

TABLE I.

v_1	v_2	v_3	ν_0 cm ⁻¹	A cm ⁻¹	B cm ⁻¹	C cm ⁻¹
0	2	1	6871.37	33.50	14.84	8.87
1	2	0	6775.00	34.43	14.67	8.78
0	3	0	4666.70	42.05	14.98	8.88

the bending fundamental. Most of the levels up to $J=6$ have been found, but the analysis is complicated by the overlapping in the R branch with the stronger CO_2 absorption. Further measurements with relatively large amounts of H_2O in the absorbing path are planned in order to develop this band more fully. The third overtone (040), which should fall in the relatively clear region $1.54\text{--}1.64\mu$, will also be sought under these conditions.

Between 2.22μ and 2.50μ , the latter being the approximate limit of complete absorption as a result of the strong ν_3 fundamental, resolved lines have been assigned principally to the $\Delta J=+1$, $\Delta\tau=+3$ transitions of that fundamental up to $J=10$. A few lines of the $\Delta J=+1$, $\Delta\tau=+7$ type have been located, and a number of the strong lines near 2.5μ doubtless result from the $\Delta J=+1$, $\Delta\tau=-1$ transitions, with J from 10 to 15, but definite assignments for these lines must await corresponding measurements in the long wave-length wing of the band.

The position of the zero rotational level and the approximate effective reciprocal moments of inertia for the three newly resolved bands are shown in Table I.

The relative intensities of the various bands may be estimated approximately, by comparing, for fully resolved lines of equal absorption in the several bands, the calculated intensities.⁴ If the probability of vibrational transition in (001) is assigned the value 5000, the probabilities for the other bands are: (101)=80; (200)=20; (021)=8; (120)=1; (011)=150; (110)=3; (030)=1.

Further details of the analysis will be published by one of us, together with results obtained in the photographic region.⁵

¹ R. R. McMath, O. C. Mohler, and L. Goldberg, Phys. Rev. 73, 1203 (1948).

² T. G. Cowling, Nature 152, 694 (1943).

³ R. C. Nelson and W. S. Benedict, following communication.

⁴ P. C. Cross, R. M. Hainer, and G. W. King, J. Chem. Phys. 12, 210 (1944).

⁵ W. S. Benedict, Bull. Am. Phys. Soc., 23, 54 (1948).

Absorption of Water Vapor Between 1.34 μ and 1.97 μ

R. C. NELSON

Northwestern University, Evanston, Illinois

AND

W. S. BENEDICT

National Bureau of Standards, Washington, D. C.

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THE absorption of water vapor between 1.34μ and 1.97μ has been recorded using the PbS photoconductive cell with the spectrograph and amplifier described by Nelson and Wilson.¹ The absorption path within the spectrograph was 11 meters long, and the extent

TABLE I.

v_1	v_2	v_3	ν_0 cm ⁻¹	A cm ⁻¹	B cm ⁻¹	C cm ⁻¹
1	0	1	7249.8	25.89	14.12	8.98
2	0	0	7201.4	26.38	14.20	8.94
0	1	1	5331.2	29.52	14.61	8.98
1	1	0	5235.0	30.13	14.45	8.93

of absorption was controlled by varying the humidity in the instrument. There are two principal regions of absorption, 1.34 to 1.48μ and 1.78 to 1.97μ . In the former, the effective slit width was 0.18 cm^{-1} ; this permitted 70 scale divisions deflection on the Speedomax recorder with a noise level (illuminated) of one division. In the longer wave-length region the lower sensitivity of the detector required slits of 0.40 cm^{-1} .

The spectrum obtained bears a general resemblance to that previously reported,² but the resolution is markedly improved and there is a systematic deviation in the wave-lengths—our values, after correction to vacuum, being from 1.5 to 2.0 cm^{-1} lower in the 1.4μ -region, and 0.8 to 1.2 cm^{-1} lower in the 1.9μ -region. The present values, obtained by comparison with lines of Ne in higher orders, are believed accurate to $\pm 0.1\text{ cm}^{-1}$. Agreement to within this limit is found with measurements made with atmospheric path lengths with both photo-cell³ and photographic⁴ recording.

A rotational analysis of the lines has been made, using the known rotational levels of the ground state⁵ to locate groups of lines with a common upperstate level. The calculated energy and intensity tables for the rigid asymmetric rotor⁶ served as valuable guides in making the assignments. The principal absorption between 1.36μ and 1.42μ is due to the well-known perpendicular band ($v_1v_2v_3=101$), but, as was found to be the case with corresponding bands in the photographic region,⁷ there are many lines that must be attributed to a weaker band of parallel symmetry type (200). The relative intensity of the two bands is about 4:1, except for a few lines going to closely lying rotational levels of equal J and the same total symmetry, when perturbations of the Coriolis type occur, giving rise to displacements of the calculated term values and enhancement of the intensity of the weaker band. The rotational levels of (101) have been completely located up to $J=6$, together with many of the stronger, low τ , levels of higher J , and of (200) up to $J=5$. These account for practically all the lines in the central region. At longer wave-lengths a number of weaker lines may be assigned to the perpendicular band (021), and a few to the parallel band (120), in agreement with the rotational analysis previously made from the solar absorption.² At the shortest wave-lengths there remain a few unassigned lines which undoubtedly belong to the second parallel band (002). A tentative analysis of the present data together with the photographic atmospheric absorption³ locates most of the levels of this band up to $J=3$, giving $\nu_0=7445.0\text{ cm}^{-1}$, but further studies of the region from $1.30\text{--}1.37\mu$ with long absorbing paths are required to confirm this identification.

