POSITRON SWARMS IN ARGON

M.Šuvakov[a], Z. Lj. Petrović[a] and S.J. Buckman[b]

a) Institute of Physics, P.O.B. 68, 11080 Belgrade, Serbia and Montenegro
b) Research School of Physical Sciences and Engineering, Australian National University, Canberra Australia

Recently systematic measurements have been made of positron atom cross sections and it has become possible to compile complete sets of cross sections and to calculate parameters for positron swarms. In this paper we have tried to compile such a set for argon, and to compare the calculated transport coefficients to those of electrons in the same gas.

Total cross sections were measured by Kauppila and coworkers [1] and total elastic cross sections were calculated by McEchran [2]. The two sets agree fairly well but we have selected the theoretical data as the basis because it allowed us to separate elastic and inelastic processes. We have extrapolated the theoretical results to low and high energies, and to obtain the summed (total) cross section we have added the inelastic cross sections. The positronium formation and ionization were taken from Marler et al [3] while direct annihilation has been neglected. Measured excitation cross sections for the lowest states of argon were used [4]. We have also added the cross section for higher singlet levels for electron excitation [5] of argon. As the energy dependence of both the elastic and inelastic cross sections for electrons and positrons is completely different, we may expect all aspects of positron transport to differ significantly from that of electrons. Positronium formation will lead to the loss of positrons and therefore will be analogous to electron attachment in electron transport. At the same time, ionization will not lead to an increase of the number of positrons so it should be treated as an inelastic, conservative process.

We have performed calculations by using a new Monte Carlo program that has been tested to give good benchmark results for electrons, especially in treatment of non-conservative transport [6]. The results show the effect of positronium formation which sweeps the distribution function below the threshold until E/N becomes sufficiently high.

E/N (Td)	mean energy (eV)	V_{dr} (flux) m/s	V_{dr} (bulk) m/s	D_T/μ (flux) (V)
1	3.55	5780	2271	2.88
5	3.97	27160	458	3.27
10	4.12	52710	266	3.28
50	5.00	21650	5700	4.08
100	5.88	36190	27830	4.56
500	13.40	913900	342100	7.22

Table 1 Transport coefficients for positrons in argon

At the same time, transport coefficients (shown in Table 1) show a huge effect of non-conservative collisions due to positronium formation, as the bulk drift velocity becomes almost two orders of magnitude smaller than the flux drift velocity. At higher E/N, however, the two drift velocities have the same order of magnitude. An interesting feature of these results is the relatively slow increase of the mean energy and of D_T/μ while the drift velocity increases by several orders of magnitude.

The transport coefficients were calculated for swarms of positrons in pure argon. Their basic features follow the standard effects of non-conservative transport, in this case due to positronium formation. Positron transport for a model gas was discussed by Robson [7] and our results are in general agreement with his predictions.

[1] W. E. Kauppila and T. S. Stein, *Adv. At., Mol., Opt. Phys*. 26, (1990) 1.
[2] W.McEchran (2004) personal communication to S.J.Buckman
[3] J. P. Marler, J. P. Sullivan, and C. M. Surko, *Phys. Rev.* A 71, (2005) 022701.
[4] J. P. Sullivan, J. P. Marler, S. J. Gilbert, S. J. Buckman and C. M. Surko *Phys. Rev. Lett*. **87** 073201 (2001)
[5] A.V. Phelps and K. Tachibana personal communication (1985)
[6] M. Šuvakov, Z. Ristivojević, Z.Lj. Petrović, S. Dujko, Z.M. Raspopović, N.A. Dyatko, A.P. Napartovich, *IEEE Trans. Plasma Sci*. **33** (2) (2005) 532- 533.
[7] R.E. Robson, *J. Chem. Phys*. 85 (1986) 4486.