# Problem Set II: Due February 10, 2016

1.) a.) Consider a weakly damped linear harmonic oscillator driven by white noise.

i.) Derive the fluctuation spectrum at thermal equilibrium.

ii.) What value of forcing is required to achieve stationarity at temperature $T$?

b.) Now consider a forced nonlinear oscillator

$$\ddot{x} + \gamma\dot{x} + \omega_0^2 x + \alpha x^3 = \tilde{f}\,.$$

Again, assume $\tilde{f}$ is white noise. Characterize the equilibrium fluctuation spectrum as completely as you can. Hint: You may find it useful to review Section 29 of "Mechanics", by Landau and Lifshitz.

2.) a.) Derive the dispersion relation for a simple acoustic wave, in hydrodynamics.

b.) Derive an energy theorem for the acoustic wave directly from the basic equations. Your theorem should have a structure similar to the Poynting theorem in Electromagnetism. Include viscous dissipation.

c.) Now derive the energy theorem for an ion acoustic wave. Take $\mathrm{v}_{Thi} << \omega/k < \mathrm{v}_{The}$. Use a fluid model. Don't assume $\lambda_{De}$ small!

3.) a.) Compute the average power dissipated by a test particle moving at velocity $\underline{\mathrm{V}}$ thru a plasma. Do this by computing $\left(\underline{E}\cdot\underline{J}\right)$, for $\underline{J} = q\underline{\mathrm{v}}\delta\left(\underline{x} - \underline{\mathrm{v}}t\right)$.

b.) Now, integrate your result from a.) over a distribution $\langle f \rangle$ of test particles and compare that to the power dissipated by the dynamical friction term in the Lenard-Balescu equation.

c.) What can we conclude from this? Discuss your result.

4.) Kulsrud 10.1

5.) Kulsrud 10.2

6.) Read the posted article by Peter Sturrock on "Negative Energy Waves". Write a 1-2 page summary and prepare a sort (15 min) summary talk. Explain Sturrock's message concerning slow waves.

7.) Read the posted article by John Dawson on "Landau Damping". Write a 1-2 page summary and prepare a short (15 min) summary talk. Clearly explain the physical model of Landau damping Dawson is proposing.

8.) Consider the beam-plasma system in the limit $k\text{v}_0 > \omega_{pe}$.

a.) Show that charge bunching is stable.

b.) Treat the beam and plasma *kinetically*. What are the stability conditions?

c.) For the case of instability, what happens?