

Check Root Finders nx(nz)

Open Additional files:

Get dispersion routines by evaluating Disper_no_package.nb

Get plotting and printing routines by evaluating PlotPack.nb

Data

```
In[2931]:= dataSet = "GDT-Alfven";
```

RF Parameters

```
In[3197]:= freq = 7.5;  
c = 3. × 108;  
k0 =  $\frac{2 N[\pi] \text{freq } 10^6}{c}$ ;  
nz = 127.324;  
kz = k0 * nz
```

```
Out[3201]= 20.
```

Plasma Parameters

In[3586]:=

```

ne0 = 0.22 × 1020;
B0 = 1.2;

etaList = Table[0., {i, 1, 5}];
etaList[[1]] = 0.; etaList[[2]] = 1.; etaList[[3]] = 0.0;
etaList[[4]] = 0.; etaList[[5]] = 0.;

TList = Table[0., {i, 1, 6}];
TList[[1]] = .0001; TList[[2]] = 0.;
TList[[3]] = 0.0001; TList[[4]] = 0.;
TList[[5]] = 0.; TList[[6]] = 0.;

modellist = Table[0, {i, 1, 6}];
modellist[[1]] = 1; modellist[[2]] = 1;
modellist[[3]] = 1; modellist[[4]] = 0;
modellist[[5]] = 0; modellist[[6]] = 0;

nminList = Table[0., {i, 1, 6}];
nminList[[1]] = -1; nminList[[2]] = -2;
nminList[[3]] = -2; nminList[[4]] = -2;
nminList[[5]] = -2; nminList[[6]] = -2;

nmaxList = Table[0., {i, 1, 6}];
nmaxList[[1]] = 1; nmaxList[[2]] = 2;
nmaxList[[3]] = 2; nmaxList[[4]] = 2;
nmaxList[[5]] = 2;
nmaxList[[6]] = 2;

```

Low Density, $n_e = 1. \times 10^{19}$, All waves cut off

Find Roots T = 0.1 ev

Cold Plasma

```
In[3035]:= ColdDis2FS[freq, ne0, B0, nz, etaList]
           paramPrint[{dataSet, freq, ne0, B0, nz, etaList}];

Out[3035]= {0. + 54.7545 i, 3838.11}

           dataSet=GDT-Alfven
           freq=7.5
           ne0=1. × 1019
           B0=1.2
           nz=127.324
           etaList={0., 1., 0., 0., 0.}
```

Warm Plasma (6th order system solved with NSolve)

```
Out[3039]= {0. + 55.3905 i, 3868.93, 176 202., 0. - 55.3905 i, -3868.93, -176 202.}

           dataSet=GDT-Alfven
           ne0=1. × 1019
           B0=1.2
           freq=7.5
           nz=127.324
           etaList={0., 1., 0., 0., 0.}
           TList={0.0001, 0., 0.0001, 0., 0., 0.}
```

Warm Plasma (6th order system solved with FindRoot i.e. all species modelList=1)

```
Out[3043]= {nx → 0. + 55.3905 i}

Out[3044]= {nx → 3868.93 - 3.5419 × 10-62 i}

Out[3045]= {nx → 176 202. + 1.52824 × 10-63 i}

Out[3046]= {nx → 0. - 55.3905 i}

Out[3047]= {nx → -3868.93 + 3.5419 × 10-62 i}
```

```

Out[3048]= {nx → -176 202. - 1.52824 × 10-63 i}

dataSet=GDT-Alfven
ne0=1. × 1019
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.0001, 0., 0.0001, 0., 0., 0.}
modelList={1, 1, 1, 0, 0, 0}

```

Hot Plasma (Full Maxwellian system solved with FindRoot i.e. all species modelList=2)

```

Out[3052]= {nx → -3.56023 × 10-67 + 55.3905 i}
Out[3053]= {nx → 3868.93 - 3.54189 × 10-62 i}
Out[3054]= {nx → 3868.93 - 2.25164 × 10-63 i}
Out[3055]= {nx → 3.56023 × 10-67 - 55.3905 i}
Out[3056]= {nx → -3868.93 + 3.54189 × 10-62 i}
Out[3057]= {nx → -3868.93 + 2.25164 × 10-63 i}

dataSet=GDT-Alfven
ne0=1. × 1019
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.0001, 0., 0.0001, 0., 0., 0.}
modelList={1, 1, 1, 0, 0, 0}

