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[1065]:= **dataSet = "GDT-Alfven";**

RF Parameters

In[1066]:= **freq = 7.5;**
c = 3. × 10^8;
k0 = $\dfrac{2\,N[\pi]\,freq\,10^6}{c}$;
nz = 127.324;
kz = k0 * nz

Out[1070]= **20.**

Plasma Parameters

```
ne0 = 0.22 × 10^20;
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

In[1071]:= **ne0 = 0.1 × 10^20;**

Find Roots T = 0.1 ev

In[1085]:= **TList[[1]] = 0.0001;**
TList[[3]] = 0.0001;

Cold Plasma

In[1087]:= `ColdDis2FS[freq, ne0, B0, nz, etaList]`
`paramPrint[{dataSet, freq, ne0, B0, nz, etaList}];`

Out[1087]= $\{0. + 54.7545\, \mathbb{i}\,, 3838.11\}$

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[1089]:= `rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]`
`paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList}];`

Out[1089]= $\{0. + 55.3905\, \mathbb{i}\,, 3868.93, 176\,202., 0. - 55.3905\, \mathbb{i}\,, -3868.93, -176\,202.\}$

dataSet=GDT-Alfven

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

B0=1.2

freq=7.5

nz=127.324

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

TList={0.0001, 0., 0.0001, 0., 0., 0.}

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

```
In[1091]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
       model1 = Table[1, {i, 1, 6}];
       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, model1}];
```

Out[1091]= $\{0. + 55.3905\ \dot{\mathbb{i}}, 3868.93, 176\,202., 0. - 55.3905\ \dot{\mathbb{i}}, -3868.93, -176\,202.\}$

Out[1093]= $\{nx \to 0. + 55.3905\ \dot{\mathbb{i}}\}$

Out[1094]= $\{nx \to 3868.93 - 3.5419 \times 10^{-62}\ \dot{\mathbb{i}}\}$

Out[1095]= $\{nx \to 176\,202. + 1.52824 \times 10^{-63}\ \dot{\mathbb{i}}\}$

Out[1096]= $\{nx \to 0. - 55.3905\ \dot{\mathbb{i}}\}$

Out[1097]= $\{nx \to -3868.93 + 3.5419 \times 10^{-62}\ \dot{\mathbb{i}}\}$

Out[1098]= $\{nx \to -176\,202. - 1.52824 \times 10^{-63}\ \dot{\mathbb{i}}\}$

```
dataSet=GDT-Alfven
```

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

```
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.0001, 0., 0.0001, 0., 0., 0.}
model1={1, 1, 1, 1, 1, 1}
```

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

```
In[1100]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
        model2 = Table[2, {i, 1, 6}];
        FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList,
            nminList, nmaxList, model2], {nx, rootsWarm[[1]]}, MaxIterations -> 30]
        FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
            nmaxList, model2], {nx, rootsWarm[[2]]}, MaxIterations -> 30]
        FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
            nmaxList, model2], {nx, rootsWarm[[3]]}, MaxIterations -> 30]
        FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
            nmaxList, model2], {nx, rootsWarm[[4]]}, MaxIterations -> 30]
        FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
            nmaxList, model2], {nx, rootsWarm[[5]]}, MaxIterations -> 30]
        FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
            nmaxList, model2], {nx, rootsWarm[[6]]}, MaxIterations -> 30]
        paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList, model2}];
```

Out[1100]= $\{0. + 55.3905\ \dot{\imath}, 3868.93, 176\,202., 0. - 55.3905\ \dot{\imath}, -3868.93, -176\,202.\}$

Out[1102]= $\left\{nx \rightarrow -3.56023 \times 10^{-67} + 55.3905\ \dot{\imath}\right\}$

Out[1103]= $\left\{nx \rightarrow 3868.93 - 3.54189 \times 10^{-62}\ \dot{\imath}\right\}$

Out[1104]= $\left\{nx \rightarrow 3868.93 - 2.25164 \times 10^{-63}\ \dot{\imath}\right\}$

Out[1105]= $\left\{nx \rightarrow 3.56023 \times 10^{-67} - 55.3905\ \dot{\imath}\right\}$

Out[1106]= $\left\{nx \rightarrow -3868.93 + 3.54189 \times 10^{-62}\ \dot{\imath}\right\}$

Out[1107]= $\left\{nx \rightarrow -3868.93 + 2.25164 \times 10^{-63}\ \dot{\imath}\right\}$

```
dataSet=GDT-Alfven
ne0=1. × 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.}
model2={2, 2, 2, 2, 2, 2}
```

Find Roots T = 1ev

In[1113]:= ```TList〚1〛 = 0.001;```
```TList〚3〛 = 0.001;```

Cold Plasma

In[1109]:= ```ColdDis2FS[freq, ne0, B0, nz, etaList]```
```paramPrint[{dataSet, freq, ne0, B0, nz, etaList}];```

Out[1109]= $\{0. + 54.7545\, \dot{\imath}, 3838.11\}$

```
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[1111]:= ```rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]```
```paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList}];```

Out[1111]= $\{0. + 55.3905\, \dot{\imath}, 3868.93, 176\,202., 0. - 55.3905\, \dot{\imath}, -3868.93, -176\,202.\}$

```
dataSet=GDT-Alfven
```

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

```
B0=1.2
```

```
freq=7.5
```

```
nz=127.324
```

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

```
TList={0.0001, 0., 0.0001, 0., 0., 0.}
```

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

```
In[1115]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
          model1 = Table[1, {i, 1, 6}];
          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[1115]= $\{4.8776 \times 10^{-7} - 55.3468\,\mathbb{i},\ 4084.82 - 0.0571229\,\mathbb{i},\ 55\,450.5 + 0.0081923\,\mathbb{i},$
$-4.8776 \times 10^{-7} + 55.3468\,\mathbb{i},\ -4084.82 + 0.0571229\,\mathbb{i},\ -55\,450.5 - 0.0081923\,\mathbb{i}\}$

Out[1117]= $\{nx \to 4.8776 \times 10^{-7} - 55.3468\,\mathbb{i}\}$

Out[1118]= $\{nx \to 4084.82 - 0.0571229\,\mathbb{i}\}$

Out[1119]= $\{nx \to 55\,450.5 + 0.0081923\,\mathbb{i}\}$

Out[1120]= $\{nx \to -4.8776 \times 10^{-7} + 55.3468\,\mathbb{i}\}$

Out[1121]= $\{nx \to -4084.82 + 0.0571229\,\mathbb{i}\}$

Out[1122]= $\{nx \to -55\,450.5 - 0.0081923\,\mathbb{i}\}$

```
dataSet=GDT-Alfven
ne0=1. × 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.}
modelList={0, 0, 2, 0, 0, 0}
```

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

In[1124]:=
```
rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
model2 = Table[2, {i, 1, 6}];
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList,
   nminList, nmaxList, model2], {nx, rootsWarm[[1]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
   nmaxList, model2], {nx, rootsWarm[[2]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
   nmaxList, model2], {nx, rootsWarm[[3]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
   nmaxList, model2], {nx, rootsWarm[[4]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
   nmaxList, model2], {nx, rootsWarm[[5]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
   nmaxList, model2], {nx, rootsWarm[[6]]}, MaxIterations -> 30]
paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList, model2}];
```

Out[1124]= $\{4.8776 \times 10^{-7} - 55.3468\,\dot{\mathbb{i}},\ 4084.82 - 0.0571229\,\dot{\mathbb{i}},\ 55\,450.5 + 0.0081923\,\dot{\mathbb{i}},$
$-4.8776 \times 10^{-7} + 55.3468\,\dot{\mathbb{i}},\ -4084.82 + 0.0571229\,\dot{\mathbb{i}},\ -55\,450.5 - 0.0081923\,\dot{\mathbb{i}}\}$

