which leads to a less considerable decrease of $\kappa_2(t)$ [3, 5]. An estimate of the minimal value of the parameter λ_{so} yielded a value on the order of 0.3[1] whereas according to the theory [5] a strong spin-orbit interaction is characterized by the condition $\lambda_{so} \gg 0.2$[2]. Obviously, for exact quantitative comparison with the theory it is necessary to measure in the experiment not only $\rho_f(H)$ but also $(dM/dH)_{H_{c2}(t)}$ in order to determine $\kappa_2(t)$, as well as the quantities γ and $\partial H^e_{c2}(t)/\partial t$ which enter in the definition of the parameters of the theory.

[1] C. Caroli and K. Maki, Phys. Rev. 164, 591 (1967).
[2] K. Maki, Phys. Rev. 169, 381 (1968).
[3] R.R. Hake, Phys. Rev. 158, 356 (1967); Appl. Phys. Lett. 10, 189 (1967).
[4] J.A. Cape, Phys. Rev. 148, 257 (1966).
[5] K. Maki, Phys. Rev. 148, 362 (1966).
[6] J.A. Cape and I.F. Silvera, Phys. Rev. Lett. 20, 326 (1968).
[7] K. Noto, K. Mori, and Y. Muto, Paper at Soviet-Japanese Conference on Low-temperature Physics, Novosibirsk, 1969; Physica 55, 362 (1971).
[8] N. Usui, T. Ogasawara, Ko Yasukochi, and S. Tomoda, J. Phys. Soc. Japan 27, 574 (1969).
[9] A.R. Strnad, C.F. Hemstead, and Y.B. Kim, Phys. Rev. Lett. 13, 794 (1964). Y.B. Kim, C.F. Hempstead, and A.R. Strnad, Phys. Rev. 139, A1163 (1965).
[10] N.Ya. Fogel', Paper at 17-th All-union Conference on Low-temperature Physics, Donetsk, 1972; Zh. Eksp. Teor. Fiz. 63, 1371 (1972) [Sov. Phys.-JETP 36, No. 4 (1973)].
[11] J. Le G.Gilchrist and P. Moncean, Proc. of the Conf. on the A.C. Properties of Superconductors and Their Applications, Coventry, England, 1968.
[12] I.N. Goncharov and I.S. Khukhareva, Zh. Eksp. Teor. Fiz. 62, 627 (1972) [Sov. Phys.-JETP 35, 331 (1972)].
[13] I.N. Goncharov, G.L. Doroveev, L.V. Petrova, and I.S. Khukhareva, JINR Preprint R8-6260, 1972.
[14] D. Saint-James, G. Sarma, and E. Thomas, Type-II Superconductivity, Pergamon (Russ. transl., Mir, 1970, p. 220).
[15] N.R. Werthamer, E. Helfand, and P.C. Hohenberg, Phys. Rev. 147, 295 (1966).

DISPERSION OF RESONANT OPTICO-ACOUSTICAL EFFECT

S.N. Murzin and B.D. Osipov
Spectroscopy Institute, USSR Academy of Sciences

Submitted 12 December 1972
ZhETF Pis. Red. 17, No. 2, 88 - 91 (20 January 1973)

1. The resonant optico-acoustical effect (ROAE) in polyatomic gases, wherein a standing sound wave is produced in a closed volume and draws energy from the internal degrees of freedom of the molecules of the same gas, which are excited by pulsed laser radiation, was observed in [1, 2].

[1] This estimate was obtained from a comparison of the experimental value $h^*_{min}(\alpha, \lambda_{so})_{t=0} = 0.693[(H^7_{c2}(0)/H^{GLAG}_{c2}(0) = 0.425$ with the theoretical $h^*(\alpha, \lambda_{so})_{t=0}$ dependence [15, 3]. The value $\lambda_{so} = 8.45$ given in [12] should be regarded as the maximum possible, since it has been calculated for $\lambda_{so} = 2\ell$.

[2] We note incidentally that formula (57) of [5] for $\kappa_2(\alpha, \lambda_{so}, t)$ obviously contains an error, for when the corresponding parameters are substituted it it the result is absurd and does not lead to the plot given in the same reference.

