PHYSICS 180E, WINTER 2020

**LAB 3: WHISTLER WAVES**

In this experiment, you will launch whistler waves using an antenna immersed in a magnetized plasma produced by a radiofrequency (RF) source. You will measure the characteristics of the waves: dispersion (wavelength versus frequency), damping, and perpendicular phase velocity and compare to theoretical expectations. You will need to use a Langmuir probe to measure the electron density and temperature to be able to compare to theory.

# Whistler wave dispersion relation and damping

Use the magnetic pickup-probe on the probe drive to measure the spatial pattern of the antenna launched whistler wave as a function of frequency. You will use this spatial pattern to determine the wavelength as a function of frequency. Measure the plasma density and temperature to compare to the theoretical dispersion relation. In taking data, you can vary the background magnetic field and also the timing of the launch of the wave compared to the end of the RF pulse that creates the plasma. By doing the latter, the density and temperature of the plasma will change (the temperature and density decay exponentially after the turn off of the RF source; the temperature decays much faster than the density). Consider the following questions as you perform the experiments:

**[1.]** The standard approach to mapping out wavelength as a function of frequency is to launch a short (in time) wavepacket that contains a few wave cycles at the frequency in question. However, since it is a time-localized wavepacket, the frequency content has to be broader than the "carrier" frequency. Can you estimate (or calculate) the spread in frequency within the packet? You can look for effects associated with this in your data or utilize this spread as an error bar on the frequency.

**[2.]** Do you see any effects of wave reflection off of the far end of the chamber? Why or why not?

**[3.]** You can change the antenna driver to instead drive a pulse of current, resulting in a broad range of frequencies being excited all at once. You should see the higher frequencies arrive at the probe first in this casel; do you? Can you use this approach to get a dispersion relation measurement from a single pulse?

**[4.]** Do you see evidence for propagation across the magnetic field as well as along it? Can you determine the perpendicular wavelength from your data?

**[5.]** Do you see spatial wave damping in your measured wave patterns? What is the damping length as a function of frequency? Try to account for energy spreading due to cross field propagation. How does the damping length compare to theoretical expectations?

**[6.]** Do you see a change in the direction of the perpendicular phase speed as you change the frequency (do you see frequency ranges with "forward" and "backward" perpendicular propagation)? At what frequency do you see the switch? Is it consistent with theoretical expectations?