Demonstration of the Ramsauer–Townsend Effect in a Xenon Thyratron

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The anomalously small scattering of electrons near 1 eV energy by noble gas atoms may be easily demonstrated using a 2D21 xenon thyratron. This experiment is suitable for a lecture demonstration or for an undergraduate physics laboratory. The probability of scattering and the scattering cross section may be obtained as a function of electron energy by measuring the grid and plate currents in the tube.

The scattering cross section for electrons on noble gas atoms exhibits a very small value at electron energies near 1 eV. This cross section is much smaller than that obtained from measurements involving atom–atom collisions. This is the Ramsauer–Townsend effect and provides an example of a phenomenon which requires a quantum mechanical description of the interaction of particles. If the atoms are treated classically as hard spheres, the calculated cross section is independent of the incident electron energy and we cannot account for the Ramsauer–Townsend effect. If the noble-gas atoms are considered to present an attractive potential (e.g., square well, screened Coulomb) of typical atomic dimensions, the solution of the Schrödinger equation for the electrons indicates that the cross section will have a minimum at electron energies near 1 eV. Reviews of the Ramsauer–Townsend effect are given by Mott and Massey[1] and Brode.[2]

[1] N. F. Mott and H. S. W. Massey, *The Theory of Atomic Collisions* (Oxford University Press, London, 1965), 3rd ed., Chap. 18.

[2] R. B. Brode, Rev. Mod. Phys. **5**, 257 (1933).

The problem of scattering of electrons by a square well is considered in many introductory quantum physics texts.[3–7] The one-dimensional model predicts that the scattering will go to zero whenever half the electron wavelength in the well is a multiple of the well width. The difficulty with this model is that only one distinct minimum is observed.

A slightly better model of the xenon atom is a three dimensional square well. Then the scattering cross section will have a very small value when the phase shift δ_0 of the $l=0$ partial wave is π. Here the scattering due to the $l=0$ partial wave will vanish and the scattering due to higher l partial waves will be small if the width of the

[3] L. I. Schiff, *Quantum Mechanics* (McGraw-Hill Book Co., New York, 1955), Chap. 5.

[4] E. Merzbacher, *Quantum Mechanics* (John Wiley & Sons, Inc., New York, 1955), Chaps. 6, 12.

[5] D. Bohm, *Quantum Theory* (Prentice-Hall Inc., Englewood Cliffs, N.J., 1951), Chaps. 11.9, 21.51.

[6] A. Messiah, *Quantum Mechanics I* (North-Holland Publ. Co., Amsterdam, 1961), Chaps. III-6.

[7] R. M. Eisberg, *Fundamentals of Modern Physics* (John Wiley & Sons, Inc., N.Y., 1961), Chap. 15.