```

Find Roots T = 1ev

Warm Plasma (6th order system solved with NSolve)

```

Out[3082]= {4.8776 × 10-7 - 55.3468 i, 4084.82 - 0.0571229 i, 55 450.5 + 0.0081923 i,
-4.8776 × 10-7 + 55.3468 i, -4084.82 + 0.0571229 i, -55 450.5 - 0.0081923 i}

dataSet=GDT-Alfven
ne0=1. × 1019

```

```

B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.001, 0., 0.001, 0., 0., 0.}

```

Warm Plasma (6th order system solved with FindRoot i.e. all species modelList=1)

```

Out[3086]= {nx → 4.8776 × 10-7 - 55.3468 i}
Out[3087]= {nx → 4084.82 - 0.0571229 i}
Out[3088]= {nx → 55 450.5 + 0.0081923 i}
Out[3089]= {nx → -4.8776 × 10-7 + 55.3468 i}
Out[3090]= {nx → -4084.82 + 0.0571229 i}
Out[3091]= {nx → -55 450.5 - 0.0081923 i}

dataSet=GDT-Alfven
ne0=1. × 1019
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.001, 0., 0.001, 0., 0., 0.}
modelList={1, 1, 1, 0, 0, 0}

```

Hot Plasma (Full Maxwellian system solved with FindRoot i.e. all species modelList=2)

```

Out[3095]= {nx → 4.8776 × 10-7 - 55.3468 i}
Out[3096]= {nx → 4084.74 - 0.0571175 i}
Out[3097]= {nx → 4084.74 - 0.0571175 i}
Out[3098]= {nx → -4.8776 × 10-7 + 55.3468 i}
Out[3099]= {nx → -4084.74 + 0.0571175 i}
Out[3100]= {nx → -4084.74 + 0.0571175 i}

dataSet=GDT-Alfven
ne0=1. × 1019

```

```

B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.001, 0., 0.001, 0., 0., 0.}
modelList={1, 1, 1, 0, 0, 0}

```

Find Roots T = 5ev

Warm Plasma (6th order system solved with NSolve)

```

Out[3125]= {0.00511244 - 55.1516 i, 5188.77 - 1418.54 i, 23 954.2 + 560.118 i,
           -0.00511244 + 55.1516 i, -5188.77 + 1418.54 i, -23 954.2 - 560.118 i}

dataSet=GDT-Alfven
ne0=1. × 1019
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.005, 0., 0.005, 0., 0., 0.}

```

Warm Plasma (6th order system solved with FindRoot i.e. all species modelList=1)

```

Out[3138]= {nx → 0.00511244 - 55.1516 i}
Out[3139]= {nx → 5188.77 - 1418.54 i}
Out[3140]= {nx → 23 954.2 + 560.118 i}
Out[3141]= {nx → -0.00511244 + 55.1516 i}
Out[3142]= {nx → -5188.77 + 1418.54 i}
Out[3143]= {nx → -23 954.2 - 560.118 i}

dataSet=GDT-Alfven
ne0=1. × 1019
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.005, 0., 0.005, 0., 0., 0.}

```

```
modelList={1, 1, 1, 0, 0, 0}
```

Hot Plasma (Full Maxwellian system solved with FindRoot i.e. all species modelList=2)

```
Out[3147]= {nx → 0.00511244 - 55.1516 i}
```

```
Out[3148]= {nx → 5187.15 - 1410.75 i}
```

```
Out[3149]= {nx → 5187.15 - 1410.75 i}
```

```
Out[3150]= {nx → -0.00511244 + 55.1516 i}
```

```
Out[3151]= {nx → -5187.15 + 1410.75 i}
```

```
Out[3152]= {nx → -5187.15 + 1410.75 i}
```

```
dataSet=GDT-Alfven
```

```
ne0=1. × 1019
```

```
B0=1.2
```

```
freq=7.5
```

```
nz=127.324
```

```
etaList={0., 1., 0., 0., 0.}
```

```
TList={0.005, 0., 0.005, 0., 0., 0.}
```

```
modelList={1, 1, 1, 0, 0, 0}
```

