EE507 – Plasma Physics and Applications

Homework #5

1. A probe whose collecting surface is a square tantalum foil 2x2 mm in area is found to give a saturation current of 100 μA in a singly ionized argon plasma (atomic weight = 40). If kT_e = 2 eV, what is the approximate plasma density? (Hint: both sides of the probe collect ions). If a bias voltage of -20 V is applied between the probe and ground, calculate sheath thickness, using the collisionless Child law, to determine if the plane collector assumption is justified.

2. A solar satellite consisting of 10 m^2 of photovoltaic panels is placed in synchronous orbit around the earth. It is immersed in a 1-eV atomic hydrogen plasma at density 10^6 m^{-3}. During solar storms the satellite is bombarded by energetic electrons, which charge it to a potential of -2 kV. Calculate the flux of energetic ions bombarding each m^2 of the panels.

3. The sheath criterion was derived for a cold ion plasma. Suppose the ion distribution has a thermal spread in velocity around an average drift speed u_o. Without mathematics, indicate whether you would expect the value of u_o to be above or below the Bohm value, and explain why.

4. An ion velocity analyzer consists of a stainless steel cylinder 5 mm in diameter with one end covered with a fine tungsten mesh grid (grid 1). Behind this, inside the cylinder, are a series of insulated, parallel grids. Grid 1 is at "floating" potential – it is not electrically connected. Grid 2 is biased negative to repel all electrons coming through grid 1, but transmit ions. Grid 3 is the analyzer grid, biased so as to decelerate ions accelerated by grid 2. Those ions able to pass through grid 3 are all collected by a collector plate. Grid 4 is a suppressor grid that turns back secondary electrons emitted by the collector. If the plasma density is too high, a space charge problem occurs near grid 3 because the ion density is so large that a potential hill forms in front of grid 3 and repels ions which would otherwise reach grid 3. Using the Langmuir-Child law, estimate the maximum meaningful He^{+1} current that can be measured on a 4-mm-diam collector if grids 2 and 3 are separated by 1 mm and 100 V.