

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[749]:= dataSet = "GDT-Alfven";
```

RF Parameters

```
In[750]:= freq = 7.5;  
c = 3. × 108;  
k0 =  $\frac{2 N[\pi] \text{freq } 10^6}{c}$ ;  
nz = 127.324;  
kz = k0 * nz
```

```
Out[754]= 20.
```

Plasma Parameters

```

In[755]:=
ne0 = 0.1 × 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]] = .000; TList[[2]] = 0.;
TList[[3]] = 0.0001; TList[[4]] = 0.;
TList[[5]] = 0.; TList[[6]] = 0.;

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

```

In[776]:= ne0 = 0.1 × 1020;

```

Find Roots T = 0.1 ev

```
In[777]:= TList = Table[0., {i, 1, 6}];
          TList[[1]] = .00; TList[[2]] = 0.;
          TList[[3]] = 0.001; TList[[4]] = 0.;
          TList[[5]] = 0.;
          TList[[6]] = 0.;
```

Cold Plasma

```
In[781]:= ColdDis2FS[freq, ne0, B0, nz, etaList]
          paramPrint[{dataSet, freq, ne0, B0, nz, etaList}];
```

```
Out[781]:= {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)

```
In[783]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
          paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList}];
```

```
Out[783]:= {0. + 55.3492 i, 3866.3, 55481., 0. - 55.3492 i, -3866.3, -55481.}

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

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

```

In[785]:= modelList[[3]] = 1;
rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[1]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[2]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[3]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[4]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[5]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[6]]}, MaxIterations -> 30]
paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList, modelList}];

Out[786]= {0. + 55.3492 i, 3866.3, 55481., 0. - 55.3492 i, -3866.3, -55481.}

Out[787]= {nx -> 0. + 55.3492 i}

Out[788]= {nx -> 3866.3 + 0. i}

Out[789]= {nx -> 55481. + 0. i}

Out[790]= {nx -> 0. - 55.3492 i}

Out[791]= {nx -> -3866.3 + 0. i}

Out[792]= {nx -> -55481. + 0. i}

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

```

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

```

In[794]:= modelList[[3]] = 2;
rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[1]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[2]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[3]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[4]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[5]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[6]]}, MaxIterations -> 30]
paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList, modelList}];

Out[794]= {0. + 55.3492 i, 3866.3, 55481., 0. - 55.3492 i, -3866.3, -55481.}

Out[795]= {nx -> 0. + 55.3492 i}

Out[796]= {nx -> 3866.25 + 0. i}

Out[797]= {nx -> 3866.25 + 0. i}

Out[798]= {nx -> 0. - 55.3492 i}

Out[799]= {nx -> -3866.25 + 0. i}

Out[800]= {nx -> -3866.25 + 0. i}

dataSet=GDT-Alfven
ne0=1. × 1019
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0., 0., 0.001, 0., 0., 0.}
modelList={0, 0, 2, 0, 0, 0}

```

Find Roots T = 1ev

```
In[802]:= TList[[1]] = .0;
          TList[[3]] = 0.001;
```

Cold Plasma

```
In[804]:= ColdDis2FS[freq, ne0, B0, nz, etaList]
          paramPrint[{dataSet, freq, ne0, B0, nz, etaList}];

Out[804]= {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)

```
In[806]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
          paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList}];

Out[806]= {0. + 55.3492 i, 3866.3, 55481., 0. - 55.3492 i, -3866.3, -55481.}

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

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

```
In[808]:= modelList[[3]] = 1;
```

```

In[809]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[1]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[2]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[3]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[4]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[5]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[6]]}, MaxIterations -> 30]
paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList, modelList}];

```

```
Out[809]= {0. + 55.3492 i, 3866.3, 55481., 0. - 55.3492 i, -3866.3, -55481.}
```

```
Out[810]= {nx -> 0. + 55.3492 i}
```

```
Out[811]= {nx -> 3866.3 + 0. i}
```

```
Out[812]= {nx -> 55481. + 0. i}
```

```
Out[813]= {nx -> 0. - 55.3492 i}
```

```
Out[814]= {nx -> -3866.3 + 0. i}
```

```
Out[815]= {nx -> -55481. + 0. i}
```

```
dataSet=GDT-Alfven
```

```
ne0= $1. \times 10^{19}$ 
```

```
B0=1.2
```

```
freq=7.5
```

```
nz=127.324
```

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

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

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

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

```
In[817]:= modelList[[3]] = 2;
```

```

In[818]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[1]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[2]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[3]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[4]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[5]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[6]]}, MaxIterations -> 30]
paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList, modelList}];

```

```
Out[818]= {0. + 55.3492 i, 3866.3, 55481., 0. - 55.3492 i, -3866.3, -55481.}
```

```
Out[819]= {nx -> 0. + 55.3492 i}
```

```
Out[820]= {nx -> 3866.25 + 0. i}
```

```
Out[821]= {nx -> 3866.25 + 0. i}
```

```
Out[822]= {nx -> 0. - 55.3492 i}
```

```
Out[823]= {nx -> -3866.25 + 0. i}
```

```
Out[824]= {nx -> -3866.25 + 0. i}
```

```
dataSet=GDT-Alfven
```

```
ne0= $1. \times 10^{19}$ 
```

```
B0=1.2
```

```
freq=7.5
```

```
nz=127.324
```