Find Roots T = 50ev

Warm Plasma (6th order system solved with NSolve)

```
Out[3177]= {1047.61 - 2416.22 i, 0.030746 - 52.8956 i, 8455.93 + 687.452 i,  
-1047.61 + 2416.22 i, -0.030746 + 52.8956 i, -8455.93 - 687.452 i}
```

```
dataSet=GDT-Alfven
```

```
ne0=1. × 1019
```

```
B0=1.2
```

```
freq=7.5
```

```
nz=127.324
```

```
etaList={0., 1., 0., 0., 0.}
```

```
TList={0.05, 0., 0.05, 0., 0., 0.}
```

Warm Plasma (6th order system solved with FindRoot i.e. all species modelList=1)

```

Out[3181]= {nx → 1047.61 - 2416.22 i}
Out[3182]= {nx → 0.030746 - 52.8956 i}
Out[3183]= {nx → 8455.93 + 687.452 i}
Out[3184]= {nx → -1047.61 + 2416.22 i}
Out[3185]= {nx → -0.030746 + 52.8956 i}
Out[3186]= {nx → -8455.93 - 687.452 i}

dataSet=GDT-Alfven
ne0=1. × 1019
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.05, 0., 0.05, 0., 0., 0.}
modelList={1, 1, 1, 0, 0, 0}

```

Hot Plasma (Full Maxwellian system solved with FindRoot i.e. all species modelList=2)

```

Out[3190]= {nx → 1030.53 - 2423.05 i}
Out[3191]= {nx → 0.030746 - 52.8956 i}
Out[3192]= {nx → 0.030746 - 52.8956 i}
Out[3193]= {nx → -1030.53 + 2423.05 i}
Out[3194]= {nx → -0.030746 + 52.8956 i}
Out[3195]= {nx → -0.030746 + 52.8956 i}

dataSet=GDT-Alfven
ne0=1. × 1019
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.05, 0., 0.05, 0., 0., 0.}
modelList={1, 1, 1, 0, 0, 0}

```

Higher density, $n_e = 1.5 \times 10^{19}$,
 Alfven wave propagates Higher density,
 $n_e = 2.2 \times 10^{19}$, above Alfven resonance. Is
 there any sign of kinetic Alfven wave?

Find Roots T = 0.1 ev

Warm Plasma (6th order system solved with NSolve)

```
Out[3408]= {135.515, 2775.54, 176 198., -135.515, -2775.54, -176 198.}

dataSet=Proto MPEX IC Kinetic Alfven
ne0= $1.5 \times 10^{19}$ 
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.0001, 0., 0.0001, 0., 0., 0.}
```

Warm Plasma (6th order system solved with FindRoot i.e. all species
 modelList=1)

```
Out[3410]= {135.515, 2775.54, 176 198., -135.515, -2775.54, -176 198.}

Out[3412]= {nx →  $135.515 + 4.94207 \times 10^{-66} i$ }
Out[3413]= {nx →  $2775.54 - 2.54898 \times 10^{-62} i$ }
Out[3414]= {nx →  $176 198. + 1.52745 \times 10^{-63} i$ }
Out[3415]= {nx →  $-135.515 - 4.94207 \times 10^{-66} i$ }
Out[3416]= {nx →  $-2775.54 + 2.54898 \times 10^{-62} i$ }
Out[3417]= {nx →  $-176 198. - 1.52745 \times 10^{-63} i$ }

dataSet=Proto MPEX IC Kinetic Alfven
ne0= $1.5 \times 10^{19}$ 
B0=1.2
freq=7.5
```

```

nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.0001, 0., 0.0001, 0., 0., 0.}
modelList={1, 1, 1, 0, 0, 0}

