Electron drift velocity and longitudinal diffusion coefficients in H_2O-He and H_2O-Ar gaseous mixtures

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We present the measurement of the flux electron drift velocity, W_F, and the flux longitudinal diffusion coefficient, $ND_{L,F}$, over a wide range of the density-normalised electric field intensity, E/N. The share of H_2O vapour in the H_2O-He and H_2O-Ar mixtures ranged from 0.5% to 70%. In this abstract we shall only present and discuss two cases. The whole set of measurements will be presented at the Conference. The measured transport coefficients were derived from the analysis of electron transients obtained from a Pulsed Townsend Apparatus which has been described thoroughly in [1,2].

We shall focus this presentation on the effects on both the electron drift velocity and the longitudinal diffusion coefficient over the E/N regions where the negative differential conductivity (NDC) effects are apparent. Explanations of this effect, consisting in a decrease of the electron drift velocity with increasing E/N, has been given in several papers, of which we single out that of Petrovic et al [3], who provide simple models of elastic and inelastic collision cross sections for electron scattering in which NDC can occur without the presence of a Ramsauer-Townsend minimum, as in the case of Ar and other gases.

Figure 1 shows the drift velocities, W_F, for the particular case of 5% content of H_2O in Ar and He and, for comparison in trends, those of He, Ar and H_2O. We see that the NDC effect in the 5% H_2O-Ar mixture is large since Ar has a very pronunced minimum in its momentum transfer cross section at 0.3 eV [4]. On the other hand, the momentum transfer cross section for electron scattering in He has no such minimum [4], but the drift velocity curve does show the NDC effect very clearly. H_2O has a shallow minimum in its momentum transfer cross section at a much larger collision energy around 6 eV [5]. Thus, a better explanation may be given with one of the NDC models presented in [3], with a He rising cross section, together with comparatively small inelastic cross sections (a factor of 100 is considered for Model 1 in Ref. [3], which in the case of H_2O would correspond with the rotational cross sections.

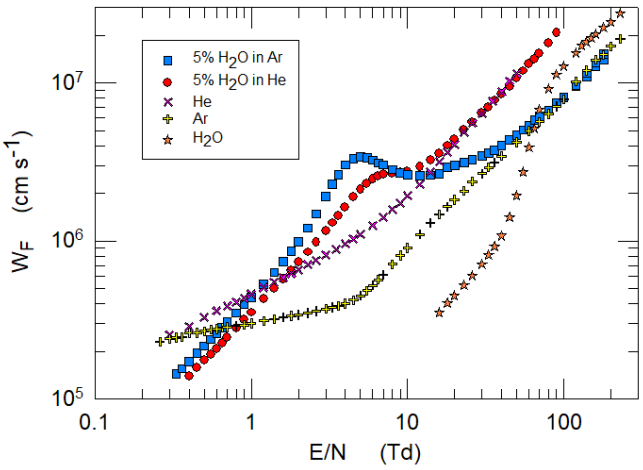

Fig. 1: Electron drift velocity (Flux) in 5% H_2O-He and 5% H_2O-Ar mixtures, and their comparison with the coresponding curves for He, Ar and H_2O

To the best of our knowledege no other data have been presented for W_F nor for $ND_{L,F}$ in these mixtures before.

The case for the longitudinal diffusion coefficient is also very interesting and is shown in Fig. 2, where one can see a very large NDC effect for the 2% H_2O-Ar curve, with a sharp decay starting at a maximum located at E/N=1.4 Td and ending at a minimum at 3.5 Td, with a difference in values of nearly two orders of magnitude. Past this minimum, the curve grows and merges those of Ar and H_2O. On the other hand, the case for the 2% H_2O-He curve is modest in comparison with the former, although very interesting also, and it is concomitant with the effect shown for the corresponding drift velocity. Again, past the minimum, the curve rises and merges with that of He.

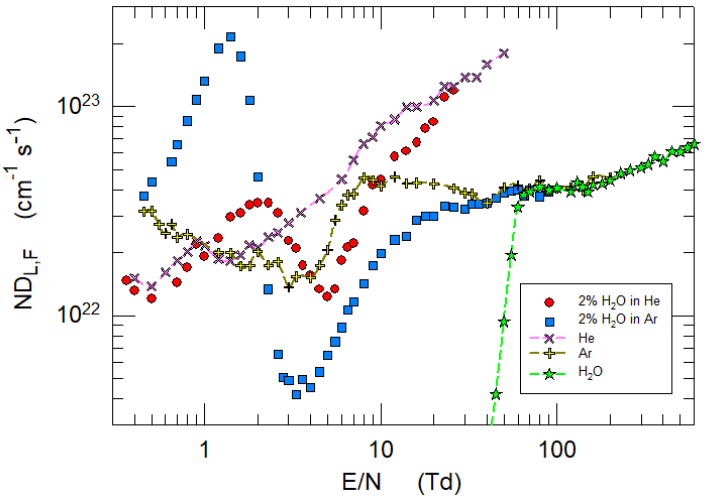

Fig. 2: Density-normalised longitudinal diffusion coefficient (Flux) in 2% H_2O-He and H_2O-Ar mixtures, and their comparison with the coresponding curves for He, Ar and H_2O

We believe that these measurements, derived over a wide range of E/N and for mixtures between 0.5% and 70% H_2O, may be useful for improving the still incomplete cross section set of H_2O, as dicussed by Song et al [6] and Budde et al [7,8].

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