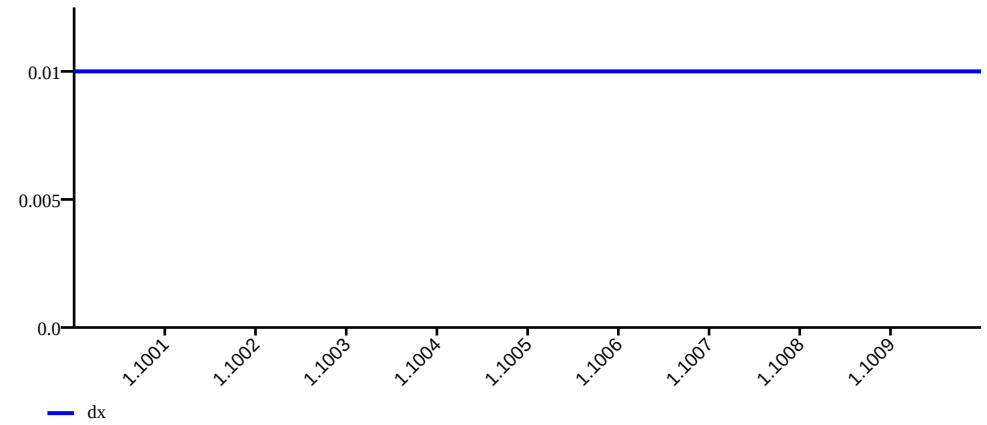
zs_mode: 1.0

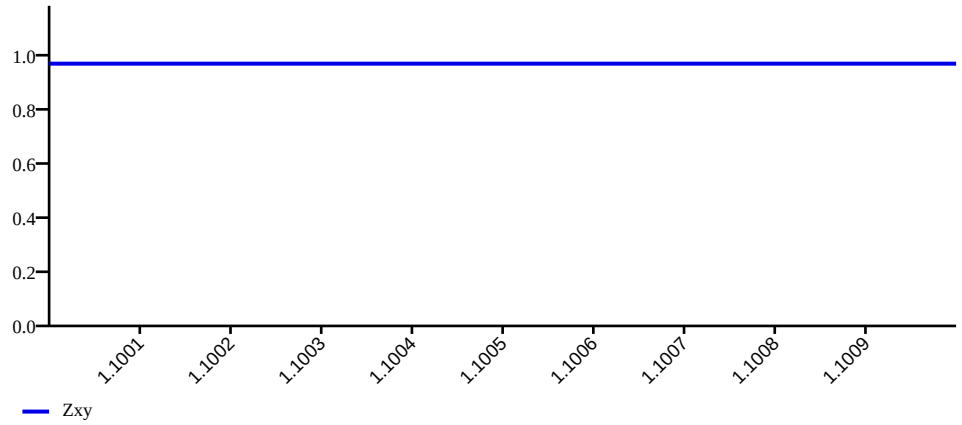
zs_phase: 0.5

Te_x: [10.] eV



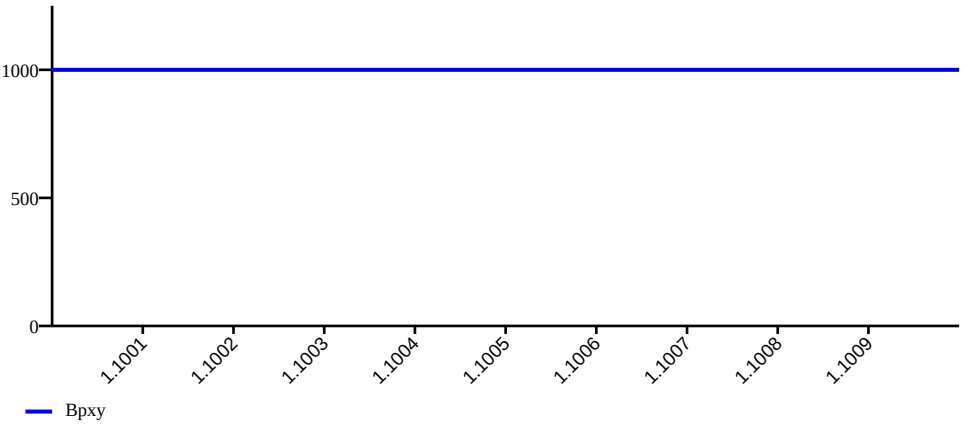




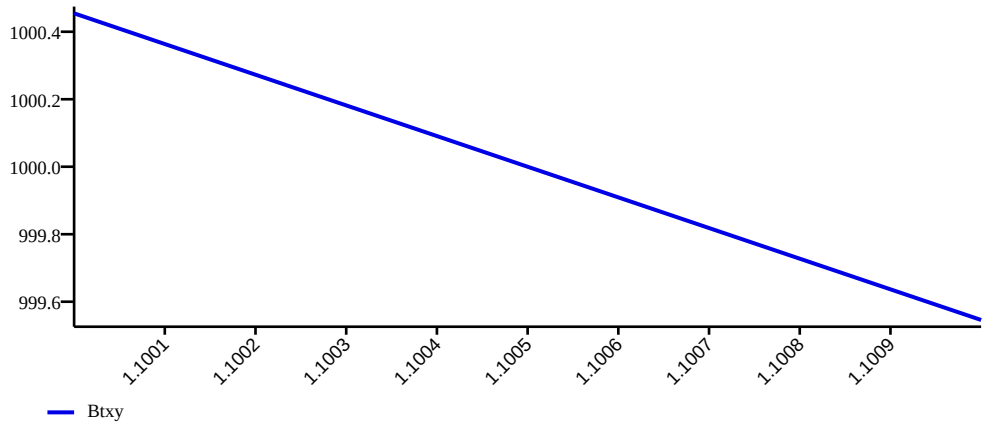


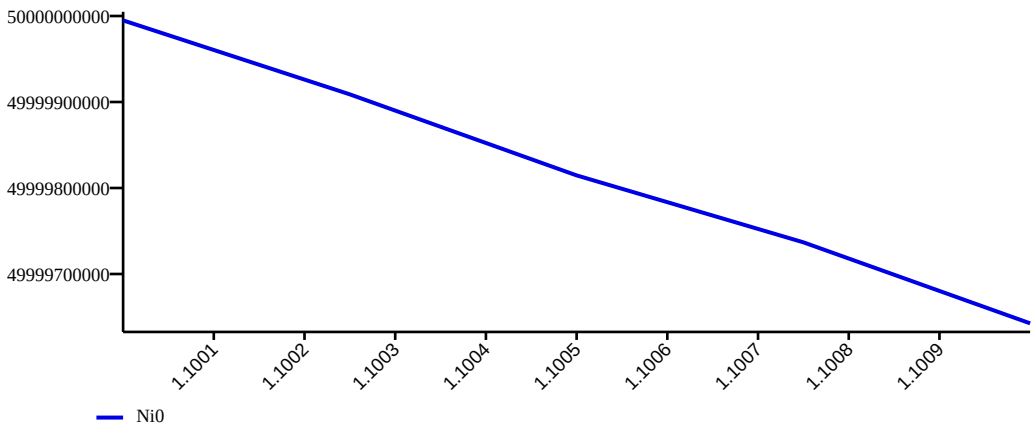
Ti_x: [0.01] eV

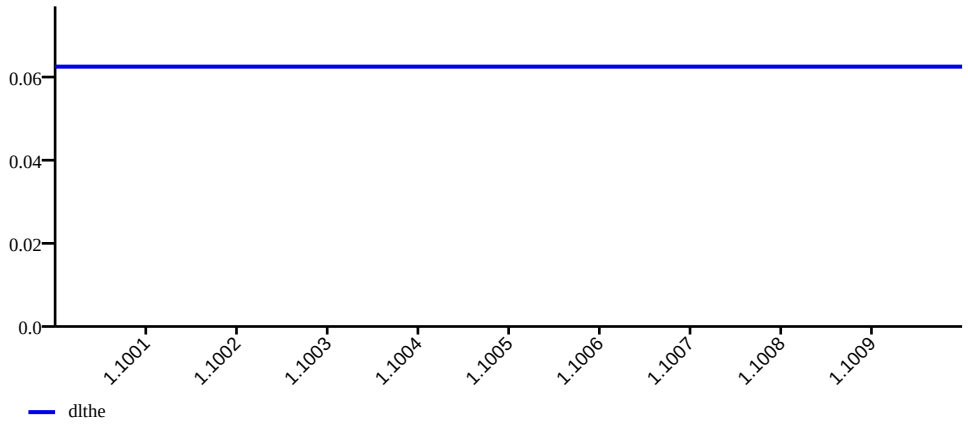
bmag: [1414.53503418] gauss



hthe0: [0.31830987] m







Ni_x: [4.99999949e+10] cm^-3

nx: 5

ny: 32

dt: 50.0

rho_s: [0.32247901] cm

rho_i: [0.01019768] cm

rho_e: [0.00532063] cm

fmei: 0.000272301492212

lambda_ei: [13.98494053]

lambda_ii: [3.4280262]

wci: [6775623.]

wpi: [2.08710320e+08]

wce: [2.51787244e+10]

wpe: [1.26114222e+10]

v_the: [1.32499432e+08]

v_thi: [69225.75]

c_s: [2826129.5]

v_A: [689376.5625]

nueix: [64346.30078125]

nuiix: [5793313.]

nu_hat: [0.03798694]

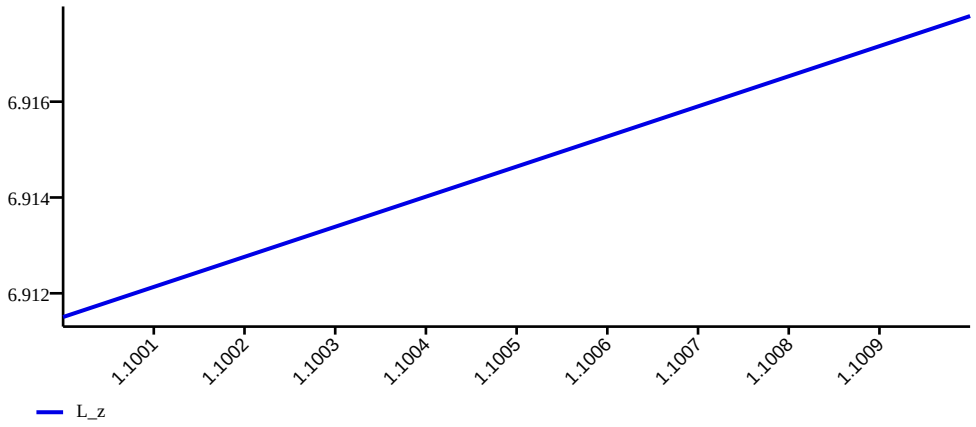
L_d: [0.01050761]

L_i_inrt: [144.19987488]

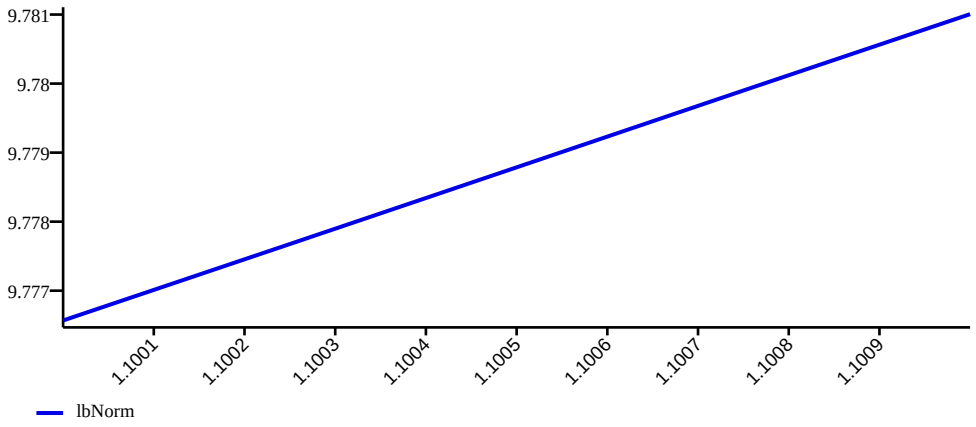
L_e_inrt: [1.18735200e+11]

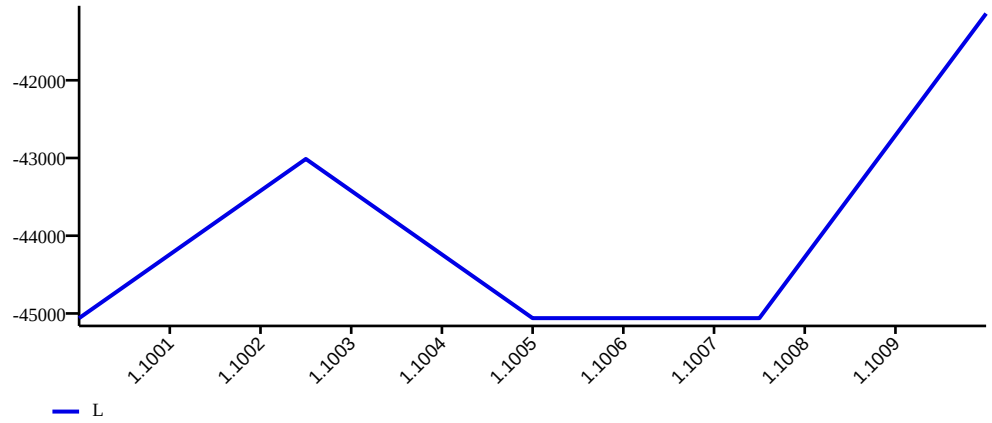
Ve_x: [4.19000000e+08]

R0: 1.1004999876

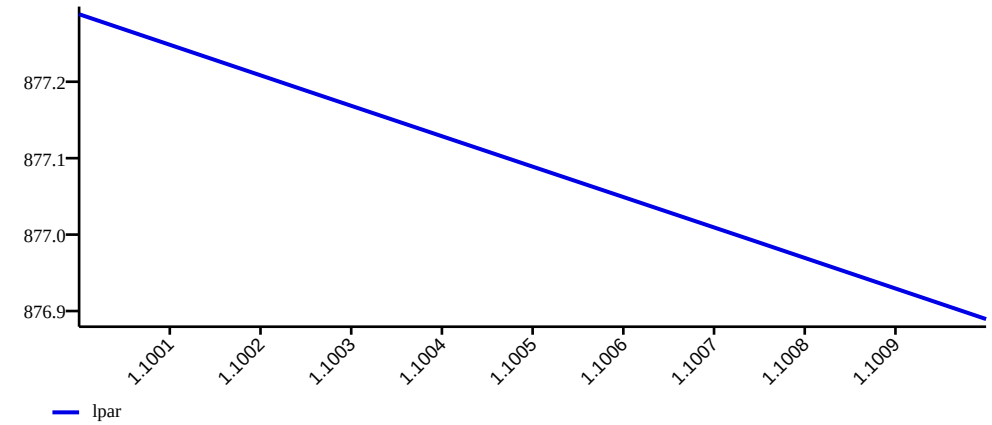


dz: [0.01]





w_Ln: [3.14380231e-05]



sig_par: [189559.46875]

