

accurate calculation may change somewhat the form of the maxima of the function $\alpha^2(\omega)F(\omega)$.

The arrows in Fig. 2c shows the Van-Hove singularities, at $q \neq 0$, of the phonon spectrum of ordinary bismuth, as calculated by E. G. Brovman and Yu. M. Kaganov in accord with neutron-diffraction investigations [1]. The letter a designates singularities due to the split-off optical branch. The maxima of $F(\omega)$ of ordinary bismuth are located near these values of ω . The transition of the bismuth into the superconducting crystalline modification is apparently accompanied by an essential change in the distribution density of the phonon spectrum. This may be connected with the difference between the crystallographic structures of the metal in the ordinary and superconducting modifications [8].

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*Inasmuch as superconductivity theory [3] deals with a metal having an ideal crystal lattice, one cannot exclude the possibility that the conclusions of the theory [3-4] are not fully applicable to samples in the form of films, which are usually used in experiments on the tunnel effect, and all the more the films of metal condensed at helium temperature, in which the very concept of regular crystal lattice loses meaning [8]. It is obvious that in using Eq. (1) to reconstruct the function $\alpha(\omega)F(\omega)$ we are performing an operation which is not fully correct from the point of view of the theory [3]. It would be more correct to compare the experimental data with the theory of an amorphous superconducting metal. However, this question has not been fully considered theoretically.

DETERMINATION OF THE DIFFUSION COEFFICIENTS BY HETERODYNING LIGHT SCATTERED BY LIQUID SOLUTIONS

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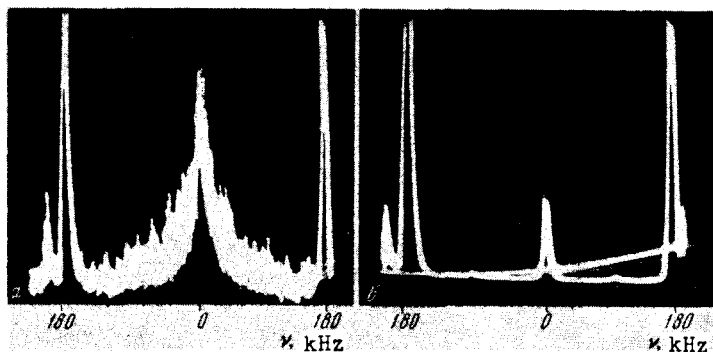
The kinetics of the thermal fluctuations in pure liquids and of the concentration in solutions becomes manifest in the spectrum of the scattered light in the form of an unshifted line whose width is proportional to the coefficient of temperature conductivity or to the coefficient of diffusion [1]. The line half-widths due to the temperature-conductivity or diffusion coefficients range from several Hz to dozens of MHz. These lines are particularly nar-

row at the critical point of a pure substance or near the mixing temperature of solutions.

A suitable method for measuring the half widths in these cases is the method of quadratic detection or heterodyning of light, first proposed in [2] and realized in [3]. In [4] this method has already been used to measure the widths of the central components in the spectra of light scattered by a suspension of macromolecules, by a binary mixture near the critical mixing temperature, and by pure liquids near the critical points and under ordinary conditions.

We report in this Letter the first experiments aimed at determining the diffusion coefficients in liquid solutions of acetone in carbon disulfide and bromoform in n-propanol under normal conditions.

Fig.1. Spectrum-analyzer signal observed in scattering at an angle $\theta = 90^\circ$ in an acetone solution in carbon disulfide; b - spectrum-analyzer signal when photomultiplier cathode is not illuminated. This is the signal of the first heterodyne of the spectrum analyzer at zero frequency. In the reduction of the spectrograms, b was subtracted from a and the half-width of the line measured at half the resultant amplitude at zero frequency.



In our experimental setup we realized the method of quadratic detection, in which the analyzed spectrum of the photomultiplier output current is a convolution of the spectrum of the radiation incident on the photocathode with itself and has a maximum at zero frequency.

The scattering spectrum was excited with a helium-neon laser (LG-35, $\lambda = 6328 \text{ \AA}$) operating in the multimode regime with approximate output power 15 MW. The light scattered by the solution was focused with a lens on the cathode of a photomultiplier (FEU-27) covered by a diaphragm of about 1.5 mm diameter. The ac component of the photomultiplier current was amplified by two series-connected UR-3 amplifiers and fed to the input of an S4-8 analyzer.

The total half-width of the apparatus spectrum of the spectrometer was $7 \pm 0.5 \text{ kHz}$, of which approximately 4 kHz belong to the analyzer band and 3 kHz to the laser line.

Figure 1 shows the signal observed on the spectrum analyzer in the case of scattering at an angle $\theta = 90^\circ$ in a solution of acetone in carbon disulfide. Inasmuch as in the solutions under consideration the intensity, per unit frequency, of scattering by density fluctuations is approximately 10^3 times larger than for entropy fluctuations, and approximately 10^4 times larger than for pressure fluctuations, it can be assumed that the observed signal is due to scattering by density fluctuations in practically all cases.

