Electron–Xenon Scattering: The Ramsauer-Townsend Effect

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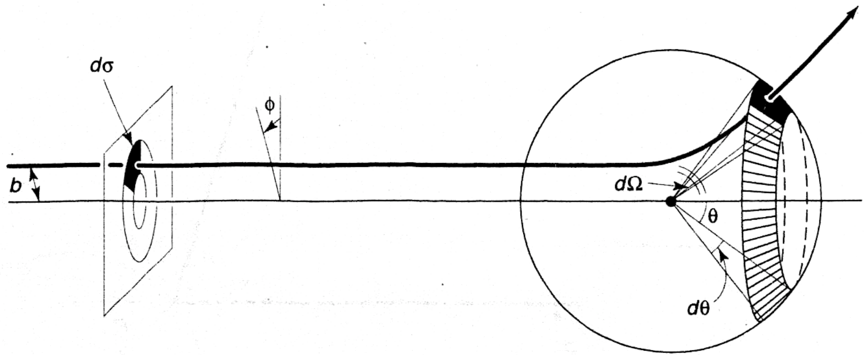
History of Ramsauer-Townsend

- Ramsauer (1921) discovers unexpected behavior in scattering experiments
- Townsend and Bailey (1922) confirm effect using a different method
- Bohr proposes interference of matter waves
- Effect explained using Schrödinger equation (1927-31)

Scattering

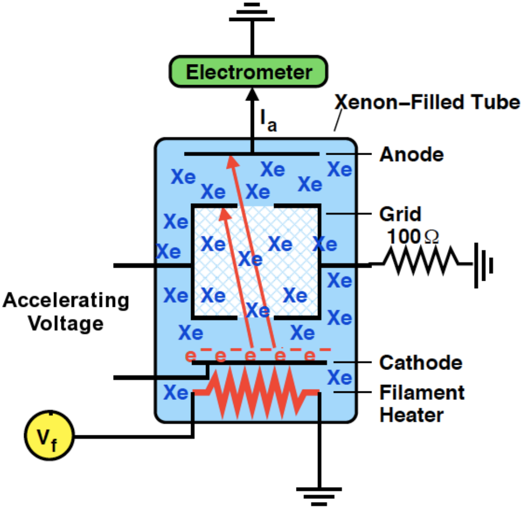


- $\mathrm{d}\sigma = D(\theta)\,\mathrm{d}\Omega$
- $\sigma(E) = \int D(\theta)\,\mathrm{d}\Omega$

Matter Waves and Interference

- Electrons and atoms cannot be treated as billiard balls
- Objects are diffuse, described by a wave function
- Interference between wave functions can produce unexpected effects
- Ramsauer-Townsend: $\sigma = 0$ for a particular energy

Apparatus



- Can freeze out Xe using liquid nitrogen

Calculating the Cross-Section

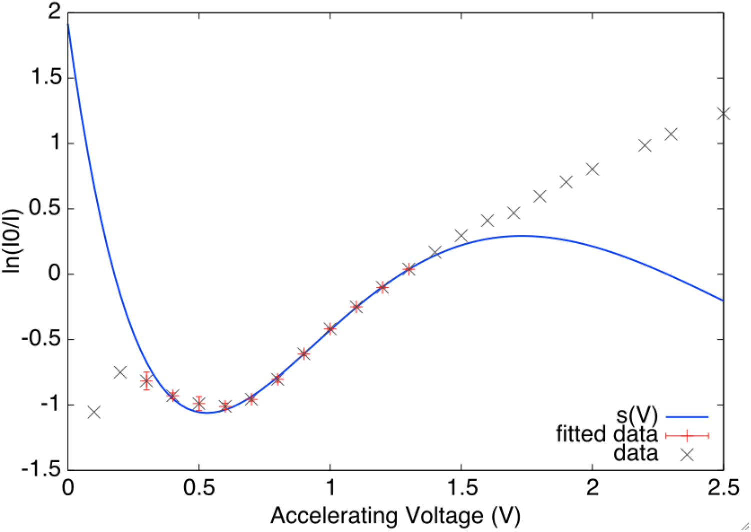
- Uniform gas density $\rightarrow$ constant scattering probability for a fixed distance

$$I = I_0 \, e^{-\frac{L}{\lambda}}$$

$$\frac{1}{\lambda} = n \, \sigma$$

$$\sigma(V) = \frac{1}{nL} \ln \left[\frac{I_0 \, (V)}{I \, (V)} \right]$$

Cross-Section Measurements



$$\chi_r^2 = 1.93$$

Results

- Minimum σ occurs at $0.53 \pm 0.077\ V$
  - Significantly off from true value of 0.9 V
- Random errors insufficient
- Systematic errors
  - Contact potential
  - Nonzero initial electron energy
  - Unequal filament temperatures
- Corrected value: $0.88 \pm 0.092\ V$

Improvements and Extensions

- Additional experiments to determine contact potential and initial electron energy
- Collect more data in vicinity of minimum σ
- Determine voltage necessary to get equal filament temperatures

Summary

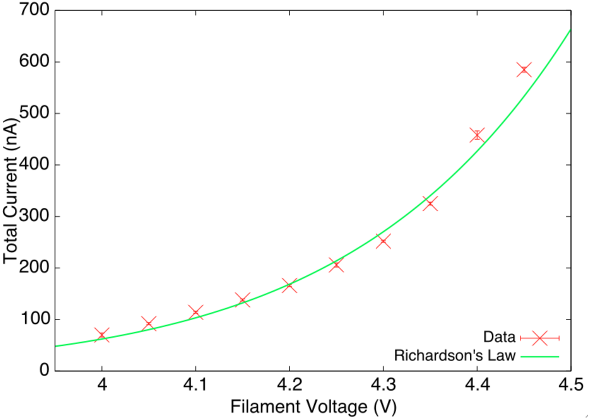
- Observed the Ramsauer-Townsend effect in electron–Xenon collisions
- Found minimum cross-section near expected energy
- Provided evidence for interference in matter waves and quantum theory

Questions?

- History of Ramsauer-Townsend
- Scattering
- Matter Waves
- Dependence of cross section on energy

Richardson's Law

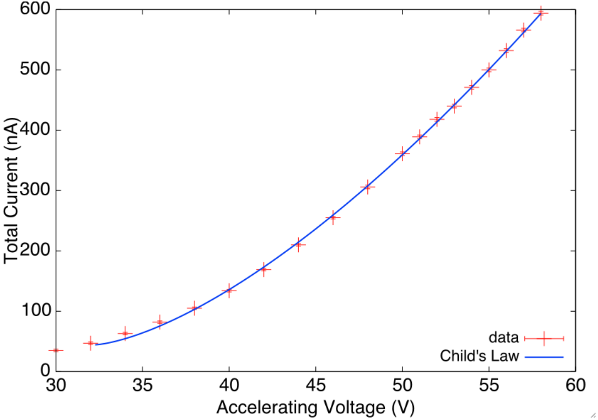
- $I \propto T^2 e^{\frac{-W}{kT}}$
- Only radiative heat transfer $\rightarrow V^2 \propto T^4$



$$\chi_r^2 = 44.7$$

Child's Law

- $I \propto V^{\frac{3}{2}}$



$$\chi_r^2 = 4.59$$