

## Physics 136c

Homework associated with **Chapter 22**, Nonlinear Dynamics of Plasmas

Handed out April 25, 2001

Due, May 2

To be graded by Xinkai Wu

As usual, if any problem is trivial for you, do not do it – simply state that it is trivial and pick some other problem or make up your own.

1. Ex. 22.2 (Particle Energy in a Wave), Blandford & Thorne
2. Ex. 22.4 (Cerenkov power) B&T

3. **Non-linear excitation of Particle motion**

Consider electrons moving freely in the presence of an electric field that contains two harmonics of comparable strength, i.e.,  $E = E_1 \cos(k_1 z - \omega_1 t) + E_2 \cos(k_2 z - \omega_2 t + \phi)$ . Show that this can set up oscillations of the electron at sum and difference frequencies and wavevectors ( $\omega_1 \mp \omega_2$ ,  $k_1 \mp k_2$ ). What is the dimensionless number that characterizes the excitation of these new modes (relative to excitation of motion in the applied field)? What is the value of this number in laser fusion experiments ( $E \sim 10^{10}$  V/m,  $k \sim 10^{-6}$  m<sup>-1</sup>,  $\omega \sim 3 \times 10^{15}$  s<sup>-1</sup>)?

4. Ex. 22.10 (Solar wind Termination shock), B & T. As an update, Voyager 1 is currently at  $1.2 \times 10^{13}$  m (~80 AU) from the Sun, moving at velocity 17.25 km/sec, and is in weekly contact with us. It is expected to continue functioning (at this very low power level) until 2020.