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

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

```
modelList={0, 0, 2, 0, 0, 0}
```

Find Roots T = 5ev

```

In[826]:= TList[[1]] = .0;
          TList[[3]] = 0.005;

```


Cold Plasma

```
In[828]:= ColdDis2FS[freq, ne0, B0, nz, etaList]
          paramPrint[{dataSet, freq, ne0, B0, nz, etaList}];

Out[828]= {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)

```
In[830]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
          paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList}];

Out[830]= {0. + 55.1636 i, 3941.69, 24 318.9, 0. - 55.1636 i, -3941.69, -24 318.9}

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

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

```
In[832]:= modelList[[3]] = 1;
```

```

In[833]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modellList], {nx, rootsWarm[[1]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modellList], {nx, rootsWarm[[2]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modellList], {nx, rootsWarm[[3]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modellList], {nx, rootsWarm[[4]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modellList], {nx, rootsWarm[[5]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modellList], {nx, rootsWarm[[6]]}, MaxIterations -> 30]
paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList, modellList}];

```

```
Out[833]= {0. + 55.1636 i, 3941.69, 24 318.9, 0. - 55.1636 i, -3941.69, -24 318.9}
```

```
Out[834]= {nx ->  $6.71064 \times 10^{-242} + 55.1636 i$ }
```

```
Out[835]= {nx ->  $3941.69 - 9.35903 \times 10^{-241} i$ }
```

```
Out[836]= {nx ->  $24\,318.9 - 1.46382 \times 10^{-240} i$ }
```

```
Out[837]= {nx ->  $-6.71064 \times 10^{-242} - 55.1636 i$ }
```

```
Out[838]= {nx ->  $-3941.69 + 9.35903 \times 10^{-241} i$ }
```

```
Out[839]= {nx ->  $-24\,318.9 + 1.46382 \times 10^{-240} i$ }
```

```
dataSet=GDT-Alfven
```

```
ne0= $1. \times 10^{19}$ 
```

```
B0=1.2
```

```
freq=7.5
```

```
nz=127.324
```

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

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

```
modellList={0, 0, 1, 0, 0, 0}
```

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

```

In[841]:= modelList[[3]] = 2;
rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[1]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[2]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[3]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[4]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[5]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[6]]}, MaxIterations -> 30]
paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList, modelList}];

Out[841]= {0. + 55.1636 i, 3941.69, 24 318.9, 0. - 55.1636 i, -3941.69, -24 318.9}

Out[842]= {nx → 6.71064 × 10-242 + 55.1636 i}

Out[843]= {nx → 3940.03 - 9.39459 × 10-241 i}

Out[844]= {nx → 3940.03 - 1.84497 × 10-240 i}

Out[845]= {nx → -6.71064 × 10-242 - 55.1636 i}

Out[846]= {nx → -3940.03 + 9.39459 × 10-241 i}

Out[847]= {nx → -3940.03 + 1.84497 × 10-240 i}

dataSet=GDT-Alfven
ne0=1. × 1019
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0., 0., 0.005, 0., 0., 0.}
modelList={0, 0, 2, 0, 0, 0}

```

Find Roots T = 50ev

```
In[849]:= TList[[1]] = .0;
          TList[[3]] = 0.05;
```

Cold Plasma

```
In[851]:= ColdDis2FS[freq, ne0, B0, nz, etaList]
          paramPrint[{dataSet, freq, ne0, B0, nz, etaList}];

Out[851]= {0. + 54.7545 i, 3838.11}

dataSet=GDT-Alfven
freq=7.5
ne0= $1. \times 10^{19}$ 
B0=1.2
nz=127.324
etaList={0., 1., 0., 0., 0.}
```

Warm Plasma (6th order system solved with NSolve)

```
In[853]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
          paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList}];

Out[853]= {0. + 52.9527 i, 5187.91 - 1770.52 i, 5187.91 + 1770.52 i,
          0. - 52.9527 i, -5187.91 + 1770.52 i, -5187.91 - 1770.52 i}

dataSet=GDT-Alfven
ne0= $1. \times 10^{19}$ 
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0., 0., 0.05, 0., 0., 0.}
```

