High resolution studies of electron attachment to SF_5Cl and SF_5CF_3

1. Visit to Kaiserslautern (5 days: 4th-8th July)

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Studies of the low energy electron attachment to SF_5Cl and SF_5CF_3 were continued using high resolution (~ 1meV) by means of mass spectrometric detection of the product anions. Laser photoelectron attachment was used for determining the threshold behaviour and for investigating electron attachment from approximately 20 meV up to 2 eV. Results are shown below.

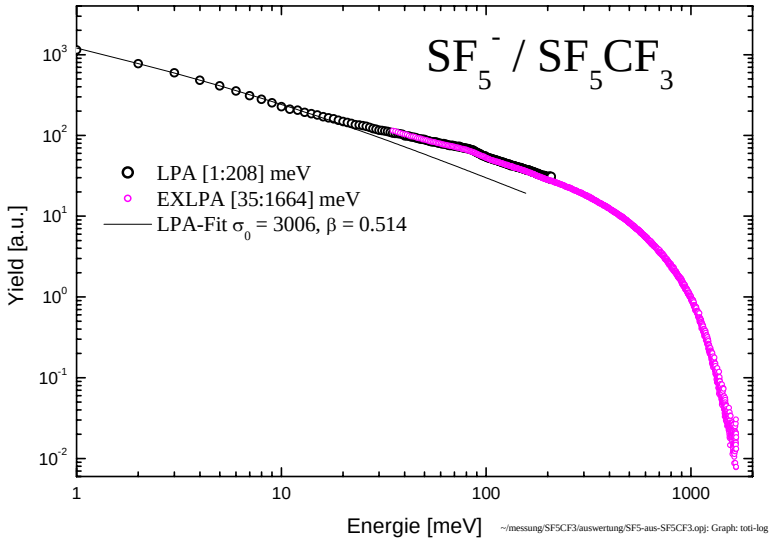

Figure 1. Relative ion yield over the electron energy range 0-1 eV. This will be placed on an absolute scale using the thermal swarm measurements made by us in Birmingham.

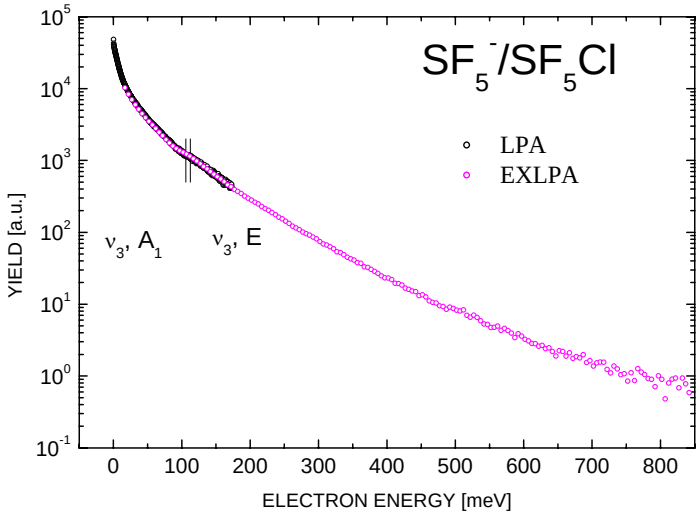

Figure 2. Relative cross-section for electron attachment to SF_5Cl. This too will be placed on an absolute scale using the thermal swarm measurements made by us in Birmingham.

In addition to the LPA, Rydberg electron transfer measurements were made to determine product anions. The results of these measurements are illustrated below in figure 3.