```

Hot Plasma (Full Maxwellian system solved with FindRoot i.e. all species modelList=2)

```

Out[3419]= {135.515, 2775.54, 176 198., -135.515, -2775.54, -176 198.}

Out[3421]= {nx → 135.515 + 4.94207 × 10-66 i}

Out[3422]= {nx → 2775.54 - 2.54898 × 10-62 i}

Out[3423]= {nx → 2775.54 - 1.95557 × 10-63 i}

Out[3424]= {nx → -135.515 - 4.94207 × 10-66 i}

Out[3425]= {nx → -2775.54 + 2.54898 × 10-62 i}

Out[3426]= {nx → -2775.54 + 1.95557 × 10-63 i}

```

```

dataSet=Proto MPEX IC Kinetic Alfven
ne0=1.5 × 1019
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.0001, 0., 0.0001, 0., 0., 0.}
modelList={1, 1, 1, 0, 0, 0}

```

Find Roots T = 1ev

Warm Plasma (6th order system solved with NSolve)

```

Out[3434]= {135.568 + 6.77702 × 10-6 i, 2930.46 - 0.0410981 i, 55 450.2 + 0.00814961 i,
-135.568 - 6.77702 × 10-6 i, -2930.46 + 0.0410981 i, -55 450.2 - 0.00814961 i}

dataSet=Proto MPEX IC Kinetic Alfven
ne0=1.5 × 1019
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}

```

```
TList={0.001, 0., 0.001, 0., 0., 0.}
```

Warm Plasma (6th order system solved with FindRoot i.e. all species modelList=1)

```
Out[3438]= {nx → 135.568 + 6.77702 × 10-6 i}
Out[3439]= {nx → 2930.46 - 0.0410981 i}
Out[3440]= {nx → 55 450.2 + 0.00814961 i}
Out[3441]= {nx → -135.568 - 6.77702 × 10-6 i}
Out[3442]= {nx → -2930.46 + 0.0410981 i}
Out[3443]= {nx → -55 450.2 - 0.00814961 i}

dataSet=Proto MPEX IC Kinetic Alfven
ne0=1.5 × 1019
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.001, 0., 0.001, 0., 0., 0.}
modelList={1, 1, 1, 0, 0, 0}
```

Hot Plasma (Full Maxwellian system solved with FindRoot i.e. all species modelList=2)

```
Out[3447]= {nx → 135.568 + 6.77702 × 10-6 i}
Out[3448]= {nx → 2930.43 - 0.0410961 i}
Out[3449]= {nx → 2930.43 - 0.0410961 i}
Out[3450]= {nx → -135.568 - 6.77702 × 10-6 i}
Out[3451]= {nx → -2930.43 + 0.0410961 i}
Out[3452]= {nx → -2930.43 + 0.0410961 i}

dataSet=Proto MPEX IC Kinetic Alfven
ne0=1.5 × 1019
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
```

```
TList={0.001, 0., 0.001, 0., 0., 0.}
modelList={1, 1, 1, 0, 0, 0}
```

Find Roots T = 5ev

Warm Plasma (6th order system solved with NSolve)

```
Out[3460]= {135.806 + 0.0710592 i, 3721.6 - 1015.23 i, 23 966.3 + 536.809 i,
-135.806 - 0.0710592 i, -3721.6 + 1015.23 i, -23 966.3 - 536.809 i}

dataSet=Proto MPEX IC Kinetic Alfven
ne0= $1.5 \times 10^{19}$ 
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.005, 0., 0.005, 0., 0., 0.}
```

Warm Plasma (6th order system solved with FindRoot i.e. all species modelList=1)

```
Out[3462]= {135.806 + 0.0710592 i, 3721.6 - 1015.23 i, 23 966.3 + 536.809 i,
-135.806 - 0.0710592 i, -3721.6 + 1015.23 i, -23 966.3 - 536.809 i}

Out[3464]= {nx → 135.806 + 0.0710592 i}
Out[3465]= {nx → 3721.6 - 1015.23 i}
Out[3466]= {nx → 23 966.3 + 536.809 i}
Out[3467]= {nx → -135.806 - 0.0710592 i}
Out[3468]= {nx → -3721.6 + 1015.23 i}
Out[3469]= {nx → -23 966.3 - 536.809 i}

dataSet=Proto MPEX IC Kinetic Alfven
ne0= $1.5 \times 10^{19}$ 
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.005, 0., 0.005, 0., 0., 0.}
modelList={1, 1, 1, 0, 0, 0}
```