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

```

In[855]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList,
  nminList, nmaxList, model1], {nx, rootsWarm[[1]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, model1], {nx, rootsWarm[[2]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, model1], {nx, rootsWarm[[3]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, model1], {nx, rootsWarm[[4]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, model1], {nx, rootsWarm[[5]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, model1], {nx, rootsWarm[[6]]}, MaxIterations -> 30]
paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList, modelList}];

Out[855]= {0. + 52.9527 i, 5187.91 - 1770.52 i, 5187.91 + 1770.52 i,
  0. - 52.9527 i, -5187.91 + 1770.52 i, -5187.91 - 1770.52 i}

Out[856]= {nx -> 1.09815 x 10-21 + 52.9527 i}

Out[857]= {nx -> 5187.91 - 1770.52 i}

Out[858]= {nx -> 5187.91 + 1770.52 i}

Out[859]= {nx -> -1.09815 x 10-21 - 52.9527 i}

Out[860]= {nx -> -5187.91 + 1770.52 i}

Out[861]= {nx -> -5187.91 - 1770.52 i}

dataSet=GDT-Alfven
ne0=1. x 1019
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0., 0., 0.05, 0., 0., 0.}
modelList={0, 0, 2, 0, 0, 0}

```

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

```

In[863]:= modelList[[3]] = 2;
rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[1]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[2]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[3]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[4]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[5]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[6]]}, MaxIterations -> 30]
paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList, modelList}];

Out[863]= {0. + 52.9527 i, 5187.91 - 1770.52 i, 5187.91 + 1770.52 i,
  0. - 52.9527 i, -5187.91 + 1770.52 i, -5187.91 - 1770.52 i}

Out[864]= {nx -> 1.09815 x 10-21 + 52.9527 i}
Out[865]= {nx -> 5725.97 - 3.81297 x 10-20 i}
Out[866]= {nx -> 5725.97 - 3.61825 x 10-20 i}
Out[867]= {nx -> -1.09815 x 10-21 - 52.9527 i}
Out[868]= {nx -> -5725.97 + 3.81297 x 10-20 i}
Out[869]= {nx -> -5725.97 + 3.61825 x 10-20 i}

dataSet=GDT-Alfven
ne0=1. x 1019
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0., 0., 0.05, 0., 0., 0.}
modelList={0, 0, 2, 0, 0, 0}

```

Higher density, $n_e = 1.5 \times 10^{19}$,

Alfven wave propagates

```
In[871]:= ne0 = 0.15 × 1020;
```

Find Roots T = 0.1 ev

```
In[872]:= TList = Table[0., {i, 1, 6}];
          TList[[1]] = .0001; TList[[2]] = 0.;
          TList[[3]] = .0001; TList[[4]] = 0.;
          TList[[5]] = 0.;
          TList[[6]] = 0.;
```

Cold Plasma

```
In[876]:= ColdDis2FS[freq, ne0, B0, nz, etaList]
          paramPrint[{dataSet, freq, ne0, B0, nz, etaList}];
Out[876]= {136.848, 2746.25}

dataSet=GDT-Alfven
freq=7.5
ne0=1.5 × 1019
B0=1.2
nz=127.324
etaList={0., 1., 0., 0., 0.}
```

Warm Plasma (6th order system solved with NSolve)

```
In[878]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
          paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList}];
Out[878]= {135.515, 2775.54, 176 198., -135.515, -2775.54, -176 198.}

dataSet=GDT-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.}
```

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

```

In[880]:= modelList[[3]] = 1;

In[881]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList,
  nminList, nmaxList, model1], {nx, rootsWarm[[1]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, model1], {nx, rootsWarm[[2]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, model1], {nx, rootsWarm[[3]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, model1], {nx, rootsWarm[[4]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, model1], {nx, rootsWarm[[5]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, model1], {nx, rootsWarm[[6]]}, MaxIterations -> 30]
paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList, modelList}];

Out[881]= {135.515, 2775.54, 176 198., -135.515, -2775.54, -176 198.}

Out[882]= {nx → 135.515 + 4.94259 × 10-66 i}

Out[883]= {nx → 2775.54 - 2.54927 × 10-62 i}

Out[884]= {nx → 176 198. + 1.52762 × 10-63 i}

Out[885]= {nx → -135.515 - 4.94259 × 10-66 i}

Out[886]= {nx → -2775.54 + 2.54927 × 10-62 i}

Out[887]= {nx → -176 198. - 1.52762 × 10-63 i}

dataSet=GDT-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={0, 0, 1, 0, 0, 0}

```


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

```
In[889]:= modelList[[3]] = 1;
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[1]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[2]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[3]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[4]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[5]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[6]]}, MaxIterations -> 30]
paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList, modelList}];
```

```
Out[890]= {nx → 135.517 + 0. i}
```

```
Out[891]= {nx → 2762.18 + 0. i}
```

```
Out[892]= {nx → 176 199. + 0. i}
```

```
Out[893]= {nx → -135.517 + 0. i}
```

```
Out[894]= {nx → -2762.18 + 0. i}
```

```
Out[895]= {nx → -176 199. + 0. i}
```

```
dataSet=GDT-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={0, 0, 1, 0, 0, 0}
```

Find Roots T = 1ev

```
In[897]:= TList = Table[0., {i, 1, 6}];
          TList[[1]] = 0.001; TList[[2]] = 0.;
          TList[[3]] = 0.001; TList[[4]] = 0.;
          TList[[5]] = 0.;
          TList[[6]] = 0.;
```