Out[1126]= $\{nx \to 4.8776 \times 10^{-7} - 55.3468\,\dot{\mathbb{i}}\}$

Out[1127]= $\{nx \to 4084.74 - 0.0571175\,\dot{\mathbb{i}}\}$

Out[1128]= $\{nx \to 4084.74 - 0.0571175\,\dot{\mathbb{i}}\}$

Out[1129]= $\{nx \to -4.8776 \times 10^{-7} + 55.3468\,\dot{\mathbb{i}}\}$

Out[1130]= $\{nx \to -4084.74 + 0.0571175\,\dot{\mathbb{i}}\}$

Out[1131]= $\{nx \to -4084.74 + 0.0571175\,\dot{\mathbb{i}}\}$

```
dataSet=GDT-Alfven
ne0=1. × 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.}
model2={2, 2, 2, 2, 2, 2}
```

Find Roots T = 5ev

In[1133]:= `TList[[1]] = 0.005;`
`TList[[3]] = 0.005;`

Cold Plasma

In[1135]:= `ColdDis2FS[freq, ne0, B0, nz, etaList]`
`paramPrint[{dataSet, freq, ne0, B0, nz, etaList}];`

Out[1135]= $\{0. + 54.7545\ \mathbb{i}, 3838.11\}$

```
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[1137]:= `rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]`
`paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList}];`

Out[1137]= $\{0.00511244 - 55.1516\ \mathbb{i}, 5188.77 - 1418.54\ \mathbb{i}, 23\,954.2 + 560.118\ \mathbb{i},$
$-0.00511244 + 55.1516\ \mathbb{i}, -5188.77 + 1418.54\ \mathbb{i}, -23\,954.2 - 560.118\ \mathbb{i}\}$

```
dataSet=GDT-Alfven
```
ne0=$1. \times 10^{19}$
```
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.005, 0., 0.005, 0., 0., 0.}
```

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

```
In[1139]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
         model1 = Table[1, {i, 1, 6}];
         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[1139]= $\{0.00511244 - 55.1516\,\dot{\mathbb{i}}, 5188.77 - 1418.54\,\dot{\mathbb{i}}, 23\,954.2 + 560.118\,\dot{\mathbb{i}},$
$-0.00511244 + 55.1516\,\dot{\mathbb{i}}, -5188.77 + 1418.54\,\dot{\mathbb{i}}, -23\,954.2 - 560.118\,\dot{\mathbb{i}}\}$

Out[1141]= $\{nx \rightarrow 0.00511244 - 55.1516\,\dot{\mathbb{i}}\}$

Out[1142]= $\{nx \rightarrow 5188.77 - 1418.54\,\dot{\mathbb{i}}\}$

Out[1143]= $\{nx \rightarrow 23\,954.2 + 560.118\,\dot{\mathbb{i}}\}$

Out[1144]= $\{nx \rightarrow -0.00511244 + 55.1516\,\dot{\mathbb{i}}\}$

Out[1145]= $\{nx \rightarrow -5188.77 + 1418.54\,\dot{\mathbb{i}}\}$

Out[1146]= $\{nx \rightarrow -23\,954.2 - 560.118\,\dot{\mathbb{i}}\}$

```
dataSet=GDT-Alfven
ne0=1. × 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={0, 0, 2, 0, 0, 0}
```

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

In[1148]:=
```
rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
model2 = Table[2, {i, 1, 6}];
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList,
   nminList, nmaxList, model2], {nx, rootsWarm[[1]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
   nmaxList, model2], {nx, rootsWarm[[2]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
   nmaxList, model2], {nx, rootsWarm[[3]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
   nmaxList, model2], {nx, rootsWarm[[4]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
   nmaxList, model2], {nx, rootsWarm[[5]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
   nmaxList, model2], {nx, rootsWarm[[6]]}, MaxIterations -> 30]
paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList, modelList}];
```

Out[1148]= $\{0.00511244 - 55.1516\,\dot{\mathbb{i}},\ 5188.77 - 1418.54\,\dot{\mathbb{i}},\ 23\,954.2 + 560.118\,\dot{\mathbb{i}},$
$-0.00511244 + 55.1516\,\dot{\mathbb{i}},\ -5188.77 + 1418.54\,\dot{\mathbb{i}},\ -23\,954.2 - 560.118\,\dot{\mathbb{i}}\}$

Out[1150]= $\{nx \to 0.00511244 - 55.1516\,\dot{\mathbb{i}}\}$

Out[1151]= $\{nx \to 5187.15 - 1410.75\,\dot{\mathbb{i}}\}$

Out[1152]= $\{nx \to 5187.15 - 1410.75\,\dot{\mathbb{i}}\}$

Out[1153]= $\{nx \to -0.00511244 + 55.1516\,\dot{\mathbb{i}}\}$

Out[1154]= $\{nx \to -5187.15 + 1410.75\,\dot{\mathbb{i}}\}$

Out[1155]= $\{nx \to -5187.15 + 1410.75\,\dot{\mathbb{i}}\}$

```
dataSet=GDT-Alfven
ne0=1.×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={0, 0, 2, 0, 0, 0}
```

Find Roots T = 50ev

In[1157]:=
```
TList[[1]] = 0.05;
TList[[3]] = 0.05;
```

Cold Plasma

In[1159]:=
```
ColdDis2FS[freq, ne0, B0, nz, etaList]
paramPrint[{dataSet, freq, ne0, B0, nz, etaList}];
```

Out[1159]= $\{0. + 54.7545\, \dot{\imath}\, , 3838.11\}$

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[1161]:=
```
rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList}];
```

Out[1161]= $\{1047.61 - 2416.22\, \dot{\imath}\, , 0.030746 - 52.8956\, \dot{\imath}\, , 8455.93 + 687.452\, \dot{\imath}\, ,$
$-1047.61 + 2416.22\, \dot{\imath}\, , -0.030746 + 52.8956\, \dot{\imath}\, , -8455.93 - 687.452\, \dot{\imath}\, \}$

dataSet=GDT-Alfven

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

B0=1.2

freq=7.5

nz=127.324

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

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

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

```
In[1172]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
    model1 = Table[1, {i, 1, 6}];
    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, model1}];
```

Out[1172]= $\{1047.61 - 2416.22\,\dot{\mathbb{i}},\ 0.030746 - 52.8956\,\dot{\mathbb{i}},\ 8455.93 + 687.452\,\dot{\mathbb{i}},$
$-1047.61 + 2416.22\,\dot{\mathbb{i}},\ -0.030746 + 52.8956\,\dot{\mathbb{i}},\ -8455.93 - 687.452\,\dot{\mathbb{i}}\}$

Out[1174]= $\{nx \to 1047.61 - 2416.22\,\dot{\mathbb{i}}\}$

Out[1175]= $\{nx \to 0.030746 - 52.8956\,\dot{\mathbb{i}}\}$

Out[1176]= $\{nx \to 8455.93 + 687.452\,\dot{\mathbb{i}}\}$

Out[1177]= $\{nx \to -1047.61 + 2416.22\,\dot{\mathbb{i}}\}$

Out[1178]= $\{nx \to -0.030746 + 52.8956\,\dot{\mathbb{i}}\}$

Out[1179]= $\{nx \to -8455.93 - 687.452\,\dot{\mathbb{i}}\}$

```
dataSet=GDT-Alfven
ne0=1. × 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.}
model1={1, 1, 1, 1, 1, 1}
```

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

```
In[1181]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
         model2 = Table[2, {i, 1, 6}];
         FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList,
             nminList, nmaxList, model2], {nx, rootsWarm[[1]]}, MaxIterations -> 30]
         FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
             nmaxList, model2], {nx, rootsWarm[[2]]}, MaxIterations -> 30]
         FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
             nmaxList, model2], {nx, rootsWarm[[3]]}, MaxIterations -> 30]
         FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
             nmaxList, model2], {nx, rootsWarm[[4]]}, MaxIterations -> 30]
         FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
             nmaxList, model2], {nx, rootsWarm[[5]]}, MaxIterations -> 30]
         FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
             nmaxList, model2], {nx, rootsWarm[[6]]}, MaxIterations -> 30]
         paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList, model2}];
```