In the 1.9μ -region the absorption is due almost entirely to the (011) band. With the aid of the weaker lines in the

atmospheric absorption, all levels up to $J_r = 8_6$, and many of higher J , have been located. The accompanying parallel band (110) has also been found; its intensity relative to (011) is about 1:50, so that only the strongest transitions, or those strengthened by Coriolis perturbation, are resolved.

The zero rotational levels and approximate effective reciprocal moments of inertia of these bands are as shown in Table I. The moments for (101) and (011) are in fair agreement with those given by Nielsen,¹ but our term values, except for the lowest levels, are in many cases quite different.

Further details of the experimental and theoretical aspects of this work will be published separately.

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¹ R. C. Nelson and W. R. Wilson, Proc. Nat. Electronics Conf. 3, 579 (1947).

² H. H. Nielsen, Phys. Rev. 62, 422 (1942).

³ See preceding letter.

⁴ H. D. Babcock and C. E. Moore, *The Solar Spectrum from $\lambda 6600$ to $\lambda 13495$* (Carnegie Institute of Washington, 1947), p. 579.

⁵ D. M. Dennison, Rev. Mod. Phys. 12, 189 (1940).

⁶ G. W. King, R. M. Hainer, and P. C. Cross, J. Chem. Phys. 11, 27 (1943); *ibid.* 12, 210 (1944).

⁷ W. S. Benedict, Bull. Am. Phys. Soc. 23, No. 3, 54 (1948).

Tracks of Low Ionizing Particles in Photographic Emulsions

J. SPENCE, J. CASTLE, AND J. H. WEBB
Kodak Research Laboratories, Eastman Kodak Company,
Rochester, New York
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THE improvement in photographic emulsions for the registration of charged particles of low ionizing power has been very great in recent months, as may be seen from the accompanying pictures of tracks of electrons and

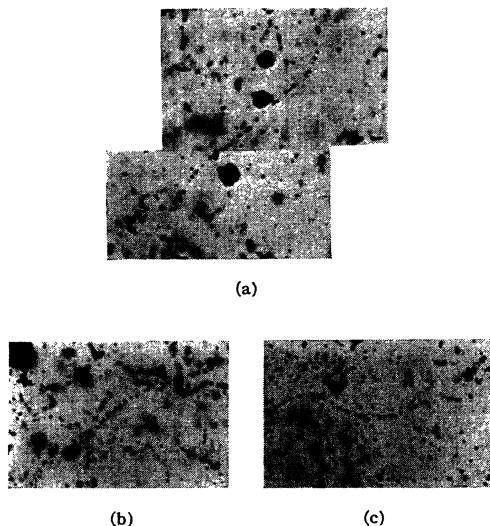


FIG. 1. Electron tracks obtained on Eastman NTB emulsion to beta-rays from $RaD + RaE$ in electron mass spectrograph.

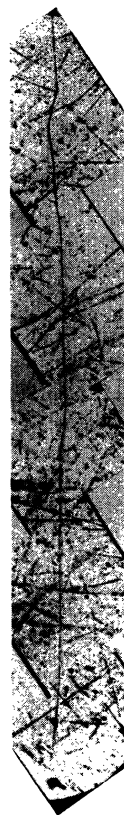


FIG. 2. Meson track in Eastman NTB emulsion obtained by exposure in University of California cyclotron.

mesons. One year ago it was doubtful that electrons could be registered as recognizable trails of grains at all by the photographic emulsion, although at that time a few tracks of several grains' length had been observed¹ that were attributed to electrons of a few kev energy. In a paper by Berriman² early this year, unmistakable tracks of electrons were obtained using the NTP-2a plate made by Kodak Limited, in Harrow, England. More recently, electron tracks of considerably greater range were observed using the NTP-2a plate of Kodak Limited³ and the NTB plate of the Eastman Kodak Company in America.⁴ The longest of these tracks were of the order 20–30-microns emulsion range corresponding to electron energies of around 40–60-kev energy.

The tracks shown in Fig. 1 are records of electron paths recently obtained on Eastman NTB emulsions exposed to beta-rays from a source of $RaD + RaE$ in an electron mass spectrograph. The tracks shown represent some of the longer tracks selected from the high energy end of the spectrum. The longest track shown here, Fig. 1a, had a range in the emulsion of approximately 56 microns, which corresponds to an electron energy of about 100 kev.

The particle track shown in Fig. 2 is of a meson on an Eastman NTB emulsion exposed to laboratory-produced mesons obtained in the University of California cyclotron.