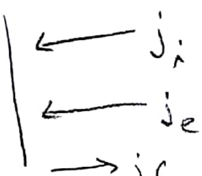
2010 I: Q3 Diagnostics

a.)

$$\underbrace{n_e\left(\frac{kT_e}{2\pi m_e}\right)^{1/2}\exp\left(\frac{-e(U_{sp}-U_f)}{kT_e}\right)}_{j_e} = \underbrace{0.6\,n_e\left(\frac{kT_e}{m_i}\right)^{1/2}}_{j_i}$$

With secondary electron emission, we have an additional electron current traveling away from the probe:



All currents must still balance so we need a bigger j_e and a smaller j_i

$$j_e - j_{\delta e} = j_i \quad , \quad j_{\delta e} \sim \delta_e\, j_i$$

b.) As δ_e increases, the floating potential approaches the space potential. ($U_{sp} - U_f \to 0$). Using $j_{\delta e} \approx 0.5\, j_i$ gives

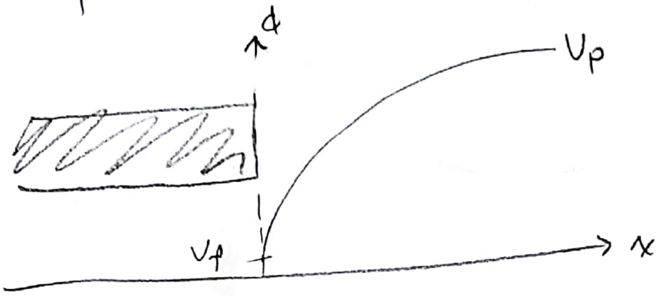
$$n_e\left(\frac{kT_e}{2\pi m_e}\right)^{1/2}\exp\left(-\frac{e}{kT_e}(\Delta U)\right) = 1.5\left(0.6\,n_e\left(\frac{kT_e}{m_i}\right)^{1/2}\right)$$

$$-\frac{e}{kT_e}\Delta U = \ln(1.5) + \ln\left(0.6\sqrt{2\pi}\sqrt{\frac{m_e}{m_i}}\right)$$

$$\Delta U = -\frac{kT_e}{e}\ln(1.5) + (\Delta U)_{(\delta_e = 0)}$$

c.) $U_{sp} - U_f = 0$ if $\delta_e = Z$, where Z is the ion charge. (The secondary electron current must fully cancle the incoming electron current. Each ion must produce Z electrons) If you can't find a material with a large enough δ_e, use an emissive probe instead. Alteratively, in a magnetized plasma you can use shielding to force $j_e = 0$ due to the smaller electron Larmor radius.

(d.) If a limiter is not at the plasma potential, it will develop a sheath:



If the limiter is biased away from the floating potential it will draw a net current.

Biasing the limiter towards the space potential (positively) will draw a large electron current and thus a large power flow.

(e.) A nonconducting limiter will collect zero net current, and thus be at the Floating patential. Power flow is thus the same as an unbiased limited, which is less than the biased limiter in part (d.)