Out[1181]= $\{1047.61 - 2416.22\,\dot{\imath},\ 0.030746 - 52.8956\,\dot{\imath},\ 8455.93 + 687.452\,\dot{\imath},$
$-1047.61 + 2416.22\,\dot{\imath},\ -0.030746 + 52.8956\,\dot{\imath},\ -8455.93 - 687.452\,\dot{\imath}\}$

Out[1183]= $\{nx \to 1030.53 - 2423.05\,\dot{\imath}\}$

Out[1184]= $\{nx \to 0.030746 - 52.8956\,\dot{\imath}\}$

Out[1185]= $\{nx \to 0.030746 - 52.8956\,\dot{\imath}\}$

Out[1186]= $\{nx \to -1030.53 + 2423.05\,\dot{\imath}\}$

Out[1187]= $\{nx \to -0.030746 + 52.8956\,\dot{\imath}\}$

Out[1188]= $\{nx \to -0.030746 + 52.8956\,\dot{\imath}\}$

```
dataSet=GDT-Alfven
ne0=1.×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.}
model2={2, 2, 2, 2, 2, 2}
```

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

Alfven wave propagates

In[1190]:= **ne0 = 1.5 × 10^{20};**

Find Roots T = 0.1 ev

In[1191]:= **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[1195]:= **ColdDis2FS[freq, ne0, B0, nz, etaList]**
paramPrint[{dataSet, freq, ne0, B0, nz, etaList}];

Out[1195]= {102.764, 0. + 13 638.3 𝕚}

dataSet=GDT-Alfven

freq=7.5

ne0=1.5 × 10^{20}

B0=1.2

nz=127.324

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

Warm Plasma (6th order system solved with NSolve)

In[1197]:= **rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]**
paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList}];

Out[1197]= {0. + 13 707.5 𝕚, 102.7, 176 193., 0. − 13 707.5 𝕚, −102.7, −176 193.}

dataSet=GDT-Alfven

ne0=1.5 × 10^{20}

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[1208]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
         model1 = Table[1, {i, 1, 6}];
         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, model1}];
```

Out[1208]= $\{0. + 13\,707.5\,\mathbb{i},\ 102.7,\ 176\,193.,\ 0. - 13\,707.5\,\mathbb{i},\ -102.7,\ -176\,193.\}$

Out[1210]= $\left\{nx \to 1.25407 \times 10^{-61} + 13\,707.5\,\mathbb{i}\right\}$

Out[1211]= $\left\{nx \to 102.7 + 6.29186 \times 10^{-68}\,\mathbb{i}\right\}$

Out[1212]= $\left\{nx \to 176\,193. + 1.50865 \times 10^{-63}\,\mathbb{i}\right\}$

Out[1213]= $\left\{nx \to -1.25407 \times 10^{-61} - 13\,707.5\,\mathbb{i}\right\}$

Out[1214]= $\left\{nx \to -102.7 - 6.29186 \times 10^{-68}\,\mathbb{i}\right\}$

Out[1215]= $\left\{nx \to -176\,193. - 1.50865 \times 10^{-63}\,\mathbb{i}\right\}$

```
dataSet=GDT-Alfven
```
$ne0=1.5 \times 10^{20}$
```
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.0001, 0., 0.0001, 0., 0., 0.}
model1={1, 1, 1, 1, 1, 1}
```

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

```
In[1217]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
        model2 = Table[2, {i, 1, 6}];
        FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList,
          nminList, nmaxList, model2], {nx, rootsWarm[[1]]}, MaxIterations -> 30]
        FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
          nmaxList, model2], {nx, rootsWarm[[2]]}, MaxIterations -> 30]
        FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
          nmaxList, model2], {nx, rootsWarm[[3]]}, MaxIterations -> 30]
        FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
          nmaxList, model2], {nx, rootsWarm[[4]]}, MaxIterations -> 30]
        FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
          nmaxList, model2], {nx, rootsWarm[[5]]}, MaxIterations -> 30]
        FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
          nmaxList, model2], {nx, rootsWarm[[6]]}, MaxIterations -> 30]
        paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList, model2}];
```

Out[1217]= $\{0. + 13\,707.5\,\dot{\mathbb{i}},\ 102.7,\ 176\,193.,\ 0. - 13\,707.5\,\dot{\mathbb{i}},\ -102.7,\ -176\,193.\}$

Out[1219]= $\{nx \to 1.25408 \times 10^{-61} + 13\,707.5\,\dot{\mathbb{i}}\}$

Out[1220]= $\{nx \to 102.7 + 6.2919 \times 10^{-68}\,\dot{\mathbb{i}}\}$

Out[1221]= $\{nx \to 102.7 + 6.03048 \times 10^{-63}\,\dot{\mathbb{i}}\}$

Out[1222]= $\{nx \to -1.25408 \times 10^{-61} - 13\,707.5\,\dot{\mathbb{i}}\}$

Out[1223]= $\{nx \to -102.7 - 6.2919 \times 10^{-68}\,\dot{\mathbb{i}}\}$

Out[1224]= $\{nx \to -102.7 - 6.03048 \times 10^{-63}\,\dot{\mathbb{i}}\}$

```
dataSet=GDT-Alfven
ne0=1.5 × 10^20
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.0001, 0., 0.0001, 0., 0., 0.}
model2={2, 2, 2, 2, 2, 2}
```

Find Roots T = 1ev

In[1226]:= `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[1230]:= `ColdDis2FS[freq, ne0, B0, nz, etaList]`
`paramPrint[{dataSet, freq, ne0, B0, nz, etaList}];`

Out[1230]= $\{102.764, 0. + 13\,638.3\,\mathring{\imath}\}$

dataSet=GDT-Alfven

freq=7.5

ne0=1.5×10^{20}

B0=1.2

nz=127.324

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

Warm Plasma (6th order system solved with NSolve)

In[1232]:= `rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]`
`paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList}];`

Out[1232]= $\big\{0.20195 + 14\,469.6\,\mathring{\imath}, 102.697 + 8.72338 \times 10^{-8}\,\mathring{\imath}, 55\,470.1 + 0.00710428\,\mathring{\imath},$
$-0.20195 - 14\,469.6\,\mathring{\imath}, -102.697 - 8.72338 \times 10^{-8}\,\mathring{\imath}, -55\,470.1 - 0.00710428\,\mathring{\imath}\big\}$

dataSet=GDT-Alfven

ne0=1.5×10^{20}

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[1234]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
       model1 = Table[1, {i, 1, 6}];
       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, model1}];
```

Out[1234]= $\{0.20195 + 14\,469.6\,i,\ 102.697 + 8.72338 \times 10^{-8}\,i,\ 55\,470.1 + 0.00710428\,i,$
$-0.20195 - 14\,469.6\,i,\ -102.697 - 8.72338 \times 10^{-8}\,i,\ -55\,470.1 - 0.00710428\,i\}$

Out[1236]= $\{nx \to 0.20195 + 14\,469.6\,i\}$

Out[1237]= $\{nx \to 102.697 + 8.72338 \times 10^{-8}\,i\}$

Out[1238]= $\{nx \to 55\,470.1 + 0.00710428\,i\}$

Out[1239]= $\{nx \to -0.20195 - 14\,469.6\,i\}$

Out[1240]= $\{nx \to -102.697 - 8.72338 \times 10^{-8}\,i\}$

Out[1241]= $\{nx \to -55\,470.1 - 0.00710428\,i\}$

```
dataSet=GDT-Alfven

ne0=1.5 × 10^20

B0=1.2

freq=7.5

nz=127.324

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

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

model1={1, 1, 1, 1, 1, 1}
```