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int physics_run(BoutReal t) { solve_phi_tridag(rho, phi, phi_flags); if(estatic || ZeroElMass) { Apar = 0.0; }else { solve_apar_tridag(Ajpar, Apar, apar_flags); } mesh->communicate(comms); Nit = Ni0; Tit = Ti0; Tet = Te0; Vit = Vi0; nu = nu_hat * Nit / (Tet^1.5); mu_i = mui_hat * Nit / (Tit^0.5); kapa_Te = 3.2*(1./fmei)*(wci/nueix)*(Tet^2.5); kapa_Ti = 3.9*(wci/nuiix)*(Tit^2.5); pei = (Te0+Ti0)*Ni + (Te + Ti)*Ni0; pe = Te0*Ni + Te*Ni0; if(ZeroElMass) { jpar = ((Te0*Grad_par_LtoC(Ni)) - (Ni0*Grad_par_LtoC(phi)))/(fmei*0.51*nu); jpar = lowPass(jpar,8); /* for(int jx=MXG;jxngx-MXG;jx++) { for(int jy=MYG;jyngy-MYG;jy++) { for(int jz=0;jzngz;jz++) { jpar[jx][jy][jz] = ( (Te0[jx][jy] * (Ni[jx][jy+1][jz] - Ni[jx][jy][jz])) - (Ni0[jx][jy] * (phi[jx][jy+1][jz] - phi[jx][jy][jz])) ) / (fmei * 0.51 * nu[jx][jy][jz] * dy[jx][jy] * sqrt(mesh->g_22[jx][jy])); } } } */ jpar.applyBoundary(); mesh->communicate(jpar); Ve = Vi - jpar/Ni0; Ajpar = Ve; }else { Ve = Ajpar + Apar; jpar = Ni0*(Vi - Ve); } ddt(Ni) = 0.0; if(evolve_ni) { ddt(Ni) -= vE_Grad(Ni0, phi); /* ddt(Ni) -= Vpar_Grad_par(Vi, Ni0) + Vpar_Grad_par(Vi0, Ni) + Vpar_Grad_par(Vi, Ni); ddt(Ni) -= Ni0*Div_par(Vi) + Ni*Div_par(Vi0) + Ni*Div_par(Vi); ddt(Ni) += Div_par(jpar); ddt(Ni) += 2.0*V_dot_Grad(b0xcv, pe); ddt(Ni) -= 2.0*(Ni0*V_dot_Grad(b0xcv, phi) + Ni*V_dot_Grad(b0xcv, phi0) + Ni*V_dot_Grad(b0xcv, phi)); */ ddt(Ni) = lowPass(ddt(Ni),8); } ddt(Vi) = 0.0; if(evolve_vi) { ddt(Vi) -= vE_Grad(Vi0, phi) + vE_Grad(Vi, phi0) + vE_Grad(Vi, phi); ddt(Vi) -= Vpar_Grad_par(Vi0, Vi) + Vpar_Grad_par(Vi, Vi0) + Vpar_Grad_par(Vi, Vi); ddt(Vi) -= Grad_par(pei)/Ni0; } ddt(Te) = 0.0; if(evolve_te) { ddt(Te) -= vE_Grad(Te0, phi) + vE_Grad(Te, phi0) + vE_Grad(Te, phi); ddt(Te) -= Vpar_Grad_par(Ve, Te0) + Vpar_Grad_par(Ve0, Te) + Vpar_Grad_par(Ve, Te); ddt(Te) += 1.333*Te0*( V_dot_Grad(b0xcv, pe)/Ni0 - V_dot_Grad(b0xcv, phi) ); ddt(Te) += 3.333*Te0*V_dot_Grad(b0xcv, Te); ddt(Te) += (0.6666667/Ni0)*Div_par_K_Grad_par(kapa_Te, Te); } ddt(Ti) = 0.0; if(evolve_ti) { ddt(Ti) -= vE_Grad(Ti0, phi) + vE_Grad(Ti, phi0) + vE_Grad(Ti, phi); ddt(Ti) -= Vpar_Grad_par(Vi, Ti0) + Vpar_Grad_par(Vi0, Ti) + Vpar_Grad_par(Vi, Ti); ddt(Ti) += 1.333*( Ti0*V_dot_Grad(b0xcv, pe)/Ni0 - Ti*V_dot_Grad(b0xcv, phi) ); ddt(Ti) -= 3.333*Ti0*V_dot_Grad(b0xcv, Ti); ddt(Ti) += (0.6666667/Ni0)*Div_par_K_Grad_par(kapa_Ti, Ti); } ddt(rho) = 0.0; if(evolve_rho) { /* ddt(rho) -= vE_Grad(rho0, phi) + vE_Grad(rho, phi0) + vE_Grad(rho, phi); ddt(rho) -= Vpar_Grad_par(Vi, rho0) + Vpar_Grad_par(Vi0, rho) + Vpar_Grad_par(Vi, rho); */ ddt(rho) += mesh->Bxy*mesh->Bxy*Div_par_CtoL(jpar); /* for(int jx=MXG;jxngx-MXG;jx++) { for(int jy=MYG;jyngy-MYG;jy++) { for(int jz=0;jzngz;jz++) { ddt(rho)[jx][jy][jz] = Bxy[jx][jy]*Bxy[jx][jy] * (jpar[jx][jy+1][jz] - jpar[jx][jy][jz]) / (dy[jx][jy] * sqrt(mesh->g_22[jx][jy])); } } } */ } ddt(Ajpar) = 0.0; if(evolve_ajpar) { /* for(int jx=MXG;jxngx-MXG;jx++) { for(int jy=MYG;jyngy-MYG;jy++) { for(int jz=0;jzngz;jz++) { ddt(Ajpar)[jx][jy][jz] += (1./fmei) * (phi[jx][jy][jz] - phi[jx][jy-1][jz]) / (dy[jx][jy] * sqrt(mesh->g_22[jx][jy])); ddt(Ajpar)[jx][jy][jz] -= (1./fmei)*(Te0[jx][jy]/Ni0[jx][jy])*(Ni[jx][jy][jz] - Ni[jx][jy-1][jz]) / (dy[jx][jy] * sqrt(mesh->g_22[jx][jy])); } } } */ ddt(Ajpar) += (1./fmei)*Grad_par(phi, CELL_YLOW); ddt(Ajpar) -= (1./fmei)*(Te0/Ni0)*Grad_par(Ni, CELL_YLOW); ddt(Ajpar) += 0.51*interp_to(nu, CELL_YLOW)*jpar/Ni0; }
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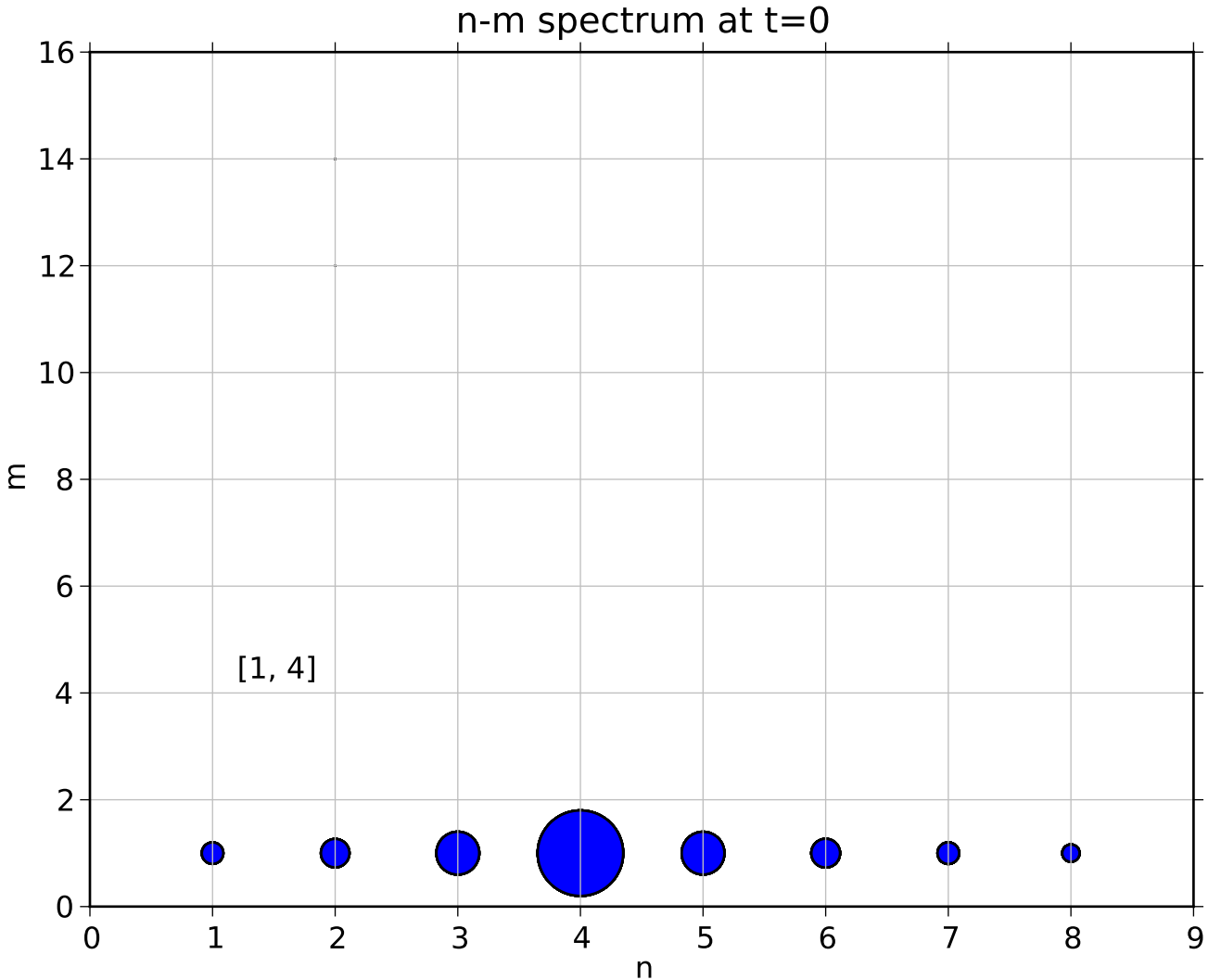
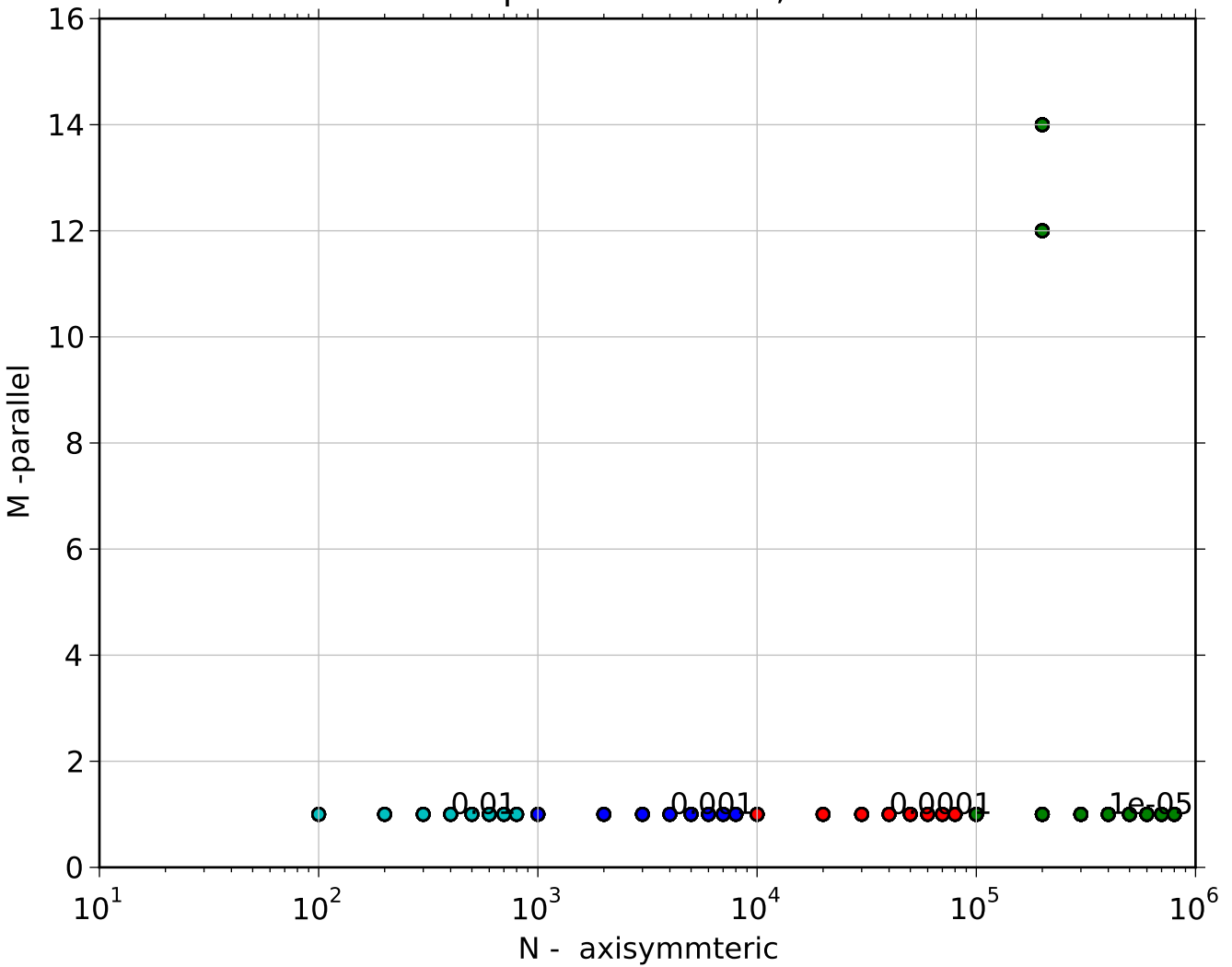
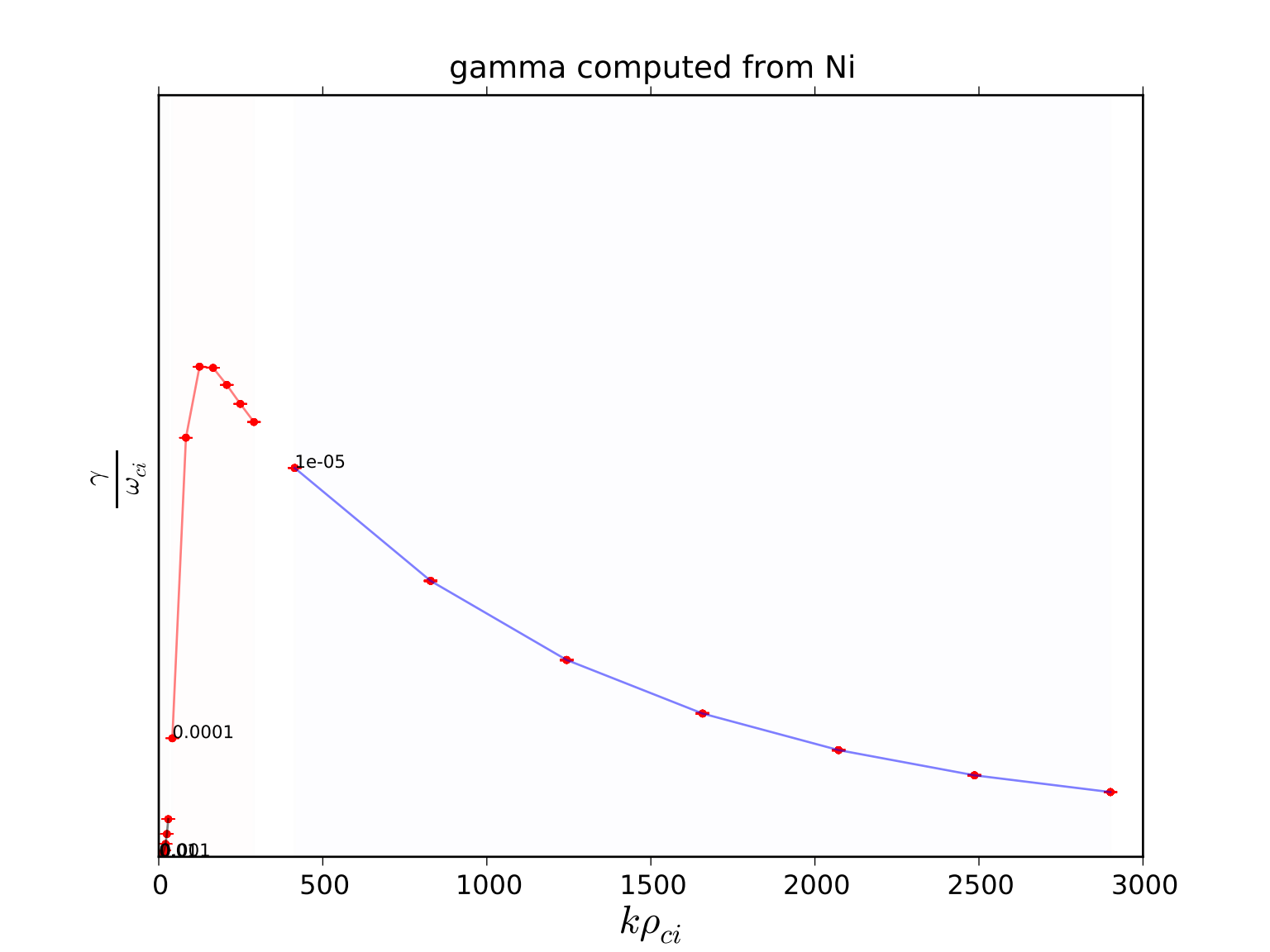
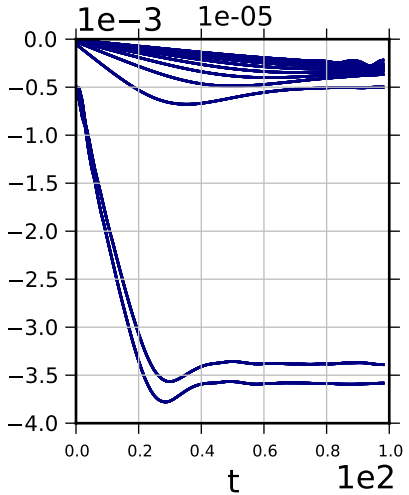
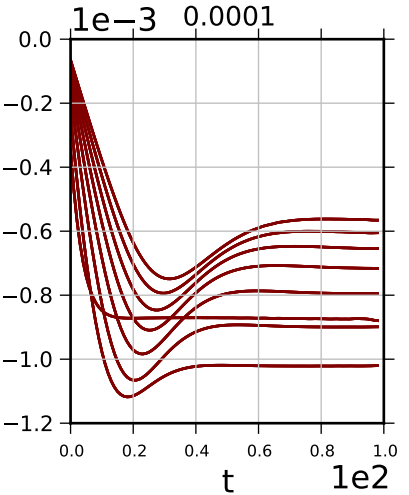

n-m spectrum at t=0
m
n
[1, 4]
0
2
4
6
8
10
12
14
16
0
1
2
3
4
5
6
7
8
9

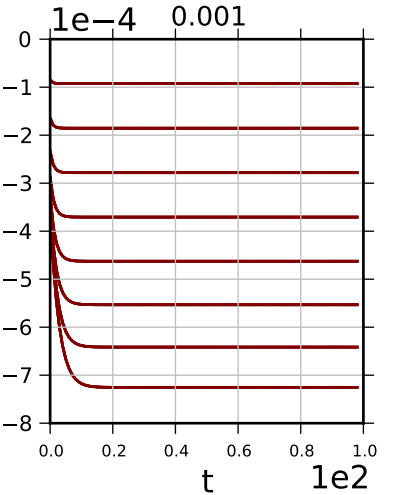

Ni spectrum at t=0, all x
M -parallel
N - axisymmteric
0.01
0.001
0.0001
1e-05

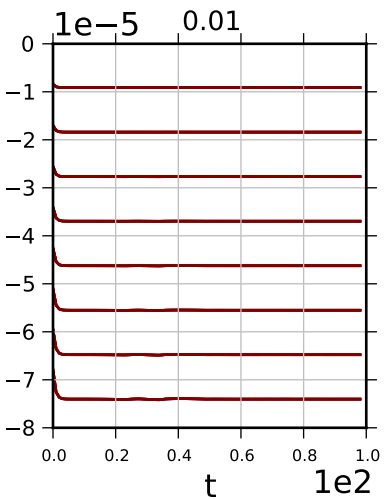

gamma computed from Ni
$\frac{\gamma}{\omega_{ci}}$
1e-05
0.0001
0.001
0.01
0
500
1000
1500
2000
2500
3000
$k\rho_{ci}$

