IS Radar Spectral Shape group exercises

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Note that some things (e.g. ion mass) are not on sliders
These need to be hand edited here before running the block →

```
# set fixed parameters
indict={'Nion': 2, # number of ions \
       'mi': numpy.array([16, 30]), # list of ion masses, AMU \
       'B': 5e-5, # backgrond magnetic field, Tesla \
       'f0': 449.3e6, # radar frequency, Hz \
       'te': 1000.0, # electron temperature, K \
       'alpha': 60.0, # angle between look direction and magnetic field, deg (90 = perp to B) \
       'ne': 1e11, # electron density, m^-3 \
       'ti': numpy.array([1000.0, 1000.0]), # ion temperature, K \
       'ni': numpy.array([1.0, 0.0]), # list of ion fractions (sum must = 1) \
       've': 0.0, # electron velocity, m/s \
       'vi': numpy.array([0.0, 0.0]), # ion velocity, m/s \
       'nuen': 0.0, # electron-neutral collision frequency, Hz \
       'nuin': numpy.array([0.0, 0.0]) # ion-neutral collision frequency, Hz \
       }
```

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- **Group 1:** What is the effect of very large Te compared to Ti? Can you relate the spectral shape and ACF to the principles in the "Signal Processing" lectures? Examine the zero crossing of the ACF. How does it relate to the spectral width?

- **Group 2:** Alter the notebook so you are using two ion species in the topside ionosphere: O+ (AMU=16) and H+ (AMU=1). Examine the 100% O+ and 100% H+ cases. Try to produce a parameter set using all the "knobs" for 100% H+ that looks spectrally (or in ACF) like 100% O+. How can this behavior be related to the ion-acoustic dispersion relation? What conclusion can you draw about determining ion composition and determining plasma temperature at the same time with an IS radar?

- **Group 3:** Use the default case of two ion species: O+ (AMU=16) and NO+ (AMU=30). Examine 100% O+ and 100% NO+ cases. Try to produce a parameter set using all the "knobs" for all NO+ that looks spectrally like O+. How different are the parameter sets? What conclusion can you draw regarding the ease (or difficulty) of remote sensing of NO+ vs. remote sensing of O+?

- **Group 4:** Use default parameters but introduce a non-zero velocity. Can you explain the characteristics of the resulting complex ACF shape as well as the power spectrum?

- **Group 5:** Alter the notebook so you are using two ion species in the topside ionosphere: O+ (AMU=16) and H+ (AMU=1). Examine three cases: 100% O+, 100% H+, and 50% of each species. What are the characteristics of each case in the spectral and ACF domains? How does this result demonstrate collective plasma behavior?

- **Group 6:** Change the transmit frequency from AMISR (449.3 MHz) to Jicamarca (49.92 MHz). What effect does this have on the power spectrum? On the ACF? Can you draw a conclusion regarding the length of pulse one would use at each facility to measure the IS power spectrum?