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

```
In[1243]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
        model2 = Table[2, {i, 1, 6}];
        FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList,
          nminList, nmaxList, model2], {nx, rootsWarm[[1]]}, MaxIterations -> 30]
        FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
          nmaxList, model2], {nx, rootsWarm[[2]]}, MaxIterations -> 30]
        FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
          nmaxList, model2], {nx, rootsWarm[[3]]}, MaxIterations -> 30]
        FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
          nmaxList, model2], {nx, rootsWarm[[4]]}, MaxIterations -> 30]
        FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
          nmaxList, model2], {nx, rootsWarm[[5]]}, MaxIterations -> 30]
        FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
          nmaxList, model2], {nx, rootsWarm[[6]]}, MaxIterations -> 30]
        paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList, model2}];
```

Out[1243]= $\{0.20195 + 14469.6\,\dot{\imath}, 102.697 + 8.72338 \times 10^{-8}\,\dot{\imath}, 55470.1 + 0.00710428\,\dot{\imath},$
$-0.20195 - 14469.6\,\dot{\imath}, -102.697 - 8.72338 \times 10^{-8}\,\dot{\imath}, -55470.1 - 0.00710428\,\dot{\imath}\}$

Out[1245]= $\{nx \rightarrow 0.202155 + 14472.7\,\dot{\imath}\}$

Out[1246]= $\{nx \rightarrow 102.697 + 8.72338 \times 10^{-8}\,\dot{\imath}\}$

Out[1247]= $\{nx \rightarrow 102.697 + 8.72338 \times 10^{-8}\,\dot{\imath}\}$

Out[1248]= $\{nx \rightarrow -0.202155 - 14472.7\,\dot{\imath}\}$

Out[1249]= $\{nx \rightarrow -102.697 - 8.72338 \times 10^{-8}\,\dot{\imath}\}$

Out[1250]= $\{nx \rightarrow -102.697 - 8.72338 \times 10^{-8}\,\dot{\imath}\}$

```
dataSet=GDT-Alfven

ne0=1.5 × 10^20

B0=1.2

freq=7.5

nz=127.324

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

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

model2={2, 2, 2, 2, 2, 2}
```

Find Roots T = 5ev

```
In[1256]:= TList = Table[0., {i, 1, 6}];
          TList[[1]] = 0.005; TList[[2]] = 0.;
          TList[[3]] = 0.005; TList[[4]] = 0.;
          TList[[5]] = 0.;
          TList[[6]] = 0.;
```

Cold Plasma

```
In[1260]:= ColdDis2FS[freq, ne0, B0, nz, etaList]
          paramPrint[{dataSet, freq, ne0, B0, nz, etaList}];
```

Out[1260]= $\{102.764, 0. + 13638.3\,\dot{\imath}\}$

dataSet=GDT-Alfven

freq=7.5

ne0=1.5×10^{20}

B0=1.2

nz=127.324

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

Warm Plasma (6th order system solved with NSolve)

```
In[1262]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
          paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList}];
```

Out[1262]= $\{4701.81 + 18244.7\,\dot{\imath}, 102.683 + 0.00161781\,\dot{\imath}, 24263.2 + 213.085\,\dot{\imath},$
$-4701.81 - 18244.7\,\dot{\imath}, -102.683 - 0.00161781\,\dot{\imath}, -24263.2 - 213.085\,\dot{\imath}\}$

dataSet=GDT-Alfven

ne0=1.5×10^{20}

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[1264]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
        model1 = Table[1, {i, 1, 6}];
        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, model1}];
```

Out[1264]= $\{4701.81 + 18\,244.7\,\dot{\mathbb{i}},\ 102.683 + 0.00161781\,\dot{\mathbb{i}},\ 24\,263.2 + 213.085\,\dot{\mathbb{i}},$
$-4701.81 - 18\,244.7\,\dot{\mathbb{i}},\ -102.683 - 0.00161781\,\dot{\mathbb{i}},\ -24\,263.2 - 213.085\,\dot{\mathbb{i}}\}$

Out[1266]= $\{nx \rightarrow 4701.81 + 18\,244.7\,\dot{\mathbb{i}}\}$

Out[1267]= $\{nx \rightarrow 102.683 + 0.00161781\,\dot{\mathbb{i}}\}$

Out[1268]= $\{nx \rightarrow 24\,263.2 + 213.085\,\dot{\mathbb{i}}\}$

Out[1269]= $\{nx \rightarrow -4701.81 - 18\,244.7\,\dot{\mathbb{i}}\}$

Out[1270]= $\{nx \rightarrow -102.683 - 0.00161781\,\dot{\mathbb{i}}\}$

Out[1271]= $\{nx \rightarrow -24\,263.2 - 213.085\,\dot{\mathbb{i}}\}$

```
dataSet=GDT-Alfven
```

ne0=1.5×10^{20}

```
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.005, 0., 0.005, 0., 0., 0.}
model1={1, 1, 1, 1, 1, 1}
```

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

```
In[1273]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
model2 = Table[2, {i, 1, 6}];
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList,
    nminList, nmaxList, model2], {nx, rootsWarm[[1]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
    nmaxList, model2], {nx, rootsWarm[[2]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
    nmaxList, model2], {nx, rootsWarm[[3]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
    nmaxList, model2], {nx, rootsWarm[[4]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
    nmaxList, model2], {nx, rootsWarm[[5]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
    nmaxList, model2], {nx, rootsWarm[[6]]}, MaxIterations -> 30]
paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList, model2}];
```

Out[1273]= $\{4701.81 + 18\,244.7\,\dot{\mathbb{i}}, 102.683 + 0.00161781\,\dot{\mathbb{i}}, 24\,263.2 + 213.085\,\dot{\mathbb{i}},$
$-4701.81 - 18\,244.7\,\dot{\mathbb{i}}, -102.683 - 0.00161781\,\dot{\mathbb{i}}, -24\,263.2 - 213.085\,\dot{\mathbb{i}}\}$

Out[1275]= $\{nx \rightarrow 4828.42 + 18\,342.3\,\dot{\mathbb{i}}\}$

Out[1276]= $\{nx \rightarrow 102.683 + 0.00161781\,\dot{\mathbb{i}}\}$

Out[1277]= $\{nx \rightarrow 102.683 + 0.00161781\,\dot{\mathbb{i}}\}$

Out[1278]= $\{nx \rightarrow -4828.42 - 18\,342.3\,\dot{\mathbb{i}}\}$

Out[1279]= $\{nx \rightarrow -102.683 - 0.00161781\,\dot{\mathbb{i}}\}$

Out[1280]= $\{nx \rightarrow -102.683 - 0.00161781\,\dot{\mathbb{i}}\}$

```
dataSet=GDT-Alfven
ne0=1.5 × 10^20
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.005, 0., 0.005, 0., 0., 0.}
model2={2, 2, 2, 2, 2, 2}
```

Find Roots T = 50ev

```
In[1282]:= TList = Table[0., {i, 1, 6}];
    TList[[1]] = .05; TList[[2]] = 0.;
    TList[[3]] = 0.05; TList[[4]] = 0.;
    TList[[5]] = 0.;
    TList[[6]] = 0.;
```

Cold Plasma

```
In[1286]:= ColdDis2FS[freq, ne0, B0, nz, etaList]
    paramPrint[{dataSet, freq, ne0, B0, nz, etaList}];
```

Out[1286]= $\{102.764, 0. + 13\,638.3\,\dot{\imath}\}$

dataSet=GDT-Alfven

freq=7.5

ne0=1.5×10^{20}

B0=1.2

nz=127.324

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

Warm Plasma (6th order system solved with NSolve)

```
In[1288]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
    paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList}];
```

Out[1288]= $\{102.584 + 0.0441028\,\dot{\imath}, 7289.22 + 305.127\,\dot{\imath}, 9896.95 + 4768.98\,\dot{\imath},$
$-102.584 - 0.0441028\,\dot{\imath}, -7289.22 - 305.127\,\dot{\imath}, -9896.95 - 4768.98\,\dot{\imath}\}$

dataSet=GDT-Alfven

ne0=1.5×10^{20}

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[1290]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
        model1 = Table[1, {i, 1, 6}];
        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, model1}];
```