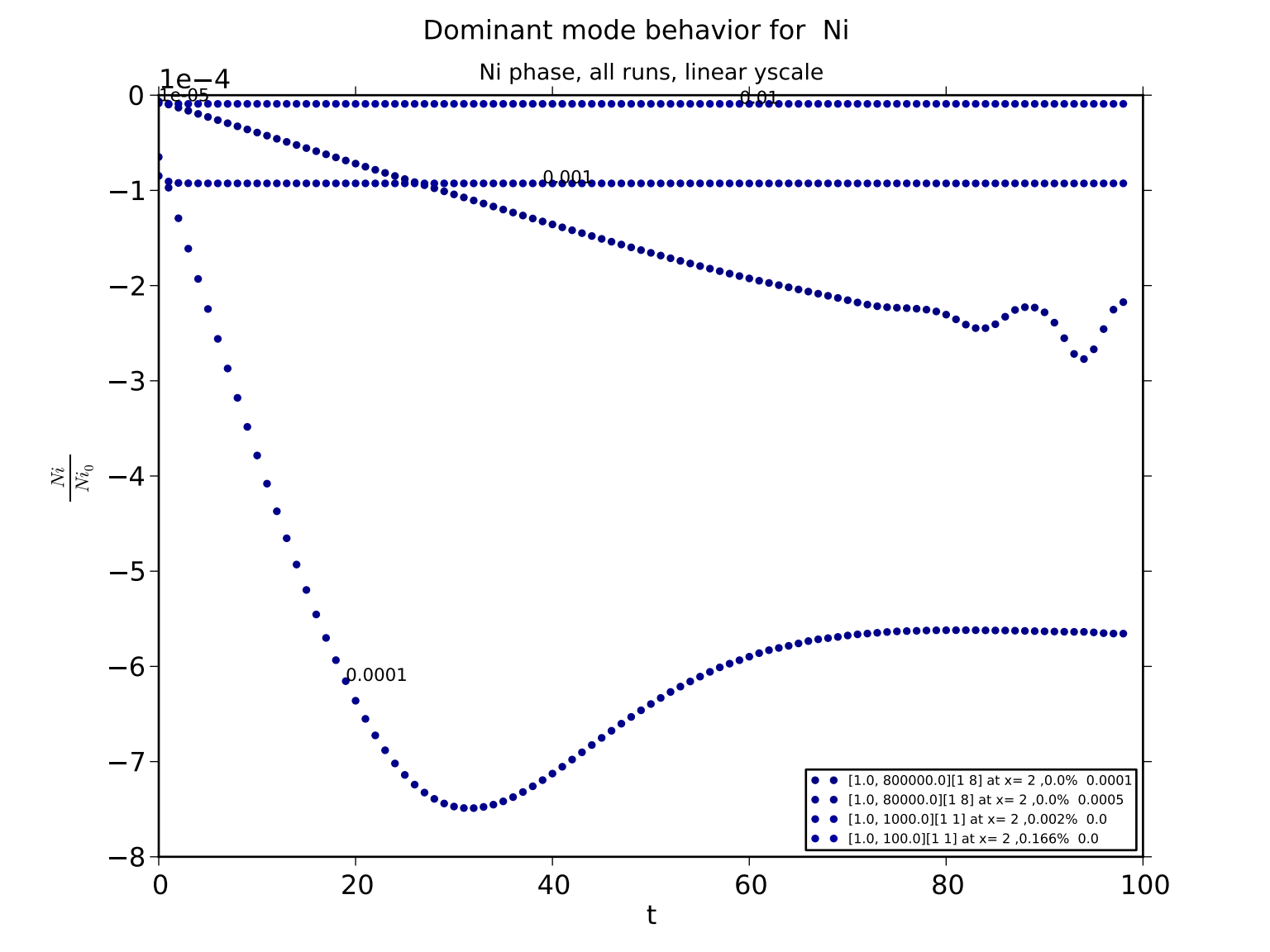
Dominant mode phase for Ni

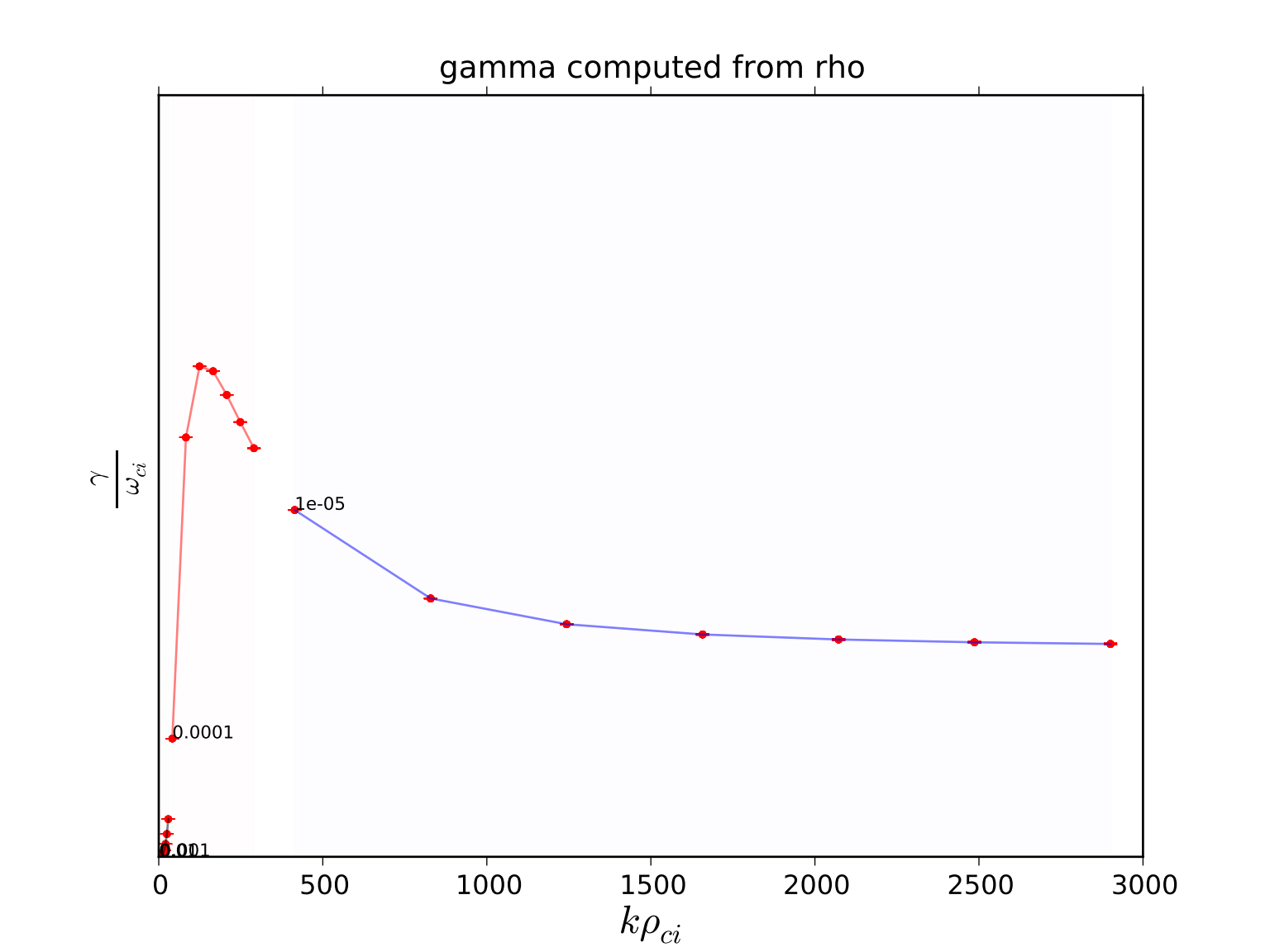




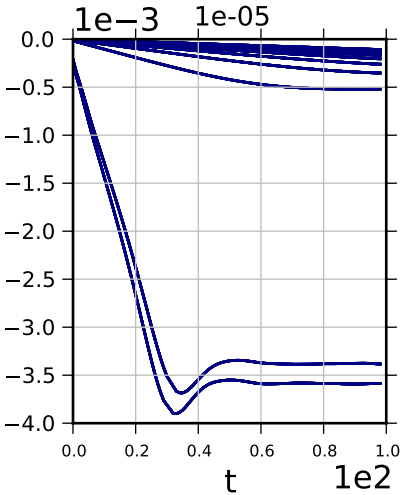


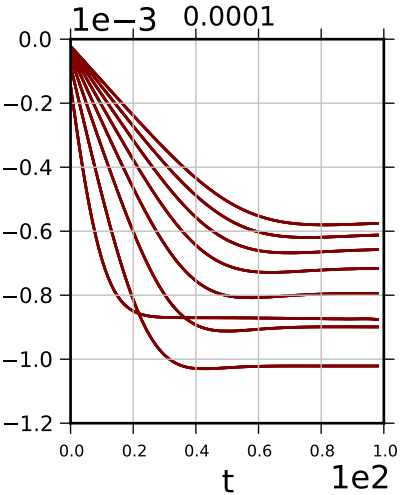


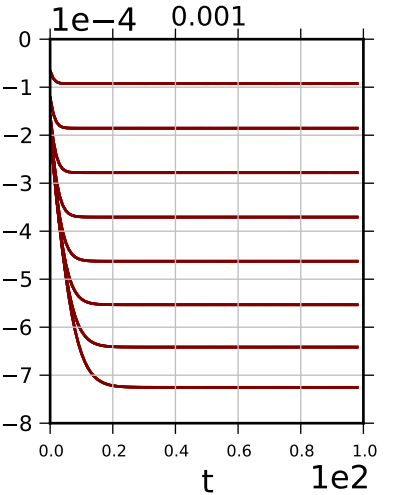

Dominant mode behavior for Ni
Ni phase, all runs, linear yscale
1e−4
0
−1
−2
−3
−4
−5
−6
−7
−8
0
20
40
60
80
100
t
$\frac{Ni}{Ni_0}$
1e-05
0.01
0.001
0.0001
[1.0, 800000.0][1 8] at x= 2 ,0.0% 0.0001
[1.0, 80000.0][1 8] at x= 2 ,0.0% 0.0005
[1.0, 1000.0][1 1] at x= 2 ,0.002% 0.0
[1.0, 100.0][1 1] at x= 2 ,0.166% 0.0

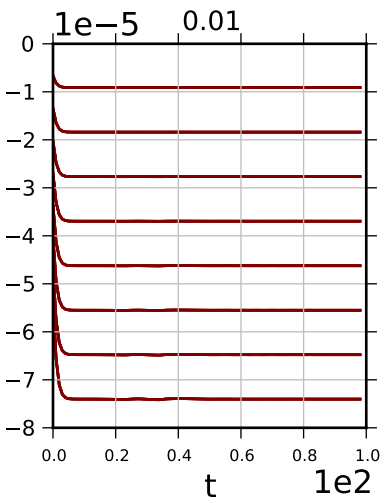

gamma computed from rho
$\frac{\gamma}{\omega_{ci}}$
1e-05
0.0001
0.001
0.01
0
500
1000
1500
2000
2500
3000
$k\rho_{ci}$

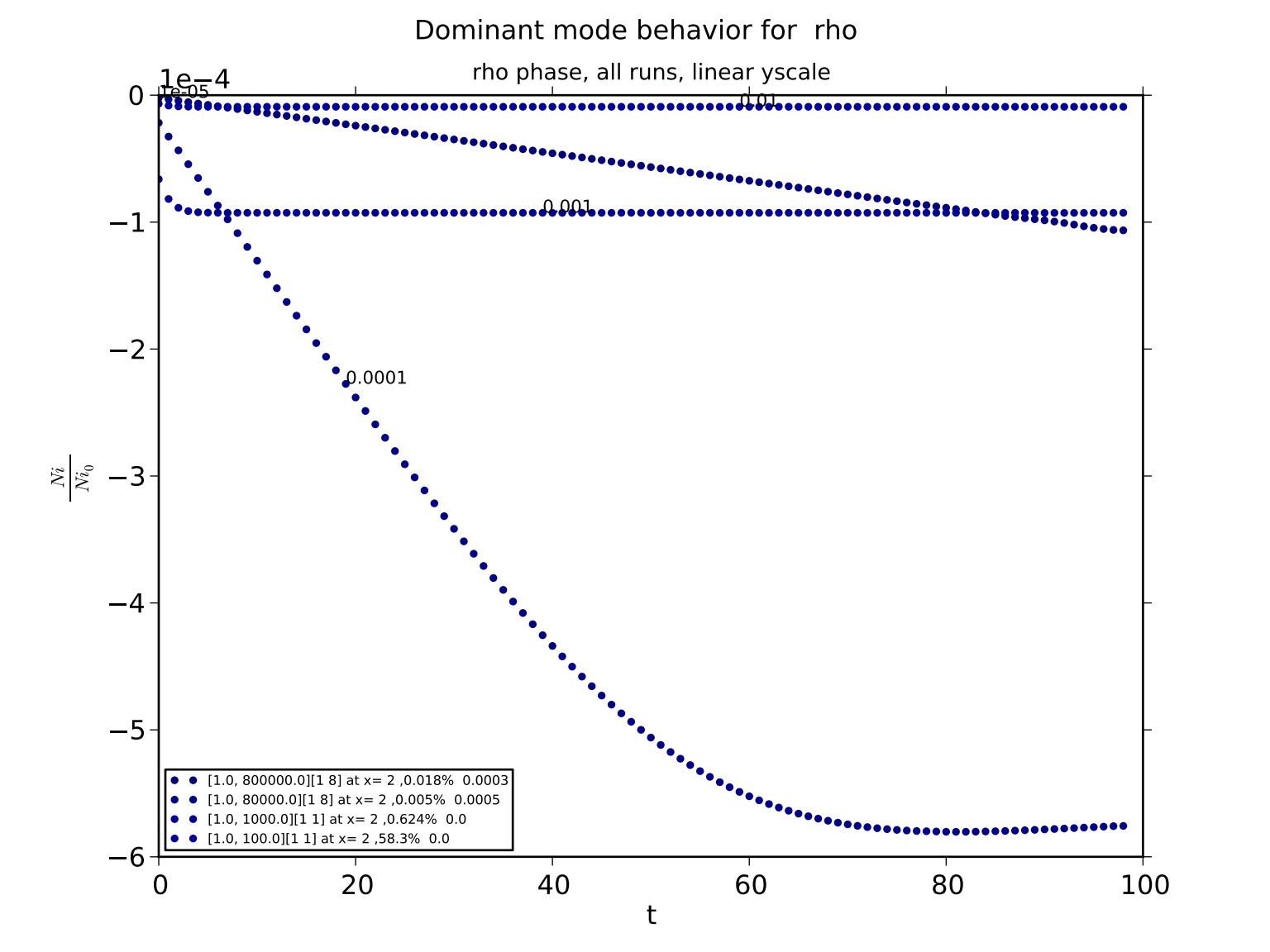
Dominant mode phase for rho



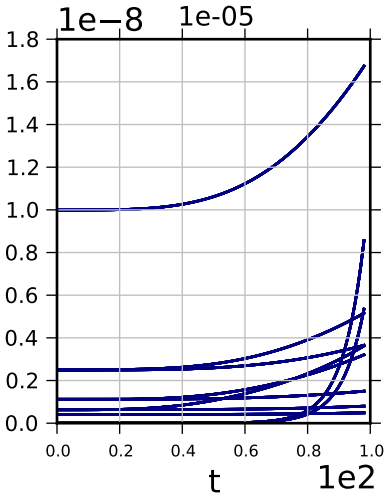


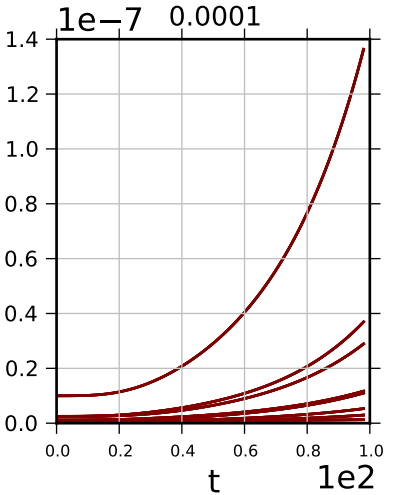


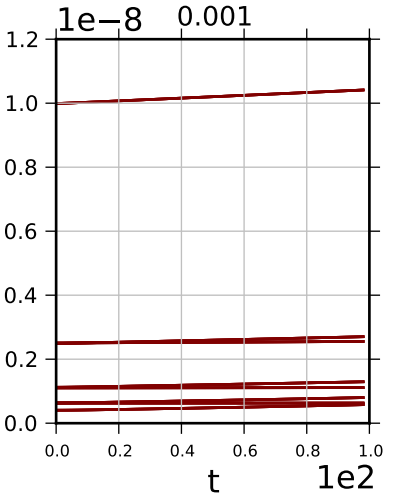


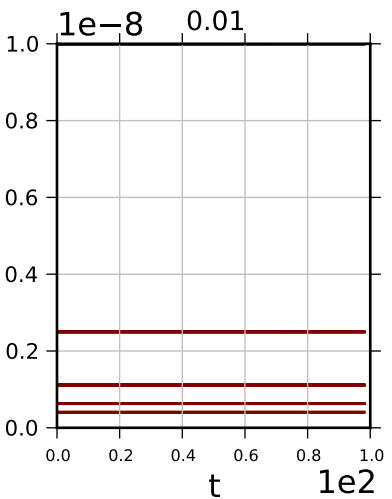

Dominant mode behavior for rho
rho phase, all runs, linear yscale
1e−4
0
−1
−2
−3
−4
−5
−6
0
20
40
60
80
100
t
$\frac{Ni}{Ni_0}$
1e-05
0.01
0.001
0.0001
[1.0, 800000.0][1 8] at x= 2 ,0.018% 0.0003
[1.0, 80000.0][1 8] at x= 2 ,0.005% 0.0005
[1.0, 1000.0][1 1] at x= 2 ,0.624% 0.0
[1.0, 100.0][1 1] at x= 2 ,58.3% 0.0