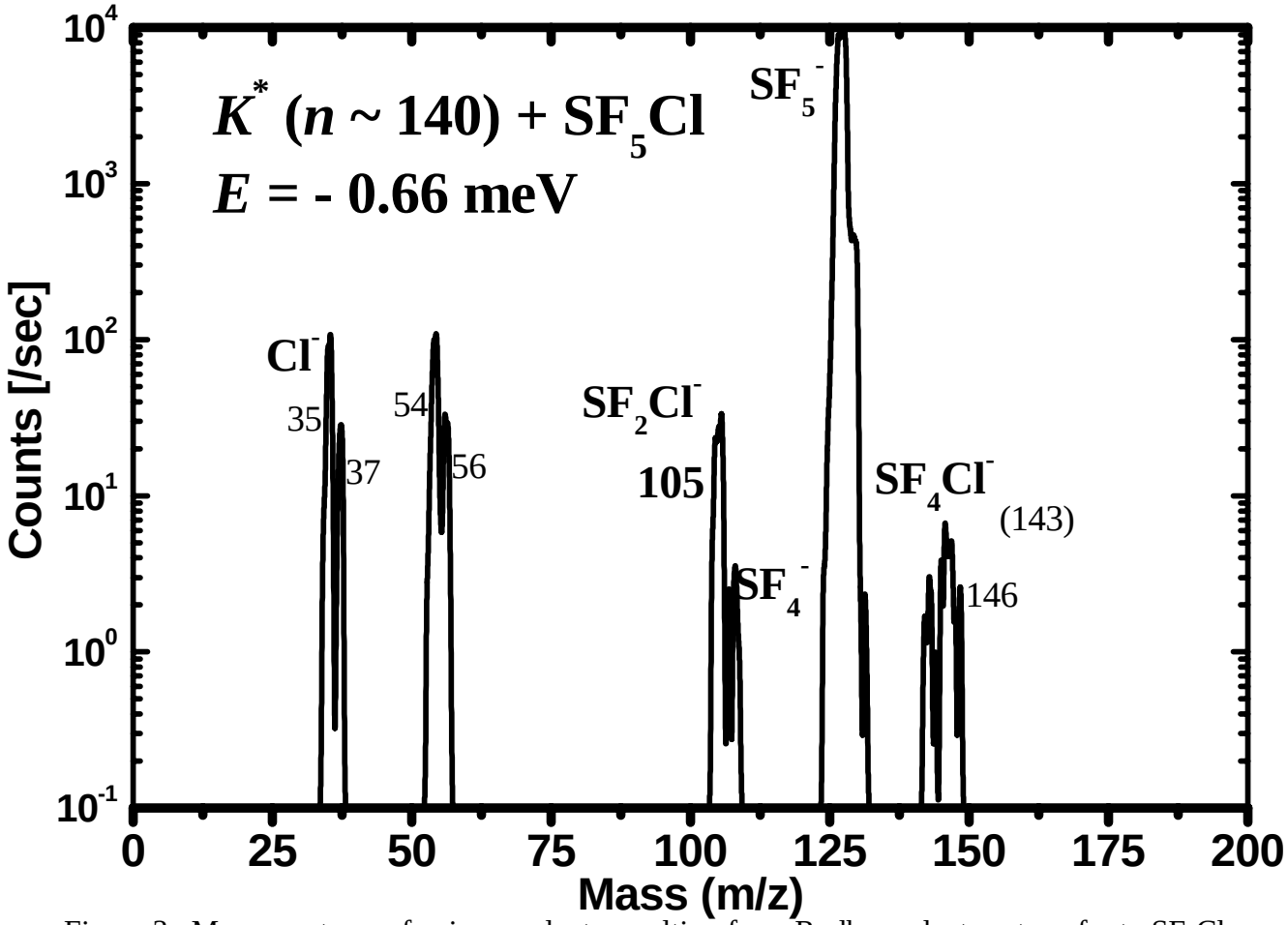

Figure 3. Mass spectrum of anion products resulting from Rydberg electron transfer to SF_5Cl.

2. Visit to Innsbruck (10 days: 18th – 27th July)

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Ongoing instrumental problems meant that unfortunately we could not perform any new experiments. For the four weeks previous to the visit there have been major beam instabilities, leading to the electron beam apparatus being inoperable during that time. Together with J. Fedor, we helped to find what problems were causing this instability. Towards the end of the visit, we discovered the cause of the instabilities and for the remaining few days fixed these problems. In addition to helping with the repair of the instrument, we took the opportunity to work on some data we recorded last year which dealt with the SF_5Cl molecule. This included electron attachment and electron impact ionisation studies. We had useful discussions with Prof. P Scheier on both the

positive and anion mass spectra. The positive ion discussion led in particular to a revaluation of the positive ion spectra.