We have investigated the frequency characteristics of the ROAE in the polyatomic gases SF_6, BCl_3, and CH_3Br, and ascertained the feasibility of determining the relaxation parameters of the gas from the ROAE dispersion.

A sound wave is usually detected by a well-known mechanical method, using a condenser microphone with high inertia. It is apparently just this inertia of the sound-wave pressure pickup which has made it impossible to measure the frequency characteristics of the observed phenomenon in [2].

2. We have investigated the ROAE by a new practically inertialess method of detecting sound oscillation of a gas; this method is a microwave analog of Toepler's optical method.

The experimental setup is shown in Fig. 1. The radiation from a pulsed CO_2 laser (λ = 10.6 μ, power 10 W, pulse duration τ = 100 μsec) was focused on the entrance window of an acoustic resonator; the attained energy flux density was 1 kW/cm^2. The acoustic resonator served simultaneously as a microwave resonator tuned to 18 GHz. Variation of the gas density in the resonator changed the frequency of the microwave resonator. A signal proportional to the change of the gas density was amplified and recorded with a two-beam oscilloscope.

3. The ROAE dispersion was investigated as a function of the parameter $\omega\tau$, where ω is the natural frequency of the acoustic oscillations in the resonator and τ is the gas relaxation time. The value of τ was varied by changing the pressure of the investigated gas in the range from 10 to 750 Torr.

At low pressures (up to 50 Torr), an aperiodic change of the gas density was observed after the action of the laser pulse. With increasing pressure, the aperiodic process gave way to an oscillatory variation of the gas density at the natural frequency of the acoustic oscillations of the gas in the resonator.

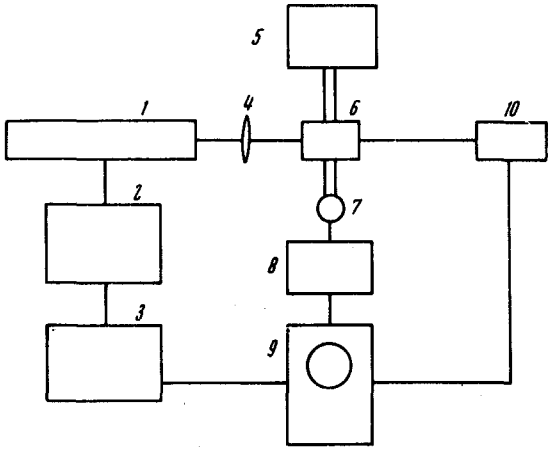

Fig. 1

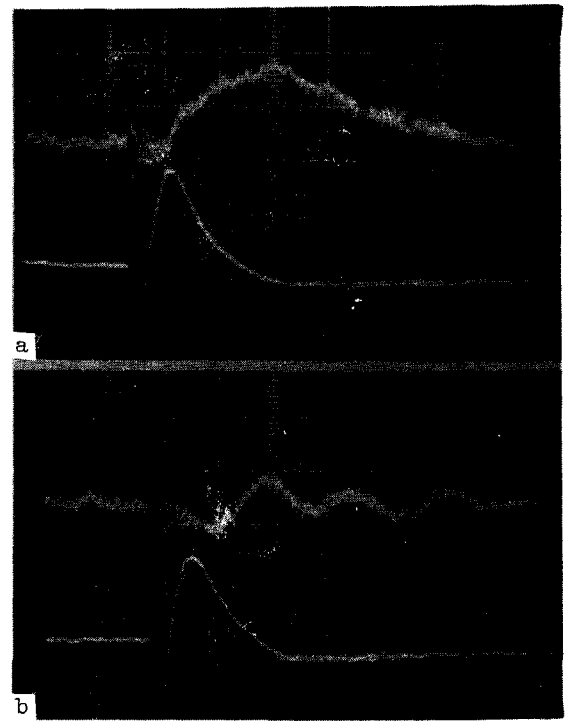

Fig. 2

Fig. 1. 1 - pulsed CO_2 laser, 2 - modulator, 3 - driving generator, 4 - focusing lens, 5 - microwave generator, 6 - resonator, 7 - microwave detector, 8 - broadband amplifier, 9 - two-beam oscilloscope, 10 - GeAu receiver.

Fig. 2. Variation of SF_6 gas density in an acoustic wave: a - pressure 30 Torr, b - 300 Torr. Sweep 100 μsec/cm.