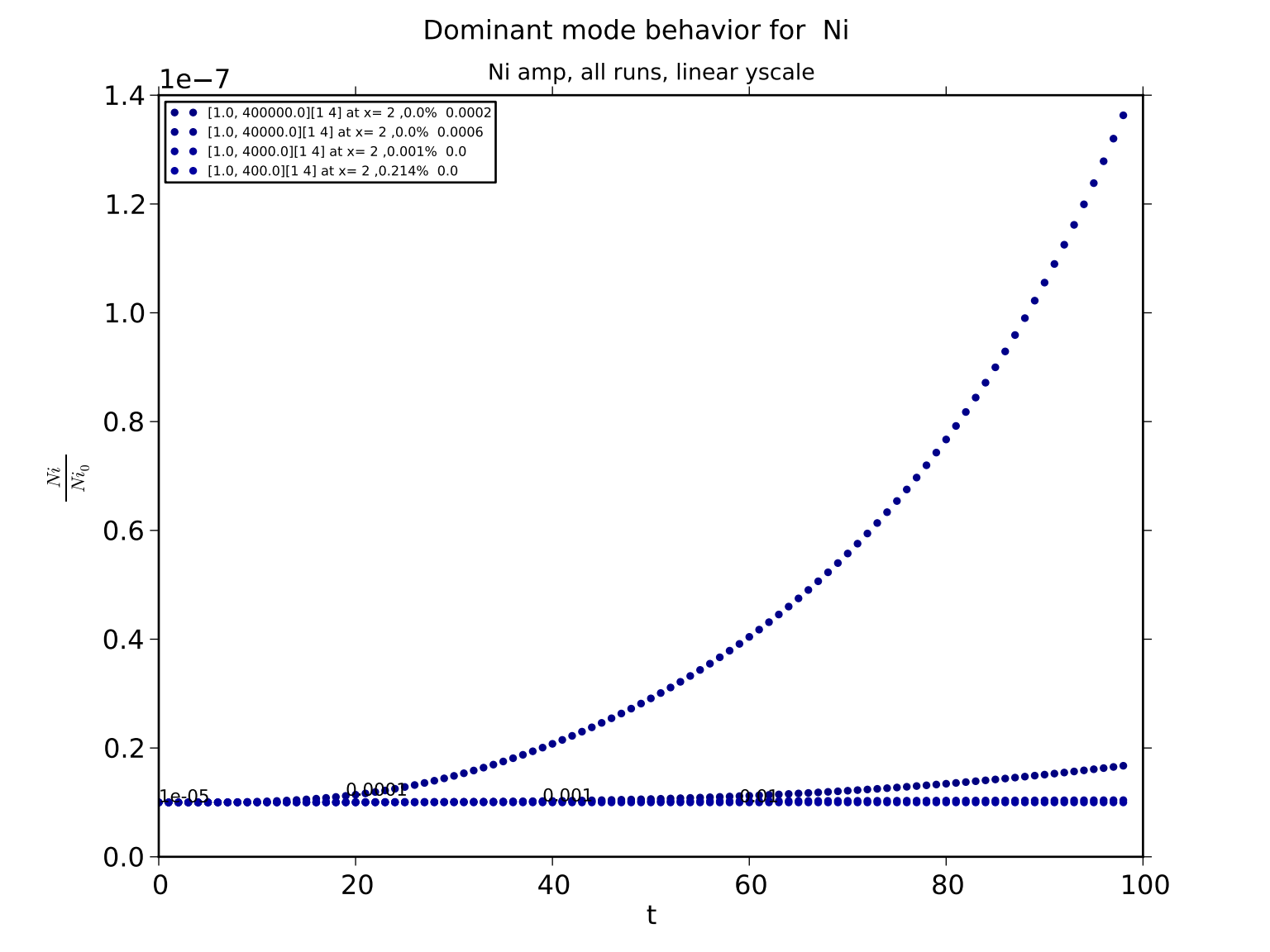
Dominant mode amp for Ni



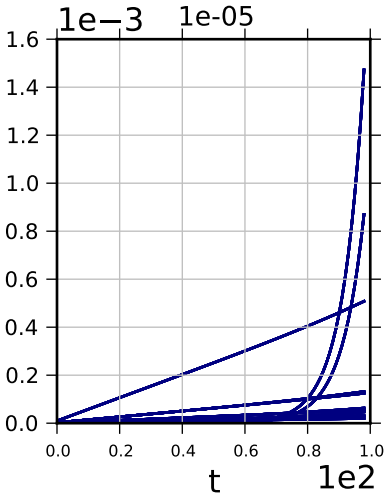


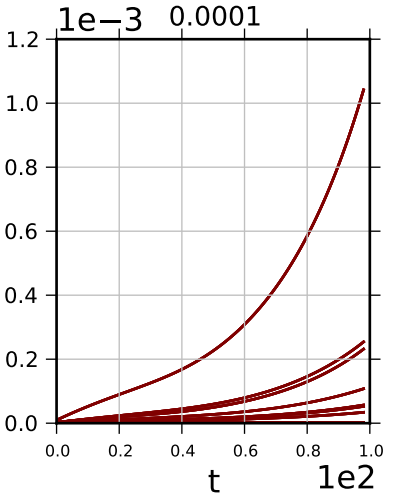


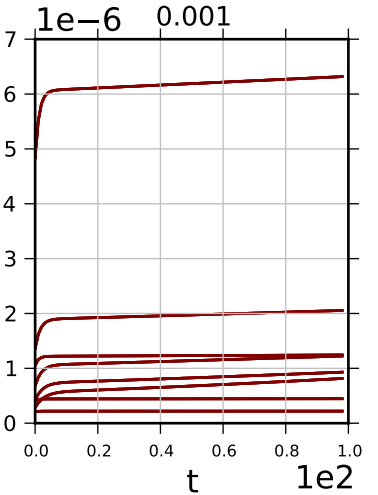


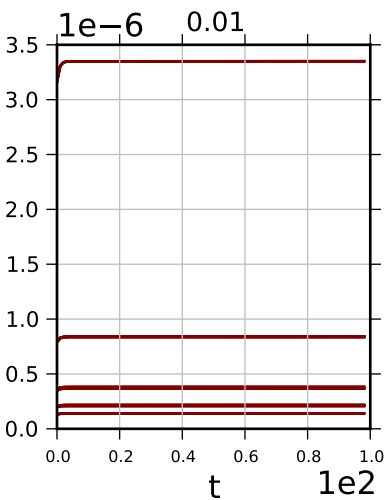

Dominant mode behavior for Ni
Ni amp, all runs, linear yscale
1e−7
[1.0, 400000.0][1 4] at x= 2 ,0.0% 0.0002
[1.0, 40000.0][1 4] at x= 2 ,0.0% 0.0006
[1.0, 4000.0][1 4] at x= 2 ,0.001% 0.0
[1.0, 400.0][1 4] at x= 2 ,0.214% 0.0
$\frac{Ni}{Ni_0}$
1e-05
0.0001
0.001
0.01
t