Cold Plasma

```
In[901]:= ColdDis2FS[freq, ne0, B0, nz, etaList]
          paramPrint[{dataSet, freq, ne0, B0, nz, etaList}];
```

```
Out[901]= {136.848, 2746.25}
```

```
dataSet=GDT-Alfven
freq=7.5
ne0= $1.5 \times 10^{19}$ 
B0=1.2
nz=127.324
etaList={0., 1., 0., 0., 0.}
```

Warm Plasma (6th order system solved with NSolve)

```
In[903]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
          paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList}];
```

```
Out[903]= {135.568 + 6.77704  $\times 10^{-6}$  i, 2930.46 - 0.0410985 i, 55450.2 + 0.0081497 i,
          -135.568 - 6.77704  $\times 10^{-6}$  i, -2930.46 + 0.0410985 i, -55450.2 - 0.0081497 i}
```

```
dataSet=GDT-Alfven
ne0= $1.5 \times 10^{19}$ 
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)

```

In[905]:= modelList[[3]] = 1;
rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[1]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[2]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[3]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[4]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[5]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[6]]}, MaxIterations -> 30]
paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList, modelList}];

Out[905]= {135.568 + 6.77704 × 10-6 i, 2930.46 - 0.0410985 i, 55450.2 + 0.0081497 i,
  -135.568 - 6.77704 × 10-6 i, -2930.46 + 0.0410985 i, -55450.2 - 0.0081497 i}

Out[906]= {nx → 135.598 - 2.46519 × 10-32 i}
Out[907]= {nx → 2773.2 - 3.06078 × 10-28 i}
Out[908]= {nx → 55480.5 + 1.60366 × 10-50 i}
Out[909]= {nx → -135.598 + 2.46519 × 10-32 i}
Out[910]= {nx → -2773.2 + 3.06078 × 10-28 i}
Out[911]= {nx → -55480.5 - 1.60366 × 10-50 i}

dataSet=GDT-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={0, 0, 1, 0, 0, 0}

```

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

```

In[913]:= modelList[[3]] = 2;
rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[1]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[2]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[3]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[4]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[5]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[6]]}, MaxIterations -> 30]
paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList, modelList}];

Out[913]= {135.568 + 6.77704 × 10-6 i, 2930.46 - 0.0410985 i, 55450.2 + 0.0081497 i,
  -135.568 - 6.77704 × 10-6 i, -2930.46 + 0.0410985 i, -55450.2 - 0.0081497 i}

Out[914]= {nx → 135.598 + 0. i}

Out[915]= {nx → 2773.18 - 4.00741 × 10-28 i}

Out[916]= {nx → 2773.18 + 2.76402 × 10-24 i}

Out[917]= {nx → -135.598 + 0. i}

Out[918]= {nx → -2773.18 + 4.00741 × 10-28 i}

Out[919]= {nx → -2773.18 - 2.76402 × 10-24 i}

dataSet=GDT-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={0, 0, 2, 0, 0, 0}

```

Find Roots T = 5ev

```
In[921]:= TList = Table[0., {i, 1, 6}];
          TList[[1]] = .005; TList[[2]] = 0.;
          TList[[3]] = 0.005; TList[[4]] = 0.;
          TList[[5]] = 0.;
          TList[[6]] = 0.;
```

Cold Plasma

```
In[925]:= ColdDis2FS[freq, ne0, B0, nz, etaList]
          paramPrint[{dataSet, freq, ne0, B0, nz, etaList}];

Out[925]= {136.848, 2746.25}

dataSet=GDT-Alfven
freq=7.5
ne0= $1.5 \times 10^{19}$ 
B0=1.2
nz=127.324
etaList={0., 1., 0., 0., 0.}
```

Warm Plasma (6th order system solved with NSolve)

```
In[927]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
          paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList}];

Out[927]= {135.806 + 0.0710588 i, 3721.61 - 1015.23 i, 23 966.3 + 536.81 i,
          -135.806 - 0.0710588 i, -3721.61 + 1015.23 i, -23 966.3 - 536.81 i}

dataSet=GDT-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)

```

In[929]:= modelList[[3]] = 1;
rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[1]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[2]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[3]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[4]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[5]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[6]]}, MaxIterations -> 30]
paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList, modelList}];

Out[929]= {135.806 + 0.0710588 i, 3721.61 - 1015.23 i, 23 966.3 + 536.81 i,
  -135.806 - 0.0710588 i, -3721.61 + 1015.23 i, -23 966.3 - 536.81 i}

Out[930]= {nx -> 135.959 + 1.84823 × 10-24 i}
Out[931]= {nx -> 2824.67 - 1.95776 × 10-18 i}
Out[932]= {nx -> 24 326.2 - 6.46235 × 10-26 i}
Out[933]= {nx -> -135.959 - 1.84823 × 10-24 i}
Out[934]= {nx -> -2824.67 + 1.95776 × 10-18 i}
Out[935]= {nx -> -24 326.2 + 6.46235 × 10-26 i}

dataSet=GDT-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={0, 0, 1, 0, 0, 0}

