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INVESTIGATIONS OF INDUCED RAMAN SCATTERING IN MIXTURES

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Submitted to JETP editor November 10, 1964

J. Exptl. Theoret. Phys. (U.S.S.R.) 48, 378-380 (January, 1965)

WE present in this report the results of an experimental investigation of the excitation threshold and line intensity of induced Raman scattering. We studied the dependence of these quantities on the concentration of the investigated medium in the mixture, and also the dependence of the intensity of the Raman lines on the intensity of the exciting light.

1. The excitation threshold was measured by means of the method described in[1]. Mixtures of carbon disulfide and benzene were investigated.

The results of the measurements of the excitation threshold of the CS_2 lines with frequency 656 cm^{-1} are shown in Fig. 1. Excitation of this line in our installation could be realized at a volume concentration of CS_2 in the mixture ranging from 100 to 50%. At a 40% concentration, the excitation of the 992 cm^{-1} of benzene started.

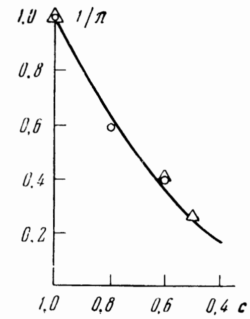

FIG. 1. Dependence of the excitation threshold of the 656 cm^{-1} carbon disulfide line on the concentration. Continuous line – $1/\pi = c^2$, the points correspond to two series of experiments.

As shown by the results, the reciprocal of the excitation threshold π is proportional, within the limits of experimental error, to the square of the concentration c of the carbon disulfide in the mixture. Thus, by combining this result with the previously obtained[1] dependence of the threshold on the intensity of the line in the spectrum of ordinary Raman scattering I_{ord}, we can write

$$1/\pi = AI_{ord}c^2, \quad (1)$$

where A—factor depending on the employed installation and on the experimental conditions.

2. In the study of the dependence of the intensity of the lines in the induced Raman scattering spectrum on the intensity of the exciting light, we used the method of photographic photometry. The blackening marks were produced with the aid of an optical step wedge, and the source of the light in this case was a flash from a ruby laser (to avoid the influence of the Schwarzschild factor). During the processing and measurement of the spectrograms, the usual methods were employed with all the necessary precautions.

To broaden the range of the measured intensities, neutral optical filters were used, the transmission of which was measured with the same installation [1)]. To measure the intensity of the exciting light we used, as in the measurement of the threshold[1], a stack of glass plates.

The measurements have shown that the intensity of the induced Raman scattering lines, I, is determined by the excess of intensity of the exciting light I_{exc} over threshold, that is, by the quantity $x = I_{exc} - \pi$. In the mixtures, the quantity I turned out to be approximately proportional to the square of the concentration of the given component.

These results can be written in the form of a general formula:

$$I = Bc^2 f(x). \quad (2)$$

Here B—a factor which is constant for the given experimental conditions. The function f(x) is described with sufficient accuracy by the expression

$$f(x) = e^{kx} - 1, \quad (3)$$

where k—coefficient that depends on the choice of the measurement units for x. Taking (3) into account, we can rewrite (2) in the form

$$kx = \ln(1 + y), \quad (4)$$

where we put $y = kI/B'c^2$; $B' = kB$. The values of the constants B′ and k can be obtained in the following fashion. For small x and y we get from (4) $kx = y$, which yields $B' = I/c^2x$ (here I and x are expressed in the arbitrary units adopted in the given experiment). The constant k is determined from the requirement that Eq. (4) be satisfied for a certain (sufficiently large) value of x.

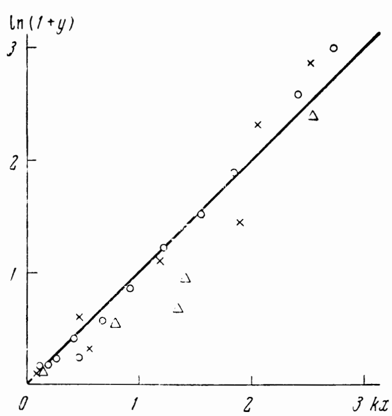

FIG. 2. Dependence of the intensity in the spectrum of induced Raman scattering on the excess of intensity of the excited light above the threshold (CS_2, 656 cm^{-1}): o – pure CS_2; × – mixture 60% CS_2 + 40% C_6H_6; Δ – mixture 50% CS_2 and 50% C_6H_6.

Figure 2 shows the measurement results for the 656 cm^{-1} line in pure CS_2 and in its mixtures with benzene (as in the investigation of the threshold, we measured the first Stokes components). It can be seen that all the experimental points lie within the limits of experimental error, on one straight line. This shows that formula (2) represents sufficiently accurately the experiment results.

3. The nonlinear dependence of the line intensity on the concentration, observed in our experiments, is in our opinion of independent interest. In usual Raman scattering, each molecule scatters like an independent system. Accordingly, the intensity of the lines is proportional to the number of particles. Deviations from this law are observed, but are usually small.

The nonlinearity of the radiation intensity relative to the number of particles can occur if the molecules radiate like a single quantum system. The theory of this process is given in the well-known papers by Dicke[2], Faĭn[3] and others. However, this theory cannot be applied directly to Raman scattering. On the other hand, Faĭn and Khanin[4] indicate that a quadratic dependence of the intensity on the number of particles is characteristic of any stimulated emission, independently of the particle interaction. We can hope that the results obtained by us will help answer this group of questions.

In conclusion we thank P. A. Bazhulin, N. G. Basov, and A. M. Prokhorov for interest in the work.

1)It turned out that the transmission of pulsed high-power radiation through the optical filters was considerably larger than when ordinary radiation of the same wavelength is used.

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CURRENT-CONVECTIVE INSTABILITY OF COLLISIONLESS PLASMA

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Submitted to JETP editor November 20, 1964

J. Exptl. Theoret. Phys. (U.S.S.R.) 48, 380-382 (January, 1965).

It was shown in[1] that when current flows through a plasma, an instability may arise, connected with the spatial inhomogeneity of the current. This result was obtained under the assumption that the frequency of collision between the particles and