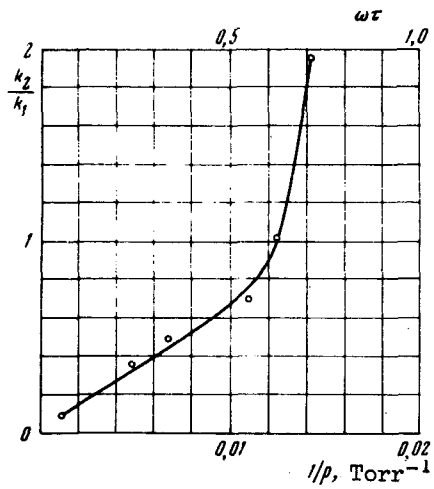

Fig. 3. Dispersion of ROAE in SF_6.

The gases SF_6, BCl_3, and CH_3Br had each their own characteristic pressures at which the aperiodic process gave way to the oscillatory one. Oscillograms of the density of SF_6 are shown in Fig. 2.

Figure 3 shows the experimentally obtained quantity k_2/k_1, which characterizes the acoustic losses in the resonator at a distance equal to the wavelength, as a function of the pressure and of the corresponding value of the parameter $\omega\tau$, at τp = 2.5 msec-Torr.

4. It is known from the theory of sound propagation in a polyatomic gas [3] that the dependence of the wave vector k on the parameter $\omega\tau$ is given by the formula

$$k = k_1 + ik_2 = \omega\sqrt{\frac{1 - i\omega\tau}{C_0^2 - C_\infty^2 i\omega\tau}}, \qquad (1)$$

where C_0 and C_∞ are the speeds of sound at $\omega = 0$ and $\omega = \infty$, respectively.

It is seen from (1) that at $\omega\tau \ll 1$ and $\omega\tau \gg 1$ the damping of the sound at a distance equal to the wavelength is small. A region of maximum absorption exists at values of $\omega\tau$ close to $\sqrt{C_0/C_\infty}$.

In the case of ROAE, the rate of energy transfer from the internal degrees of freedom of the molecules to the sound wave is limited by the relaxation time, and the region $\omega\tau \geq \sqrt{C_0/C_\infty}$ is therefore forbidden. Thus, the region in which ROAE occurs is bounded by the condition $\omega\tau \leq \sqrt{C_0/C_\infty}$, where the ROAE dispersion is described by Eq. (1). If $\omega\tau \ll 1$, we can use the linear approximation

$$\frac{k_2}{k_1} = \frac{\omega\tau}{2}\left(\frac{C_\infty^2}{C_0^2} - 1\right). \qquad (2)$$

It is seen from Fig. 3 that at $\omega\tau > 0.7$ there is no ROAE in SF_6, and that at $\omega\tau < 0.5$ the value of k_2/k_1 depends linearly on $\omega\tau$. The value of $\sqrt{C_0/C_\infty}$ determined from the slope of the linear section of Fig. 3 is 0.7, in agreement with the ROAE limit $\omega\tau > 0.7$.

Similar relations were observed for the gases BCl_3 and CH_3Br. An exception was NH_3, in which no ROAE was observed up to 750 Torr, perhaps owing to the relatively large time of oscillatory relaxation and the larger speed of sound.

Using independent measurements of $\omega\tau = \sqrt{C_0/C_\infty}$ and (2) we can determine the time of vibrational relaxation of the gas. The obtained values of τp (in units of msec-Torr) were 2.5, 4.0, and 8.0 for SF_6, BCl_3, and CH_3Br, respectively, in good agreement with [2, 4].

This phenomenon can apparently be observed also in gas mixtures and used to study the kinetics of chemical reactions and phase transitions.

[1] R.D. Bates, Jr., G.W. Flynn, and J.T. Kundtson, J. Chem. Phys. 53, 3621 (1970).
[2] T. Aoki and M. Katayama, Japan. J. Appl. Phys. 10, 1303 (1971).
[3] L.D. Landau and E.M. Lifshitz, Mekhanika sploshnykh sred, GITTL, 1954, p. 376 [Fluid Mechanics, Addison-Wesley, 1959].