Hot Plasma (Full Maxwellian system solved with FindRoot i.e. all species modelList=2)

```

Out[3471]= {135.806 + 0.0710592 i, 3721.6 - 1015.23 i, 23 966.3 + 536.809 i,
           -135.806 - 0.0710592 i, -3721.6 + 1015.23 i, -23 966.3 - 536.809 i}

Out[3473]= {nx → 135.806 + 0.0710592 i}

Out[3474]= {nx → 3720.96 - 1012.44 i}

Out[3475]= {nx → 3720.96 - 1012.44 i}

Out[3476]= {nx → -135.806 - 0.0710592 i}

Out[3477]= {nx → -3720.96 + 1012.44 i}

Out[3478]= {nx → -3720.96 + 1012.44 i}

dataSet=Proto MPEX IC Kinetic Alfven
ne0=1.5 × 1019
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.005, 0., 0.005, 0., 0., 0.}
modelList={1, 1, 1, 0, 0, 0}

```

Find Roots T = 50ev

Warm Plasma (6th order system solved with NSolve)

```

Out[3486]= {734.654 - 1732.23 i, 139.433 + 0.4499 i, 8454.02 + 733. i,
           -734.654 + 1732.23 i, -139.433 - 0.4499 i, -8454.02 - 733. i}

dataSet=Proto MPEX IC Kinetic Alfven
ne0=1.5 × 1019
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.05, 0., 0.05, 0., 0., 0.}

```

Warm Plasma (6th order system solved with FindRoot i.e. all species modelList=1)

```

Out[3490]= {nx → 734.654 - 1732.23 i}
Out[3491]= {nx → 139.433 + 0.4499 i}
Out[3492]= {nx → 8454.02 + 733. i}
Out[3493]= {nx → -734.654 + 1732.23 i}
Out[3494]= {nx → -139.433 - 0.4499 i}
Out[3495]= {nx → -8454.02 - 733. i}

dataSet=Proto MPEX IC Kinetic Alfven
ne0= $1.5 \times 10^{19}$ 
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.05, 0., 0.05, 0., 0., 0.}
modelList={1, 1, 1, 0, 0, 0}

```

Hot Plasma (Full Maxwellian system solved with FindRoot i.e. all species modelList=2)

```

Out[3499]= {nx → 728.254 - 1735.07 i}
Out[3500]= {nx → 139.433 + 0.449903 i}
Out[3501]= {nx → 139.433 + 0.449903 i}
Out[3502]= {nx → -728.254 + 1735.07 i}
Out[3503]= {nx → -139.433 - 0.449903 i}
Out[3504]= {nx → -139.433 - 0.449903 i}

dataSet=Proto MPEX IC Kinetic Alfven
ne0= $1.5 \times 10^{19}$ 
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.05, 0., 0.05, 0., 0., 0.}
modelList={1, 1, 1, 0, 0, 0}

```

Higher density, $n_e = 2.2 \times 10^{19}$,
above Alfvén resonance. Is there
any sign of kinetic Alfvén wave?

Find Roots $T = 0.1$ eV

Warm Plasma (6th order system solved with NSolve)

```
Out[3624]= {0. + 1501.65 i, 0. + 406.118 i, 176 196., 0. - 1501.65 i, 0. - 406.118 i, -176 196.}

dataSet=Proto MPEX IC Kinetic Alfvén
ne0= $2.2 \times 10^{19}$ 
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.0001, 0., 0.0001, 0., 0., 0.}
```

Warm Plasma (6th order system solved with FindRoot i.e. all species
modelList=1)

```
Out[3637]= {nx →  $1.47514 \times 10^{-62} + 1501.65 i$ }
Out[3638]= {nx →  $-2.74597 \times 10^{-64} + 406.118 i$ }
Out[3639]= {nx →  $176 196. + 1.52651 \times 10^{-63} i$ }
Out[3640]= {nx →  $-1.47514 \times 10^{-62} - 1501.65 i$ }
Out[3641]= {nx →  $2.74597 \times 10^{-64} - 406.118 i$ }
Out[3642]= {nx →  $-176 196. - 1.52651 \times 10^{-63} i$ }

dataSet=Proto MPEX IC Kinetic Alfvén
ne0= $2.2 \times 10^{19}$ 
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.0001, 0., 0.0001, 0., 0., 0.}
```

```
modelList={1, 1, 1, 0, 0, 0}
```

