Rb-vapor density—shown in Fig. 2—is of interest. Concurrent studies of the scattered radiation spectra showed the existence in the density range $\sim 10^{14}$–$10^{16}$ cm$^{-3}$ of lines corresponding to the transitions $6P_{3/2,1/2} \rightarrow 5S_{1/2}$ ($\lambda = 4202$ Å and $\lambda = 4210$ Å) and VEGR between the levels $5P_{3/2}$ and $5P_{1/2}$. A correlation between the strength of the EMF signal and these lines was noted which, evidently, is associated with the different population of the magnetic sublevels of the ground state in the presence or absence of these processes. Figure 2 shows clearly that the signal changes its sign for the second time when the frequency differences are negative or large and at greater densities, which may be explained by the dependence of the VEGR processes and population of excited levels on the frequency difference and the occurrence in the medium of self- or defocusing.

We should also note that the IMM may be used to register the presence of alkali metals with a sensitivity far exceeding the optical methods. For instance, at frequency differences of $\sim 1$ Å, the IMM signal is observed at Rb-vapor densities of $10^{10}$ cm$^{-3}$.


**NH$_3$ laser pumped by two CO$_2$ lasers**

A. N. Bobrovskii, A. A. Vedenov, A. V. Kozhevnikov, and D. N. Sobolenko

*I. V. Kurchatov Institute of Atomic Energy*

(Submitted 30 March 1979)

Pis'ma Zh. Eksp. Teor. Fiz. 29, No. 9, 589–592 (5 May 1979)

A new method is proposed for exciting the second vibrational level of the $v_2$ mode of NH$_3$ molecule. A number of new laser lines is obtained from an optically pumped NH$_3$ laser.

PACS numbers: 42.55.Hq, 42.60.By, 33.80.Be

1. Coincidence of certain absorption lines of the $v_2$ mode of a NH$_3$ molecule and emission lines of a CO$_2$ laser has made possible an optically-pumped NH$_3$ laser. Moreover, this has resulted in emission at many wavelengths in the far$^{1,2}$ and intermediate$^{3-4}$ IR ranges. In this work we report on a new method of pumping the NH$_3$
molecule by means of two CO₂ lasers, and observation of new oscillation lines at the following wavelengths: 12.00, 13.23, 13.66, 15.78 and 15.86 μm. Identification of these lines has been made.

2. Figure 1 shows a partial level diagram of a NH₃ molecule. We shall use the following designation of vibrational-rotational energy levels of the ν₂ mode of NH₃: (ν ± , J, K), where ν is vibrational quantum number, J is rotational quantum number, K is a quantum number corresponding to projection of J, "±" corresponds to the symmetrical and antisymmetrical states. A number of CO₂ laser lines coincide with NH₃ absorption lines between the zeroth and first (0 ± , J, K) → (1 ± , J', K) and the first and second (1 ± , J, K) → (2 ± , J', K) vibrational levels of the ν₂ mode. However, none of these coincidences result in a situation where the upper level of the resonant transition (0 ± , J, K) → (1 ± , J', K) constitutes the lower level of the (1 ± , J', K) → (2 ± , J", K) transition. We devised the following method of exciting the second vibrational level of the ν₂ mode (see Fig. 1). The P(32) line in the 10.4-μm band of CO₂ laser (10.72 μm) pumps the resonant transition (0⁺, 5, 3) → (1⁺, 5, 3) of the NH₃ molecule in a volume placed in a resonator with respect to far-IR. Subsequently, cascade generation of far-IR radiation takes place due to the (1⁺, 5, e) → (1⁺, 4, 3) and (1⁺, 4, 3) → (1⁺, 4, 3)
transitions. Moreover, emission occurs at 151.8 and 291.3 \( \mu \)m, respectively. And, finally, the \( P(24) \) line in the 9.4 \( \mu \)m band of CO\(_2\) laser (9.59 \( \mu \)m)—which is resonant with the \((1^+,4,3) \rightarrow (2^-,5,3)\) transition—excites the \((2^-,5,3)\) level.

3. Figure 2 shows the experimental setup. The output of two synchronized CO\(_2\) lasers (1) tuned by means of 100-line/mm diffraction gratings (2) to the \( P(32) \) line in the 10.4-\( \mu \)m band and the \( P(24) \) line in the 9.4-\( \mu \)m band with respective power output of \(0.5 \times 10^4\) and \(1 \times 10^4\) W was spatially integrated by means of a parallel-plane Ge plate (3) and coupled to a cell containing NH\(_3\) (4). The cell input window was a KBr plate (5) which also served as one of the resonator mirrors with respect to far-IR (reflectivity \( R \sim 20\%)\) and mid-IR (\( R \sim 8\%)\). On the opposite side of the cell a metallic mirror with 6-m radius (6) was placed; the resonator length was 1.4 m. Emission from the cell was coupled to a grating monochromator (7) and recorded by Ge:Ga detector (8) which was designed in the shape of a lightpipe into a portable liquid helium dewar to record far-IR radiation due the \((1^+,5,3) \rightarrow (1^-,4,3)\) and \((1^-,4,3) \rightarrow (1^+,4,3)\) transitions; the metallic mirror (6) was replaced with a Ge mirror with identical radius. The emission was recorded by means of an InSb detector.

4. We have established the absorption of the 9.59-\( \mu \)m CO\(_2\) laser emission increases sharply in the presence of high-power laser emission at 10.72-\( \mu \)m. This confirms the fact that the foregoing pumping system excites the \((1^+,4,3)\) level. We measured cell
<table>
<thead>
<tr>
<th>wavelength, $\mu$m</th>
<th>Transition</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.00</td>
<td>$(1^+, 4, 3) \Rightarrow (0^-, 5, 3)$</td>
</tr>
<tr>
<td>13.23</td>
<td>$(2^+, 6, 3) \Rightarrow (1^-, 5, 3)$</td>
</tr>
<tr>
<td>13.66</td>
<td>$(2^+, 5, 3) \Rightarrow (1^-, 4, 3)$</td>
</tr>
<tr>
<td>15.78</td>
<td>$(2^+, 5, 3) \Rightarrow (1^-, 5, 8)$</td>
</tr>
<tr>
<td>15.86</td>
<td>$(2^+, 4, 3) \Rightarrow (1^-, 4, 3)$</td>
</tr>
</tbody>
</table>

Output wavelengths in the 12–16-$\mu$m range. Moreover, we identified five spectral lines at wavelengths indicated in the table below. Line identification was made using data from Ref. 5. Generation of emission at 12.00 $\mu$m was observed for excitation by a single line in the 10.4-$\mu$m band of a CO$_2$ laser.

Generation was observed at NH$_3$ cell pressure of 1–8 mm Hg and it attained a maximum at 4 mm Hg. Generation at the 15.86-, 13.66- and 12.00-$\mu$m lines occurs practically concurrently with the pumping pulses, while at the 15.78- and 13.23-$\mu$m lines a delay of approximately $5 \times 10^{-7}$ sec occurs with respect to the onset of generation of the CO$_2$ lasers.

5. The described method of pumping the $(2^-,5,3)$ level of the $\nu_2$ mode of NH$_3$ molecule has resulted in a number of new laser lines. This method may also be used for pumping other levels of the $\nu_2$ mode. For example, having tuned a CO$_2$ laser to the $R$ (14) and $P$ (14) lines of the 10.4-$\mu$m band, it becomes possible to excite the $(2^-,1,1)$ level of NH$_3$ molecule as follows:

The authors thank G. D. Myl'nikov for useful discussions.

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