(i) Negative Ion Studies

The dissociative electron attachment spectrometer in Innsbruck was used previously to investigate electron attachment to SF_5Cl over the electron energy range 0-10 eV. Electron attachment to SF_5Cl in the electron energy range 0-10 eV generates a large number of anionic products. Data obtained for SF_5Cl was normalised and worked on during the trip, the results of which are shown below.

The mass spectrometer was kept at the lowest possible resolution to minimise mass discrimination effects. The production of the product anions SF_5Cl^-, SF_4Cl^-, SF_5^-, and SF^- only occurs with the resonance at 0 eV, with SF_5^- being the dominant species, as is illustrated in figure 4. Figure 4 shows a high resolution mass scan of the anion products obtained using the beam apparatus with electron energy set at approximately 0 eV. A typical relative cross-section for these anions is illustrated in figure 5, which is that obtained for SF_5^-.

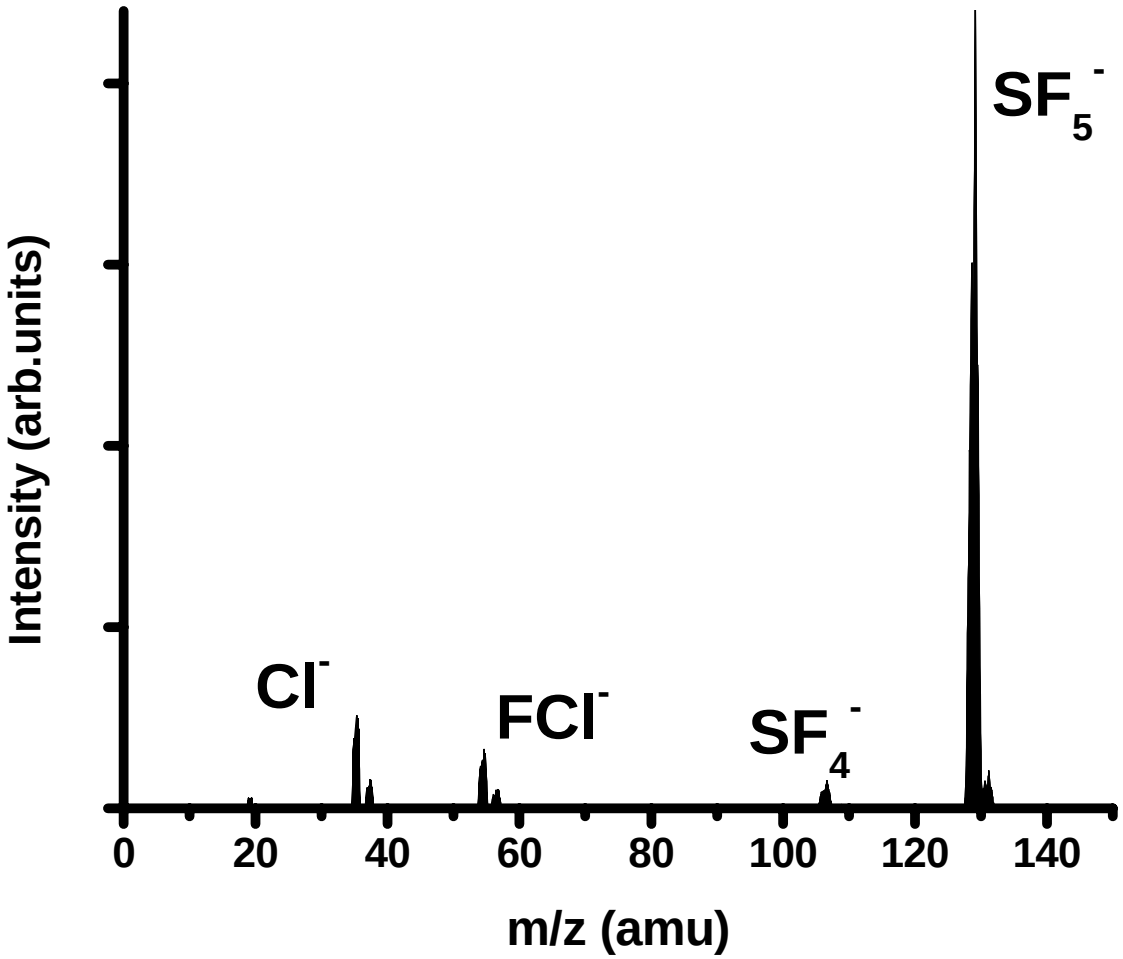

Figure 4. High resolution mass spectrum of anion products obtained using the TEM with an electron energy of approximately 0 eV (electron energy resolution 100 meV)

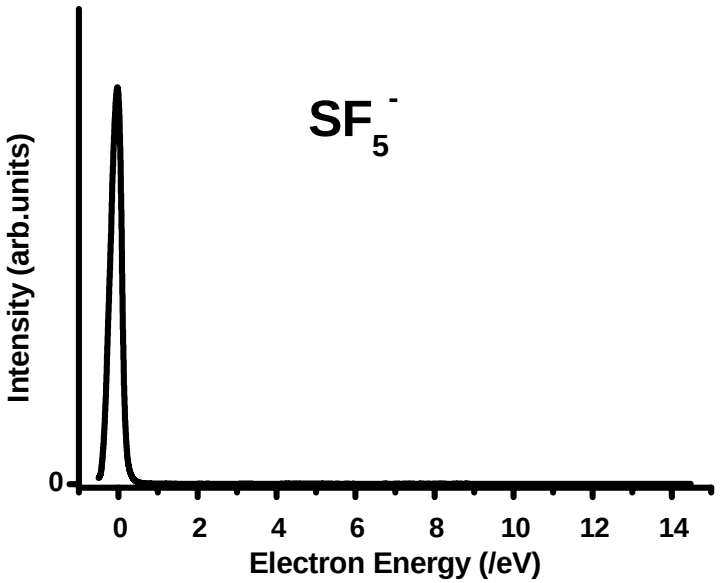

Figure 5. Formation of SF_5^- from electron attachment to SF_5Cl.

Figure 6 below shows the energy resonances for formation of the other major product anions observed using the Innsbruck beam apparatus.