Hot Plasma (Full Maxwellian system solved with FindRoot i.e. all species modelList=2)

```
Out[3646]= {nx → 1.47514 × 10-62 + 1501.65 i}
Out[3647]= {nx → -2.74597 × 10-64 + 406.118 i}
Out[3648]= {nx → -0.0723376 - 1.54119 × 10-63 i}
Out[3649]= {nx → -1.47514 × 10-62 - 1501.65 i}
Out[3650]= {nx → 2.74597 × 10-64 - 406.118 i}
Out[3651]= {nx → 0.0723376 + 1.54119 × 10-63 i}

dataSet=Proto MPEX IC Kinetic Alfven
ne0=2.2 × 1019
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.0001, 0., 0.0001, 0., 0., 0.}
modelList={1, 1, 1, 0, 0, 0}
```

Find Roots T = 1ev

Cold Plasma

Warm Plasma (6th order system solved with NSolve)

```
Out[3659]= {0.0236968 + 1593.25 i, 0.000363734 - 404.211 i, 55 450.7 + 0.00809012 i,
-0.0236968 - 1593.25 i, -0.000363734 + 404.211 i, -55 450.7 - 0.00809012 i}

dataSet=Proto MPEX IC Kinetic Alfven
ne0=2.2 × 1019
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.001, 0., 0.001, 0., 0., 0.}
```

Warm Plasma (6th order system solved with FindRoot i.e. all species

modelList=1)

```

Out[3663]= {nx → 0.0236968 + 1593.25 i}
Out[3664]= {nx → 0.000363734 - 404.211 i}
Out[3665]= {nx → 55 450.7 + 0.00809012 i}
Out[3666]= {nx → -0.0236968 - 1593.25 i}
Out[3667]= {nx → -0.000363734 + 404.211 i}
Out[3668]= {nx → -55 450.7 - 0.00809012 i}

dataSet=Proto MPEX IC Kinetic Alfven
ne0=2.2 × 1019
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.001, 0., 0.001, 0., 0., 0.}
modelList={1, 1, 1, 0, 0, 0}

```

Hot Plasma (Full Maxwellian system solved with FindRoot i.e. all species modelList=2)

```

Out[3670]= {0.0236968 + 1593.25 i, 0.000363734 - 404.211 i, 55 450.7 + 0.00809012 i,
           -0.0236968 - 1593.25 i, -0.000363734 + 404.211 i, -55 450.7 - 0.00809012 i}
Out[3672]= {nx → 0.0236971 + 1593.25 i}
Out[3673]= {nx → 0.000363734 - 404.211 i}
Out[3674]= {nx → -0.376535 + 0.0347842 i}
Out[3675]= {nx → -0.0236971 - 1593.25 i}
Out[3676]= {nx → -0.000363734 + 404.211 i}
Out[3677]= {nx → 0.376535 - 0.0347842 i}

dataSet=Proto MPEX IC Kinetic Alfven
ne0=2.2 × 1019
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.001, 0., 0.001, 0., 0., 0.}
modelList={1, 1, 1, 0, 0, 0}

```

Find Roots T = 5ev

Warm Plasma (6th order system solved with NSolve)

```
Out[3688]= { 576.435 + 2059.97 i, 3.3074 - 396.401 i, 23 983.9 + 506.327 i,
            - 576.435 - 2059.97 i, - 3.3074 + 396.401 i, - 23 983.9 - 506.327 i }

dataSet=Proto MPEX IC Kinetic Alfven
ne0= $2.2 \times 10^{19}$ 
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.005, 0., 0.005, 0., 0., 0.}
```

