

TABLE II. Internuclear distances.

Isotopic pair	d_{CH}	d_{CN}
DC ¹² N—DC ¹³ N	1.0657A	1.1556A
HC ¹² N—HC ¹³ N	1.0679A	1.1557A
HC ¹² N—DC ¹³ N	1.0623A	1.1568A
HC ¹³ N—DC ¹² N	1.0626A	1.1567A

the DC¹²N—DC¹³N pair. Our calculated value for this pair, based on the earlier frequency measurements, is included in Table II. It is seen that the values for the bond distances are now more consistent with each other than formerly. In addition, the D—C distance appears shorter than the H—C distance, rather than longer as previously reported. Variations in the bond distances listed in Table II are primarily due to variation of zero-point vibrations with isotopic substitutions. Since these are particularly large for an H—D substitution, the most accurate distances are probably given by the pairs of isotopes HC¹²N—HC¹³N and DC¹²N—DC¹³N.

The harmonic generator² used consists of a pair of crossed guides with a silicon crystal and tungsten cat whisker mounted inside the guide at the junction. One guide is of appropriate size for the fundamental wavelength (1.3 cm), the other guide is of a size suitable for the second harmonic. The use of various sizes of tapered wave guide at the output of the generator allows the separation of the several harmonics produced. The detector used is basically similar to the generator and is described more fully elsewhere.³ One generator and one detector conveniently operate over a wide range of frequencies and have been used successfully for the second, third, and fourth harmonics. The only changes necessary were adjustments of the tuning plungers in the generator and detector mounts (and replacements of the 2K33 klystron to reach widely different fundamental frequencies).

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¹ Simmons, Anderson, and Gordy, *Phys. Rev.* **77**, 77 (1950).

² The design of the generator is due to Mr. E. Richter, formerly of this laboratory and now with the Sperry Gyroscope Company.

³ Klein, Loubser, Nethercot, and Townes, *Rev. Sci. Instr.* **23**, 78 (1952).

The Velocity of Light Determined by the Band Spectrum Method*

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IT is well known that the rotational energy levels of a diatomic or linear polyatomic molecule can be expressed by the relationship $\nu = F(J) = BJ(J+1) - DJ^2(J+1)^2 + \dots$, where J is the rotational quantum number and ν is the frequency; $B = h/8\pi^2I$, where h is Planck's constant and I is the moment of inertia for the particular vibrational state in question; B , D and ν as given above are expressed in pure frequency units. In the microwave absorption spectrum it is possible to measure with high precision in pure frequency units the 0→1 rotational transition for suitable molecules. The frequency of this transition is equal to $2B - 4D$ to the approximation given above. B and D for the ground state can be determined from measurement of infrared rotation vibration bands. The values obtained from the optical spectra will be in cm^{-1} units. It follows directly that the ratio of B microwave to B infrared is identically equal to the velocity of light in vacuum.

Dr. A. E. Douglas of Ottawa pointed out to one of us (D. H. R.) that a precision determination of B infrared, preferably by interferometric means, could yield a significant value for the velocity of light. We have completed such a determination making use of two rotation vibration bands of HCN arising from the ground

state. The bands used were the 103 and 004 bands, respectively. The absorption tube was an 8-meter multiple reflection tube of the type invented by White¹ and similar to those used extensively by Bernstein and Herzberg.²

The spectrograph consisted of a plane grating mounted between collimating and focusing mirrors of 10-meter focal length. The plane grating has 15,000 lines to the inch and 6.5 inches of ruling. This grating, ruled on speculum metal by Anderson, is exceedingly perfect and shows theoretical resolving power in the fifth order as nearly as can be determined. We are indebted to Dr. A. L. Loomis for his generosity in the donation of this grating to The Johns Hopkins University after his many years of ownership, and to Prof. G. H. Dieke of Johns Hopkins for the loan of the grating.

Photographs of the bands were obtained in the first order by using a Fabry-Perot etalon of 21.35-mm spacer external to and in conjunction with the plane grating spectrograph. Calibration of the etalon was by means of neon standards. Plates were also obtained in the second order of the grating without the auxiliary interferometer, using the fourth-order iron standards. The pressure of the gas varied in different experiments from 35 to 70 mm Hg. After measurements of the plates the molecular constants were determined by least squares methods.

Dr. Douglas kindly communicated the preliminary results which he had obtained for the ground state in his extensive unpublished work on the complete near infrared system of HCN. These values of Douglas for B infrared showed that probably the measurements of B microwave by Simmons, Anderson, and Gordy³ must be in error by some multiple of ten megacycles in spite of their high precision, since no reasonable value of c could be obtained. One of us (D. H. R.) communicated with Professor Gordy concerning this matter and also later with Professor Townes pointing out the importance of obtaining a check determination in the microwave spectrum. The result obtained by Townes and his collaborators, $B = 44,315.9 \pm 0.25$ megacycles per second, after correcting for centrifugal distortion, appears in a companion letter in this issue of *The Physical Review*. Our result for B infrared is $1.47830 \text{ cm}^{-1} \pm 0.000025$. D was found to be $3.1 \times 10^{-6} \text{ cm}^{-1}$. The value obtained for the velocity of light c is $299,776 \pm 7 \text{ km/sec}$, where the uncertainty stated is the sum of the uncertainties of B microwave and B infrared. From our experience in making these measurements and treating the data we feel that somewhat improved precision of the optical measurements is possible and that systematic error can be discovered if present and materially reduced if found. The precision of measure of this hybrid optical method at present is comparable with previous optical methods and is exceeded only by the very recent pure microwave methods.⁴⁻⁷ It is certainly too early to say whether any real discrepancy between optical and microwave methods for determining the velocity of light exists. Further, more precise measurements are now in progress. A full account of these experiments will appear elsewhere.

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¹ J. U. White, *J. Opt. Soc. Am.* **32**, 285 (1942).

² H. J. Bernstein and G. Herzberg, *J. Chem. Phys.* **16**, 30 (1948).

³ Simmons, Anderson, and Gordy, *Phys. Rev.* **77**, 77 (1950).

⁴ J. A. Bearden and H. M. Watts, *Phys. Rev.* **81**, 73 (1951).

⁵ E. Bergstrand, *Ark. fys.* **3**, 479 (1951).

⁶ K. Bol, *Phys. Rev.* **80**, 298 (1950).

⁷ K. D. Froome, *Nature*, **169**, 107 (1952).

Photoconductivity of Trapped Electrons in KCl Crystals between 24°C and -190°C

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THE photoconductivity of trapped electrons in KCl¹ and KBr² crystals at room temperature has been reported previously. The same technique has now been used to study the