```

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

```

In[937]:= modelList[[3]] = 2;
rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[1]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[2]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[3]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[4]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[5]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[6]]}, MaxIterations -> 30]
paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList, modelList}];

```

```

Out[937]= {135.806 + 0.0710588 i, 3721.61 - 1015.23 i, 23 966.3 + 536.81 i,
  -135.806 - 0.0710588 i, -3721.61 + 1015.23 i, -23 966.3 - 536.81 i}

```

```

Out[938]= {nx -> 135.959 + 1.85469 × 10-24 i}

```

```

Out[939]= {nx -> 2824.07 - 2.40559 × 10-18 i}

```

```

Out[940]= {nx -> 2824.07 + 3.83176 × 10-18 i}

```

```

Out[941]= {nx -> -135.959 - 1.85469 × 10-24 i}

```

```

Out[942]= {nx -> -2824.07 + 2.40559 × 10-18 i}

```

```

Out[943]= {nx -> -2824.07 - 3.83176 × 10-18 i}

```

```

dataSet=GDT-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={0, 0, 2, 0, 0, 0}

```

Find Roots T = 50ev

Find Roots T = 1ev

```
In[945]:= TList = Table[0., {i, 1, 6}];
          TList[[1]] = 0.05; TList[[2]] = 0.;
          TList[[3]] = 0.05; TList[[4]] = 0.;
          TList[[5]] = 0.;
          TList[[6]] = 0.;
```

Cold Plasma

```
In[949]:= ColdDis2FS[freq, ne0, B0, nz, etaList]
          paramPrint[{dataSet, freq, ne0, B0, nz, etaList}];

Out[949]= {136.848, 2746.25}

dataSet=GDT-Alfven
freq=7.5
ne0= $1.5 \times 10^{19}$ 
B0=1.2
nz=127.324
etaList={0., 1., 0., 0., 0.}
```

Warm Plasma (6th order system solved with NSolve)

```
In[951]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
          paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList}];

Out[951]= {734.654 - 1732.23 i, 139.433 + 0.449897 i, 8454.02 + 733. i,
          -734.654 + 1732.23 i, -139.433 - 0.449897 i, -8454.02 - 733. i}

dataSet=GDT-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.}
```


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

```

In[953]:= modelList[[3]] = 1;
rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[1]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[2]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[3]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[4]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[5]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[6]]}, MaxIterations -> 30]
paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList, modelList}];

Out[953]= {734.654 - 1732.23 i, 139.433 + 0.449897 i, 8454.02 + 733. i,
  -734.654 + 1732.23 i, -139.433 - 0.449897 i, -8454.02 - 733. i}

Out[954]= {nx -> 140.165 + 2.19837 x 10-21 i}
Out[955]= {nx -> 140.165 + 2.04675 x 10-18 i}
Out[956]= {nx -> 4559.13 + 774.33 i}
Out[957]= {nx -> -140.165 - 2.19837 x 10-21 i}
Out[958]= {nx -> -140.165 - 2.04675 x 10-18 i}
Out[959]= {nx -> -4559.13 - 774.33 i}

dataSet=GDT-Alfven
ne0=1.5 x 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={0, 0, 1, 0, 0, 0}

```

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

```

In[961]:= modelList[[3]] = 2;
rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[1]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[2]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[3]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[4]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[5]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[6]]}, MaxIterations -> 30]
paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList, modelList}];

Out[961]= {734.654 - 1732.23 i, 139.433 + 0.449897 i, 8454.02 + 733. i,
  -734.654 + 1732.23 i, -139.433 - 0.449897 i, -8454.02 - 733. i}

Out[962]= {nx -> 140.166 + 2.19838 x 10-21 i}
Out[963]= {nx -> 140.166 + 2.04791 x 10-18 i}
Out[964]= {nx -> 3868.69 - 4.68199 x 10-15 i}
Out[965]= {nx -> -140.166 - 2.19838 x 10-21 i}
Out[966]= {nx -> -140.166 - 2.04791 x 10-18 i}
Out[967]= {nx -> -3868.69 + 4.68199 x 10-15 i}

dataSet=GDT-Alfven
ne0=1.5 x 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={0, 0, 2, 0, 0, 0}

```

Higher density, $n_e = 2.2 \times 10^{19}$,

above Alfvén resonance. Is there any sign of kinetic Alfvén wave?

```
In[969]:= ne0 =  $2.2 \times 10^{20}$ ;
```

Find Roots T = 0.1 ev

```
In[970]:= TList = Table[0., {i, 1, 6}];
TList[[1]] = .00; TList[[2]] = 0.;
TList[[3]] = 0.001; TList[[4]] = 0.;
TList[[5]] = 0.;
TList[[6]] = 0.;
```

