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Meetings and Conferences

SCIENTIFIC SESSION OF THE DIVISION OF GENERAL PHYSICS AND ASTRONOMY, USSR ACADEMY OF SCIENCES

Moscow, 23–24 April 1969

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A scientific session of the Division of General Physics and Astronomy of the USSR Academy of Sciences was held on 23 and 24 April 1969 in the conference hall of the P. N. Lebedev Physics Institute. The following papers were delivered at the session:

1. V. S. Starunov and I. L. Fabelinskiĭ, New Investigations of Thermal and Stimulated Molecular Scattering of Light.
2. A. A. Berdyev and N. B. Lezhnev, Acoustic Investigations of Liquids at Microwave Frequencies.
3. A. G. Masevich, Certain Problems of the Evolution of Stars.
4. M. A. Gintsburg, Nonlinear Waves in Cosmic Plasma.
5. A. Ya. Kipper, Certain Theoretical Problems in the Formation of Magnetic Fields of Stars and Nebulas.
6. V. A. Akulevich, L. R. Gavrilov, V. G. Grebinnik, V. A. Zhukov, G. Liebmann (East Germany), A. P. Manych, L. D. Rozenberg (deceased), Yu. A. Rudin, and G. I. Selivanov. Influence of Ultrasound on the Formation of Tracks of High Energy Particles in a Liquid-hydrogen Bubble Chamber.
7. G. A. Smolenskiĭ, R. V. Pisarev, and I. G. Siniĭ, Investigation of Magnetooptic Phenomena in Ferro- and Antiferromagnets.

We present below a brief summary of some of the papers.

V. S. Starunov and I. L. Fabelinskiĭ. New Investigations of Thermal and Stimulated Molecular Scattering of Light.

In the paper, which was delivered by I. L. Fabelinskiĭ, principal attention was paid to two new phenomena, which were first observed by the authors of the paper and their co-workers.

One new phenomenon in thermal scattering is the fine structure of the Rayleigh line wing (FSW) and consists in the fact that a doublet is observed[1] in a narrow section of the wing (such a wing characterizes the scattering spectra of a rather large number of liquids). Taking part in this investigation were E. V. Tiganov (Kemerovo) and L. M. Sibirov (Samarkand).

The second new phenomenon is stimulated by scattering of light in the Rayleigh line wing (StSW) was observed about four years ago[2]. The present article dealt with the latest investigations of the authors, dealing with the features of this phenomenon and some of its applications. Yu. I. Kyzylasov (Kemerovo) took part in this investigation.

The paper reported very briefly the progress attained in measurements, using gas lasers, of the velocity and absorption of hypersound by determining the relative positions and the widths of the Mandel'shtam-Brillouin components, initiated by the authors[3]; this method subsequently found extensive applications in investigations of the hypersonic properties of various media[4].

In the study of the FSW phenomenon, it became clear that the distance between the maxima of the doublet is different for different liquids and lies in the range $(4-10)\times 10^{-2}$ cm^{-1}. The phenomenon was investigated in liquid aniline, nitrobenzene, salol, and quinoline.

It is proposed that the FSW is due to modulation of the scattered light by the anisotropy fluctuations caused by transverse hypersonic Debye waves. This hypothesis was confirmed by measurements of the dependence of $\Delta\nu_T$ on $\sin(\vartheta/2)$, which turned out to be linear. The FSW phenomenon was later observed in six liquids by Stegeman and Stoicheff[5], who also obtained a linear dependence of $\Delta\nu_T$ on $\sin(\vartheta/2)$ and agree with the explanation proposed by the authors[1] for the nature of the FSW. In addition, the authors performed polarization measurements of the scattered light, which also yielded evidence in favor of the assumptions made concerning the nature of the FSW.

If the proposed explanation is correct, then FSW should be described by the formulas of the theory of Leontovich and Rytov, which give the distribution of the intensity in the spectra of light scattered by the anisotropy fluctuations due to shear fluctuations[6]. Measurement of the distance between the components of the doublet yielded for different liquids a hypersound velocity from 200 to 600 m/sec and a shear modulus $u \sim 10^9$ dyne/cm^2. The kinetics of the variation of the FSW in liquid salol was investigated[7] with η varying between 10^{-3} to $\sim 10^9$ poise (Fig. 1). FSW of the same character as in quinoline and other low-viscosity liquids was observed[1,5] in the temperature interval from +120 to 46°C ($\eta \sim 10^{-3}-10^{-1}$ poise).

