Momentum Transfer Cross Section and Fractional Energy Loss in the Collisions of Slow Electrons with Nitrogen Molecules*

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The momentum transfer collision cross sections, q_m, of nitrogen molecules for slow electrons and the mean fractional electron energy loss, λ, in these collisions have been determined by the method of microwave interaction in gaseous discharge plasmas. The mean energy of the electron was varied from 0.04 to 0.46 ev. The cross section, q_m, was found to be $\sim 17\times 10^{-16}$ cm² at 0.04 ev. It decreases to $\sim 8\times 10^{-16}$ cm² at 0.46 ev. The mean fractional energy loss of the electron, λ, in the energy range investigated, was found to be ~5.5 in units of $2m/M$. These results lend strong support to the theory of rotational excitation of N_2 by slow electrons.

MICROWAVE interaction[1,2] in a decaying plasma in N_2 has been used to determine the collision cross section for slow electrons, (0.04–0.5 ev), and the mean fractional energy loss of these electrons in collision with nitrogen molecules. The plasma is established by a 2-microsecond dc voltage pulse, and the gas pressure varied in a range of 0.4–1.5 mm of Hg. Measurements involving the propagation of guided microwaves in the plasma medium were made at such times (>50 microseconds after removal of the ionizing pulse) at which it was presumed the decaying plasma had become isothermal at a temperature ~300°K. At this temperature the momentum transfer collision frequency, ν_m, was found to be 6.6×10^8/sec mm Hg. In this determination the influence of the positive ion scattering of the electrons and the spatial distribution of electron density have been taken into account. The variation of the mean electron energy in the plasma was obtained by propagating through it various appropriate levels of square-pulsed "disturbing" wave at 8600 Mc/sec. The associated variation of the electron collision frequency was determined by a continuous lower level probing "wanted" wave at 9400 Mc/sec. The fractional energy loss, λ, was determined by measurement of the relaxation time constant associated with the transmission of the wanted wave in the *wake* of the disturbing wave pulse.

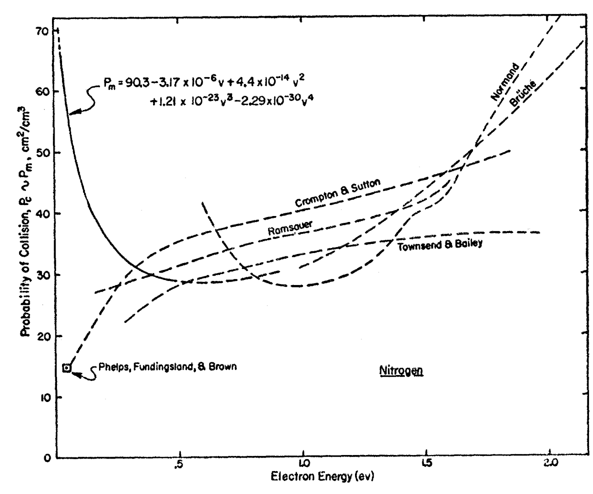

FIG. 1. Probability of collision for momentum transfer, P_m, as a function of electron energy.

The probability of collision for momentum transfer, P_m, as a function of electron energy, and consequently the associated cross section, is obtained from the *variation* of ν_m and expressed in a series expansion in terms of electron velocity (cm/sec) as shown on Fig. 1. This expression is valid from 0.04 to 0.5 ev, but would not be expected to be in considerable error from 0.02 to 1.0 ev. For purposes of comparison, other determinations of the collision probability as a function of electron energy are also reproduced.[3–8] It will be noted that for

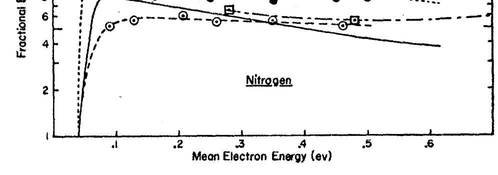

FIG. 2. Fractional energy loss, λ, as a function of mean electron energy.

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room temperature (~0.04 ev) electrons, $P_m \cong 60$ cm^2/cm^3 and is decreasing with increasing electron energy. This variation of P_m with electron energy is in qualitative agreement with results of Fundingsland *et al.*[9]

The experimentally determined fractional energy loss, λ, is plotted as the dotted open circles of Fig. 2; the circles are joined by the dashed line. Other experimental determinations of λ are also plotted on Fig. 2. It is seen that λ is greater than that corresponding to purely elastic collisions. This is, however, understandable in the light of the theory recently proposed by Gerjuoy and Stein[10] on excitation of rotational levels of N_2 in collision with slow electrons. If P_m found in these experiments is used in the calculation of λ in the above theory, then we obtain the solid curve of Fig. 2, which is in good agreement with all experimental determinations of λ.

During the experiments the gas pressure was monitored. No measurable pressure change occurred; this result would most probably exclude the presence of any appreciable amount of atomic nitrogen.

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Recoil Particles from Po^{210} and Their Ionization in Argon and Helium*

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The average energy W_r to make an ion pair for the recoil particles ejected by the disintegration of Po^{210} has been measured in argon and helium by a modification of a very old method. The ratio of this value for the recoil particles to the corresponding W_α value for the Po^{210} alpha particles was found to be 4.1 and 4.5 in helium and argon, respectively. The ratio for argon is in good agreement with an earlier determination by Madsen for an argon-air mixture. The maximum radial distance traversed by the recoil particles was found to be 7.7×10^{-3} cm and 52×10^{-3} cm in argon and helium, respectively, under standard conditions.

FOR the past fifty years the ionization produced by recoil particles from radioactive disintegrations has been an interesting subject of investigation. Since the discovery of fission such investigations have additional interest, since the ionization phenomena accompanying the stopping of a fission fragment must be very similar to those accompanying the stopping of a recoil atom. The investigation of the recoil atom, moreover, has a marked experimental advantage in that one is dealing with a monoenergetic source with a precisely calculable initial energy.

A determination has been made by Madsen[1] of the average energy to produce an ion pair in argon by the recoil atoms from Po, ThC, and ThC′ in a coincidence counter system. He found that W_r, the average energy to produce an ion pair by the recoil atom, was 4.4, 3.8, and 3.4 times the average W for the corresponding alpha particle from Po, ThC, and ThC′.

Unfortunately for work of this importance, the counter filling used was 95% argon and 5% air. Since the effect of impurities on the ionization in the noble gases may be quite large,[2] there is some question whether these results are valid in pure argon.

Soon after the appearance of this paper an experiment was devised by the present authors to repeat the work in pure argon. An adaptation of a very old method[3] was used.

A polonium source on a flat collecting electrode was placed at the geometrical center of a hemispherical ionization chamber of 4.5-cm radius. The source was electrodeposited as an invisible film on a polished platinum plate. A masking metal foil over the platinum plate allowed alpha particles to emerge only through a circular aperture of 0.5-cm diameter. The number of alpha particles emerging from the limited area was about 20 per second. This value was accurately determined by auxiliary measurements in a methane flow proportional counter.

The filling gas pressure in the ion chamber was varied, and the ionization current through the chamber measured as a function of the gas pressure (Fig. 1). This measurement was made by a drift method with a vibrating-reed electrometer and Brown recorder. The pressure was determined by a McLeod gauge, especially designed to measure pressures in the region from 0.01 to 2 cm of mercury. The argon and helium used were of high purity from breakerseal flasks, but were not continuously circulated over a purification system as has since been found desirable.

* Work performed under the auspices of the U. S. Atomic Energy Commission.

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