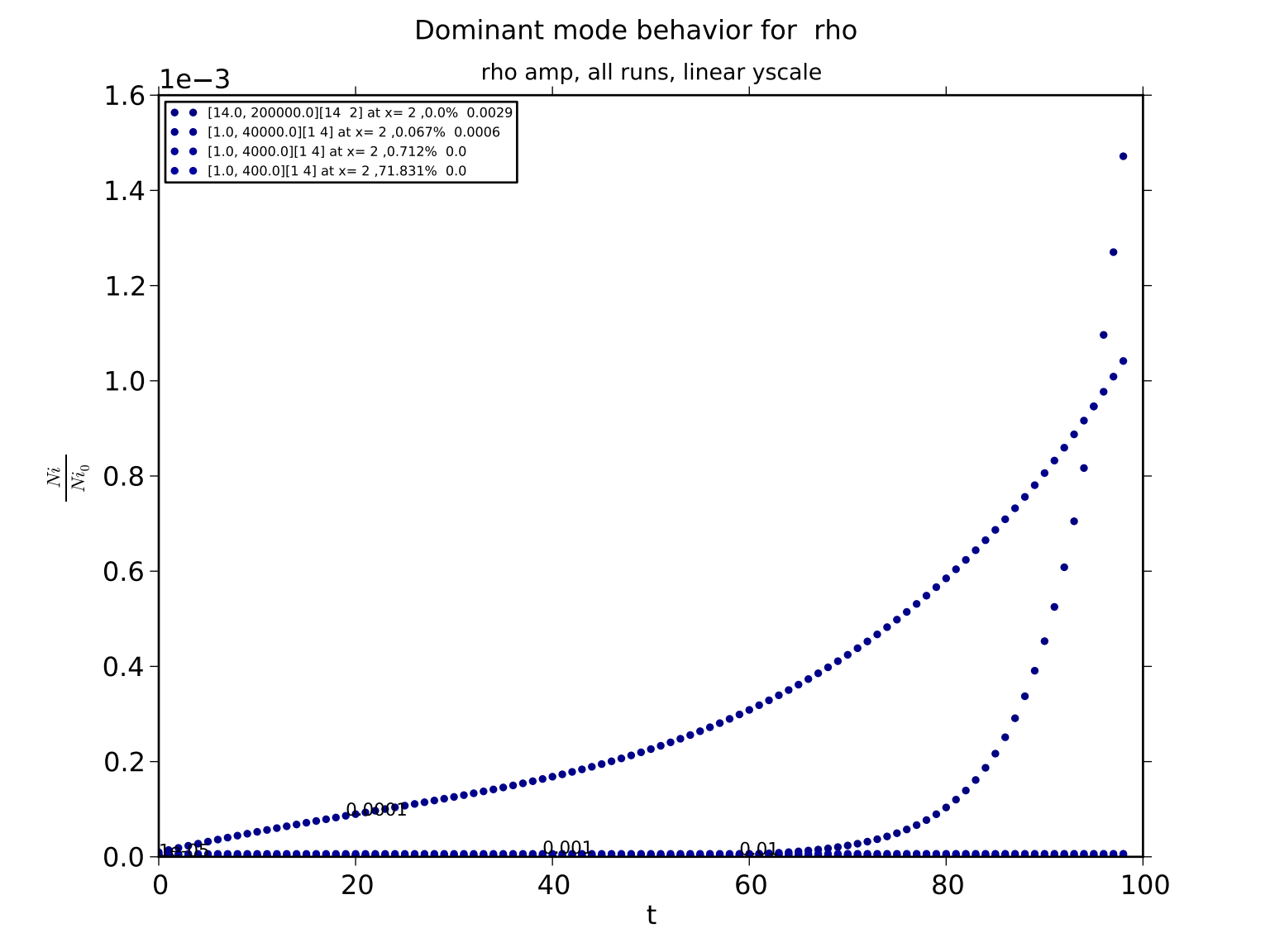
Dominant mode amp for rho

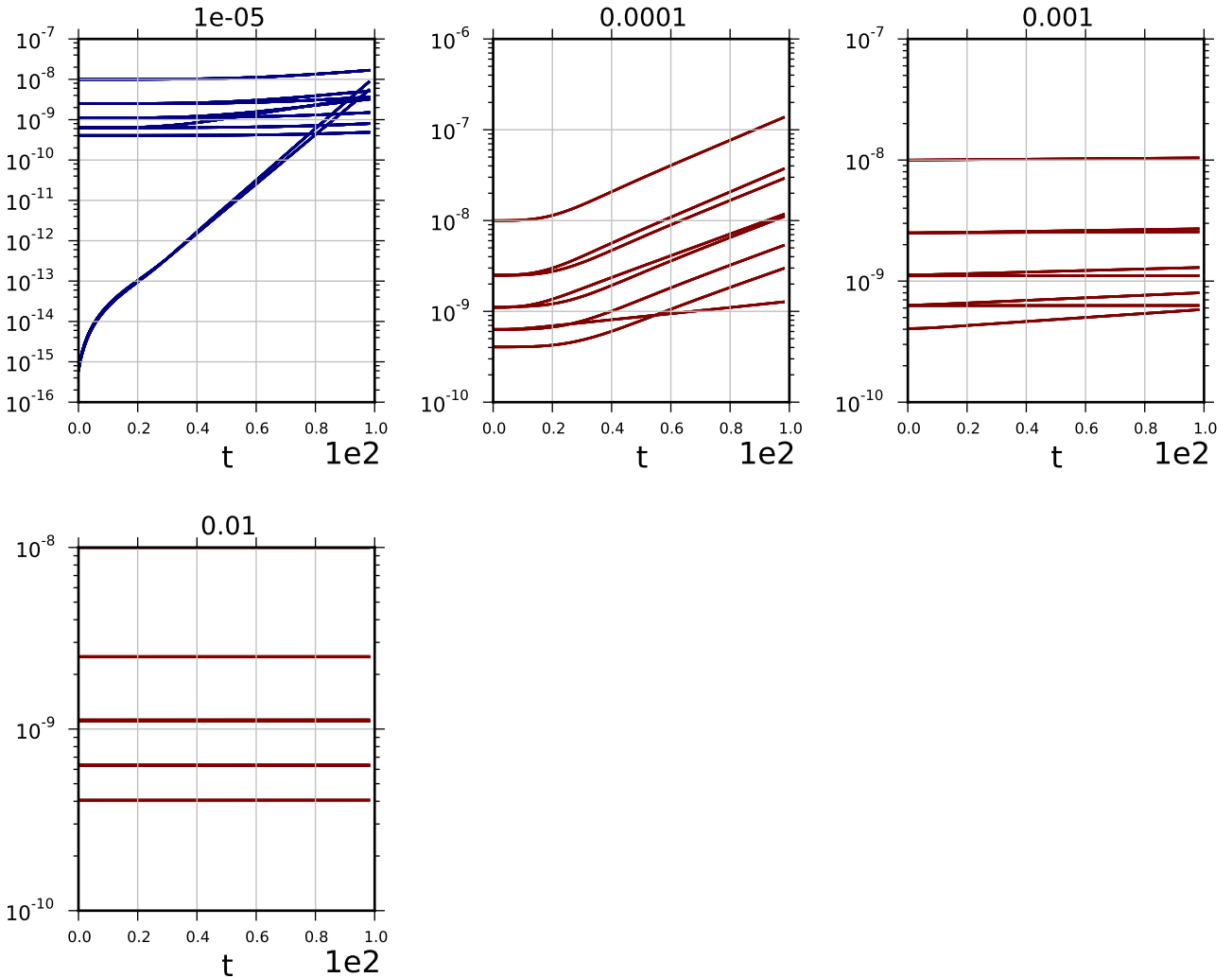


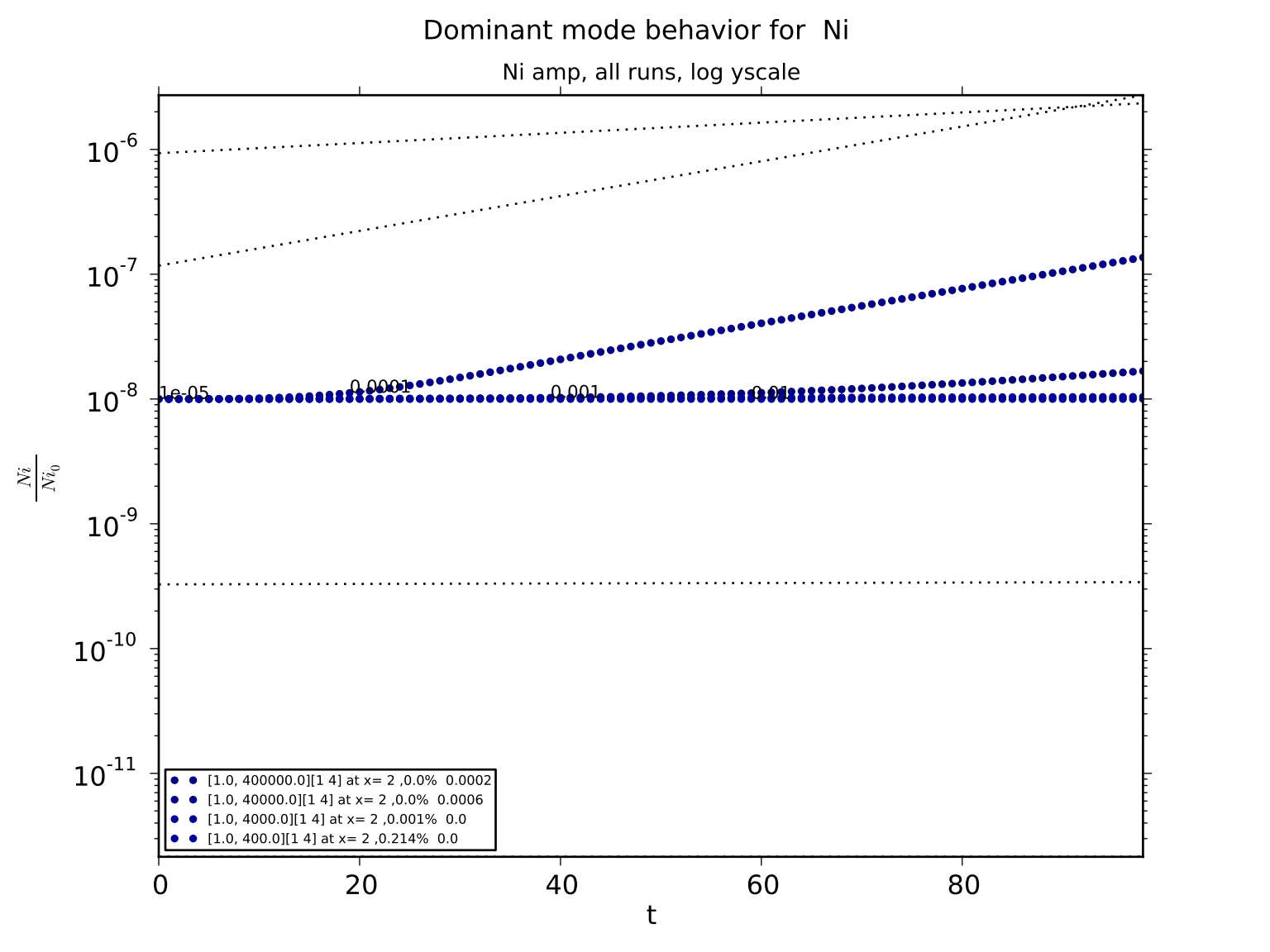


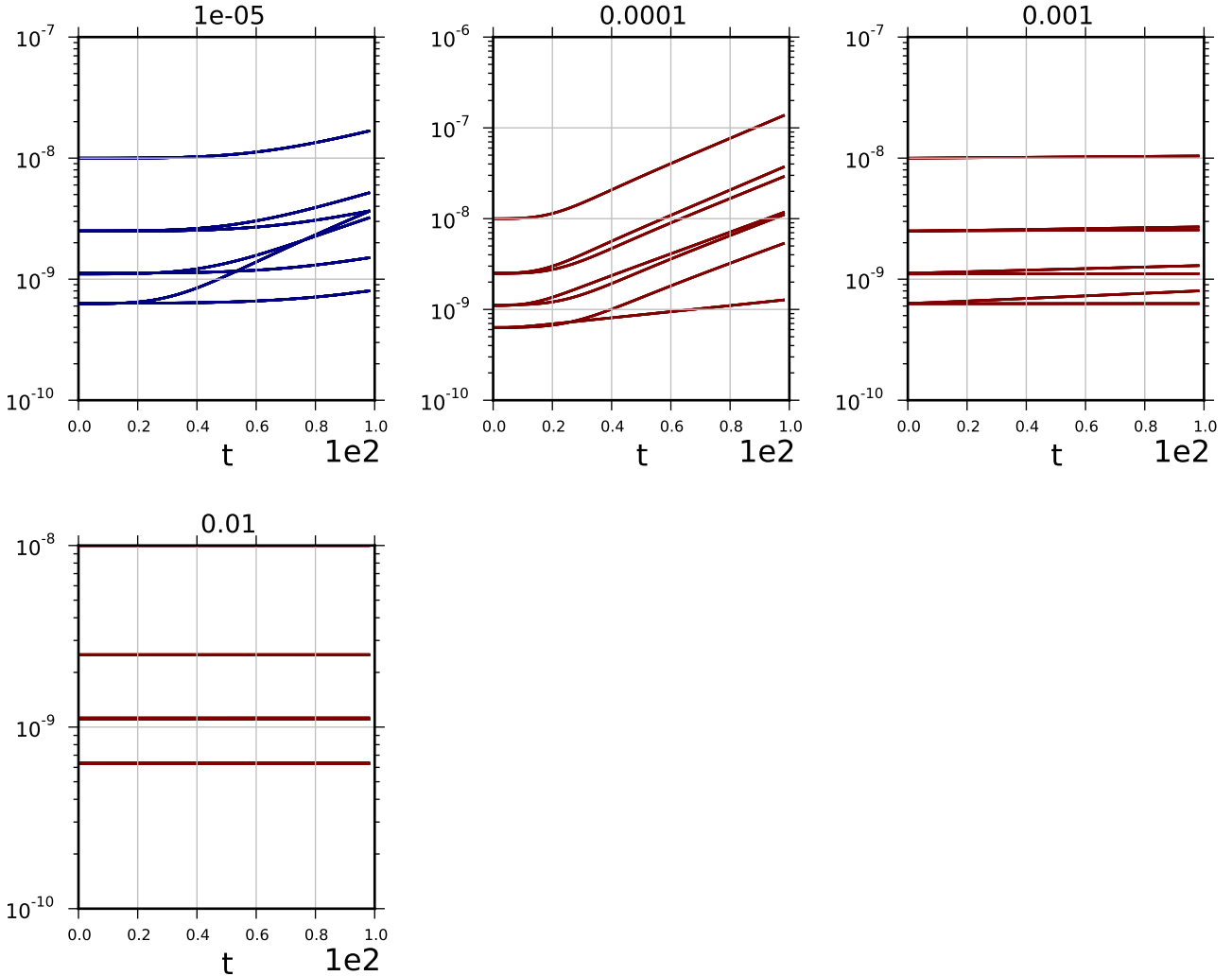


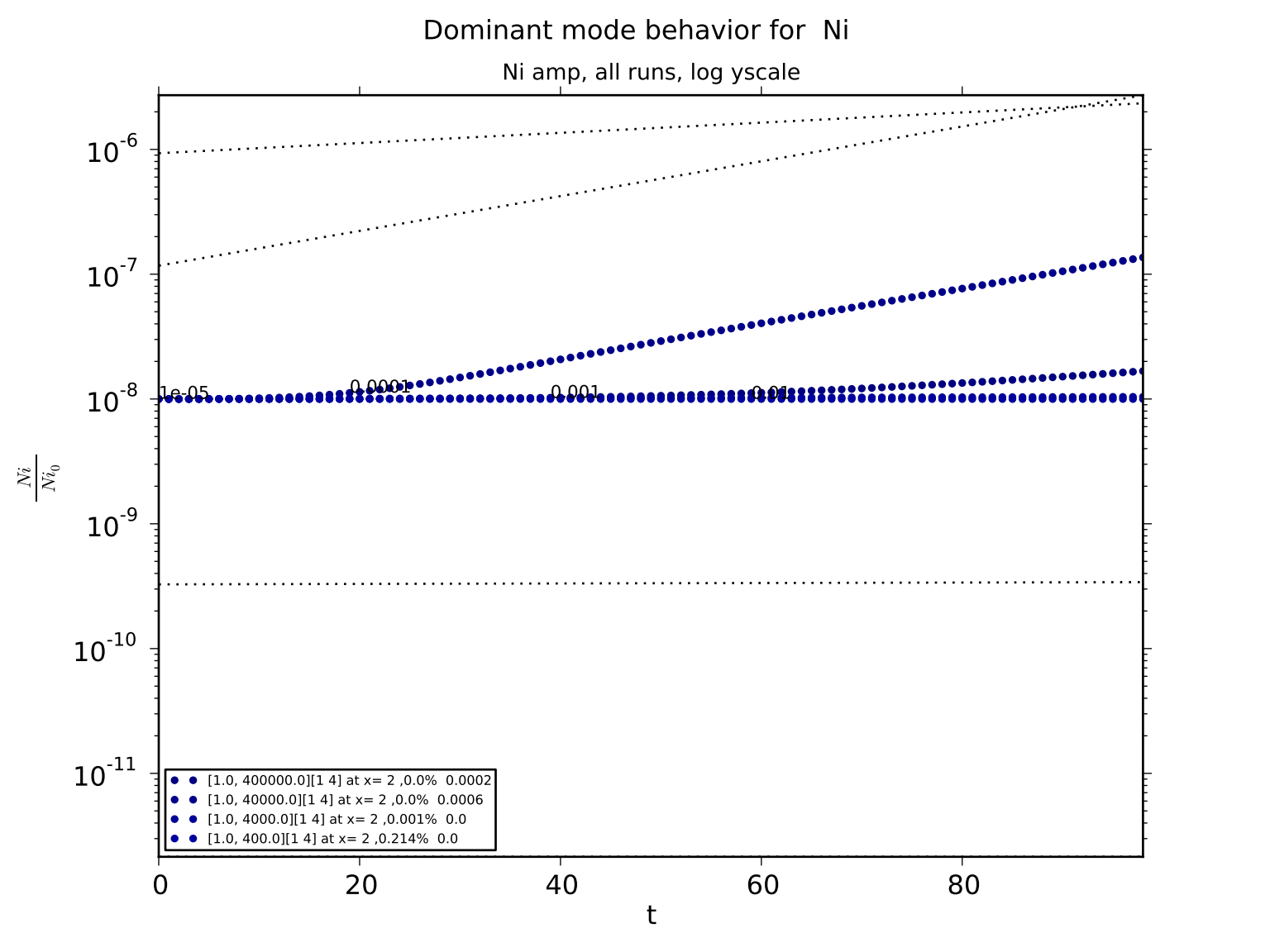



Dominant mode behavior for rho
rho amp, all runs, linear yscale
1e−3
[14.0, 200000.0][14 2] at x= 2 ,0.0% 0.0029
[1.0, 40000.0][1 4] at x= 2 ,0.067% 0.0006
[1.0, 4000.0][1 4] at x= 2 ,0.712% 0.0
[1.0, 400.0][1 4] at x= 2 ,71.831% 0.0
$\frac{Ni}{Ni_0}$
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.0001
0.001
0.01
0
20
40
60
80
100
t

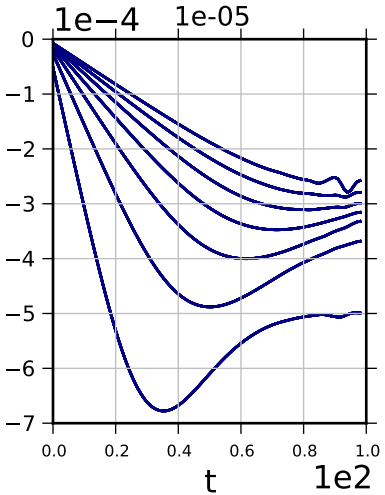

Dominant mode amp for Ni
1e-05
0.0001
0.001
0.01
t
1e2

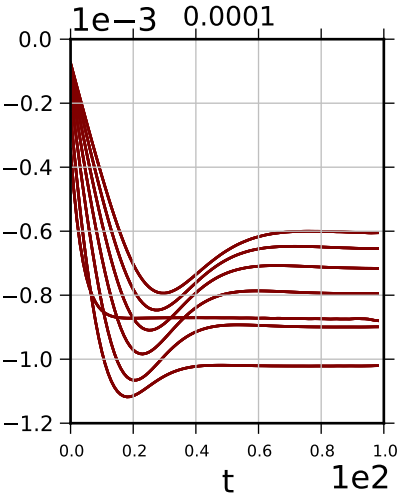

Dominant mode behavior for Ni
Ni amp, all runs, log yscale
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
10^{-11}
$\frac{Ni}{Ni_0}$
1e-05
0.0001
0.001
0.01
[1.0, 400000.0][1 4] at x= 2 ,0.0% 0.0002
[1.0, 40000.0][1 4] at x= 2 ,0.0% 0.0006
[1.0, 4000.0][1 4] at x= 2 ,0.001% 0.0
[1.0, 400.0][1 4] at x= 2 ,0.214% 0.0
0
20
40
60
80
t

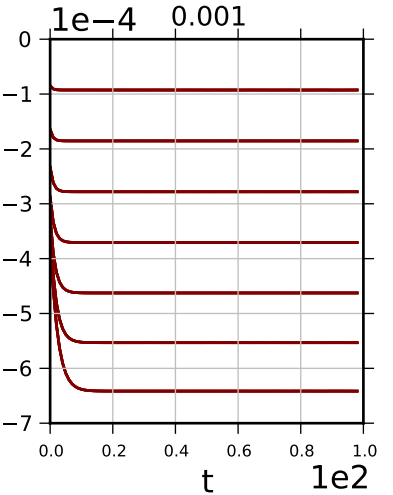

Dominant mode amp for Ni
1e-05
0.0001
0.001
0.01
t
1e2

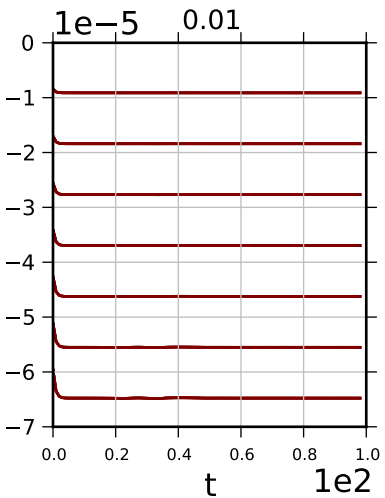

Dominant mode behavior for Ni
Ni amp, all runs, log yscale
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
10^{-11}
$\frac{Ni}{Ni_0}$
1e-05
0.0001
0.001
0.01
[1.0, 400000.0][1 4] at x= 2 ,0.0% 0.0002
[1.0, 40000.0][1 4] at x= 2 ,0.0% 0.0006
[1.0, 4000.0][1 4] at x= 2 ,0.001% 0.0
[1.0, 400.0][1 4] at x= 2 ,0.214% 0.0
0
20
40
60
80
t

