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LOW-ENERGY RESONANCES IN e^--N_2 TOTAL SCATTERING CROSS SECTIONS: THE TEMPORARY FORMATION OF N_2^- †

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A modified Ramsauer technique[1] has been used to measure absolute total e^--N_2 scattering cross sections from 0.3 to 5 eV. The well-known peak in the total cross section[2] at 2.25 eV has been partially resolved into a series of resonances. Five additional lower energy resonances (which have not previously been observed) starting at about 0.3 eV also reported here.[3]

The apparatus used for these measurements has been previously described in detail.[4] Briefly, it measures absolute total electron-molecule scattering cross sections to about ±3% with an energy-scale accuracy of about ±0.1 eV.

Figure 1 shows a plot of the total e^--N_2 scattering cross sections obtained in the present experiment for energies between 0.3 and 5 eV. The first four of the higher energy resonances (starting at about 2 eV) were first resolved by Schulz.[5] The positions of the higher energy dips shown on the plot can be identified with the elastic resonances previously reported as transmission maxima.[6] These resonances are seen on the plot to be about 0.2 eV wide (much broader than the instrumental resolution in this energy range of about 0.07 eV at half-maximum). The six additional resonances shown on the plot are also about 0.2 eV wide (again much broader than the instrumental resolution). The lower energy resonances are seen to exhibit a maximum cross-section change of about 2 Å^2 while the higher energy resonances are seen to exhibit a maximum cross-section change of about 8 Å^2. In both cases, these cross section changes at resonance are a maximum of about 25% of the total cross section. However, the higher energy resonances are superposed on a large broad peak in the total cross section, to which a large contribution is probably made

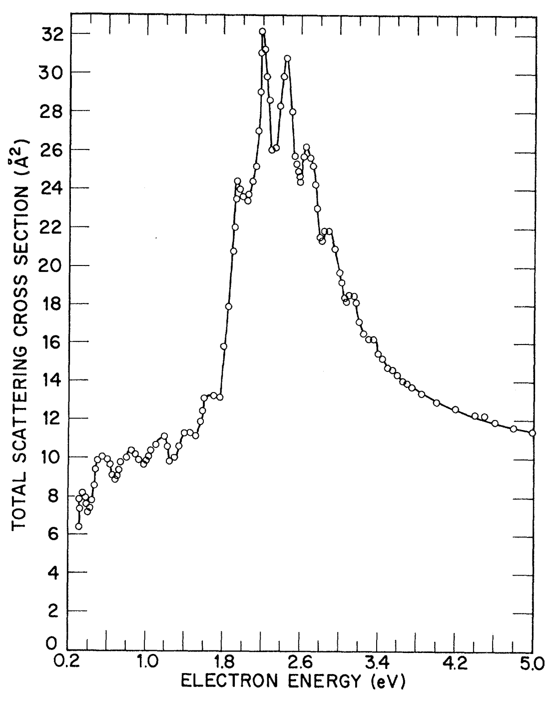

FIG. 1. Total e^--N_2 scattering cross section versus electron energy for 0.3 to 5 eV.

Table I. Observed positions of resonances in N_2, and a comparison between the observed resonance spacings and the vibrational spacings of the ground state of N_2 in eV.

Transmission maximum[a]	Observed cross-section minima This work	Spacing This work	Vibrational spacing $N_2(^1\Sigma_g^+, v'-v'')$
	0.40		
	0.68	0.28	0.29 (0-1)
	0.96	0.28	0.29 (1-2)
	1.24	0.28	0.28 (2-3)
	1.52	0.28	0.28 (3-4)
1.73	1.79	0.27	0.28 (4-5)
2.03	2.06	0.27	0.27 (5-6)
2.31	2.32	0.26	0.27 (6-7)
2.56	2.57	0.25	0.26 (7-8)
2.80	2.82	0.25	0.26 (8-9)
3.05	3.06	0.24	0.26 (9-10)
3.30	3.30	0.24	0.25 (10-11)
3.55			

[a]Ref. 5.

by vibrational excitation of N_2.[5] Since the works of Schulz[5] and Engelhardt, Phelps, and Risk[7] agree that the direct vibrational excitation of N_2 for low-electron energies is quite small, it is felt that the low-energy resonances must be elastic. The resonances starting at about 2 eV have been identified by Gilmore[8] as being temporary formations of the vibrational states of the virtual negative-ion ground state of $N_2^-(^2\pi_g)$. Gilmore[8] (based on the work of Schulz[5]) has given the potential energy minimum for $N_2^-(^2\pi_g)$ at 1.5 eV above the lowest vibrational state of the ground electronic state of $N_2(^1\Sigma_g^+, v=0)$. The present work suggests that the potential energy minimum for $N_2^-(^2\pi_g)$ is probably somewhere between 0 and 0.4 eV above $N_2(^1\Sigma_g^+, v=0)$.

The observed positions of the resonances, their spacings, and the vibrational spacings of $N_2(^1\Sigma_g^+)$ are shown in Table I.[9] It is believed that all of the observed resonances may be attributed to the temporary formation of the vibrational states of $N_2^-(^2\pi_g)$. One would expect the binding of the N atoms in $N_2^-(^2\pi_g)$ and in $N_2(^1\Sigma_g^+)$ to be similar and hence the associated vibrational spacings to be similar The comparison between the observed vibrational spacings and those for $N_2(^1\Sigma_g^+)$ are seen in Table I to be good. The present experiment could not detect whether or not another vibrational state of $N_2^-(^2\pi_g)$ can exist below 0.4 eV since it is not capable of making measurements below 0.3 eV. If another resonance were to exist at lower energies, one would expect it to lie at about 0.1 eV. Hence, this experiment can only state that the lowest resonance found is probably due to the existence of either the $v=0$ or $v=1$ vibrational state of $N_2^-(^2\pi_g)$.

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