Warm Plasma (6th order system solved with FindRoot i.e. all species modelList=1)

```
Out[3688]= { 576.435 + 2059.97 i, 3.3074 - 396.401 i, 23 983.9 + 506.327 i,
            - 576.435 - 2059.97 i, - 3.3074 + 396.401 i, - 23 983.9 - 506.327 i }

Out[3690]= { nx → 576.435 + 2059.97 i }
Out[3691]= { nx → 3.3074 - 396.401 i }
Out[3692]= { nx → 23 983.9 + 506.327 i }
Out[3693]= { nx → - 576.435 - 2059.97 i }
Out[3694]= { nx → - 3.3074 + 396.401 i }
Out[3695]= { nx → - 23 983.9 - 506.327 i }

dataSet=Proto MPEX IC Kinetic Alfven
ne0= $2.2 \times 10^{19}$ 
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.005, 0., 0.005, 0., 0., 0.}
modelList={1, 1, 1, 0, 0, 0}
```

Hot Plasma (Full Maxwellian system solved with FindRoot i.e. all species modelList=2)

```

Out[3699]= {nx → 576.893 + 2060.09 i}
Out[3700]= {nx → 3.30739 - 396.401 i}
Out[3701]= {nx → -3.30739 + 396.401 i}
Out[3702]= {nx → -576.893 - 2060.09 i}
Out[3703]= {nx → -3.30739 + 396.401 i}
Out[3704]= {nx → 3.30739 - 396.401 i}

dataSet=Proto MPEX IC Kinetic Alfven
ne0= $2.2 \times 10^{19}$ 
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.005, 0., 0.005, 0., 0., 0.}
modelList={1, 1, 1, 0, 0, 0}

```

Find Roots T = 50ev

Warm Plasma (6th order system solved with NSolve)

```

Out[3712]= {10.9224 - 362.612 i, 1084.01 + 415.513 i, 8447.13 + 802.399 i,
  -10.9224 + 362.612 i, -1084.01 - 415.513 i, -8447.13 - 802.399 i}

dataSet=Proto MPEX IC Kinetic Alfven
ne0= $2.2 \times 10^{19}$ 
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.05, 0., 0.05, 0., 0., 0.}

```

Warm Plasma (6th order system solved with FindRoot i.e. all species modelList=1)

```

Out[3716]= {nx → 10.9224 - 362.612 i}

```

```

Out[3717]= {nx → 1084.01 + 415.513 i}
Out[3718]= {nx → 8447.13 + 802.399 i}
Out[3719]= {nx → -10.9224 + 362.612 i}
Out[3720]= {nx → -1084.01 - 415.513 i}
Out[3721]= {nx → -8447.13 - 802.399 i}

dataSet=Proto MPEX IC Kinetic Alfven
ne0=2.2 × 1019
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.05, 0., 0.05, 0., 0., 0.}
modelList={1, 1, 1, 0, 0, 0}

```

Hot Plasma (Full Maxwellian system solved with FindRoot i.e. all species modelList=2)

```

Out[3725]= {nx → 10.9217 - 362.61 i}
Out[3726]= {nx → 1083.37 + 417.166 i}
Out[3727]= {nx → 1083.37 + 417.166 i}
Out[3728]= {nx → -10.9217 + 362.61 i}
Out[3729]= {nx → -1083.37 - 417.166 i}
Out[3730]= {nx → -1083.37 - 417.166 i}

dataSet=Proto MPEX IC Kinetic Alfven
ne0=2.2 × 1019
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.05, 0., 0.05, 0., 0., 0.}
modelList={1, 1, 1, 0, 0, 0}

```

Find Roots T = 500ev

Warm Plasma (6th order system solved with NSolve)

```
Out[3738]= {0.215876 + 251.314 i, 583.353 + 78.3767 i, 2737.57 + 87.6828 i,
           -0.215876 - 251.314 i, -583.353 - 78.3767 i, -2737.57 - 87.6828 i}

dataSet=Proto MPEX IC Kinetic Alfven
ne0= $2.2 \times 10^{19}$ 
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.5, 0., 0.5, 0., 0., 0.}
```