Out[1290]= $\{102.584 + 0.0441028\,\dot{\mathbb{i}},\ 7289.22 + 305.127\,\dot{\mathbb{i}},\ 9896.95 + 4768.98\,\dot{\mathbb{i}},$
$-102.584 - 0.0441028\,\dot{\mathbb{i}},\ -7289.22 - 305.127\,\dot{\mathbb{i}},\ -9896.95 - 4768.98\,\dot{\mathbb{i}}\}$

Out[1292]= $\{nx \rightarrow 102.584 + 0.0441028\,\dot{\mathbb{i}}\}$

Out[1293]= $\{nx \rightarrow 7289.22 + 305.127\,\dot{\mathbb{i}}\}$

Out[1294]= $\{nx \rightarrow 9896.95 + 4768.98\,\dot{\mathbb{i}}\}$

Out[1295]= $\{nx \rightarrow -102.584 - 0.0441028\,\dot{\mathbb{i}}\}$

Out[1296]= $\{nx \rightarrow -7289.22 - 305.127\,\dot{\mathbb{i}}\}$

Out[1297]= $\{nx \rightarrow -9896.95 - 4768.98\,\dot{\mathbb{i}}\}$

```
dataSet=GDT-Alfven
ne0=1.5 × 10^20
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.05, 0., 0.05, 0., 0., 0.}
model1={1, 1, 1, 1, 1, 1}
```

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

```
In[1299]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
        model2 = Table[2, {i, 1, 6}];
        FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList,
          nminList, nmaxList, model2], {nx, rootsWarm[[1]]}, MaxIterations -> 30]
        FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
          nmaxList, model2], {nx, rootsWarm[[2]]}, MaxIterations -> 30]
        FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
          nmaxList, model2], {nx, rootsWarm[[3]]}, MaxIterations -> 30]
        FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
          nmaxList, model2], {nx, rootsWarm[[4]]}, MaxIterations -> 30]
        FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
          nmaxList, model2], {nx, rootsWarm[[5]]}, MaxIterations -> 30]
        FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
          nmaxList, model2], {nx, rootsWarm[[6]]}, MaxIterations -> 30]
        paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList, model2}];
```

Out[1299]= $\{102.584 + 0.0441028\,\mathbb{i},\ 7289.22 + 305.127\,\mathbb{i},\ 9896.95 + 4768.98\,\mathbb{i},$
$-102.584 - 0.0441028\,\mathbb{i},\ -7289.22 - 305.127\,\mathbb{i},\ -9896.95 - 4768.98\,\mathbb{i}\}$

Out[1301]= $\{nx \to 102.584 + 0.0441029\,\mathbb{i}\}$

Out[1302]= $\{nx \to 8796.53 + 3132.34\,\mathbb{i}\}$

Out[1303]= $\{nx \to 8796.53 + 3132.34\,\mathbb{i}\}$

Out[1304]= $\{nx \to -102.584 - 0.0441029\,\mathbb{i}\}$

Out[1305]= $\{nx \to -8796.53 - 3132.34\,\mathbb{i}\}$

Out[1306]= $\{nx \to -8796.53 - 3132.34\,\mathbb{i}\}$

```
dataSet=GDT-Alfven

ne0=1.5×10^20

B0=1.2

freq=7.5

nz=127.324

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

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

model2={2, 2, 2, 2, 2, 2}
```

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

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

In[1308]:= `ne0 = 2.2 × 10²⁰;`

Find Roots T = 0.1 ev

In[1309]:=
```
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[1313]:=
```
ColdDis2FS[freq, ne0, B0, nz, etaList]
paramPrint[{dataSet, freq, ne0, B0, nz, etaList}];
```

Out[1313]= $\{171.832, 0. + 16\,922.8\,\dot{\iota}\}$

```
dataSet=GDT-Alfven

freq=7.5

ne0=2.2 × 10²⁰

B0=1.2

nz=127.324

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

Warm Plasma (6th order system solved with NSolve)

In[1315]:=
```
rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList}];
```

Out[1315]= $\{0. + 17\,010.\,\dot{\iota}, 171.768, 176\,193., 0. - 17\,010.\,\dot{\iota}, -171.768, -176\,193.\}$

```
dataSet=GDT-Alfven

ne0=2.2 × 10²⁰

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[1317]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
          model1 = Table[1, {i, 1, 6}];
          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, model1}];
```

Out[1317]= $\{0. + 17\,010.\ \dot{\mathbb{i}}, 171.768, 176\,193., 0. - 17\,010.\ \dot{\mathbb{i}}, -171.768, -176\,193.\}$

Out[1319]= $\left\{nx \to 1.55617 \times 10^{-61} + 17\,010.\ \dot{\mathbb{i}}\right\}$

Out[1320]= $\left\{nx \to 171.768 + 6.50914 \times 10^{-68}\ \dot{\mathbb{i}}\right\}$

Out[1321]= $\left\{nx \to 176\,193. + 1.49888 \times 10^{-63}\ \dot{\mathbb{i}}\right\}$

Out[1322]= $\left\{nx \to -1.55617 \times 10^{-61} - 17\,010.\ \dot{\mathbb{i}}\right\}$

Out[1323]= $\left\{nx \to -171.768 - 6.50914 \times 10^{-68}\ \dot{\mathbb{i}}\right\}$

Out[1324]= $\left\{nx \to -176\,193. - 1.49888 \times 10^{-63}\ \dot{\mathbb{i}}\right\}$

```
dataSet=GDT-Alfven
ne0=2.2 × 10^20
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.0001, 0., 0.0001, 0., 0., 0.}
model1={1, 1, 1, 1, 1, 1}
```

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

```
In[1326]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
      model2 = Table[2, {i, 1, 6}];
      FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList,
        nminList, nmaxList, model2], {nx, rootsWarm[[1]]}, MaxIterations -> 30]
      FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
        nmaxList, model2], {nx, rootsWarm[[2]]}, MaxIterations -> 30]
      FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
        nmaxList, model2], {nx, rootsWarm[[3]]}, MaxIterations -> 30]
      FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
        nmaxList, model2], {nx, rootsWarm[[4]]}, MaxIterations -> 30]
      FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
        nmaxList, model2], {nx, rootsWarm[[5]]}, MaxIterations -> 30]
      FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
        nmaxList, model2], {nx, rootsWarm[[6]]}, MaxIterations -> 30]
      paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList, model2}];
```

Out[1326]= $\{0. + 17\,010.\ \dot{\mathbb{i}},\ 171.768,\ 176\,193.,\ 0. - 17\,010.\ \dot{\mathbb{i}},\ -171.768,\ -176\,193.\}$

Out[1328]= $\left\{nx \rightarrow 1.55619 \times 10^{-61} + 17\,010.1\ \dot{\mathbb{i}}\right\}$

Out[1329]= $\left\{nx \rightarrow 171.768 + 6.50924 \times 10^{-68}\ \dot{\mathbb{i}}\right\}$

Out[1330]= $\left\{nx \rightarrow 171.768 + 1.01634 \times 10^{-62}\ \dot{\mathbb{i}}\right\}$

Out[1331]= $\left\{nx \rightarrow -1.55619 \times 10^{-61} - 17\,010.1\ \dot{\mathbb{i}}\right\}$

Out[1332]= $\left\{nx \rightarrow -171.768 - 6.50924 \times 10^{-68}\ \dot{\mathbb{i}}\right\}$

Out[1333]= $\left\{nx \rightarrow -171.768 - 1.01634 \times 10^{-62}\ \dot{\mathbb{i}}\right\}$

```
dataSet=GDT-Alfven
ne0=2.2×10²⁰
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.0001, 0., 0.0001, 0., 0., 0.}
model2={2, 2, 2, 2, 2, 2}
```