Cold Plasma

```
In[974]:= ColdDis2FS[freq, ne0, B0, nz, etaList]
paramPrint[{dataSet, freq, ne0, B0, nz, etaList}];

Out[974]= {171.832, 0. + 16922.8 i}

dataSet=GDT-Alfvén
freq=7.5
ne0= $2.2 \times 10^{20}$ 
B0=1.2
nz=127.324
etaList={0., 1., 0., 0., 0.}
```

Warm Plasma (6th order system solved with NSolve)

```
In[976]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList}];

Out[976]= {0. + 16994.9 i, 171.765, 55505.3, 0. - 16994.9 i, -171.765, -55505.3}

dataSet=GDT-Alfvén
ne0= $2.2 \times 10^{20}$ 
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0., 0., 0.001, 0., 0., 0.}
```

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

```

In[978]:= modelList[[3]] = 1;
rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[1]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[2]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[3]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[4]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[5]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[6]]}, MaxIterations -> 30]
paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList, modelList}];

Out[979]= {0. + 16 994.9 i, 171.765, 55 505.3, 0. - 16 994.9 i, -171.765, -55 505.3}

Out[980]= {nx -> 0. + 16 994.9 i}

Out[981]= {nx -> 171.765 + 0. i}

Out[982]= {nx -> 55 505.3 + 0. i}

Out[983]= {nx -> 0. - 16 994.9 i}

Out[984]= {nx -> -171.765 + 0. i}

Out[985]= {nx -> -55 505.3 + 0. i}

dataSet=GDT-Alfven
ne0= $2.2 \times 10^{20}$ 
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0., 0., 0.001, 0., 0., 0.}
modelList={0, 0, 1, 0, 0, 0}

```

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

```

In[987]:= modelList[[3]] = 2;
rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[1]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[2]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[3]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[4]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[5]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[6]]}, MaxIterations -> 30]
paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList, modelList}];

Out[987]= {0. + 16 994.9 i, 171.765, 55 505.3, 0. - 16 994.9 i, -171.765, -55 505.3}

Out[988]= {nx -> 0. + 16 999.2 i}

Out[989]= {nx -> 171.765 + 0. i}

Out[990]= {nx -> 171.765 + 0. i}

Out[991]= {nx -> 0. - 16 999.2 i}

Out[992]= {nx -> -171.765 + 0. i}

Out[993]= {nx -> -171.765 + 0. i}

dataSet=GDT-Alfven
ne0= $2.2 \times 10^{20}$ 
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0., 0., 0.001, 0., 0., 0.}
modelList={0, 0, 2, 0, 0, 0}

```

Find Roots T = 1ev

```
In[995]:= TList[[1]] = .0;
          TList[[3]] = 0.001;
```

Cold Plasma

```
In[997]:= ColdDis2FS[freq, ne0, B0, nz, etaList]
          paramPrint[{dataSet, freq, ne0, B0, nz, etaList}];

Out[997]= {171.832, 0. + 16 922.8 i}

dataSet=GDT-Alfven
freq=7.5
ne0= $2.2 \times 10^{20}$ 
B0=1.2
nz=127.324
etaList={0., 1., 0., 0., 0.}
```

Warm Plasma (6th order system solved with NSolve)

```
In[999]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
          paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList}];

Out[999]= {0. + 16 994.9 i, 171.765, 55 505.3, 0. - 16 994.9 i, -171.765, -55 505.3}

dataSet=GDT-Alfven
ne0= $2.2 \times 10^{20}$ 
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0., 0., 0.001, 0., 0., 0.}
```

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

```
In[1001]:= modelList[[3]] = 1;
```

```

In[1002]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[1]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[2]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[3]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[4]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[5]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[6]]}, MaxIterations -> 30]
paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList, modelList}];

Out[1002]= {0. + 16 994.9 i, 171.765, 55 505.3, 0. - 16 994.9 i, -171.765, -55 505.3}

Out[1003]= {nx -> 0. + 16 994.9 i}

Out[1004]= {nx -> 171.765 + 0. i}

Out[1005]= {nx -> 55 505.3 + 0. i}

Out[1006]= {nx -> 0. - 16 994.9 i}

Out[1007]= {nx -> -171.765 + 0. i}

Out[1008]= {nx -> -55 505.3 + 0. i}

dataSet=GDT-Alfven
ne0= $2.2 \times 10^{20}$ 
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0., 0., 0.001, 0., 0., 0.}
modelList={0, 0, 1, 0, 0, 0}

```

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

```

In[1010]:= modelList[[3]] = 2;

```

```

In[1011]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[1]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[2]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[3]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[4]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[5]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[6]]}, MaxIterations -> 30]
paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList, modelList}];

Out[1011]= {0. + 16994.9 i, 171.765, 55505.3, 0. - 16994.9 i, -171.765, -55505.3}

Out[1012]= {nx -> 0. + 16999.2 i}

Out[1013]= {nx -> 171.765 + 0. i}

Out[1014]= {nx -> 171.765 + 0. i}

Out[1015]= {nx -> 0. - 16999.2 i}

Out[1016]= {nx -> -171.765 + 0. i}

Out[1017]= {nx -> -171.765 + 0. i}

dataSet=GDT-Alfven
ne0= $2.2 \times 10^{20}$ 
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0., 0., 0.001, 0., 0., 0.}
modelList={0, 0, 2, 0, 0, 0}