Warm Plasma (6th order system solved with FindRoot i.e. all species modelList=1)

```
Out[3742]= {nx → 0.215876 + 251.314 i}
Out[3743]= {nx → 583.353 + 78.3767 i}
Out[3744]= {nx → 2737.57 + 87.6828 i}
Out[3745]= {nx → -0.215876 - 251.314 i}
Out[3746]= {nx → -583.353 - 78.3767 i}
Out[3747]= {nx → -2737.57 - 87.6828 i}

dataSet=Proto MPEX IC Kinetic Alfven
ne0= $2.2 \times 10^{19}$ 
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.5, 0., 0.5, 0., 0., 0.}
modelList={1, 1, 1, 0, 0, 0}
```

Hot Plasma (Full Maxwellian system solved with FindRoot i.e. all species modelList=2)

```
Out[3751]= {nx → 0.216575 + 251.323 i}
Out[3752]= {nx → 584.85 + 79.6384 i}
```

```
Out[3753]= {nx → 584.85 + 79.6384 i}
```

```
Out[3754]= {nx → -0.216575 - 251.323 i}
```

```
Out[3755]= {nx → -584.85 - 79.6384 i}
```

```
Out[3756]= {nx → -584.85 - 79.6384 i}
```

```
dataSet=Proto MPEX IC Kinetic Alfven
```

```
ne0= $2.2 \times 10^{19}$ 
```

```
B0=1.2
```

```
freq=7.5
```

```
nz=127.324
```

```
etaList={0., 1., 0., 0., 0.}
```

```
TList={0.5, 0., 0.5, 0., 0., 0.}
```

```
modelList={1, 1, 1, 0, 0, 0}
```

Find Roots T = 500ev

Warm Plasma (6th order system solved with NSolve)

```
Out[3765]= {0.215876 + 251.314 i, 583.353 + 78.3767 i, 2737.57 + 87.6828 i,  
-0.215876 - 251.314 i, -583.353 - 78.3767 i, -2737.57 - 87.6828 i}
```

```
dataSet=Proto MPEX IC Kinetic Alfven
```

```
ne0= $2.2 \times 10^{19}$ 
```

```
B0=1.2
```

```
freq=7.5
```

```
nz=127.324
```

```
etaList={0., 1., 0., 0., 0.}
```

```
TList={0.5, 0., 0.5, 0., 0., 0.}
```

Warm Plasma (6th order system solved with FindRoot i.e. all species modelList=1)

```
Out[3769]= {nx → 0.215876 + 251.314 i}
```

```
Out[3770]= {nx → 583.353 + 78.3767 i}
```

```
Out[3771]= {nx → 2737.57 + 87.6828 i}
```

```
Out[3772]= {nx → -0.215876 - 251.314 i}
```

```
Out[3773]= {nx → -583.353 - 78.3767 i}
```

```
Out[3774]= {nx → -2737.57 - 87.6828 i}
```

```

dataSet=Proto MPEX IC Kinetic Alfven
ne0=2.2 × 1019
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.5, 0., 0.5, 0., 0., 0.}
modelList={1, 1, 1, 0, 0, 0}

```

Hot Plasma (Full Maxwellian system solved with FindRoot i.e. all species modelList=2)

```
Out[3778]= {nx → 0.216575 + 251.323 i}
```

```
Out[3779]= {nx → 584.85 + 79.6384 i}
```

```
Out[3780]= {nx → 584.85 + 79.6384 i}
```

```
Out[3781]= {nx → -0.216575 - 251.323 i}
```

```
Out[3782]= {nx → -584.85 - 79.6384 i}
```

```
Out[3783]= {nx → -584.85 - 79.6384 i}
```

```

dataSet=Proto MPEX IC Kinetic Alfven
ne0=2.2 × 1019
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.5, 0., 0.5, 0., 0., 0.}
modelList={1, 1, 1, 0, 0, 0}

```

Stix criterion for kinetic Alfven wave $\beta_i > \frac{8}{3} m_e / m_i \left(1 - \frac{\omega^2}{4\Omega_i^2}\right)$

```
In[3793]= 8. / 3. / 3670 * (1 - (7.5 / (4 * 9.15) ^2))
```

```
Out[3793]= 0.000722544
```

- By my calculation at 500 ev, $\beta_i = 0.003$ so meets criterion by a lot. But I don't see a propagating or weakly damped wave.