Find Roots T = 1ev

In[1335]:= `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[1339]:= `ColdDis2FS[freq, ne0, B0, nz, etaList]`
`paramPrint[{dataSet, freq, ne0, B0, nz, etaList}];`

Out[1339]= $\{171.832, 0. + 16\,922.8\,i\}$

dataSet=GDT-Alfven

freq=7.5

ne0=2.2×10^{20}

B0=1.2

nz=127.324

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

Warm Plasma (6th order system solved with NSolve)

In[1341]:= `rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]`
`paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList}];`

Out[1341]= $\{0.250414 + 17\,953.1\,i, 171.761 + 9.17177 \times 10^{-8}\,i, 55\,480.4 + 0.00663982\,i,$
$-0.250414 - 17\,953.1\,i, -171.761 - 9.17177 \times 10^{-8}\,i, -55\,480.4 - 0.00663982\,i\}$

dataSet=GDT-Alfven

ne0=2.2×10^{20}

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[1343]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
        model1 = Table[1, {i, 1, 6}];
        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, model1}];
```

Out[1343]= $\{0.250414 + 17\,953.1\,\dot{\imath},\ 171.761 + 9.17177 \times 10^{-8}\,\dot{\imath},\ 55\,480.4 + 0.00663982\,\dot{\imath},$
$-0.250414 - 17\,953.1\,\dot{\imath},\ -171.761 - 9.17177 \times 10^{-8}\,\dot{\imath},\ -55\,480.4 - 0.00663982\,\dot{\imath}\}$

Out[1345]= $\{nx \to 0.250414 + 17\,953.1\,\dot{\imath}\}$

Out[1346]= $\{nx \to 171.761 + 9.17177 \times 10^{-8}\,\dot{\imath}\}$

Out[1347]= $\{nx \to 55\,480.4 + 0.00663982\,\dot{\imath}\}$

Out[1348]= $\{nx \to -0.250414 - 17\,953.1\,\dot{\imath}\}$

Out[1349]= $\{nx \to -171.761 - 9.17177 \times 10^{-8}\,\dot{\imath}\}$

Out[1350]= $\{nx \to -55\,480.4 - 0.00663982\,\dot{\imath}\}$

```
dataSet=GDT-Alfven

ne0=2.2 × 10^20

B0=1.2

freq=7.5

nz=127.324

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

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

model1={1, 1, 1, 1, 1, 1}
```

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

```
In[1352]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
        model2 = Table[2, {i, 1, 6}];
        FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList,
          nminList, nmaxList, model2], {nx, rootsWarm[[1]]}, MaxIterations -> 30]
        FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
          nmaxList, model2], {nx, rootsWarm[[2]]}, MaxIterations -> 30]
        FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
          nmaxList, model2], {nx, rootsWarm[[3]]}, MaxIterations -> 30]
        FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
          nmaxList, model2], {nx, rootsWarm[[4]]}, MaxIterations -> 30]
        FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
          nmaxList, model2], {nx, rootsWarm[[5]]}, MaxIterations -> 30]
        FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
          nmaxList, model2], {nx, rootsWarm[[6]]}, MaxIterations -> 30]
        paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList, model2}];
```

Out[1352]= $\{0.250414 + 17\,953.1\,\dot{\imath},\ 171.761 + 9.17177 \times 10^{-8}\,\dot{\imath},\ 55\,480.4 + 0.00663982\,\dot{\imath},$
$-0.250414 - 17\,953.1\,\dot{\imath},\ -171.761 - 9.17177 \times 10^{-8}\,\dot{\imath},\ -55\,480.4 - 0.00663982\,\dot{\imath}\}$

Out[1354]= $\{nx \to 0.250779 + 17\,958.7\,\dot{\imath}\}$

Out[1355]= $\{nx \to 171.761 + 9.17177 \times 10^{-8}\,\dot{\imath}\}$

Out[1356]= $\{nx \to 171.761 + 9.17177 \times 10^{-8}\,\dot{\imath}\}$

Out[1357]= $\{nx \to -0.250779 - 17\,958.7\,\dot{\imath}\}$

Out[1358]= $\{nx \to -171.761 - 9.17177 \times 10^{-8}\,\dot{\imath}\}$

Out[1359]= $\{nx \to -171.761 - 9.17177 \times 10^{-8}\,\dot{\imath}\}$

```
dataSet=GDT-Alfven

ne0=2.2 × 10^20

B0=1.2

freq=7.5

nz=127.324

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

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

model2={2, 2, 2, 2, 2, 2}
```

Find Roots T = 5ev

In[1361]:= **TList = Table[0., {i, 1, 6}];**
TList[[1]] = 0.005; TList[[2]] = 0.;
TList[[3]] = 0.005; TList[[4]] = 0.;
TList[[5]] = 0.;
TList[[6]] = 0.;

Cold Plasma

In[1365]:= **ColdDis2FS[freq, ne0, B0, nz, etaList]**
paramPrint[{dataSet, freq, ne0, B0, nz, etaList}];

Out[1365]= $\{171.832, 0. + 16\,922.8\,\dot{\mathbb{i}}\}$

dataSet=GDT-Alfven

freq=7.5

ne0=2.2×10^{20}

B0=1.2

nz=127.324

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

Warm Plasma (6th order system solved with NSolve)

In[1367]:= **rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]**
paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList}];

Out[1367]= $\{5751.96 + 22\,565.1\,\dot{\mathbb{i}}, 171.728 + 0.00269261\,\dot{\mathbb{i}}, 24\,365.8 + 149.55\,\dot{\mathbb{i}},$
$-5751.96 - 22\,565.1\,\dot{\mathbb{i}}, -171.728 - 0.00269261\,\dot{\mathbb{i}}, -24\,365.8 - 149.55\,\dot{\mathbb{i}}\}$

dataSet=GDT-Alfven

ne0=2.2×10^{20}

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[1369]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
        model1 = Table[1, {i, 1, 6}];
        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, model1}];
```

Out[1369]= $\{5751.96 + 22\,565.1\,\dot{\imath}, 171.728 + 0.00269261\,\dot{\imath}, 24\,365.8 + 149.55\,\dot{\imath}, $
$-5751.96 - 22\,565.1\,\dot{\imath}, -171.728 - 0.00269261\,\dot{\imath}, -24\,365.8 - 149.55\,\dot{\imath}\}$

Out[1371]= $\{nx \rightarrow 5751.96 + 22\,565.1\,\dot{\imath}\}$

Out[1372]= $\{nx \rightarrow 171.728 + 0.00269261\,\dot{\imath}\}$

Out[1373]= $\{nx \rightarrow 24\,365.8 + 149.55\,\dot{\imath}\}$

Out[1374]= $\{nx \rightarrow -5751.96 - 22\,565.1\,\dot{\imath}\}$

Out[1375]= $\{nx \rightarrow -171.728 - 0.00269261\,\dot{\imath}\}$

Out[1376]= $\{nx \rightarrow -24\,365.8 - 149.55\,\dot{\imath}\}$

```
dataSet=GDT-Alfven
ne0=2.2 × 10^20
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.005, 0., 0.005, 0., 0., 0.}
model1={1, 1, 1, 1, 1, 1}
```

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

In[1378]:=
```
rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
model2 = Table[2, {i, 1, 6}];
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList,
  nminList, nmaxList, model2], {nx, rootsWarm[[1]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, model2], {nx, rootsWarm[[2]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, model2], {nx, rootsWarm[[3]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, model2], {nx, rootsWarm[[4]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, model2], {nx, rootsWarm[[5]]}, MaxIterations -> 30]
FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
  nmaxList, model2], {nx, rootsWarm[[6]]}, MaxIterations -> 30]
paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList, model2}];
```