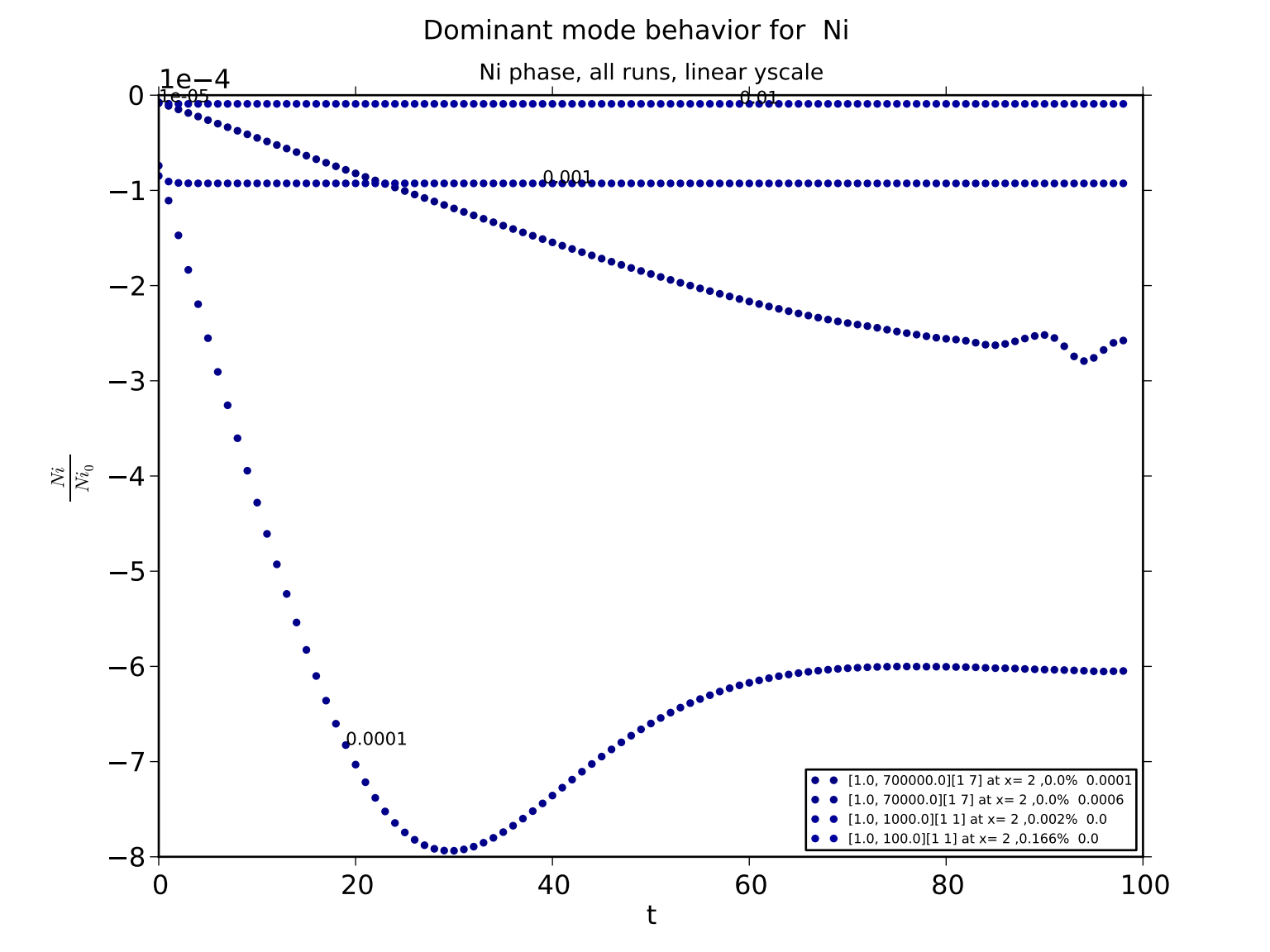
Dominant mode phase for Ni

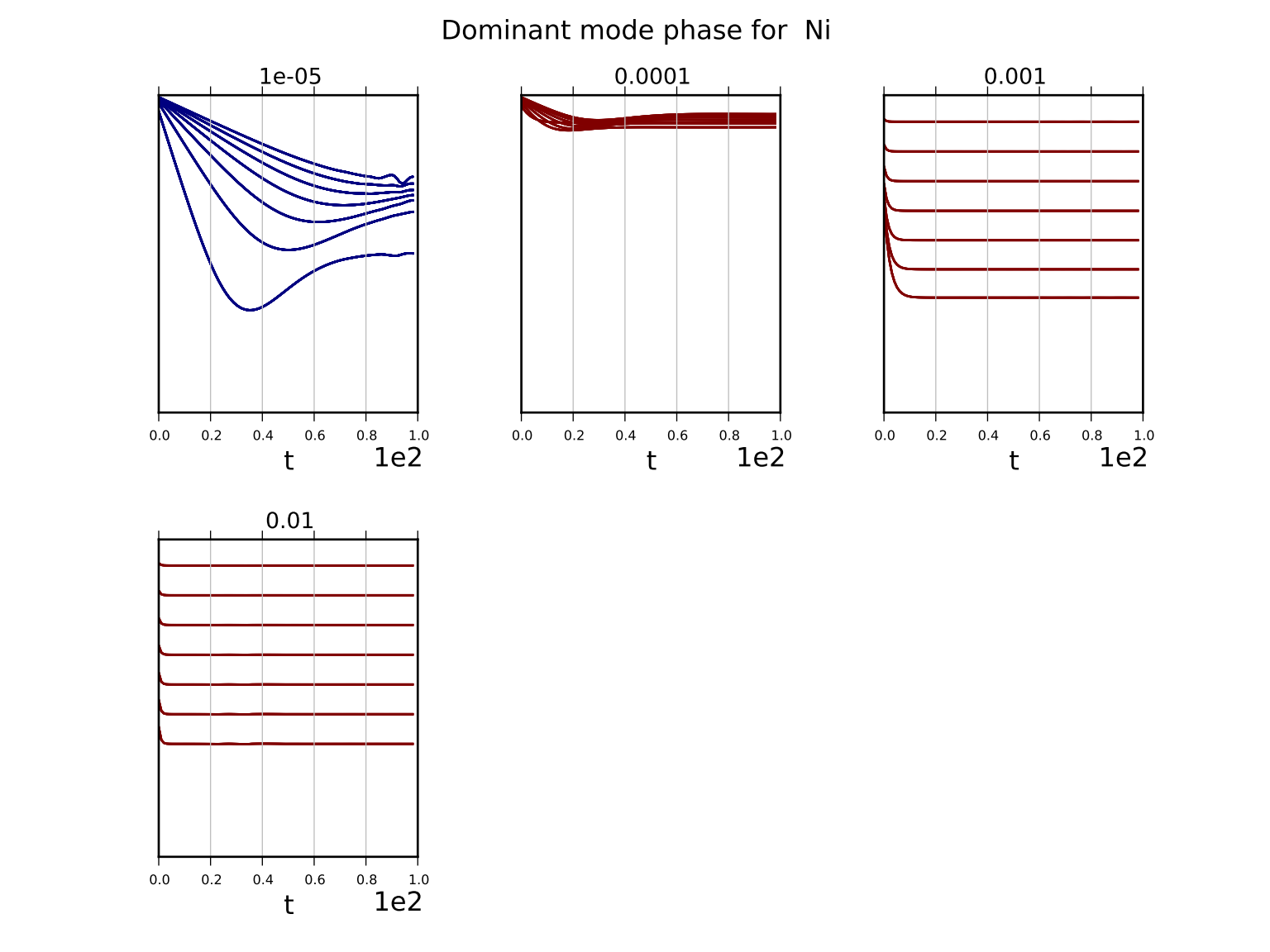


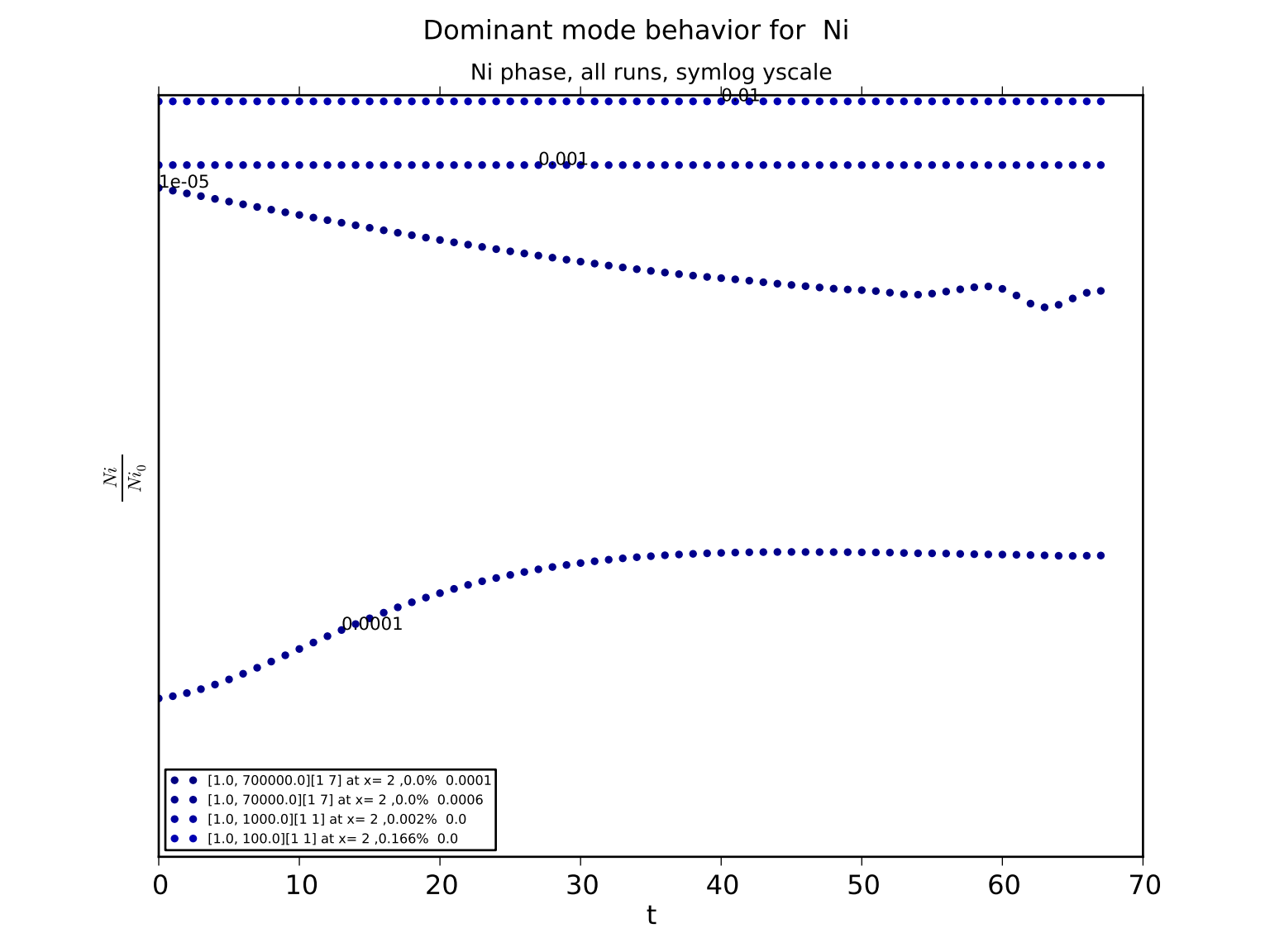


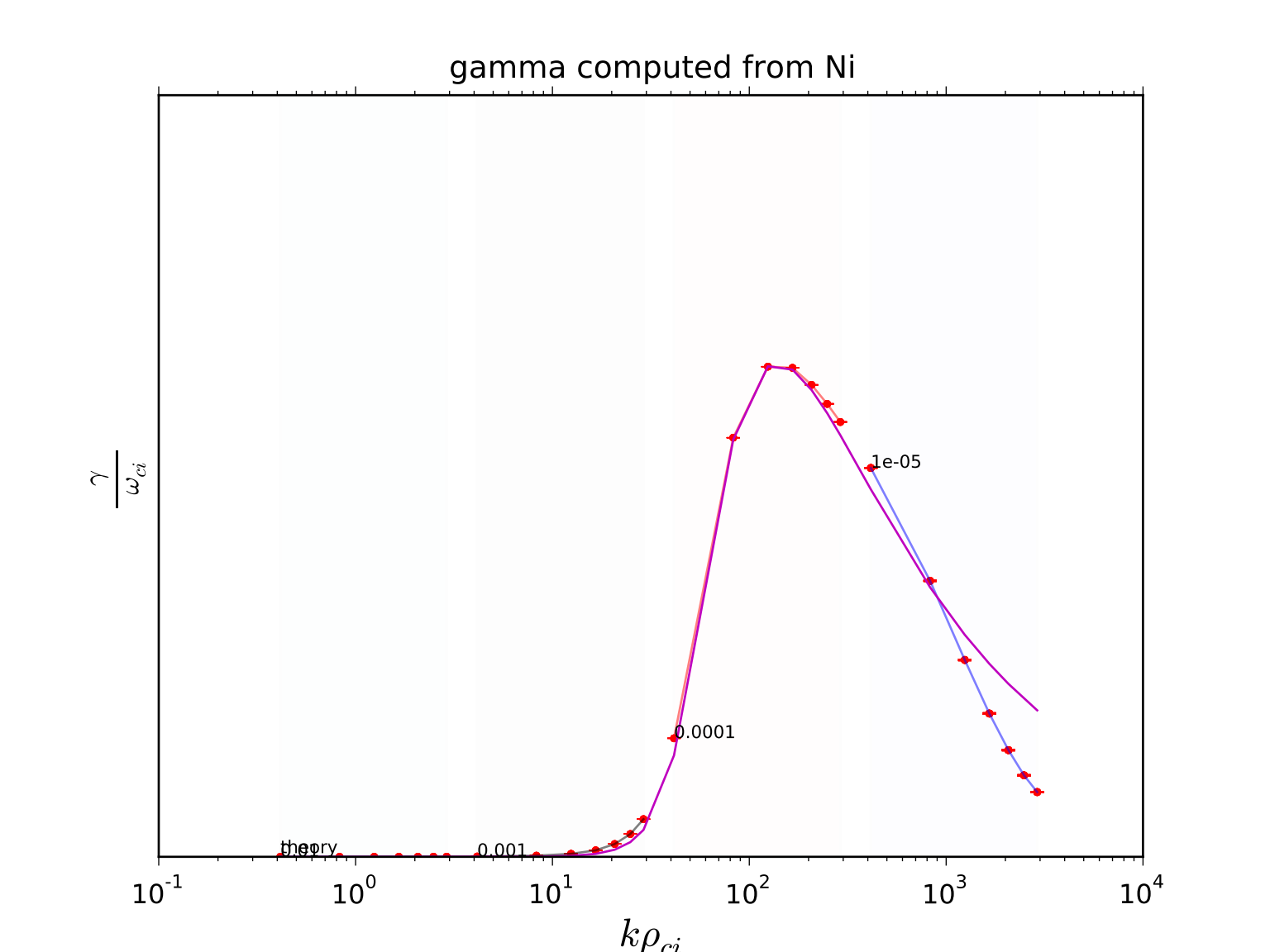


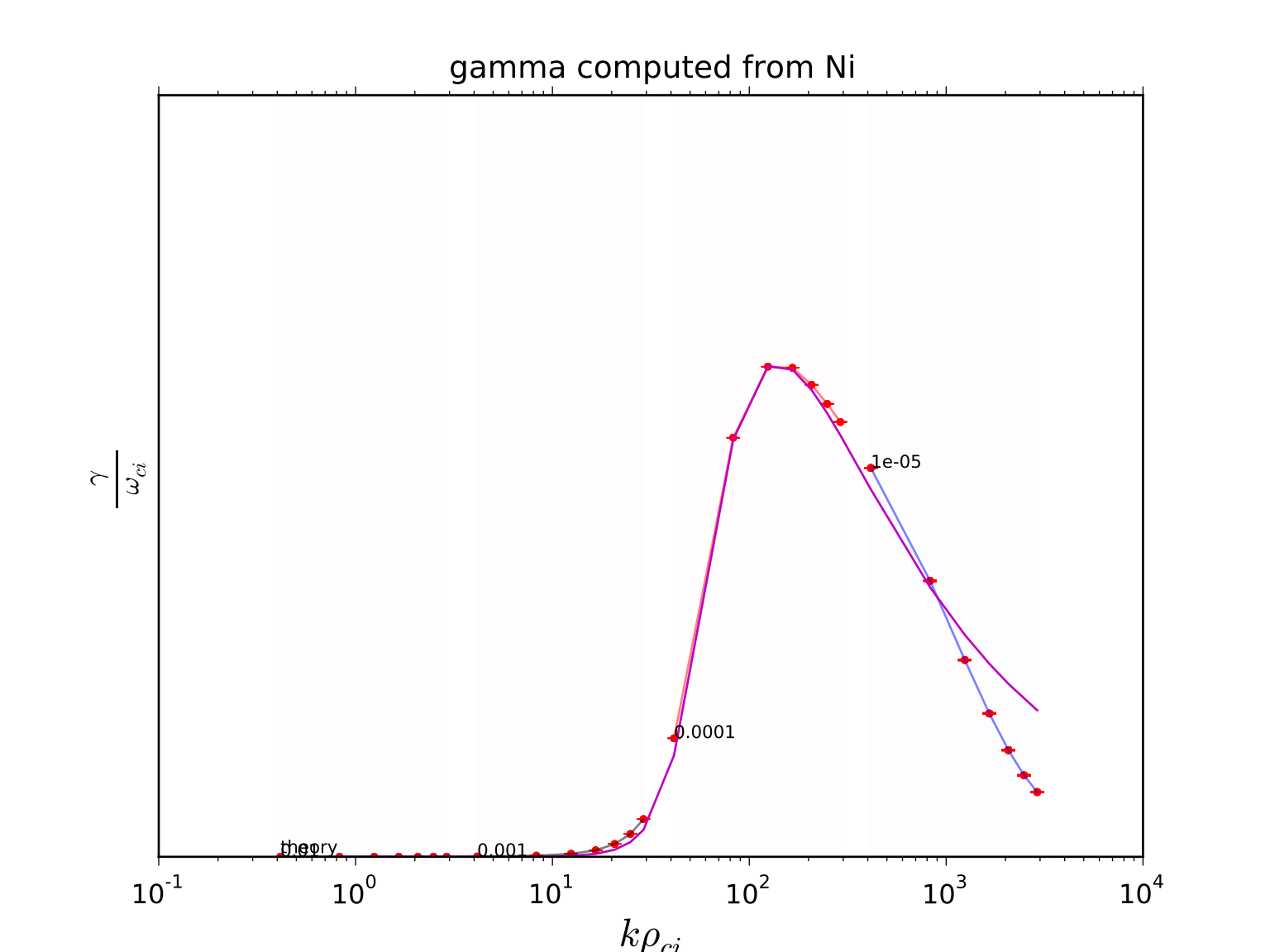


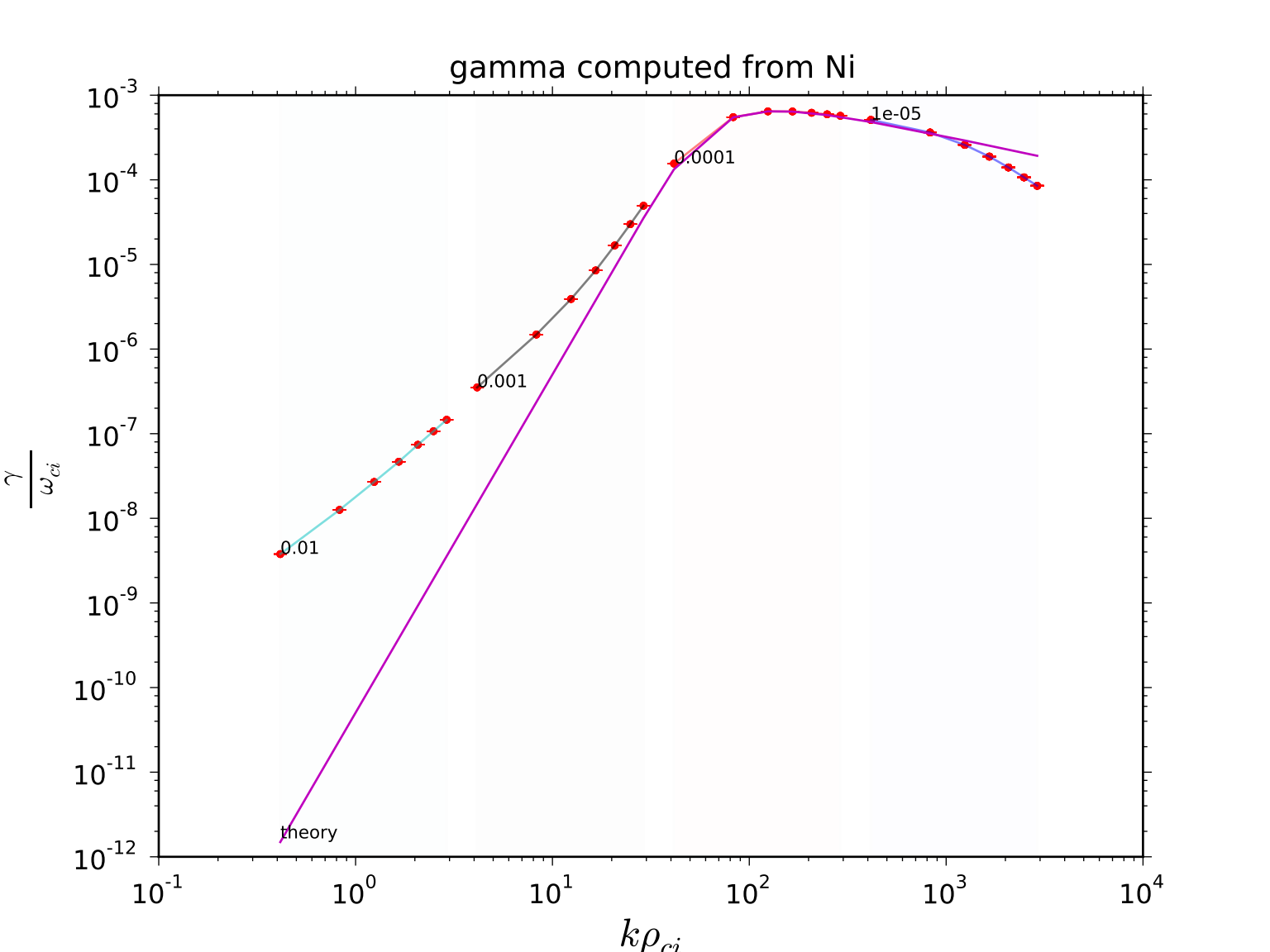

Dominant mode behavior for Ni
Ni phase, all runs, linear yscale
1e−4
1e-05
0.01
0.001
0.0001
$\frac{Ni}{Ni_0}$
t
0
−1
−2
−3
−4
−5
−6
−7
−8
0
20
40
60
80
100
[1.0, 700000.0][1 7] at x= 2 ,0.0% 0.0001
[1.0, 70000.0][1 7] at x= 2 ,0.0% 0.0006
[1.0, 1000.0][1 1] at x= 2 ,0.002% 0.0
[1.0, 100.0][1 1] at x= 2 ,0.166% 0.0

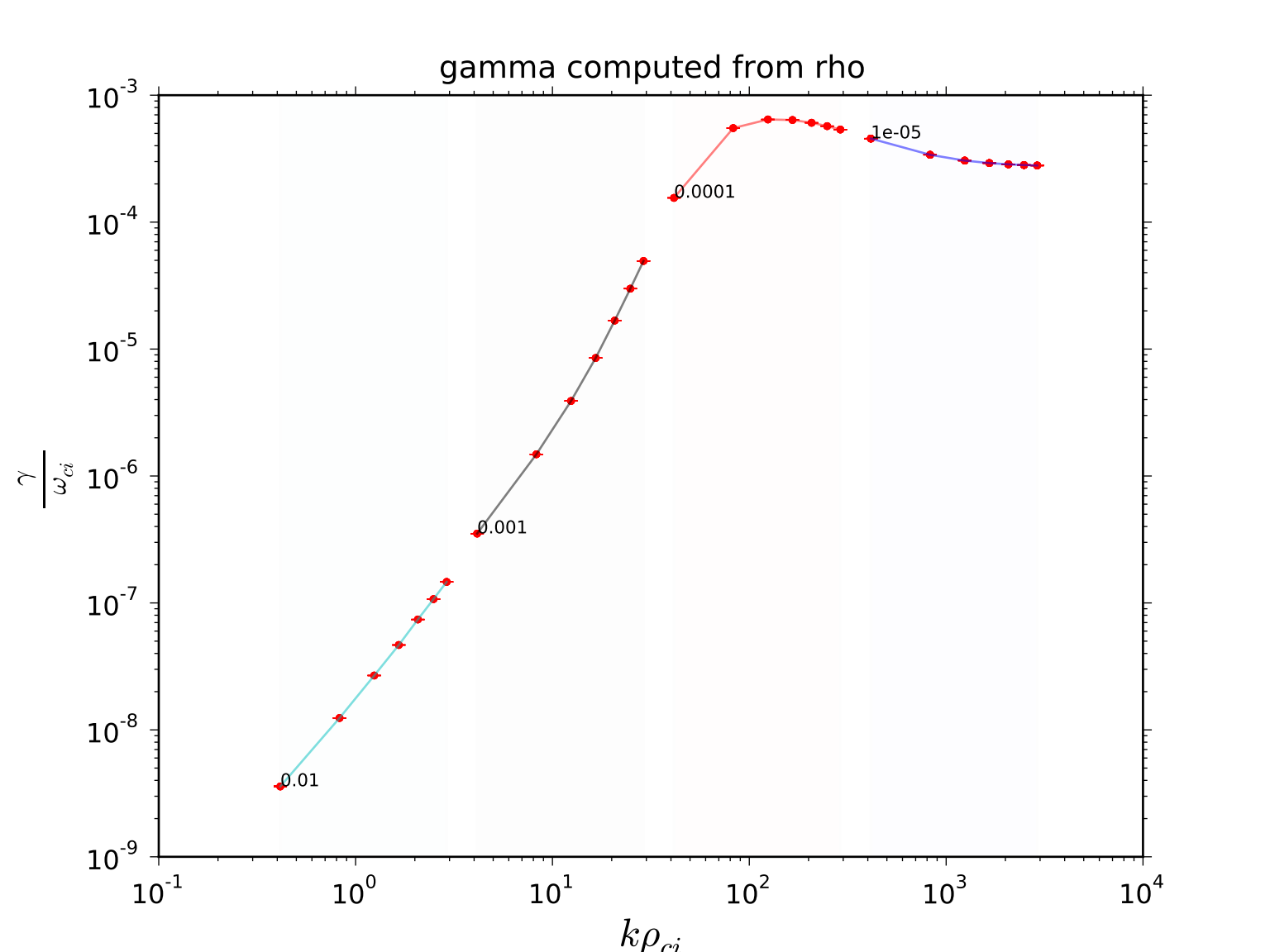

Dominant mode phase for Ni
1e-05
0.0001
0.001
0.01
0.0 0.2 0.4 0.6 0.8 1.0
t
1e2

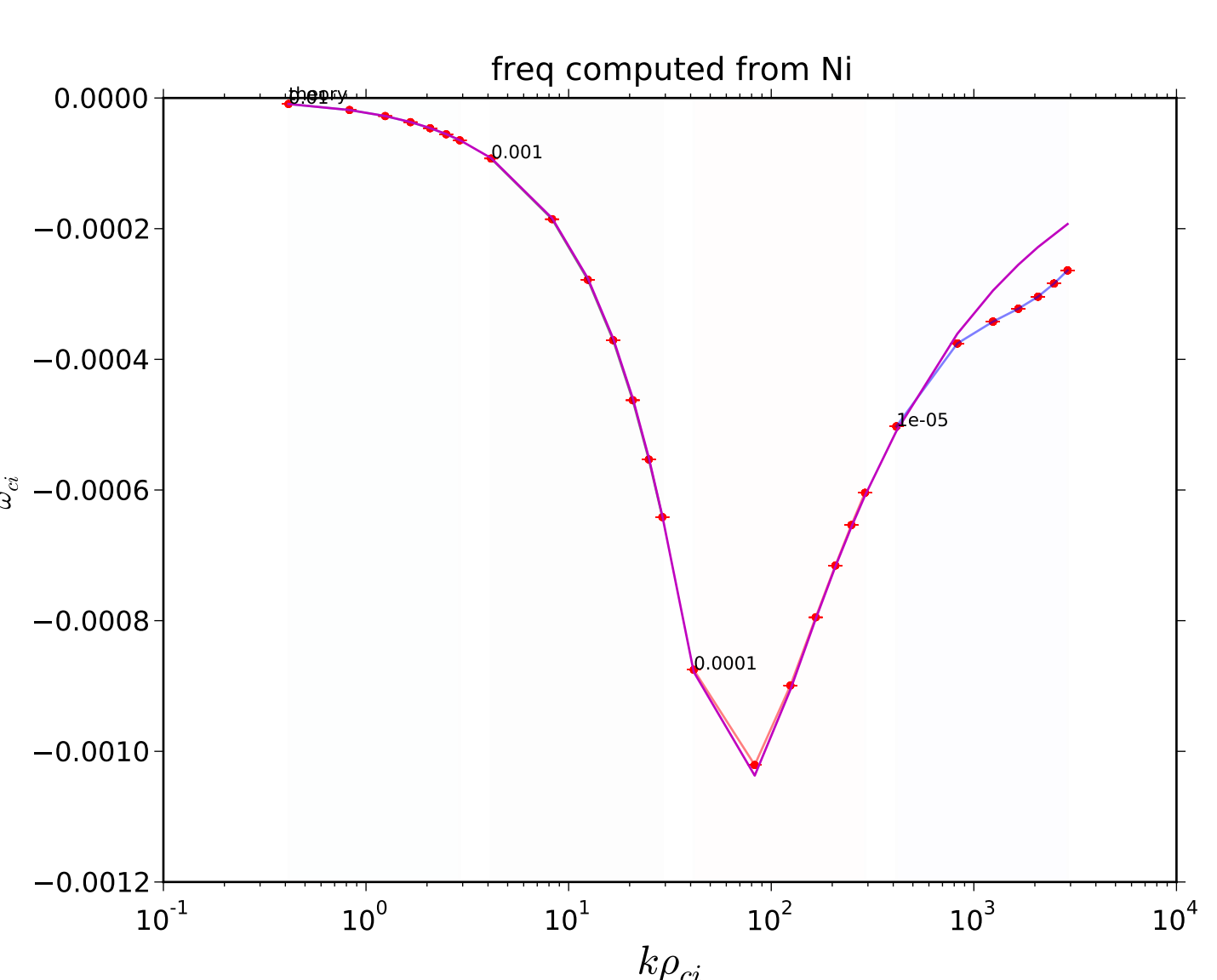

Dominant mode behavior for Ni
Ni phase, all runs, symlog yscale
0.01
0.001
1e-05
0.0001
$\frac{Ni}{Ni_0}$
[1.0, 700000.0][1 7] at x= 2 ,0.0% 0.0001
[1.0, 70000.0][1 7] at x= 2 ,0.0% 0.0006
[1.0, 1000.0][1 1] at x= 2 ,0.002% 0.0
[1.0, 100.0][1 1] at x= 2 ,0.166% 0.0
0
10
20
30
40
50
60
70
t

