

Problem Set II: Due TBA

- 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 $v_{Thi} \ll \omega/k < v_{The}$. Use a fluid model. Don't assume λ_{De} small!
- 3.) a.) Compute the average power dissipated by a test particle moving at velocity \underline{V} thru a plasma. Do this by computing $(\underline{E} \cdot \underline{J})$, for $\underline{J} = q\underline{v}\delta(\underline{x} - \underline{vt})$.
- 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 $kv_0 > \omega_{pe}$.
 - 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?