Out[1378]= $\{5751.96 + 22\,565.1\,\dot{\mathbb{i}},\ 171.728 + 0.00269261\,\dot{\mathbb{i}},\ 24\,365.8 + 149.55\,\dot{\mathbb{i}},$
$-5751.96 - 22\,565.1\,\dot{\mathbb{i}},\ -171.728 - 0.00269261\,\dot{\mathbb{i}},\ -24\,365.8 - 149.55\,\dot{\mathbb{i}}\}$

Out[1380]= $\{nx \rightarrow 5904.04 + 22\,723.9\,\dot{\mathbb{i}}\}$

Out[1381]= $\{nx \rightarrow 171.728 + 0.00269261\,\dot{\mathbb{i}}\}$

Out[1382]= $\{nx \rightarrow 171.728 + 0.00269261\,\dot{\mathbb{i}}\}$

Out[1383]= $\{nx \rightarrow -5904.04 - 22\,723.9\,\dot{\mathbb{i}}\}$

Out[1384]= $\{nx \rightarrow -171.728 - 0.00269261\,\dot{\mathbb{i}}\}$

Out[1385]= $\{nx \rightarrow -171.728 - 0.00269261\,\dot{\mathbb{i}}\}$

```
dataSet=GDT-Alfven
ne0=2.2×10^20
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.005, 0., 0.005, 0., 0., 0.}
model2={2, 2, 2, 2, 2, 2}
```

Find Roots T = 50ev

In[1387]:= ```
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[1391]:= ```
ColdDis2FS[freq, ne0, B0, nz, etaList]
paramPrint[{dataSet, freq, ne0, B0, nz, etaList}];
```

Out[1391]= $\{171.832, 0. + 16\,922.8\,\dot{\mathbb{i}}\}$

```
dataSet=GDT-Alfven

freq=7.5

ne0=2.2 × 10^20

B0=1.2

nz=127.324

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

Warm Plasma (6th order system solved with NSolve)

In[1393]:= ```
rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList}];
```

Out[1393]= $\{171.474 + 0.100576\,\dot{\mathbb{i}}, 7497.82 + 131.964\,\dot{\mathbb{i}}, 11\,825.1 + 6056.76\,\dot{\mathbb{i}},$
$-171.474 - 0.100576\,\dot{\mathbb{i}}, -7497.82 - 131.964\,\dot{\mathbb{i}}, -11\,825.1 - 6056.76\,\dot{\mathbb{i}}\}$

```
dataSet=GDT-Alfven

ne0=2.2 × 10^20

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[1395]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
          model1 = Table[1, {i, 1, 6}];
          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, model1}];
```

Out[1395]= $\{171.474 + 0.100576\,\dot{\mathbb{i}}, \ 7497.82 + 131.964\,\dot{\mathbb{i}}, \ 11825.1 + 6056.76\,\dot{\mathbb{i}},$
$-171.474 - 0.100576\,\dot{\mathbb{i}}, \ -7497.82 - 131.964\,\dot{\mathbb{i}}, \ -11825.1 - 6056.76\,\dot{\mathbb{i}}\}$

Out[1397]= $\{nx \rightarrow 171.474 + 0.100576\,\dot{\mathbb{i}}\}$

Out[1398]= $\{nx \rightarrow 7497.82 + 131.964\,\dot{\mathbb{i}}\}$

Out[1399]= $\{nx \rightarrow 11825.1 + 6056.76\,\dot{\mathbb{i}}\}$

Out[1400]= $\{nx \rightarrow -171.474 - 0.100576\,\dot{\mathbb{i}}\}$

Out[1401]= $\{nx \rightarrow -7497.82 - 131.964\,\dot{\mathbb{i}}\}$

Out[1402]= $\{nx \rightarrow -11825.1 - 6056.76\,\dot{\mathbb{i}}\}$

```
dataSet=GDT-Alfven
ne0=2.2 × 10^20
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.05, 0., 0.05, 0., 0., 0.}
model1={1, 1, 1, 1, 1, 1}
```

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

In[1404]:= `rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]`
`model2 = Table[2, {i, 1, 6}];`
`FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList,`
`  nminList, nmaxList, model2], {nx, rootsWarm[[1]]}, MaxIterations -> 30]`
`FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,`
`  nmaxList, model2], {nx, rootsWarm[[2]]}, MaxIterations -> 30]`
`FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,`
`  nmaxList, model2], {nx, rootsWarm[[3]]}, MaxIterations -> 30]`
`FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,`
`  nmaxList, model2], {nx, rootsWarm[[4]]}, MaxIterations -> 30]`
`FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,`
`  nmaxList, model2], {nx, rootsWarm[[5]]}, MaxIterations -> 30]`
`FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,`
`  nmaxList, model2], {nx, rootsWarm[[6]]}, MaxIterations -> 30]`
`paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList, model2}];`

Out[1404]= $\{171.474 + 0.100576\,\dot{\imath},\ 7497.82 + 131.964\,\dot{\imath},\ 11825.1 + 6056.76\,\dot{\imath},$
$-171.474 - 0.100576\,\dot{\imath},\ -7497.82 - 131.964\,\dot{\imath},\ -11825.1 - 6056.76\,\dot{\imath}\}$

Out[1406]= $\{nx \rightarrow 171.475 + 0.100577\,\dot{\imath}\}$

Out[1407]= $\{nx \rightarrow 10861. + 3573.08\,\dot{\imath}\}$

Out[1408]= $\{nx \rightarrow 10861. + 3573.08\,\dot{\imath}\}$

Out[1409]= $\{nx \rightarrow -171.475 - 0.100577\,\dot{\imath}\}$

Out[1410]= $\{nx \rightarrow -10861. - 3573.08\,\dot{\imath}\}$

Out[1411]= $\{nx \rightarrow -10861. - 3573.08\,\dot{\imath}\}$

`dataSet=GDT-Alfven`

`ne0=2.2 × 10²⁰` $ne0 = 2.2 \times 10^{20}$

`B0=1.2`

`freq=7.5`

`nz=127.324`

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

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

`model2={2, 2, 2, 2, 2, 2}`

Find Roots T = 500ev

In[1413]:=
```
TList = Table[0., {i, 1, 6}];
TList[[1]] = 0.5; TList[[2]] = 0.;
TList[[3]] = 0.5; TList[[4]] = 0.;
TList[[5]] = 0.;
TList[[6]] = 0.;
```

Cold Plasma

In[1417]:=
```
ColdDis2FS[freq, ne0, B0, nz, etaList]
paramPrint[{dataSet, freq, ne0, B0, nz, etaList}];
```

Out[1417]= $\{171.832, 0. + 16\,922.8\,i\}$

dataSet=GDT-Alfven

freq=7.5

ne0=2.2×10^{20}

B0=1.2

nz=127.324

etaList=$\{0., 1., 0., 0., 0.\}$

Warm Plasma (6th order system solved with NSolve)

In[1419]:=
```
rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList}];
```

Out[1419]= $\{169.609 + 0.464606\,i, 2450.31 + 11.7149\,i, 4551.73 + 729.11\,i,$
$-169.609 - 0.464606\,i, -2450.31 - 11.7149\,i, -4551.73 - 729.11\,i\}$

dataSet=GDT-Alfven

ne0=2.2×10^{20}

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)

```
In[1421]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
         model1 = Table[1, {i, 1, 6}];
         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, model1}];
```

Out[1421]= $\{169.609 + 0.464606\,\dot{\mathbb{i}},\ 2450.31 + 11.7149\,\dot{\mathbb{i}},\ 4551.73 + 729.11\,\dot{\mathbb{i}},$
$-169.609 - 0.464606\,\dot{\mathbb{i}},\ -2450.31 - 11.7149\,\dot{\mathbb{i}},\ -4551.73 - 729.11\,\dot{\mathbb{i}}\}$

Out[1423]= $\{nx \to 169.609 + 0.464606\,\dot{\mathbb{i}}\}$

Out[1424]= $\{nx \to 2450.31 + 11.7149\,\dot{\mathbb{i}}\}$

Out[1425]= $\{nx \to 4551.73 + 729.11\,\dot{\mathbb{i}}\}$

Out[1426]= $\{nx \to -169.609 - 0.464606\,\dot{\mathbb{i}}\}$

Out[1427]= $\{nx \to -2450.31 - 11.7149\,\dot{\mathbb{i}}\}$

Out[1428]= $\{nx \to -4551.73 - 729.11\,\dot{\mathbb{i}}\}$

