A genetic algorithm to optimize the fitting of avalanches observed from a pulsed Townsend experiment

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An optimization code based on a Genetic Algorithm (GA) was developed to optimize the reaction coefficients needed to simulate a pulsed Townsend avalanche in pure SF_6. Starting with a set of swarm parameters, the GA determines the best values in terms of the best fit between measurement and calculation, using a least squares procedure.

Electron detachment from negative ions and ion-molecule reactions in SF_6 have been scarcely studied in comparison with other processes such as ionization, attachment, and ion/electron transport [1]. Indeed, there still remain gaps regarding the relative importance of electron detachment from its daughter negative ions and the ion-molecule reactions leading to fragment ions and clusters from parent SF_6. A reaction scheme for ions and electrons in SF_6, is presented in Fig. 1 [2], and preliminary simulations aimed at fitting the ionic transients in SF_6 have been made with the avalanche simulator SIMAV-4 [3] by fitting the calculated ionic avalanches to the measurements derived from a pulsed Townsend experiment (PTE) [4] at E/N=360 Td for SF_6 pressures in the range 5-30 Torr. Thus far, a trial and error procedure has been followed to fit the avalanches by making educated guesses of the reaction coefficients, a process that turns out to be lengthy. A means to avoid this fastidious and time consuming procedure an optimization code based on genetic algorithm (GA) [5] has been developped and used to reproduce the measurements performed with the PTE at E/N=350 Td for several pressures.

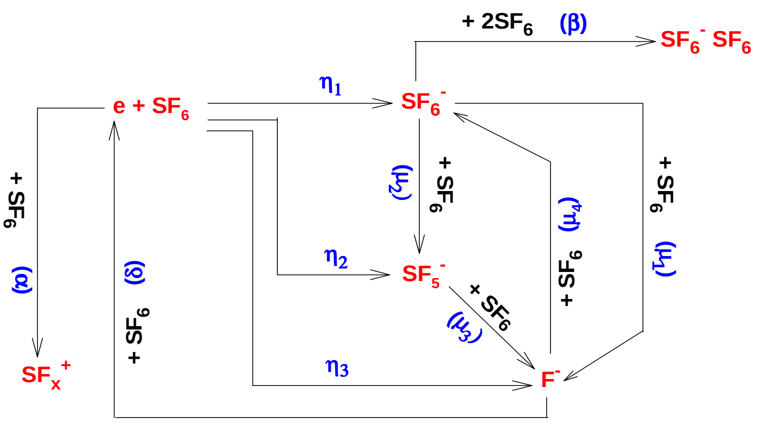

Figure 1. The complex reaction scheme used in this work for SF_6. The associated swarm coefficients are: attachment, η_1, η_2 and η_3; electron detachment, δ; ionization, α, accounting for SF_5^+ and SF_3^+, mainly; negative-ion conversion, μ_1–μ_4, and ion clustering leading to the formation of $SF_6^- SF_6$, β.

Briefly, the GA consists of reproducing the evolution of an initial population of individuals based on selecting those satisfy optimally a given criterion; these are kept for the next step of evolution (generation) and used to generate the individuals to be selected in this second generation, and so on until the evolution is stopped according to a predetermined criterion. In our case the criterion is simply based on the least squares method, and an individual is the current simulated with a set of values corresponding to the reaction coefficients of our complex reaction scheme shown in figure 1. The initial population (first generation) is based on the reaction coefficients corresponding to the above reaction scheme, taken from the literature or extrapolated from those at E/N=360 Td [1].

Table 1 summarizes the values for the initial population and the optimized (final) population at 20 Torr, and the corresponding simulated currents are plotted in figure 2, together with that measured. One can easily see how the optimized reaction coefficients allow fitting the measured current in very good agreement with the measurement, while the initial values do not produce a good fit at all.

Table 1
Initial and final values of parameters

Parameter	Initial value	Final value	Parameter	Initial value	Final value
α/N	26.3	25.2	μ_2/N	4.87	4.87
η_1/N	11.3	3.8	μ_3/N	5.91	1.83
η_2/N	16.4	20.6	μ_4/N	3.37	1.75
η_3/N	0.701	0.701	δ/N	6.00	0.24
μ_1/N	16.4	16.4	β/N^2	7.50	7.50

Values of α/N, δ/N, η/N and μ/N in units of 10^{-18} cm^2
Values of β/N^2 in units of 10^{-34} cm^5

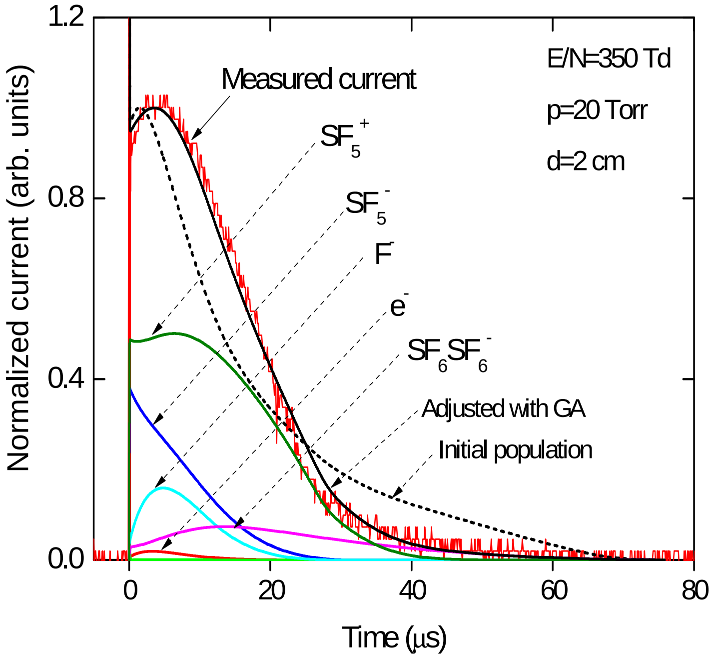

Figure 2. Measured and calculated (total and partial currents) of an ionic transients in SF_6.

Acknowledgements

This work has been partially supported by Project UNAM-PAPIIT IN 111161. A. Bekstein is grateful to UNAM for a postdoctoral grant. Thanks are due to A. Bustos for his technical assistance.

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