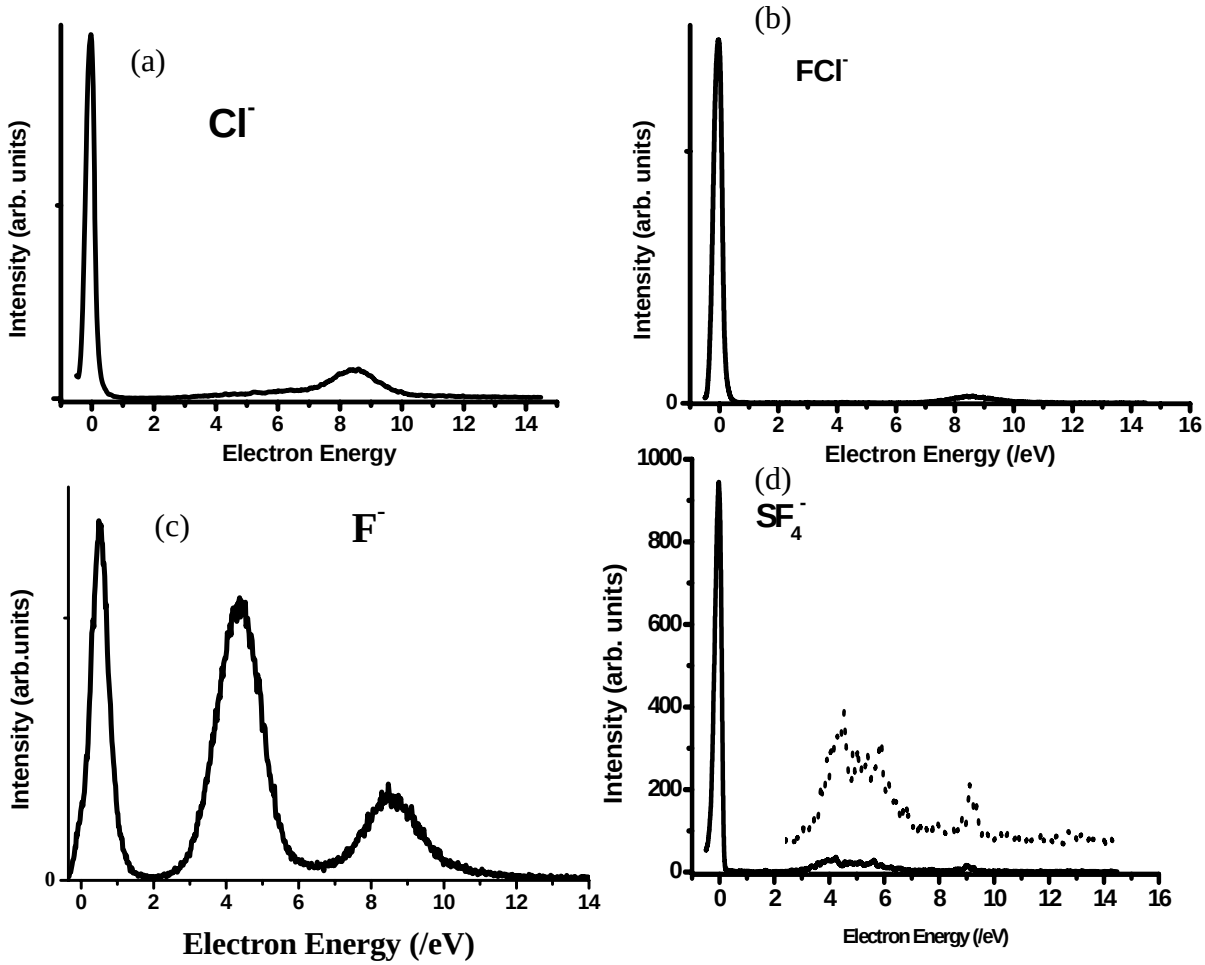

Figure 6. Formation of (a) Cl^-, (b) FCl^-, (c) F^- and (d) SF_4^- from electron attachment to SF_5Cl

(ii) Positive Ion Studies

The aim of this investigation was to measure the threshold energies for the dissociative ionisation channels of SF_5Cl. In addition to this work being independently of interest, the positive ion study provided us with information on the likely impurities in the SF_5Cl sample. This will greatly aid the interpretation of the negative ion study. By way of illustration figure 7 shows the threshold behaviour for the production of SF_5^+ from SF_5Cl.

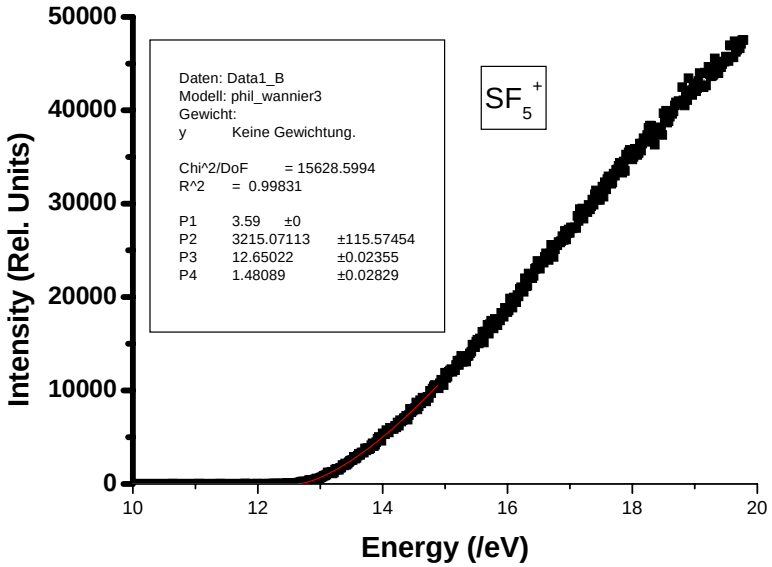

Figure 7. Electron impact ionisation of SF_5Cl leading to SF_5^+. A fitting procedure has been used to obtain the threshold value.