```
dataSet=GDT-Alfven
ne0=2.2 × 10^20
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.5, 0., 0.5, 0., 0., 0.}
model1={1, 1, 1, 1, 1, 1}
```

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

```
In[1430]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
       model2 = Table[2, {i, 1, 6}];
       FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList,
         nminList, nmaxList, model2], {nx, rootsWarm[[1]]}, MaxIterations -> 30]
       FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
         nmaxList, model2], {nx, rootsWarm[[2]]}, MaxIterations -> 30]
       FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
         nmaxList, model2], {nx, rootsWarm[[3]]}, MaxIterations -> 30]
       FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
         nmaxList, model2], {nx, rootsWarm[[4]]}, MaxIterations -> 30]
       FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
         nmaxList, model2], {nx, rootsWarm[[5]]}, MaxIterations -> 30]
       FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
         nmaxList, model2], {nx, rootsWarm[[6]]}, MaxIterations -> 30]
       paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList, model2}];
```

Out[1430]= $\{169.609 + 0.464606\,\dot{\mathbb{i}},\ 2450.31 + 11.7149\,\dot{\mathbb{i}},\ 4551.73 + 729.11\,\dot{\mathbb{i}},$
$-169.609 - 0.464606\,\dot{\mathbb{i}},\ -2450.31 - 11.7149\,\dot{\mathbb{i}},\ -4551.73 - 729.11\,\dot{\mathbb{i}}\}$

Out[1432]= $\{nx \to 169.648 + 0.465305\,\dot{\mathbb{i}}\}$

Out[1433]= $\{nx \to 3632.25 + 365.42\,\dot{\mathbb{i}}\}$

Out[1434]= $\{nx \to 3632.25 + 365.42\,\dot{\mathbb{i}}\}$

Out[1435]= $\{nx \to -169.648 - 0.465305\,\dot{\mathbb{i}}\}$

Out[1436]= $\{nx \to -3632.25 - 365.42\,\dot{\mathbb{i}}\}$

Out[1437]= $\{nx \to -3632.25 - 365.42\,\dot{\mathbb{i}}\}$

```
dataSet=GDT-Alfven
ne0=2.2 × 10^20
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.5, 0., 0.5, 0., 0., 0.}
model2={2, 2, 2, 2, 2, 2}
```

Find Roots T = 500ev

In[1439]:=
```
TList = Table[0., {i, 1, 6}];
TList[[1]] = 0.5; TList[[2]] = 0.;
TList[[3]] = 0.5; TList[[4]] = 0.;
TList[[5]] = 0.;
TList[[6]] = 0.;
```

Cold Plasma

In[1443]:=
```
ColdDis2FS[freq, ne0, B0, nz, etaList]
paramPrint[{dataSet, freq, ne0, B0, nz, etaList}];
```

Out[1443]= $\{171.832, 0. + 16\,922.8\,i\}$

dataSet=GDT-Alfven

freq=7.5

ne0=2.2×10^{20}

B0=1.2

nz=127.324

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

Warm Plasma (6th order system solved with NSolve)

In[1445]:=
```
rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList}];
```

Out[1445]= $\{169.609 + 0.464606\,i, 2450.31 + 11.7149\,i, 4551.73 + 729.11\,i,$
$-169.609 - 0.464606\,i, -2450.31 - 11.7149\,i, -4551.73 - 729.11\,i\}$

dataSet=GDT-Alfven

ne0=2.2×10^{20}

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)

```
In[1447]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
        model1 = Table[1, {i, 1, 6}];
        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, model1}];
```

Out[1447]= $\{169.609 + 0.464606\,\dot{\mathbb{i}},\ 2450.31 + 11.7149\,\dot{\mathbb{i}},\ 4551.73 + 729.11\,\dot{\mathbb{i}},$
$\ -169.609 - 0.464606\,\dot{\mathbb{i}},\ -2450.31 - 11.7149\,\dot{\mathbb{i}},\ -4551.73 - 729.11\,\dot{\mathbb{i}}\}$

Out[1449]= $\{nx \rightarrow 169.609 + 0.464606\,\dot{\mathbb{i}}\}$

Out[1450]= $\{nx \rightarrow 2450.31 + 11.7149\,\dot{\mathbb{i}}\}$

Out[1451]= $\{nx \rightarrow 4551.73 + 729.11\,\dot{\mathbb{i}}\}$

Out[1452]= $\{nx \rightarrow -169.609 - 0.464606\,\dot{\mathbb{i}}\}$

Out[1453]= $\{nx \rightarrow -2450.31 - 11.7149\,\dot{\mathbb{i}}\}$

Out[1454]= $\{nx \rightarrow -4551.73 - 729.11\,\dot{\mathbb{i}}\}$

```
dataSet=GDT-Alfven
ne0=2.2 × 10^20
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.5, 0., 0.5, 0., 0., 0.}
model1={1, 1, 1, 1, 1, 1}
```

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

```
In[1456]:= rootsWarm = WarmDis6[freq, ne0, B0, nz, etaList, TList]
       model2 = Table[2, {i, 1, 6}];
       FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList,
         nminList, nmaxList, model2], {nx, rootsWarm[[1]]}, MaxIterations -> 30]
       FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
         nmaxList, model2], {nx, rootsWarm[[2]]}, MaxIterations -> 30]
       FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
         nmaxList, model2], {nx, rootsWarm[[3]]}, MaxIterations -> 30]
       FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
         nmaxList, model2], {nx, rootsWarm[[4]]}, MaxIterations -> 30]
       FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
         nmaxList, model2], {nx, rootsWarm[[5]]}, MaxIterations -> 30]
       FindRoot[DisFuncGeneral[freq, ne0, B0, nz, nx, etaList, TList, nminList,
         nmaxList, model2], {nx, rootsWarm[[6]]}, MaxIterations -> 30]
       paramPrint[{dataSet, ne0, B0, freq, nz, etaList, TList, model2}];
```

Out[1456]= $\{169.609 + 0.464606\,\dot{\mathbb{1}},\ 2450.31 + 11.7149\,\dot{\mathbb{1}},\ 4551.73 + 729.11\,\dot{\mathbb{1}},$
$\ -169.609 - 0.464606\,\dot{\mathbb{1}},\ -2450.31 - 11.7149\,\dot{\mathbb{1}},\ -4551.73 - 729.11\,\dot{\mathbb{1}}\}$

Out[1458]= $\{nx \rightarrow 169.648 + 0.465305\,\dot{\mathbb{1}}\}$

Out[1459]= $\{nx \rightarrow 3632.25 + 365.42\,\dot{\mathbb{1}}\}$

Out[1460]= $\{nx \rightarrow 3632.25 + 365.42\,\dot{\mathbb{1}}\}$

Out[1461]= $\{nx \rightarrow -169.648 - 0.465305\,\dot{\mathbb{1}}\}$

Out[1462]= $\{nx \rightarrow -3632.25 - 365.42\,\dot{\mathbb{1}}\}$

Out[1463]= $\{nx \rightarrow -3632.25 - 365.42\,\dot{\mathbb{1}}\}$

```
dataSet=GDT-Alfven
ne0=2.2 × 10^20
B0=1.2
freq=7.5
nz=127.324
etaList={0., 1., 0., 0., 0.}
TList={0.5, 0., 0.5, 0., 0., 0.}
model2={2, 2, 2, 2, 2, 2}
```

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

```
8. / 3. / 3670 * (1 - (7.5 / (4 * 9.15) ^ 2))
```

0.000722544

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