```

Find Roots T = 5ev

```

In[1019]:= TList[[1]] = .0;
TList[[3]] = 0.005;

```


Cold Plasma

```
In[1021]:= ColdDis2FS[freq, ne0, B0, nz, etaList]
           paramPrint[{dataSet, freq, ne0, B0, nz, etaList}];

Out[1021]= {171.832, 0. + 16 922.8 i}

dataSet=GDT-Alfven
freq=7.5
ne0= $2.2 \times 10^{20}$ 
B0=1.2
nz=127.324
etaList={0., 1., 0., 0., 0.}
```

Warm Plasma (6th order system solved with NSolve)

```
In[1023]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
           paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList}];

Out[1023]= {0. + 17 202.1 i, 171.754, 24 534.9, 0. - 17 202.1 i, -171.754, -24 534.9}

dataSet=GDT-Alfven
ne0= $2.2 \times 10^{20}$ 
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0., 0., 0.005, 0., 0., 0.}
```

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

```
In[1025]:= modelList[[3]] = 1;
```

```

In[1026]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modellList], {nx, rootsWarm[[1]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modellList], {nx, rootsWarm[[2]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modellList], {nx, rootsWarm[[3]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modellList], {nx, rootsWarm[[4]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modellList], {nx, rootsWarm[[5]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modellList], {nx, rootsWarm[[6]]}, MaxIterations -> 30]
paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList, modellList}];

Out[1026]= {0. + 17 202.1 i, 171.754, 24 534.9, 0. - 17 202.1 i, -171.754, -24 534.9}

Out[1027]= {nx -> -1.63568 x 10-240 + 17 202.1 i}

Out[1028]= {nx -> 171.754 + 1.39641 x 10-243 i}

Out[1029]= {nx -> 24 534.9 - 1.10806 x 10-240 i}

Out[1030]= {nx -> 1.63568 x 10-240 - 17 202.1 i}

Out[1031]= {nx -> -171.754 - 1.39641 x 10-243 i}

Out[1032]= {nx -> -24 534.9 + 1.10806 x 10-240 i}

dataSet=GDT-Alfven
ne0=2.2 x 1020
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0., 0., 0.005, 0., 0., 0.}
modellList={0, 0, 1, 0, 0, 0}

```

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

```

In[1034]:= modelList[[3]] = 2;
rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[1]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[2]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[3]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[4]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[5]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[6]]}, MaxIterations -> 30]
paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList, modelList}];

Out[1034]= {0. + 17 202.1 i, 171.754, 24 534.9, 0. - 17 202.1 i, -171.754, -24 534.9}

Out[1035]= {nx -> -2.65689 × 10-240 + 17 272.8 i}

Out[1036]= {nx -> 171.754 + 1.39641 × 10-243 i}

Out[1037]= {nx -> 171.754 - 2.52907 × 10-240 i}

Out[1038]= {nx -> 2.65689 × 10-240 - 17 272.8 i}

Out[1039]= {nx -> -171.754 - 1.39641 × 10-243 i}

Out[1040]= {nx -> -171.754 + 2.52907 × 10-240 i}

dataSet=GDT-Alfven
ne0=2.2 × 1020
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0., 0., 0.005, 0., 0., 0.}
modelList={0, 0, 2, 0, 0, 0}

```

Find Roots T = 20ev

```
In[1487]:= TList[[1]] = .0;
           TList[[3]] = 0.02;
```

Cold Plasma

```
In[1489]:= ColdDis2FS[freq, ne0, B0, nz, etaList]
           paramPrint[{dataSet, freq, ne0, B0, nz, etaList}];

Out[1489]= {171.832, 0. + 16 922.8 i}

dataSet=GDT-Alfven
freq=7.5
ne0= $2.2 \times 10^{20}$ 
B0=1.2
nz=127.324
etaList={0., 1., 0., 0., 0.}
```

Warm Plasma (6th order system solved with NSolve)

```
In[1491]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
           paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList}];

Out[1491]= {0. + 17 502.9 i, 171.711, 12 077.2, 0. - 17 502.9 i, -171.711, -12 077.2}

dataSet=GDT-Alfven
ne0= $2.2 \times 10^{20}$ 
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0., 0., 0.02, 0., 0., 0.}
```

