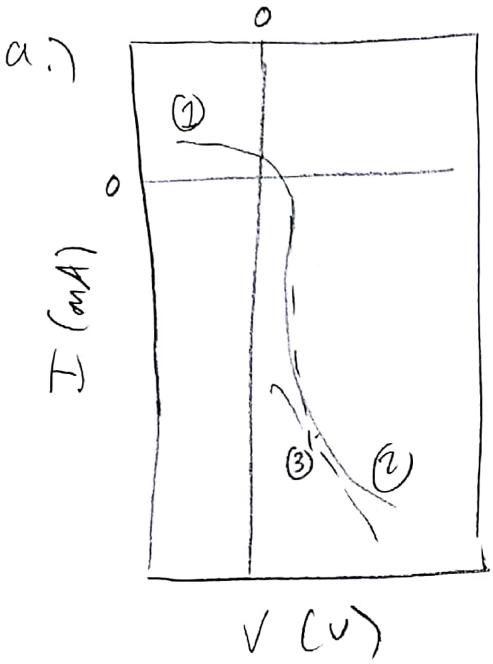
2011 I: QSA Exp

a.)



①: ion saturation
(high $V<0$ repels electrons)

②: electron saturation
(high $V>0$ repels ions)

b.) Floating potential: $I=0 \Rightarrow V_f \sim 5V$
Space potential: the knee at ③ $\Rightarrow V_p \sim 40V$

c.) Between $V=0$ and $V \sim 40V$ we have

$$I(V) = -I_{isat} + I_{esat} \exp\left(\frac{-e(V_p - V)}{kT}\right)$$ take $V = V_f$

$$\Rightarrow V_p - V_f = \ln\left(\frac{I_{isat}}{I_{esat}}\right)\left(-\frac{kT}{e}\right)$$ know I_{isat} but not I_{esat}

$$I_{isat} = 0.6 e n_e \left(\frac{kT_e}{m_i}\right)^{1/2}, \quad I_{esat} = \frac{e n_e}{4}\left(\frac{8kT_e}{\pi m_e}\right)^{1/2}$$

$$\frac{I_{isat}}{I_{esat}} = \sqrt{\frac{m_e}{m_i}}\left(\frac{4 \cdot 0.6}{\sqrt{8/\pi}}\right) \sim 1.5\sqrt{\frac{m_e}{m_i}}$$

$$e(V_p - V_f) = kT\left(\ln(1.5) + \frac{1}{2}\ln\left(\frac{m_e}{80 m_p}\right)\right)$$ (small)

$$+35eV = kT\left(-\frac{1}{2}(10)\right)$$

$$\boxed{kT \sim 7eV}$$ ✓

$8 \times 10 \times 2 \times 10^4$
$80 \cdot 2000$
$= 16 \times 10^4$
$\sim 2 \times 10^5$

$\ln(2 \times 10^5)$
~ 10 ?

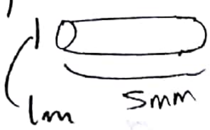
$10^5 = e^x$

$2^{10} = 1024 \approx 10^3$

$e \approx 2.7$

$3^{10} \approx 59049$
$\sim 10^3$

d.)



n_e comes from I_{isat}:

$$I_{isat} = e n_e A_p v_B \qquad v_{Bohm} = \left(\frac{ZkT_e}{m_i}\right)^{1/2} \quad (T_e \gg T_i)$$

$$A_p = (5mm)(2\pi(0.5mm)) \qquad = \sqrt{\frac{7eV}{80m_p}}$$

$$= 5\pi \ mm^2$$

$I_{isat} \sim 1 \ mA$

$$\Rightarrow \boxed{n_e \approx \frac{1mA}{5\pi \ mm^2} \frac{1}{e} \sqrt{\frac{10m_p}{1eV}}}$$

There is definite evidence of sheath expansion in the probe trace (wobbles in electron saturation region.) Sheath expansion increases the effective area for particle collection and thus the collected current. It should effect the accuracy of the density estimate by changing V_p and (slightly) I_{isat}.