[4] V.S. Arakelyan, N.V. Karlov, G.P. Kuz'min, Yu.N. Petrov, and O.M. Stel'makh, Radiotekhnika i elektronika 15, 634 (1970).

SEPARATION OF NITROGEN ISOTOPES WITH A LASER

R.V. Ambartsumyan, V.S. Letokhov, G.N. Makarov, and A.A. Puretskii
Spectroscopy Institute, USSR Academy of Sciences
Submitted 18 December 1972
ZhETF Pis. Red. 17, No. 2, 91 - 94 (20 January 1973)

1. We report here the first high-efficiency isotope separation by a method based on two-step photodissociation of molecules. In the described experiments we separated the nitrogen isotopes ^{14}N and ^{15}N by photodissociation of the ammonia molecules $^{14}NH_3$ and $^{15}NH_3$. Two-step molecule photodissociation was proposed [1] as a method for selective action of radiation on matter, and consists in the following. Monochromatic radiation of frequency ν_1 excites selectively a vibrational transition of molecules of only one isotopic composition. The molecules are simultaneously illuminated with light of frequency ν_2, the quantum energy of which is sufficient for photodissociation of only the vibrationally excited molecules.

The experimental setup is shown in Fig. 1. The source of the monochromatic IR radiation of frequency ν_1 (947.74 cm^{-1}) was a pulsed CO_2 laser with transverse discharge (1). The radiation-pulse energy was 60 mJ and the pulse duration at half-height was 300 nsec. The UV source (2) at frequency ν_2 (45 351 cm^{-1}) was a discharge in air (C = 0.3 μF, U = 20 kV). The UV pulse duration was 400 nsec at the base. The laser pulse was synchronized with the UV pulse by igniting the spark gap with a fraction (∼30%) of the laser-beam energy focused on one of the electrodes. To eliminate completely from the continuous spark-emission spectrum the UV radiation that might have been absorbed by the unexcited NH_3 molecules in the investigatec cell, an absorbing ammonia filter (3) was placed ahead of the cell. The filter was a cell with glass windows, 7.5 cm long, filled with ammonia to a pressure 1 atm. A cell (4) filled with a mixture of $^{14}NH_3$ and $^{15}NH_3$ (ratio 1:1) at a total mixture pressure 20 Torr was irradiated at the frequencies ν_1 and ν_2.

3. As shown in [2], when ammonia is pumped by a CO_2 laser, a new line appears in the electron-vibrational spectrum of NH_3 absorption, and corresponds to the transition v' = 0 ← v" = 1, where v" and v' are the vibrational numbers of the ground and excited electronic state, respectively. The frequency of the new absorption line is 45 351 cm^{-1}. In the described experiment, the population of the first vibrational level v" = 1 of the ground electronic state of the $^{15}NH_3$ molecule was 35 ± 5% at the instant of laser-pulse action [3]. At such a population, the optical density of the ammonia in cell (4) for the new absorption line was 0.8 (cell length 3 cm). The UV radiation passing through the filter was absorbed in the new absorption line

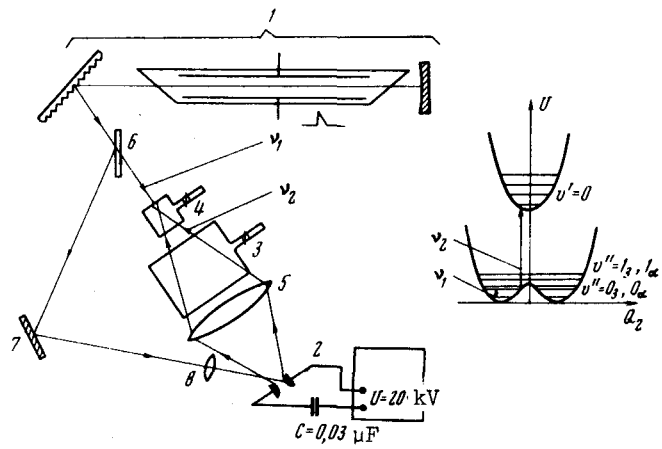

Fig. 1. Experimental setup: 1) pulsed CO_2 laser with variable emission frequency, 2) UV source, 3) absorbing ammonia filter, 4) cell with investigated gas, 5) capacitor, 6) plane-parallel plate, 7) rotary mirror, 8) focusing lens.