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

```

In[1493]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList,
  nminList, nmaxList, model1], {nx, rootsWarm[[1]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, model1], {nx, rootsWarm[[2]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, model1], {nx, rootsWarm[[3]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, model1], {nx, rootsWarm[[4]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, model1], {nx, rootsWarm[[5]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, model1], {nx, rootsWarm[[6]]}, MaxIterations -> 30]
paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList, modelList}];

Out[1493]= {0. + 17 502.9 i, 171.711, 12 077.2, 0. - 17 502.9 i, -171.711, -12 077.2}

Out[1494]= {nx -> -5.18738 x 10-57 + 17 502.9 i}

Out[1495]= {nx -> 171.711 + 5.60906 x 10-60 i}

Out[1496]= {nx -> 12 077.2}

Out[1497]= {nx -> 5.18738 x 10-57 - 17 502.9 i}

Out[1498]= {nx -> -171.711 - 5.60906 x 10-60 i}

Out[1499]= {nx -> -12 077.2}

dataSet=GDT-Alfven
ne0=2.2 x 1020
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0., 0., 0.02, 0., 0., 0.}
modelList={0, 0, 2, 0, 0, 0}

```

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

```

In[1501]:= modelList[[3]] = 2;
rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[1]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[2]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[3]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[4]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[5]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[6]]}, MaxIterations -> 30]
paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList, modelList}];

Out[1501]= {0. + 17 502.9 i, 171.711, 12 077.2, 0. - 17 502.9 i, -171.711, -12 077.2}

Out[1502]= {nx -> -8.44149 x 10-56 + 17 976.7 i}

Out[1503]= {nx -> 171.711 + 5.60919 x 10-60 i}

Out[1504]= {nx -> 171.711 - 1.13966 x 10-56 i}

Out[1505]= {nx -> 8.44149 x 10-56 - 17 976.7 i}

Out[1506]= {nx -> -171.711 - 5.60919 x 10-60 i}

Out[1507]= {nx -> -171.711 + 1.13966 x 10-56 i}

dataSet=GDT-Alfven
ne0=2.2 x 1020
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0., 0., 0.02, 0., 0., 0.}
modelList={0, 0, 2, 0, 0, 0}

```

Find Roots T = 50ev

```
In[1042]:= TList[[1]] = .0;
           TList[[3]] = 0.05;
```

Cold Plasma

```
In[1044]:= ColdDis2FS[freq, ne0, B0, nz, etaList]
           paramPrint[{dataSet, freq, ne0, B0, nz, etaList}];

Out[1044]= {171.832, 0. + 16 922.8 i}

dataSet=GDT-Alfven
freq=7.5
ne0= $2.2 \times 10^{20}$ 
B0=1.2
nz=127.324
etaList={0., 1., 0., 0., 0.}
```

Warm Plasma (6th order system solved with NSolve)

```
In[1046]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
           paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList}];

Out[1046]= {0. + 17 671. i, 171.626, 7591.79, 0. - 17 671. i, -171.626, -7591.79}

dataSet=GDT-Alfven
ne0= $2.2 \times 10^{20}$ 
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0., 0., 0.05, 0., 0., 0.}
```

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

```

In[1048]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList,
  nminList, nmaxList, model1], {nx, rootsWarm[[1]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, model1], {nx, rootsWarm[[2]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, model1], {nx, rootsWarm[[3]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, model1], {nx, rootsWarm[[4]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, model1], {nx, rootsWarm[[5]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, model1], {nx, rootsWarm[[6]]}, MaxIterations -> 30]
paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList, modelList}];

Out[1048]= {0. + 17 671. i, 171.626, 7591.79, 0. - 17 671. i, -171.626, -7591.79}

Out[1049]= {nx -> -1.69521 x 10-20 + 17 671. i}

Out[1050]= {nx -> 171.626 + 2.12067 x 10-23 i}

Out[1051]= {nx -> 7591.79 - 1.36718 x 10-21 i}

Out[1052]= {nx -> 1.69521 x 10-20 - 17 671. i}

Out[1053]= {nx -> -171.626 - 2.12067 x 10-23 i}

Out[1054]= {nx -> -7591.79 + 1.36718 x 10-21 i}

dataSet=GDT-Alfven
ne0=2.2 x 1020
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0., 0., 0.05, 0., 0., 0.}
modelList={0, 0, 2, 0, 0, 0}

```


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

```

In[1056]:= modelList[[3]] = 2;
rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[1]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[2]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[3]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[4]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[5]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, modelList], {nx, rootsWarm[[6]]}, MaxIterations -> 30]
paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList, modelList}];

Out[1056]= {0. + 17 671. i, 171.626, 7591.79, 0. - 17 671. i, -171.626, -7591.79}

Out[1057]= {nx -> -3.51919 x 10-19 - 0.0772452 i}

Out[1058]= {nx -> 171.626 + 4.24175 x 10-23 i}

Out[1059]= {nx -> -171.626 - 4.92385 x 10-20 i}

Out[1060]= {nx -> 3.51919 x 10-19 + 0.0772452 i}

Out[1061]= {nx -> -171.626 - 4.24175 x 10-23 i}

Out[1062]= {nx -> 171.626 + 4.92385 x 10-20 i}

dataSet=GDT-Alfven
ne0=2.2 x 1020
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0., 0., 0.05, 0., 0., 0.}
modelList={0, 0, 2, 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[1064]:= 8. / 3. / 3670 * (1 - (7.5 / (4 * 9.15) ^2))
```

```
Out[1064]= 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.