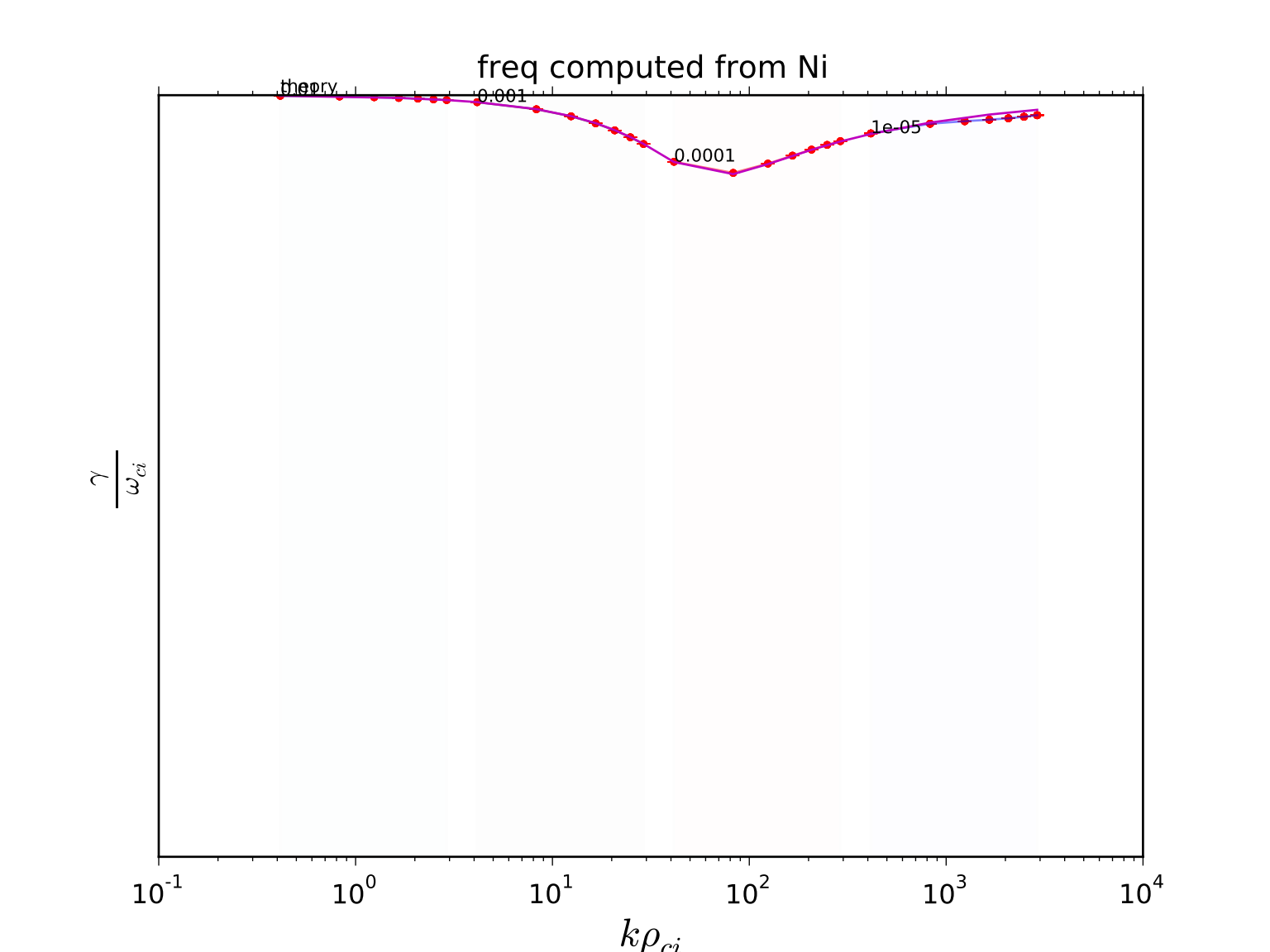

gamma computed from Ni
$\frac{\gamma}{\omega_{ci}}$
1e-05
0.0001
0.001
theory
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
$k\rho_{ci}$

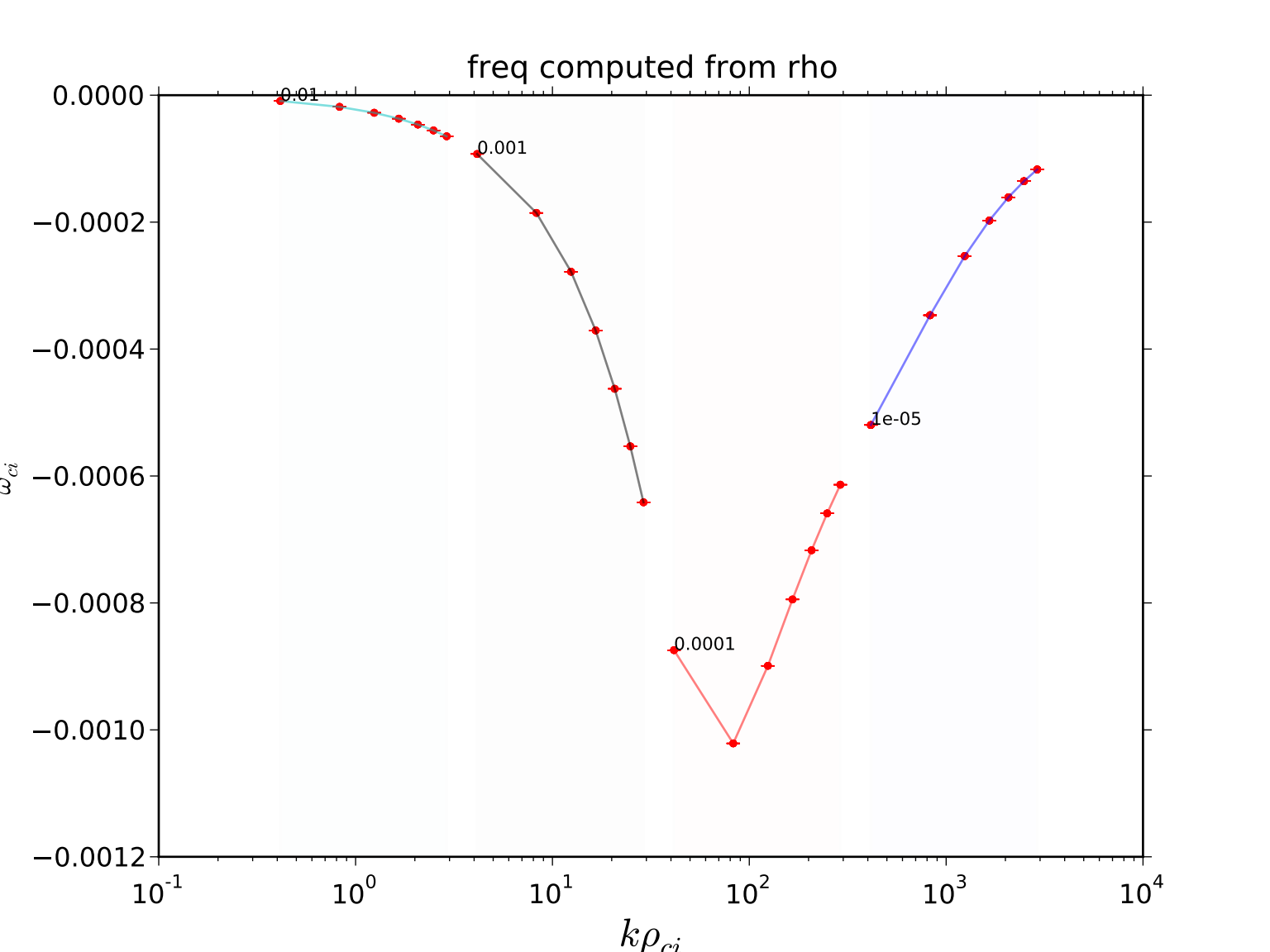

gamma computed from Ni
$\frac{\gamma}{\omega_{ci}}$
1e-05
0.0001
0.001
theory
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
$k\rho_{ci}$

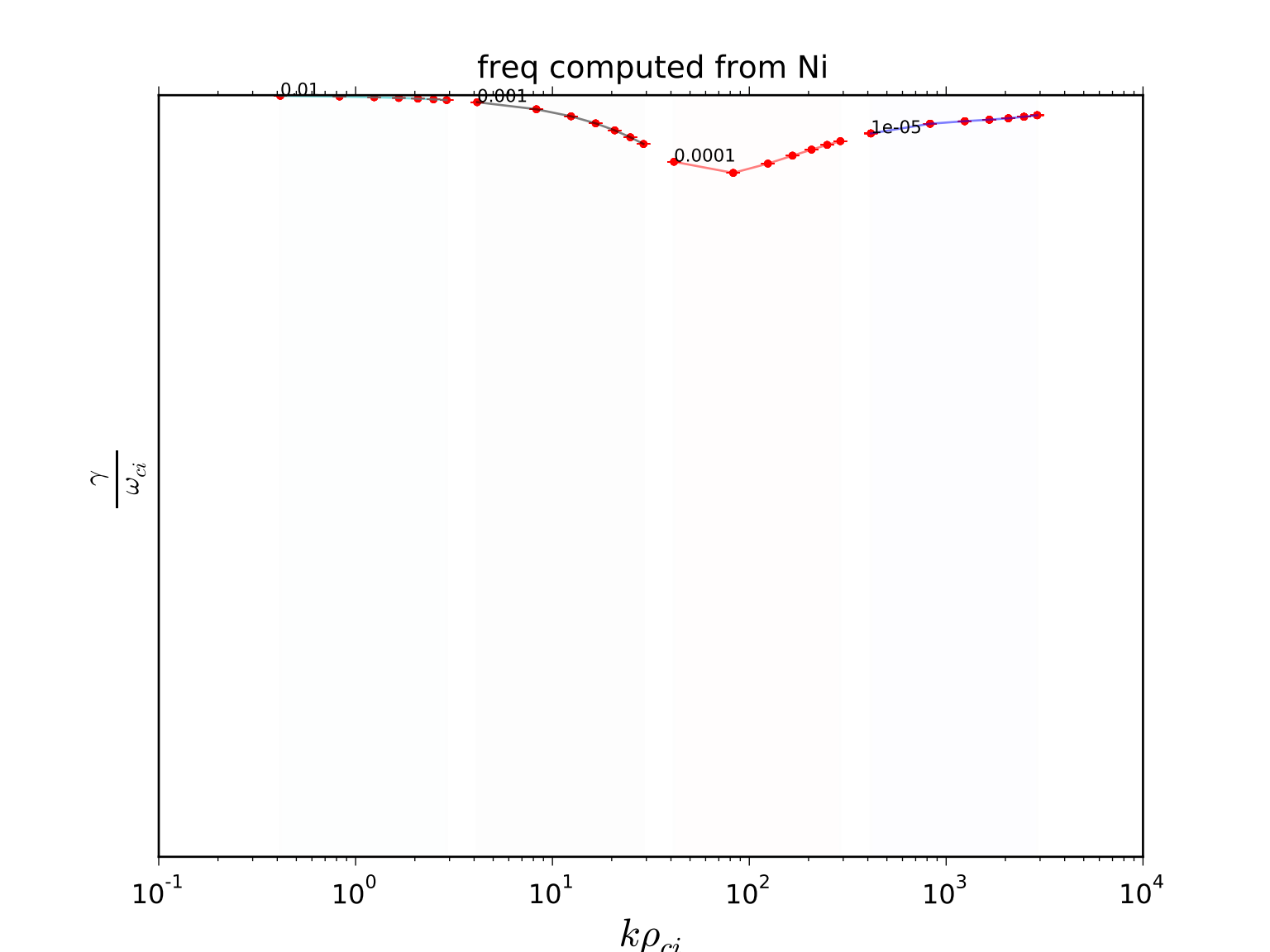

gamma computed from Ni
1e-05
0.0001
0.001
0.01
theory
$\frac{\gamma}{\omega_{ci}}$
$k\rho_{ci}$
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
10^{-11}
10^{-12}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}


gamma computed from rho
$\frac{\gamma}{\omega_{ci}}$
$k\rho_{ci}$
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
0.01
0.001
0.0001
1e-05

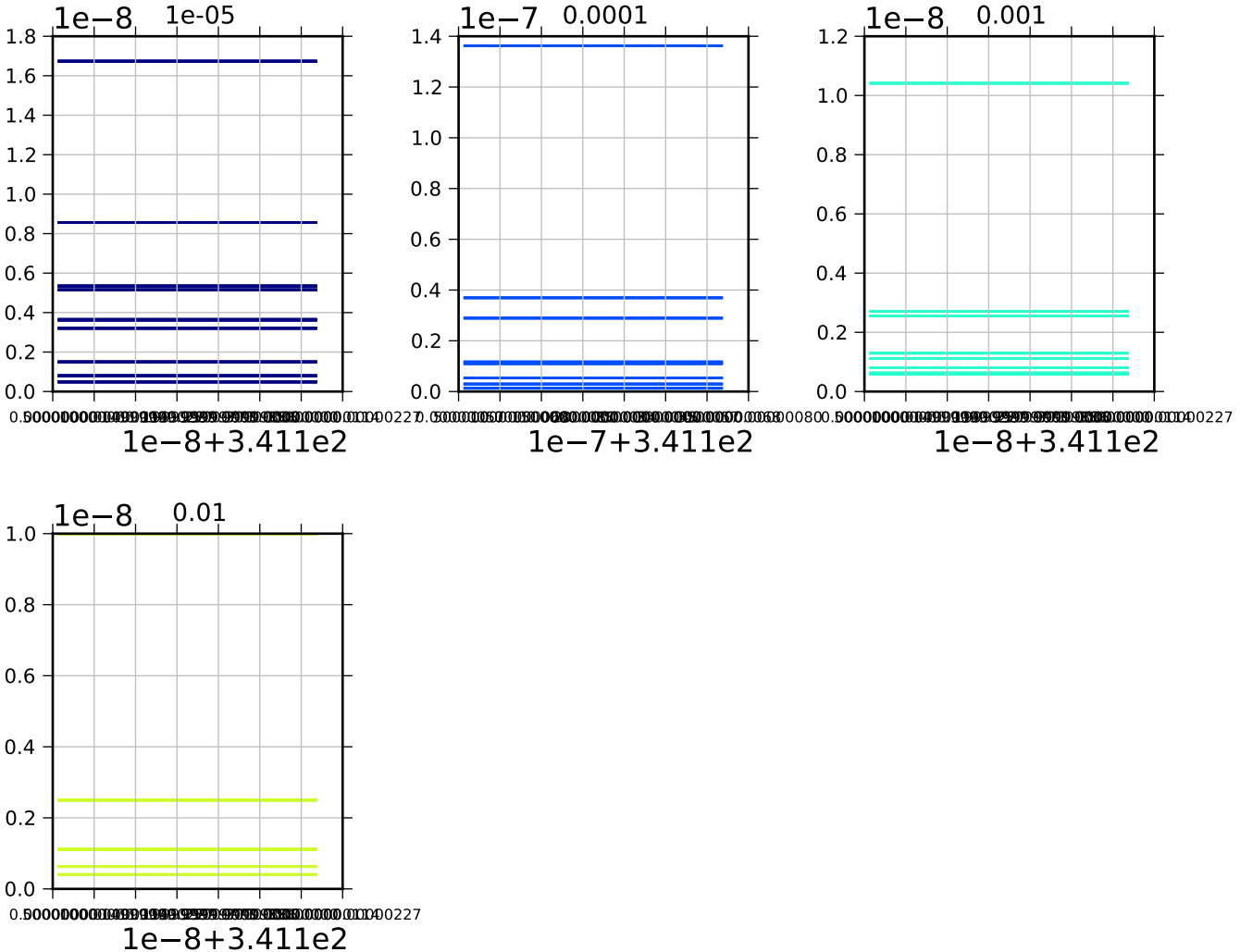

freq computed from Ni
theory
0.01
0.001
0.0001
1e-05
0.0000
−0.0002
−0.0004
−0.0006
−0.0008
−0.0010
−0.0012
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
ω_{ci}
$k\rho_{ci}$