A number of positive ions were observed, and the electron impact mass spectrum, recorded using 70 eV electron impact ionisation is illustrated in figure 8.

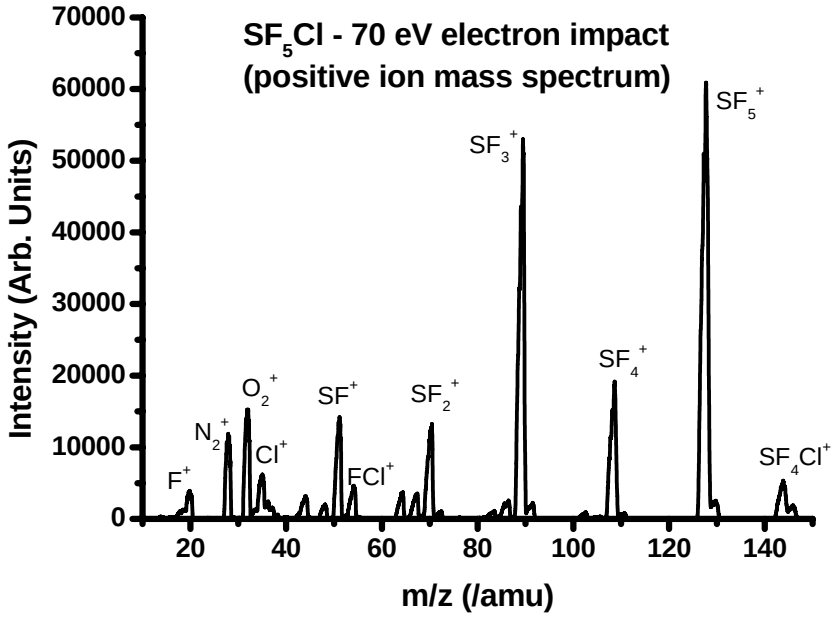

Figure 8. 70 eV electron impact mass spectrum of SF_5Cl

Using a fitting procedure in Innsbruck to the threshold measurements, the following dissociative ionisation appearance thresholds have been obtained IP(F^+(SF_5Cl)) = 16.1 eV, IP(Cl^+(SF_5Cl)) =

12.8 eV, IP($SF^+(SF_5Cl)$) = 16.0 eV, IP($SF_3^+(SF_5Cl)$) = 12.0 eV, IP($SF_4^+(SF_5Cl)$) = 16.1 eV, and IP($SF_5^+(SF_5Cl)$) = 12.7 eV, and IP($SF_4Cl^+(SF_5Cl)$) = 15.4eV.

Conclusions

- The laser photoelectron attachment and beam electron attachment investigations to SF_5Cl have helped to sort out the discrepancies in the branching ratios.
- Absolute cross-sections for electron attachment have been obtained from the LPA studies, and relative cross sections and energy resonances for electron attachment have been obtained using the beam apparatus.

The electron attachment to SF_5Cl study will result in one joint paper between Innsbruck, Kaiserslautern and Birmingham.

- The LPA work of SF_5CF_3 is highly original and will provide absolute cross-sections near to threshold energies.

A joint paper between Kaiserslautern and Birmingham will be produced.

- The electron impact study of SF_5Cl will be compared with TPEPICO studies made by us at Daresbury.

This will result is a joint paper between Innsbruck and Birmingham.

Further visits from Birmingham to Kaiserslautern and Innsbruck are planned to conclude the work on all the above molecules, and to start measurements with new molecular systems.