DETERMINATION OF THE ROTATIONAL CONSTANT OF $^{15}NH_3$

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UDC 621.378

The rotational spectrum of ^{15}N ammonia has not previously been observed. We have examined the lower rotational transition J = 0 → 1, K = 0 for $^{15}NH_3$ in the 0.525-mm range, which has given the rotational constant for this species of ammonia.

We used a gas spectroscope with video detection [1]. The cell contained $^{14}NH_3$ and $^{15}NH_3$ in the ratio of about 8 : 1. On sweeping the oscillator frequency (backward-wave tube [2]), the lines for J = 0 → 1, K = 0 for the two forms were clearly seen (Fig. 1). The distance between the lines was deduced from the frequency modulation of the source [3], which was recorded by a ChZ-9 frequency meter. The difference between the two transition frequencies was 384.8 MHz with an error of ± 0.2 MHz. The transition frequency for $^{14}NH_3$ has been measured [1] as $\nu_{0-1}(N^{14}H_3)$ = 572,499.4 MHz ± 3 MHz, so for $^{15}NH_3$ we have

$$\nu_{0-1}(N^{15}H_3) = 572\,115 \text{ MHz},$$

with the accuracy as for $\nu_{0-1}(N^{14}H_3)$.

The rotational constant B_0 was deduced as for $^{14}NH_3$ [1] and is

$$B_0(N^{15}H_3) = \frac{1}{2}\left[\nu_{0-1}(N^{15}H_3) + 4D_J + \frac{\nu_{0\,0} + \nu_{0\,1}}{2}\right],$$

where D_J is the centrifugal perturbation constant and $(\nu_{0\,0} + \nu_{0\,1})/2$ is half the sum of the frequencies for the inversion splitting of the levels J = K = 0 and J = 1, K = 0. No value has been published for D_J for $^{15}NH_3$, but the quantity is determined by an expression of the form B^3/ω^2, where B is the rotational constant and ω is the vibrational frequency [3], so the value for $^{15}NH_3$ is virtually that for $^{14}NH_3$, which is 19 MHz [3]. It is not possible to measure $\nu_{0\,0}$ and $\nu_{0\,1}$ because $^{15}NH_3$ lacks one of the inversion levels in each pair for K = 0, so one should use the dependence of the inversion frequency on J and K as found from transitions with K ≠ 0 by using the corresponding J and K.

An empirical formula [4] for the frequencies in the inversion spectrum of $^{15}NH_3$ has a standard deviation of 308 MHz and in the appropriate region (J and K small) gives values that differ from experiment by 3-10 MHz, which reduces the accuracy of the calculation. We therefore drew up the following better approximation from the measured frequencies [5]:

$$\nu_{JK}^{(\mathrm{MHz})} = 22714 \exp[-0.6489815\cdot10^{-2} J(J+1) + 0.902306\cdot10^{-2} K^2$$
$$+ 0.850786\cdot10^{-6} J^2(J+1)^2 - 0.178845\cdot10^{-5} J(J+1)K^2 + 0.52645\cdot10^{-6} K^4], \quad (1)$$

which has a standard deviation of 3.6 MHz and differences of 0.2-4.5 MHz from experiment at small J and K. Use of (1) gives a more accurate B_0 for $^{15}NH_3$ as

$$B_0(N^{15}H_3) = 297379.3 \text{ MHz}.$$

The method of [1] gave $\nu_{0-1}(N^{15}N_3)$ = 572,111.44 MHz for the frequency of the J = 0 → 1, K = 0 transition in $^{15}NH_3$, and so

$$B_0(N^{15}H_3) = 297377.5 \text{ MHz}.$$

Scientific-Research Radiophysics Institute at Gor'kii University. Translated from Izvestiya VUZ. Radiofizika, Vol. 12, No. 10, pp. 1584-1585, October, 1969. Original article submitted March 6, 1969.

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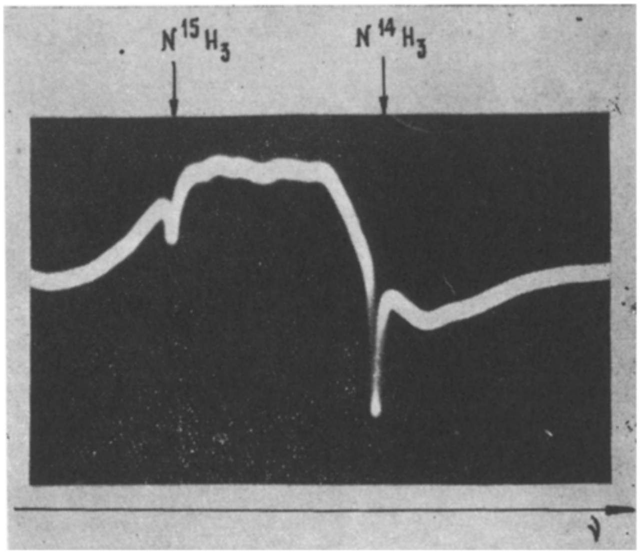

Fig. 1.

The results agree to $6 \cdot 10^{-6}$ or so, and the measured frequency for $^{14}NH_3$ is $\nu_{0-1}(N^{14}H_3)$ = 572,495.6 MHz, which corresponds to $B_0(N^{14}H_3)$ = 298,104.2 MHz. The result for the frequency difference is 384.1 MHz, which agrees well with the value above within the error of the present method.

We are indebted to A. A. Ul'yanov and V. A. Logachev for providing the specimen enriched in ^{15}N and to B. V. Gromov and E. N. Karyakin for assistance in the experiments.

LITERATURE CITED

1. A. F. Krupnov, V. A. Skvortsov, and L. A. Sinegubko, Izv. VUZ. Radiofizika, 11, No. 8, 1186 (1968).
2. M. B. Golant, R. L. Vilenskaya, E. A. Zyulina, Z. F. Kaplun, A. A. Negirev, V. A. Parilov, T. B. Rebrova, and V. S. Savel'ev, PTE, No. 4, 136 (1965).
3. C. Townes and A. Schawlow, Radio Spectroscopy [Russian translation], IL, Moscow (1959).
4. R. R. Newton and L. H. Thomas, Journ. Chem. Phys., 16, 310 (1948).
5. W. E. Good and D. K. Coles, Phys. Rev., 71, 383L (1947).