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LETTER TO THE EDITOR

Electron drift velocities in xenon

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Abstract. The electron drift velocity has been measured in xenon over the range of reduced field strength 1 Td $\leqslant E/N \leqslant$ 60 Td. Where possible comparison is made with previously published data.

The study of the motion of electrons in rare gases has received considerable attention, particularly in view of the need for such data in the modelling of laser discharges. In the case of xenon, measurements of the electron drift velocity have been made at low values of the reduced field strength (E/N) by Pack *et al* (1962) and by Bowe (1960) and at high E/N by Wagner (1964). However no data are currently available at intermediate E/N, that is in the range 14 Td $\leqslant E/N \leqslant$ 130 Td, even though high-power lasers typically operate in this regime. We report in this paper measurements made of the electron drift velocity in xenon in the range 1 Td $\leqslant E/N \leqslant$ 60 Td. At the lower values of E/N direct comparison can be made with the measurements of Pack *et al* (1962).

The apparatus used in the present work follows that detailed by Sierra *et al* (1979). Briefly, a pulsed swarm of electrons was photo-ejected from the centre of the cathode by the incidence of a short (<15 ns) pulse of UV radiation from a KrF laser. The electrons drifted across the electrode gap to the anode under the action of an applied electric field. Field uniformity was ensured by keeping the electrode spacing much smaller than lateral dimensions of the electrodes. The electron current was detected and integrated by high impedance electronics as described Sierra *et al* (1979). The duration of the current pulse directly yielded the time of flight of the electron swarm.

Research grade xenon (purity $\geqslant$99.995%) was used in the experiments without further purification. Measurements were made, at pressures of 50, 100 and 300 Torr at each electrode spacing of 1.0, 1.5 and 2.0 cm. At these pressures the non-equilibrium region near the cathode was negligible and also electron diffusion would not be expected to affect the electron drift velocity. This was confirmed by the observation that the measured drift velocity at a given E/N was not dependent on gas pressure or electrode spacing. Hence the drift velocity could be obtained directly by the simple ratio of distance to time of flight rather than from the full analytical treatment described by Blevin *et al* (1981).

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Measurements were made of the electron drift velocity W in the range $1\,\mathrm{Td} \leqslant E/N \leqslant 60\,\mathrm{Td}$. Beyond 60 Td, as the drift velocity increased and the time of flight decreased, measurements became increasingly difficult in view of the finite time resolution of the detection system (10 ns) as determined by the transient recorder. In addition electrical breakdown in the region of the electrical feed-throughs pre-empted any attempts to increase the field strength much beyond this limit. At the low end of the range ($E/N < 5$ Td) the low signal, coupled with residual noise, was a major factor in determining the error in the measurements.

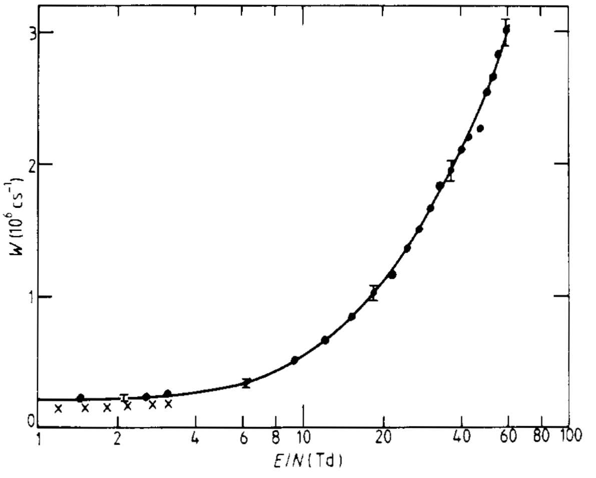

Figure 1. Electron drift velocity in xenon as a function of E/N. ●, present results; error bars indicate the error in present data; ×, Pack *et al* (1962).

The results are shown in figure 1. Each point is the mean of 36 independent measurements. For the reasons discussed above, the error at low E/N is estimated to be 10%, determined from the scatter in the results. For $E/N > 5$ Td the error is less than 5%, rising slightly at the high extreme. The results show a small dependence of the drift velocity on E/N at low values of the reduced field strength which is qualitatively in agreement with the results of Pack *et al* (1962), although the present values are 25% higher than those of Pack *et al*. At higher values of E/N the drift velocity increases at an increasing rate, such that a straightforward extrapolation carries the measurements over to the results of Wagner (1964) for $E/N \geqslant 130$ Td.

The reason for the discrepancy between the present measurements and those made by Pack *et al* is not easy to identify. One possible explanation for the discrepancy is the purity of the gas used. This low E/N region in xenon is dominated by the Ramsauer minimum in the momentum transfer cross-section. Any slight trace of impurity would tend to mask the Ramsauer minimum and hence change the drift velocity. The prediction of the exact effect of impurity on the electron drift velocity is very complex whenever $\partial Q_m/\partial \varepsilon$ exhibits a rapid change such as that at the Ramsauer minimum, the detailed shape of the Q_m versus ε curve for the pure gas and the effect of the impurity on the functional form of the curve determining the nature of the change in W. The gas used in the present work was the highest purity commercially available, although no *in situ* purification technique was used. Ultrahigh vacuum techniques were used throughout.

Other possible explanations for the discrepancy are the ignoring of diffusion effects and systematic errors. At the pressures used in the present work at low E/N ($P_0 =$ 300 Torr) the diffusion correction to the drift velocity over a 1.0 cm gap is of the order of 0.02% while the present system has been used extensively for the determination of electron drift velocities in other gases the results of which have agreed well with available published data (e.g., Sierra *et al* 1979), thereby eliminating the possibility of systematic errors in the experimental technique.

References

Bowe J C 1960 *Phys. Rev.* **117** 1411
Blevin H A, Nygaard K J and Spriggs K R 1981 *J. Phys. D: Appl. Phys.* **14** 841
Pack J L, Voshall R E and Phelps A V 1962 *Phys. Rev.* **127** 2084
Sierra R A, Books H L and Nygaard K J 1979 *Appl. Phys. Lett.* **35** 764
Wagner K H 1964 *Z. Phys.* **178** 64