According to theory [1]

$$\Delta \nu_{\text{conc}} = \frac{1}{\pi} n^2 D k^2 (1 - \cos \theta),$$

where $\Delta \nu_{\text{conc}}$ is the half-width of the scattering line in Hz, n the refractive index of the solution, D the diffusion coefficient, and k the wave vector of the exciting light.

From the measured half-widths, with allowance for the apparatus function, we determined

the diffusion coefficients in accord with the formula (see the table).

Table

Solution components		Concentration B	$10^{-5} D$ cm ² /sec
A	B		
CS ₂	C ₃ H ₆ O	10% by wt.	0.30 ± 0.04
n-C ₃ H ₈ O	CHBr ₃	1 M	0.70 ± 0.09 0.71 [5]
		2 M	0.94 ± 0.08
		3 M	1.098 ± 0.120
		4 M	1.10 ± 0.125

The concentration dependence of the diffusion coefficient is shown in Fig. 2.

Figure 3 shows the angular dependence of $\Delta\nu_{\text{conc}}$ in a solution of acetone in carbon disulfide. The experimental data are in satisfactory agreement with the theoretical formula.

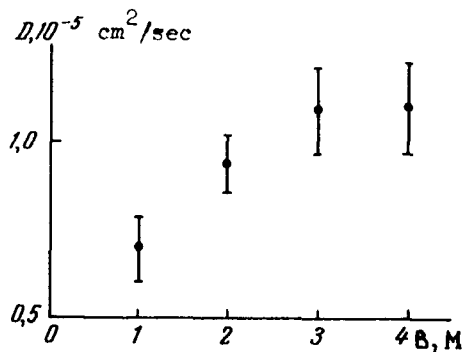


Fig. 2. Concentration dependence of the diffusion coefficient in a solution of bromoform in n-propanol.

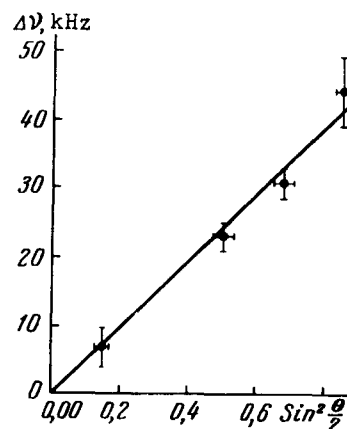


Fig. 3. Angular dependence of the half-width of the central component for a solution of acetone in CS₂.

It must be noted in conclusion that measurements of the diffusion coefficients by physical-chemistry methods are complicated and consume much time [6]. On the other hand, the diffusion coefficients are determined by the method of heterodyning the scattered light almost instantaneously.

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EXPERIMENTAL INVESTIGATION OF THE SURFACE SUPERCONDUCTIVITY OF NIOBIUM

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According to [1], surface superconductivity is possessed by superconductors with a Ginzburg-Landau parameter $0.42 < \kappa < \infty$, including superconductors of the second kind ($1/\sqrt{2} < \kappa < \infty$).

We consider a long cylinder of radius $R \gg \xi$ placed in a longitudinal magnetic field $H_{c2} < H_0 < H_{c3}$. The surface layer of the cylinders forms a superconducting tube surrounding non-superconducting metal. When the magnetic field varies, a current is induced in the tube and screens the inner part of the cylinder.

According to [2], the current reaches a critical value when its magnetic energy becomes equal to the configuration energy enclosed in the superconducting surface layer.

The dependence of the critical value of the current J_c and of the associated magnetization $\pm 4\pi M_c$ of the cylinder on an external magnetic field parallel to the surface is of the form

$$4\pi M_c = \frac{4\pi J_c}{c} = \pm \eta \frac{H_c}{\kappa} \left(\frac{2\lambda}{R} \right)^{1/2} \frac{\Delta}{\xi} F^2(R),$$

where η is a factor on the order of unity, H_c the thermodynamic magnetic field, λ the depth of penetration, R the cylinder radius, Δ the layer thickness, and $F(R)$ the modulus of the wave function on the cylinder surface.

The quantity $(\Delta/\kappa\xi)F^2(R)$ as a function of H_0/H_{c2} is tabulated in [2]. A theoretical calculation of the critical state of the surface layer of the cylinder is also given in [3].

It is seen from the formula that greatest interest attaches to an experimental investigation of superconductors with $\kappa \sim 1$. The only element that is a superconductor of the second kind with $\kappa = 1.1$ at 4.2°K is niobium. The magnetic properties of niobium in the field range $0 < H_0 < H_{c2}$ were investigated in detail in [4], but no verification was made of the concept of the critical state of a superconducting surface layer of niobium samples.

We have investigated cylindrical niobium samples of 0.4 mm diameter and 15 mm length subjected first to thermal etching in oil-free vacuum of 10^{-7} Torr at a temperature close to melting. Control measurements of the sample quality, made in the range $0 < H_0 < H_{c2}$ by a ballistic method, have demonstrated the absence of quenched magnetic moments. The values of H_{c1} and H_{c2} agree with the data of [4].

The procedure for measuring the magnetization of the samples in the $H_{c2} < H_0 < H_{c3}$ region