Physics 218A **Plasma Physics** **Winter 2017**

Problem Set III: Due Thursday, February 25, 2017

1.) Set III, 2016 - #1.

2.) Set III, 2016 - #2.

3.) Set III, 2016 - #3.

4.) Set III, 2016 - #5.

5.) Set III, 2016 - #6.

6.) Set III, 2016 - #10.

7.) Set IV, 2016 - #1.

8.) Set IV, 2016 - #4.

Note: Sets from 2016 are posted, under Winter 2016, Physics 218A, Handouts.

4.) a.) Consider a chunk of collisionless, self-gravitating matter in one dimension. Here, take a "chunk" to be:

$$f = \begin{cases} f_0, & u_0 - \Delta v < v < u_0 + \Delta v \\ 0, & \text{elsewhere} \end{cases}.$$

Here, f_0 is constant. Take $u_0, \Delta v$ fixed. Using the Vlasov-Poisson system, calculate the marginal stability criterion for Jeans instability. Compare your result to the case discussed in class for a self-gravitating gas.

b.) Now consider a plasma, with

$$f = \begin{cases} f_{max} + f_0, & u_0 - \Delta v < v < u_0 + \Delta v \\ f_{max}, & \text{elsewhere} \end{cases}.$$

Consider $f_0 > 0$ and $f_0 < 0$. f_{max} is the usual Maxwellian. Of course $f_{max} + f_0 > 0$, for all v. What is the marginality condition now? Relate your result to the bunching condition discussed in class for the beam-plasma interaction. Hint: Consider the sign of the dielectric function.

c.) For collisionless, self-gravitating matter with an initially Jeans unstable distribution, discuss how the instability might saturate. Hint: Consider simple quasi-linear analysis.

5.) Consider an electron and ion plasma which is stable, but in which the electrons carry a current, i.e. assume a drift u_0. Take T_i finite.

a.) What are the collective resonances? When are they weakly damped, and approaching marginality?

b.) Estimate the thermal fluctuation spectrum ($\langle E^2 \rangle_{k,\omega} / 8\pi$) for the system described in a.).

c.) *Quantitatively* discuss the breakdown of the test particle model assumptions as the system approaches marginality as the drift u_0 increases.

6.) For the system of Problem 5:

a.) Derive the rate of electron-ion momentum transfer. What are the key dimensionless parameters determining this? Assume parameters such that the system is stable.

b.) How does increasing drift affect the transfer? Assume the system remains stable, but approaches marginality from below.

7.) Read and summarize the posted article by Rostoker and Rosenbluth on the Test Particle Model. Describe the key ideas of the Test Particle Model and how they are developed.

8.) Read and summarize the posted article by Roberts and Nielson on Saturation of the Two-Stream Instability. Explain physically how saturation occurs.

9.) Calculate the electromagnetic energy spectrum of an electron plasma at thermal equilibrium at temperature T.

10.)

i.) How far does a plasma wave packet travel at thermal equilibrium?

ii.) Describe the electric field "wake" left by a test electron in a plasma.

iii.) Calculate the slowing down time for the particle by plasma wave emission.

iv.) How does the system off-set the natural slowing down of the particle by emission? Try to calculate this and compare it to losses due to emission.