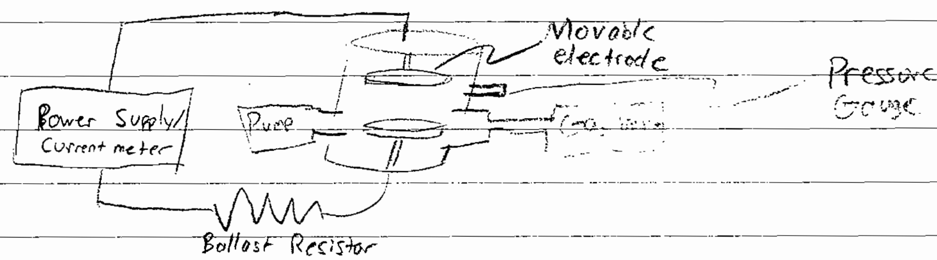
2004 Part II Q3 Exp.

A. Paschen Curve

1



- What we measured was the voltage at which the current increased from 0, indicating a plasma had formed.

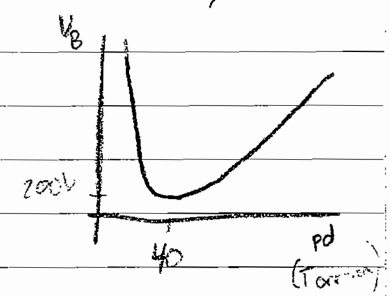
2 The main macroscopic parameter is (pd), the product of gas pressure and electrode distance.

Microscopically, the gas ionization potential and anode secondary electron emission coefficient are important.

$$V_B = \frac{B\,pd}{\ln[Apd/\ln(\frac{1}{\gamma})]}$$

$B = \sigma_n V_i / T_n$

$A = \sigma_n / T_n$



3. Uncertainty: statistical uncertainty of breakdown voltage. Repeating the process of bringing the voltage up from 0 could yield different breakdown voltages of up to 50-200 V difference.

Error: systematic error in trying to fit to the Paschen curve, because it is not a completely correct model

4. $A \sim 1.5 \ m^{-1} mT^{-1}$ $B \sim 36 \ V m^{-1} mT^{-1}$ $\gamma \sim 0.02$

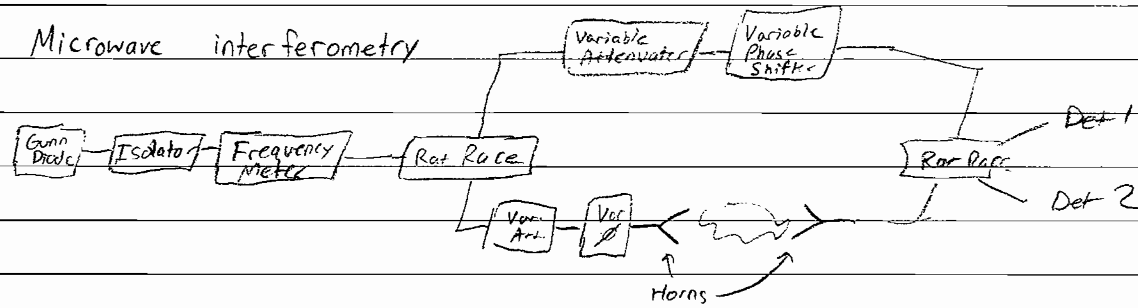
$p = 1\,atm = 760\,T = 7.6 \cdot 10^5 \ mT$ $d = 1\,m$

$\Rightarrow V_B \cong 2.2 \ MV$

Other factors: moisture

B. Microwave interferometry

1\.



2\. phase shift of an EM wave through a plasma relative to vacuum.
Using the O-wave $n^2 = 1 - \frac{\omega_{pe}^2}{\omega^2}$ or $k^2 = k_0^2 (1 - \frac{\omega_{pe}^2}{\omega^2})$ $k_0 = \frac{\omega}{c}$

$$\Delta\phi = \int (k_0 - k)\, d\ell = \frac{\omega}{c} \int 1 - \sqrt{1 - \frac{\omega_{pe}^2}{\omega^2}}\, d\ell$$ For $\omega \gg \omega_{pe}$ expand

$$= \frac{\omega}{c} \frac{1}{2\omega^2} \int \omega_{pe}^2\, d\ell$$ Proportional to line-integrated density!

3\. Errors: "length" of plasma to use

• Also, calibration of the detectors added a large uncertainty.
Measuring $\Delta\phi$ involved subtracting two phases which were close in value, so small errors in ϕ could yield large relative errors in $\Delta\phi$.
→ Different interpolations of the detector calibration curve gave different densities ~ 8%

4 $n_e \approx 1 \cdot 10^{21} m^{-3}$ ⇒ $\omega_{pe} = 1.8 \cdot 10^{12}$ ⇒ $f \gg 284$ GHz

• To get radial profile, measure the line integrated density along different chords, then perform Abel inversion to recover the radial dependence.