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LETTER TO THE EDITOR

Absolute differential cross sections for e–SF_6 scattering in the a_{1g} and t_{1u} resonance region

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Abstract. The crossed-beam technique has been used to measure differential cross sections of vibrationally elastic ($\Delta v = 0$) e–SF_6 scattering. The maximum energy was about 10 eV. Distinct regions of dominating interaction mechanism are observed in the energy dependence. Below 1 eV, the cross section appears to be determined essentially by direct scattering while in the 2–3 eV range and around 7 eV the scattering is dominated by resonances. The cross sections are obtained in absolute units. It is found that in the region of 1 eV, vibrationally elastic scattering and vibrational excitation, associated with different experiments, are of equal magnitude ($\simeq 10^{-15}$ cm^2).

Low-energy scattering cross sections for electrons on SF_6 have recently been the subject of several experimental as well as theoretical discussions. Accurate measurements of the total e–SF_6 collision cross section in absolute units have been reported by Kennerly *et al* (1978) using the time-of-flight technique. These results have been discussed in the context of multiple scattering calculations employing the Hara exchange potential of Dehmer *et al* (1978) for the integral vibrationally elastic ($\Delta v = 0$) cross section. The assumption allowing such a comparison is, of course, that vibrational excitation should be negligible. It was found that good agreement could indeed be achieved between theory and experiment for the average magnitude of the cross section for collision energies above about 5 eV. For lower energies, however, the average experimental result considerably exceeded the theoretical one. Discrepancies appeared likewise in the shape and position of the resonances in the energy spectrum. Dehmer *et al* argued that their theory must await consideration of the effects of nuclear motion for a final assessment.

In the present letter, it is shown that some of the differences in the magnitude of the cross section at low energies can be removed if vibrational excitation is taken into account explicitly. In addition, the present measurement gives absolute differential cross sections, enabling a sensitive check of theoretical models. The only previously published results of differential cross sections for $\Delta v = 0$ scattering in SF_6 in the energy range below 10 eV are the angular dependences at the fixed energies of 5 eV and 10 eV measured by Srivastava *et al* (1976).

A crossed electron-beam–molecular-beam scattering technique was employed in the present measurements. The experimental arrangement and the method have been described earlier (Rohr and Linder 1976, Rohr 1978). Absolute values of the cross section have been obtained by comparing e–SF_6 scattering rates with those for elastic e–He scattering, where the cross sections are known with reasonable accuracy. Some

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care has been necessary in taking account of the different scattering conditions in the two gases. The accuracy achieved here is therefore estimated to be about 20%.

Figure 1 shows the vibrationally elastic cross sections in the energy range from about 0·3 eV to 10 eV for scattering angles between 20° and 120°. In each curve one observes a steep increase of the cross section towards smaller energies. At higher energies, and particularly so in the 120° curve, the cross section reveals two well developed resonance structures, one in the 2–3 eV region and one around 7 eV.

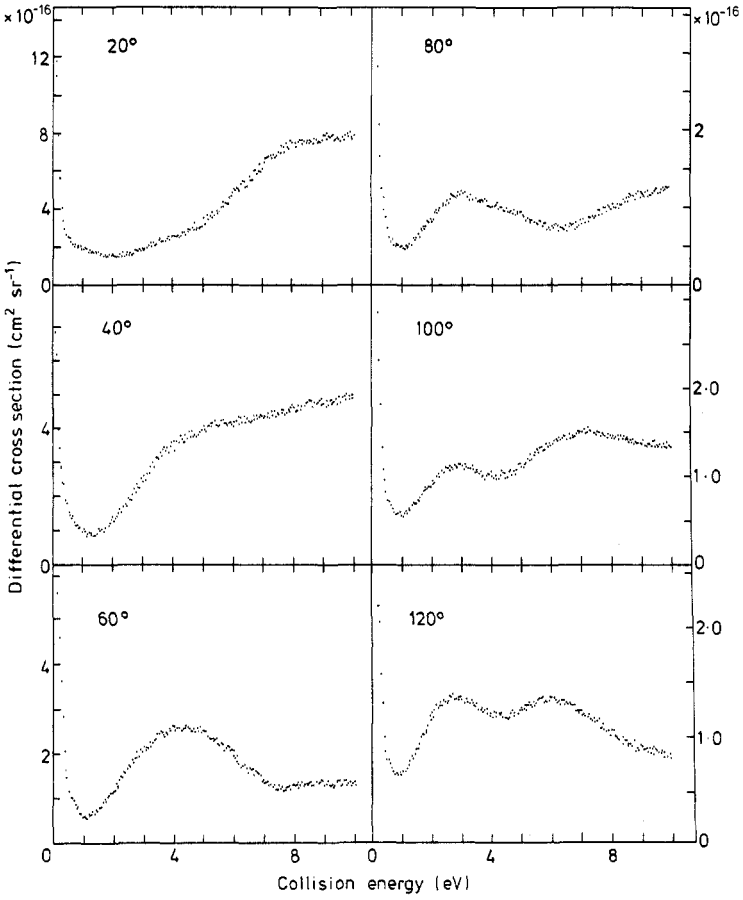

Figure 1. Differential cross sections for vibrationally elastic ($\Delta v = 0$) e–SF_6 scattering for collision energies from 0·3 eV to 10 eV and for scattering angles from 20° to 120°.