In the temperature interval from 45 to 3°C, the FSW could not be observed. Starting with 3°C, a doublet again appears, recalling the "transverse" components of scattered light in glasses[8]. It is difficult to interpret the temperature dependence of $\Delta\nu_T$ (Fig. 1) at low viscosities ($\eta \sim 10^{-3}-10^{-1}$ poise). It is apparently necessary to take into account in the theory of the phenomenon the fact that the relaxation time of the anisotropy and the Maxwellian relaxation time are different quantities. If it is assumed that at low viscosities the modulus of the orientational elasticity $\mu_a = \eta/\tau_a$ ($\tau_a = 4\pi a^3\eta/3kT$), then $\mu_a \sim NkT$, where N is the number of molecules per cm^3. An estimate of μ_a from this expression gives the correct magnitude and even a nearly correct temperature dependence, but one can hardly regard such an expression for μ_a as fully proven.

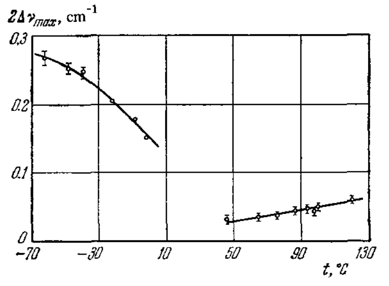

FIG. 1. Temperature dependence of $(2\Delta\nu_T) \approx (2\Delta\nu_{max})$ – the distance between the components of the fine structure of the Rayleigh-line wing in salol [7].

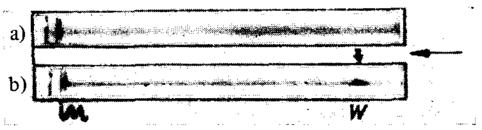

FIG. 2. Photograph of two-photon luminescence of the exciting radiation (8) and of the light scattered by nitrobenzene (b). W – maximum of two-photon luminescence, showing the existence of picosecond pulses in the stimulated scattering of light in the Rayleigh-line wing [11].

The performed experiment raises the question of a new theoretical investigation of this problem.

The authors observed and investigated four-photon interaction in stimulated scattering of the Rayleigh line; it is shown that such an interaction can cause the appearance of anti-Stokes and a large number of Stokes components of SMBS in liquids consisting of anisotropic molecules[9].

It has been previously proposed[10] that the back-scattered ($\vartheta = 180°$) StSW radiation contains ultrashort or picosecond radiation pulses of duration $t_s \leq 10^{-11}$ sec; these pulses were subsequently observed[11].

Ultrashort pulses in StSW were registered with the aid of a two-photon luminescence procedure. The scattered light passed through a vessel with a solution of rhodamine-6Zh in alcohol and was reflected backwards by a mirror. If the radiation contained short pulses, then the points of their encounter in the luminescent solution should reveal maxima of two-photon luminescence.

From the distance between these maxima it is possible to determine the time between two neighboring pulses, and from the widths of the maxima it is possible to determine the pulse duration. The StSW was excited with a giant ruby-laser pulse of power ~150–200 MW and duration 10^{-8} sec, focused inside a vessel with nitrobenzene.

Figure 2b shows the maximum of two-photon luminescence and demonstrates that the StSW radiation contained not less than two ultrashort pulses. Such pulses could be registered only if the spectrum of the scattered light revealed an intense Stokes StSW with total extent ~0.5–1.5 cm^{-1}.

The existence of the ultrashort StSW pulses explains[10,11] why the StSW spectrum usually reveals a band instead of the narrow line predicted by the stationary theory. The ultrashort StSW pulses can have a duration $t_s \sim \tau$, where τ is the anisotropy relaxation time, and consequently their spectral width is $(\Delta\Omega)_{max} \sim 1/\tau$.

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A. A. Berdyev, and N. B. Lezhnev. Acoustic Investigations of Liquids at Microwave Frequencies

The paper is a review of experiments performed in liquids at high and microwave frequencies, and also of the results obtained in the Laboratory of Molecular Acoustics of the Physicotechnical Institute of the Turkmenian Academy of Sciences.

In experimental investigations of the parameters of the liquids at microwave acoustic frequencies was carried out both by an optical method of investigating the fine structure of the line of Rayleigh scattering of lime, where incoherent radiation of phonons is used, and by direct methods in which the coherent sound is generated artificially. Whereas only a few years ago these experimental methods were separated by a frequency region extending over almost two orders of magnitude, this experimental gap has now been eliminated, owing to the efforts of Soviet and foreign scientists.

The theoretical concepts and the experimental facts show that the ultrasonic relaxation in liquids appears in a very wide range of frequencies. The acoustic apparatus developed by the authors for the frequency region 10^7–3×10^9 Hz, where new materials and methods of generating and receiving microwave acoustic frequencies are used, has made it possible to gain a greater insight in the mechanism of relaxation effects in a number of individual and viscous liquids, and also electrolyte solutions.

Recently, in connection with the development of radioelectronic and semiconductor techniques, new possibilities have appeared of obtaining microwave