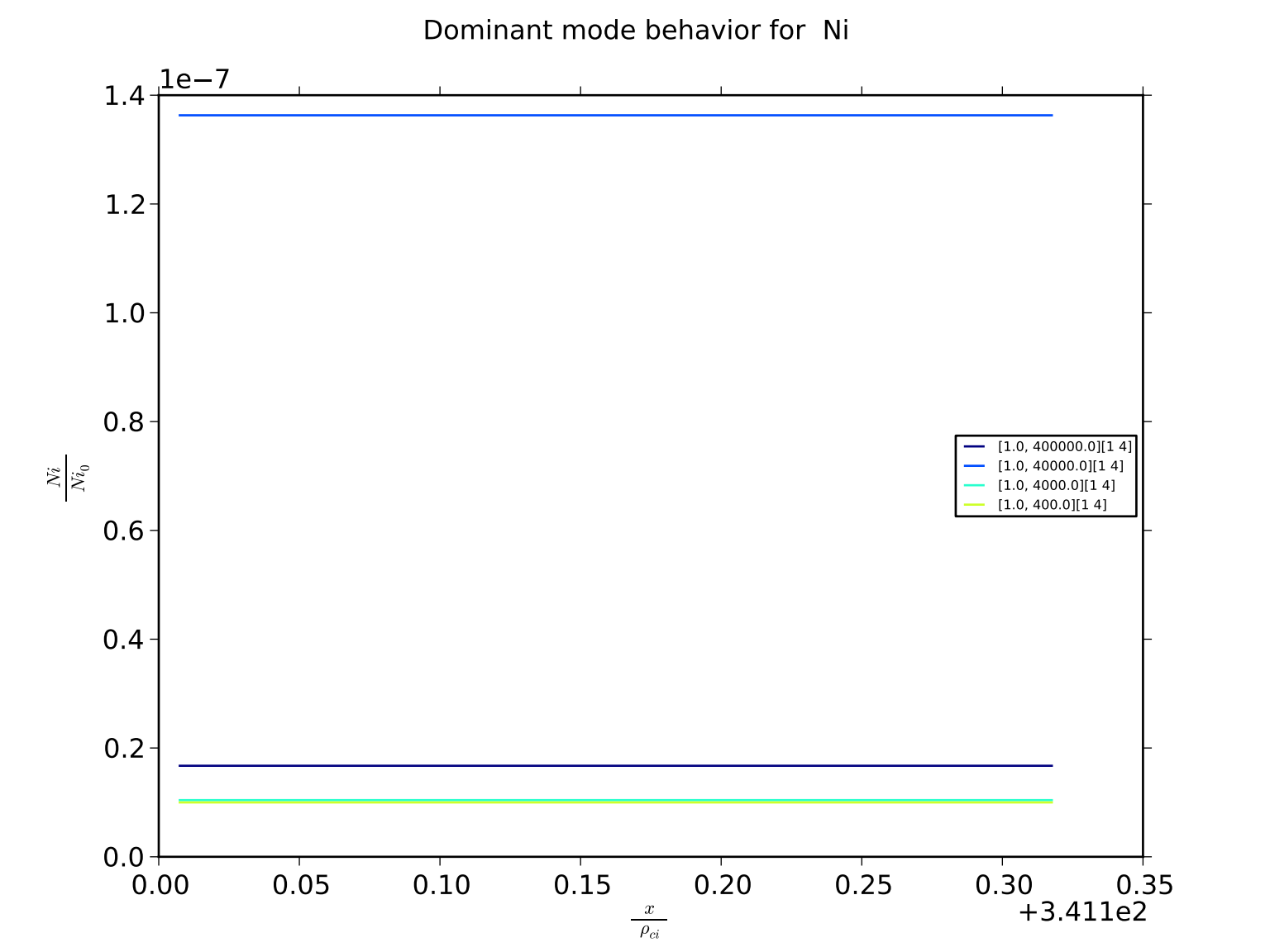

freq computed from Ni
theory
0.001
0.0001
1e-05
$\frac{\gamma}{\omega_{ci}}$
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
$k\rho_{ci}$

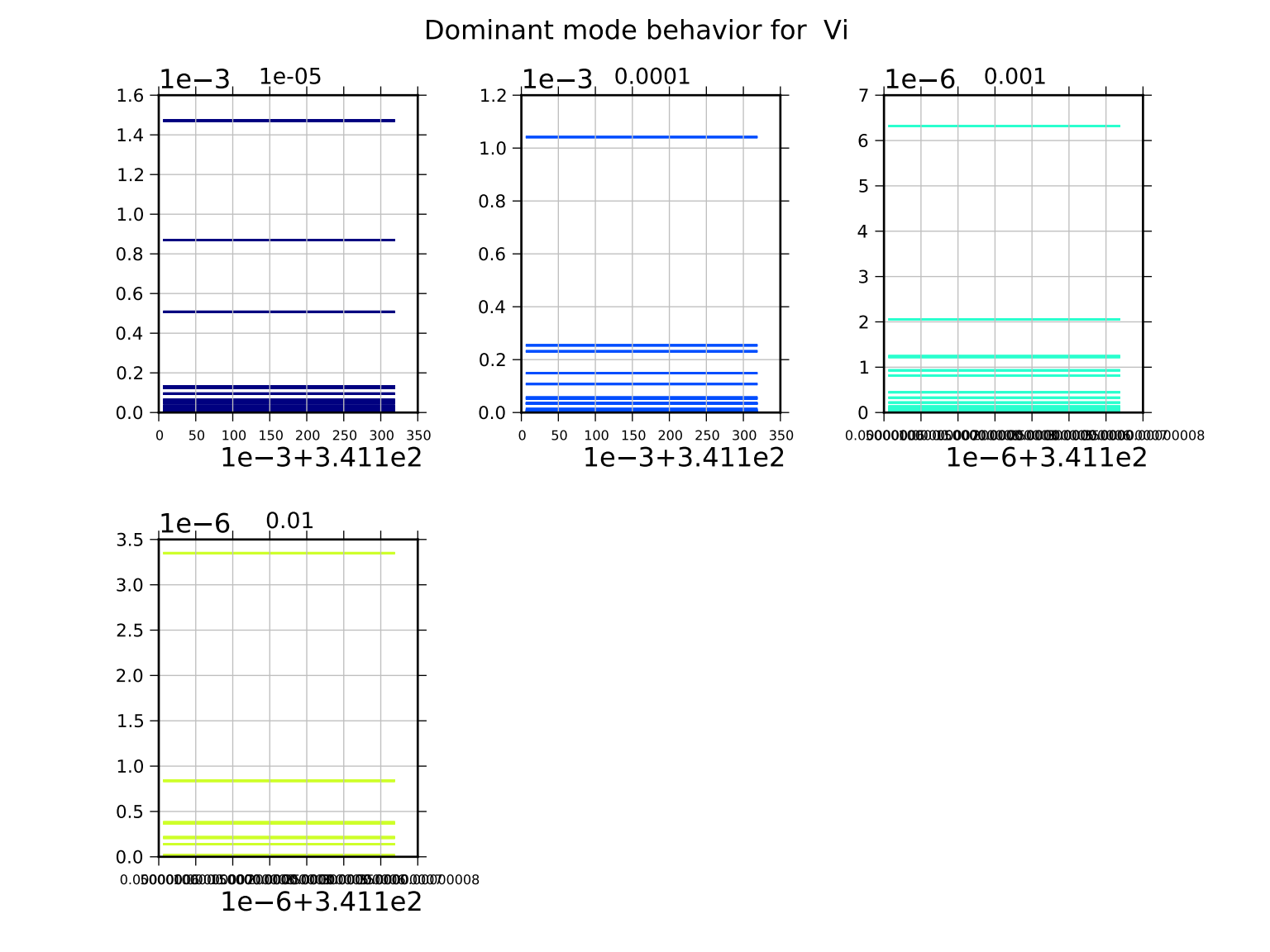

freq computed from rho
0.01
0.001
0.0001
1e-05
0.0000
−0.0002
−0.0004
−0.0006
−0.0008
−0.0010
−0.0012
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
ω_{ci}
$k\rho_{ci}$

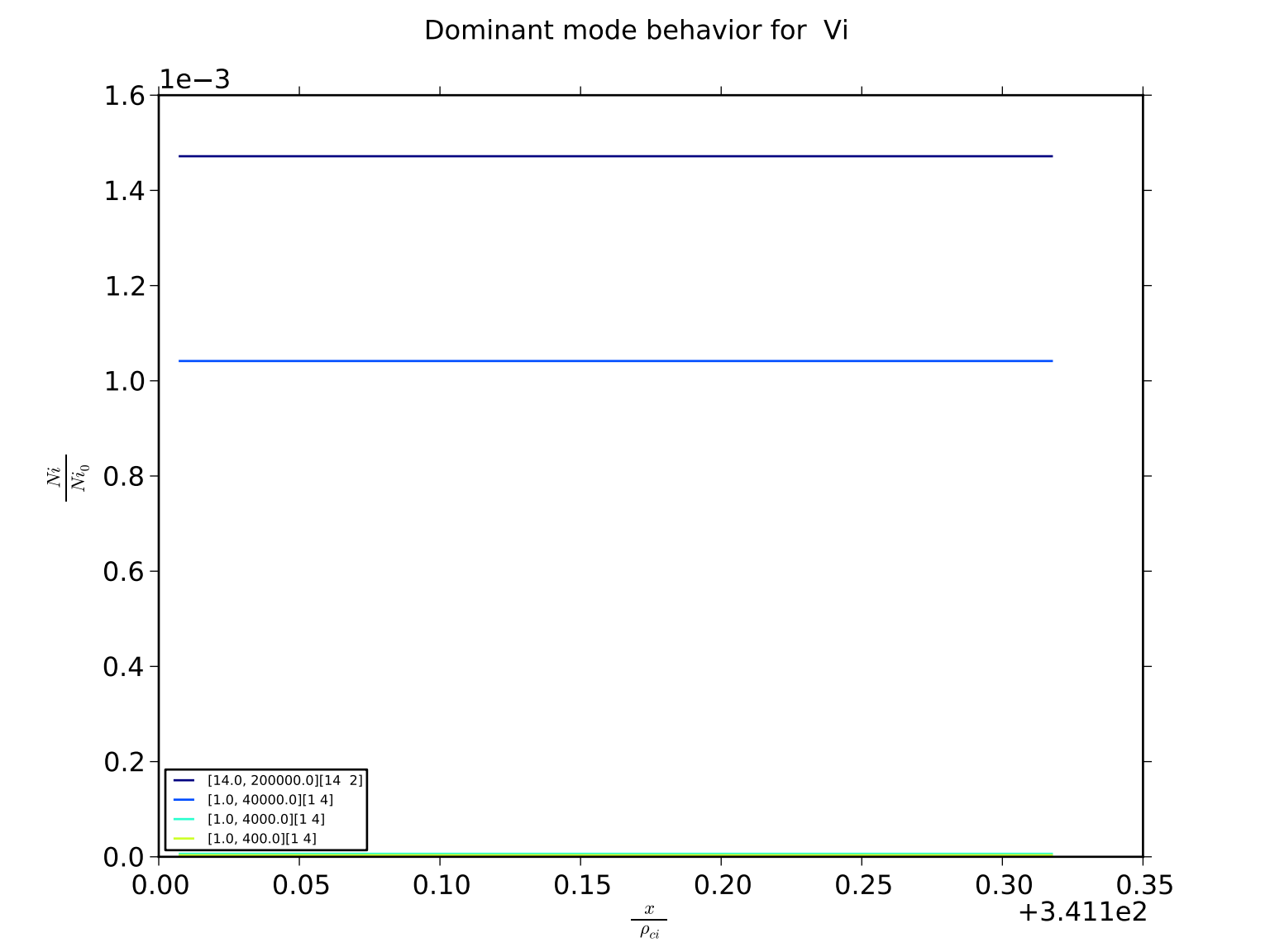

freq computed from Ni
0.01
0.001
0.0001
1e-05
$\frac{\gamma}{\omega_{ci}}$
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
$k\rho_{ci}$

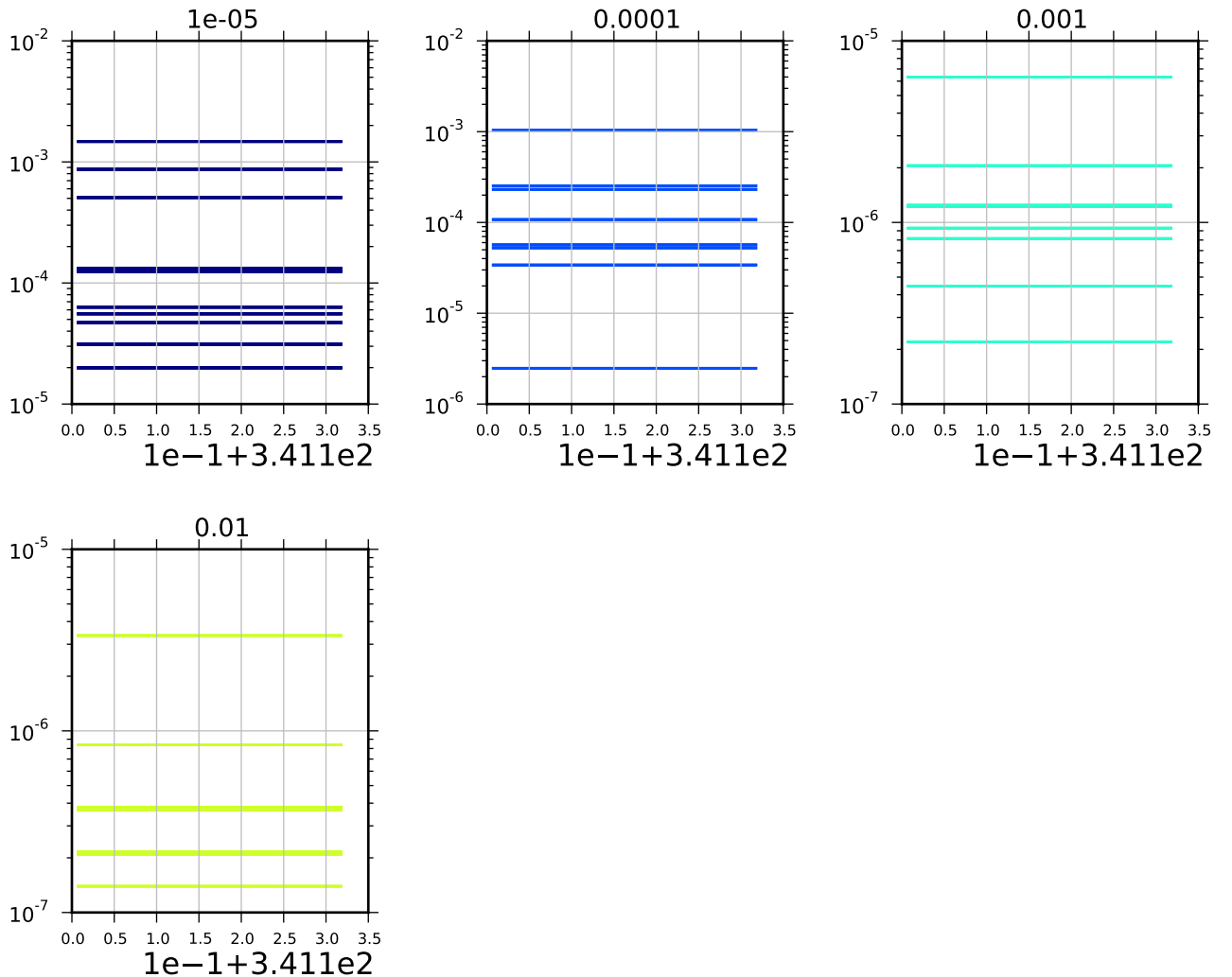
Dominant mode behavior for Ni

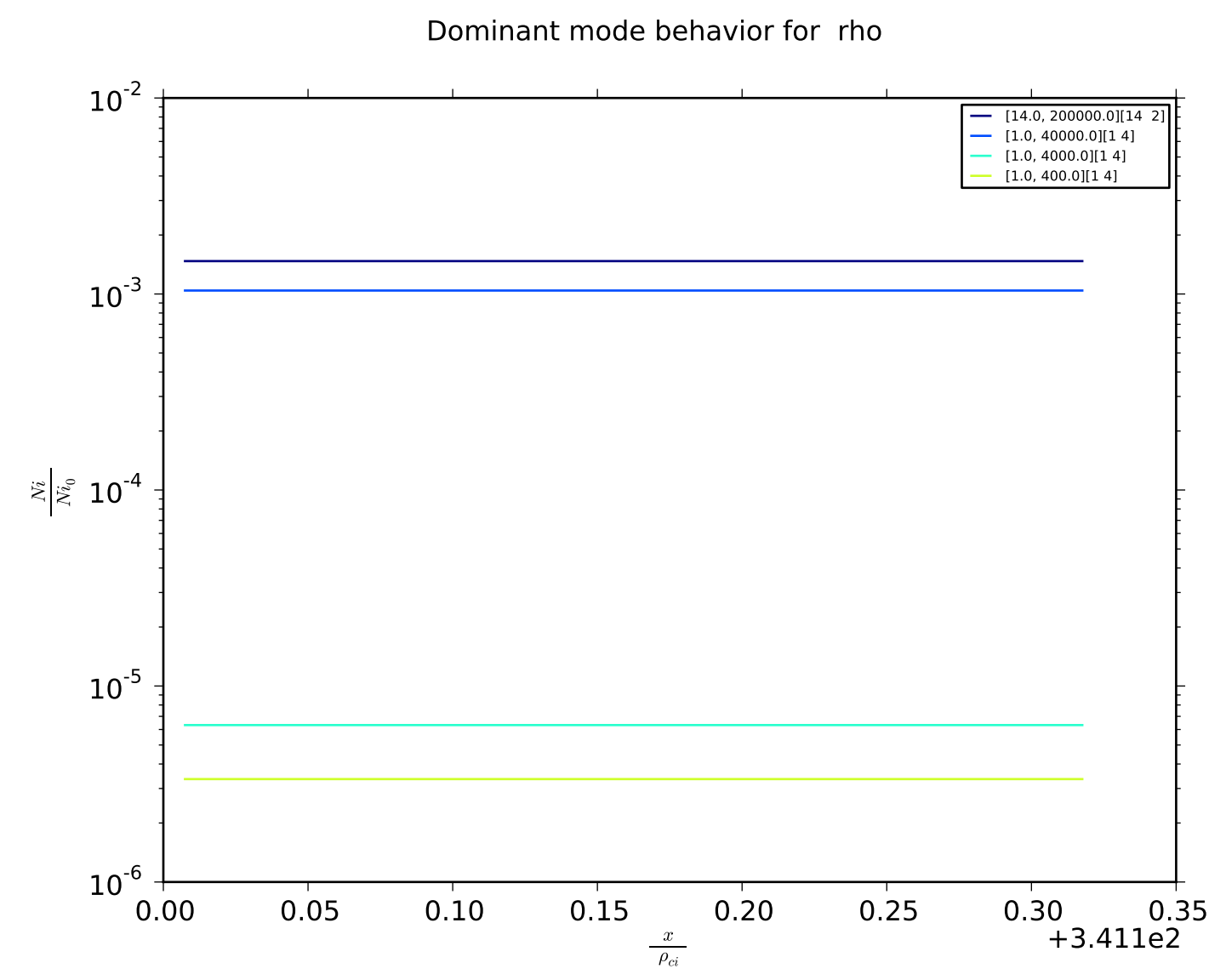



Dominant mode behavior for Ni
1e−7
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
$\frac{Ni}{Ni_0}$
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
+3.411e2
$\frac{x}{\rho_{ci}}$
[1.0, 400000.0][1 4]
[1.0, 40000.0][1 4]
[1.0, 4000.0][1 4]
[1.0, 400.0][1 4]


Dominant mode behavior for Vi
1e−3
1e-05
1e−3+3.411e2
1e−3
0.0001
1e−3+3.411e2
1e−6
0.001
1e−6+3.411e2
1e−6
0.01
1e−6+3.411e2


Dominant mode behavior for Vi
1e−3
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
$\frac{Vi}{Vi_0}$
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
+3.411e2
$\frac{x}{\rho_{ci}}$
[14.0, 200000.0][14 2]
[1.0, 40000.0][1 4]
[1.0, 4000.0][1 4]
[1.0, 400.0][1 4]


Dominant mode behavior for rho
1e-05
0.0001
0.001
0.01
1e−1+3.411e2
1e−1+3.411e2
1e−1+3.411e2
1e−1+3.411e2


Dominant mode behavior for rho
[14.0, 200000.0][14 2]
[1.0, 40000.0][1 4]
[1.0, 4000.0][1 4]
[1.0, 400.0][1 4]
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
$\frac{Ni}{Ni_0}$
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
+3.411e2
$\frac{x}{\rho_{ci}}$