Angular dependences at three fixed energies are shown in figure 2. At 0·5 eV, which lies in the ascent region of the energy dependence near the threshold, the angular behaviour is sharply peaked in the forward direction, followed by a monotonic decline towards greater angles. One can assume that, in this energy range, vibrationally elastic scattering in SF_6 is dominated by the direct scattering process, where many partial waves contribute to the cross section. The angular behaviour at 2·7 eV and 7 eV in figure 2, on the other hand, clearly indicates strong resonant contributions to the scattering process. These resonances are similarly present in the calculation of Dehmer

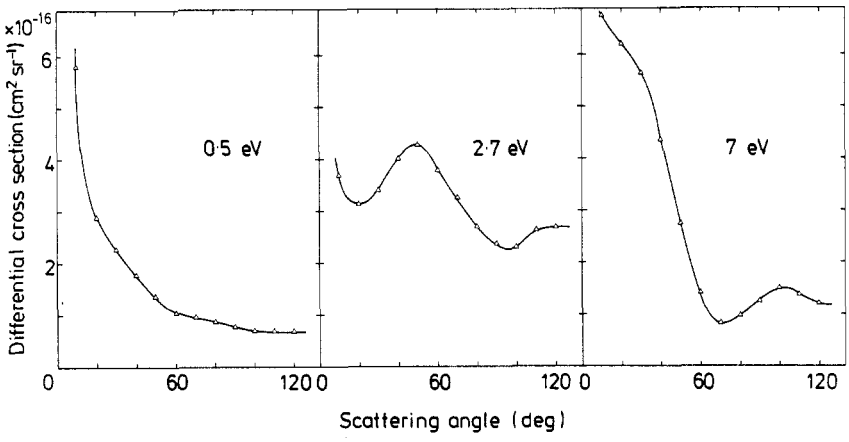

Figure 2. Angular dependence of vibrationally elastic e–SF_6 scattering at collision energies of 0·5, 2·7 and 7 eV.

et al (1978) of the integral vibrationally elastic cross section and in the measurement of the total cross section of Kennerly *et al* (1978). These authors have located the resonance positions at 2·1 eV and 7·2 eV and at 2·56 eV and 7·01 eV, respectively. Dehmer *et al* have assigned the symmetries of the resonances to a_{1g} (2·1 eV) and t_{1u} (7·2 eV), and they have found that the partial waves which comprise the resonances in the asymptotic limit are (0,4) and (1,3), respectively. This result should be comparable to the angular dependences observed here, if the underlying non-resonant contribution is taken into account. Angular dependences taken from figure 1 at energies of 5 eV and 10 eV are qualitatively in good agreement with the results of Srivastava *et al.* However,

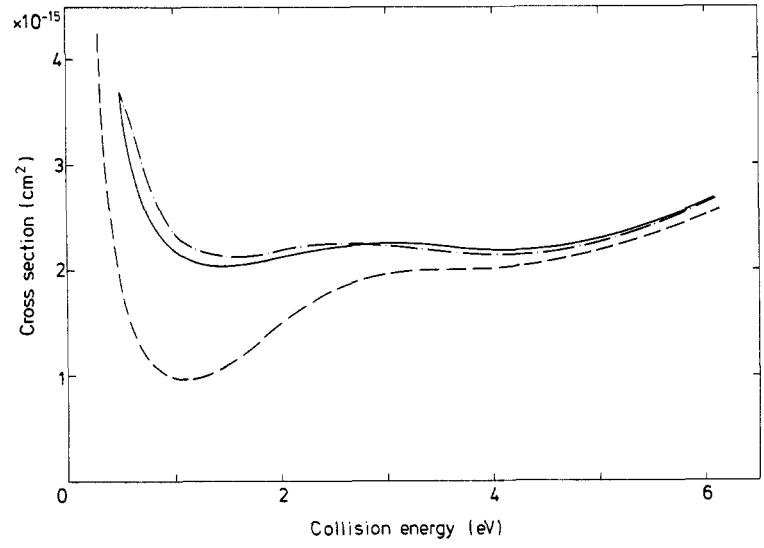

Figure 3. Energy dependence of integral e–SF_6 collision cross sections. – – –, present result for the integrated $\Delta v = 0$ cross section; ——, sum of the integrated $\Delta v = 0$ cross section (present result) and total vibrational excitation cross section (Rohr 1977); – · – · –, total scattering cross sections of Kennerly *et al* (1978).

the absolute value of the cross section in their measurement lies systematically about 40% below the present values.

In figure 3 the differential ($\Delta v = 0$) cross sections have been used to obtain integral cross sections for energies up to about 6 eV. If the result is compared with the measurements of total cross section by Kennerly *et al*, it is found that for higher energies both cross sections are of nearly equal magnitude. This means that vibrational excitation plays a relatively negligible role in this energy range. For lower collision energies, however, and it is most apparent at about 1 eV where the $\Delta v = 0$ cross section has a pronounced minimum, which is only weakly developed and at a somewhat higher energy in the total cross section, it must be expected from both measurements that vibrational excitation and vibrationally elastic scattering are of comparable magnitude. This conclusion is coincident with earlier measurements of pure vibrational excitation cross sections in SF_6 (Rohr 1977). If those results and the present ones are added to get the total cross section, remarkably good agreement is found with the total cross section of Kennerly *et al* (figure 3). This conformity, which follows from two quite independent experimental procedures, strengthens the validity of the present assessment of absolute low-energy e–SF_6 scattering cross sections.

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