EXPERIMENTAL OBSERVATION OF THE COMPLETE RAYLEIGH CENTRAL COMPONENT OF THE LIGHT SCATTERED BY A TWO-COMPONENT FLUID

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It is shown experimentally that the Rayleigh central component of the light scattered by a binary solution is composed of two Lorentzian curves.

It has been shown theoretically[1,2] that the Rayleigh central component of the spectrum of light scattered by a two-component fluid is actually composed of two Lorentzian-shaped curves. One corresponds to the scattering of light by density fluctuations (also present in a pure fluid), the other one to the scattering by concentration fluctuations.

The linewidth (in radians/second) of these curves is given by

$$\Gamma_d = (\Lambda'/\rho' C_p')K^2 \qquad (1)$$

for density fluctuations and by

$$\Gamma_c = DK^2 \qquad (2)$$

for concentration fluctuations, where the symbols have the following meanings: K is the scattering vector, Λ' the thermal conductivity of the mixture, ρ' the density of the mixture, and C_p' the specific heat of the mixture at constant pressure. In the limit of dilute mixtures, all these coefficients tend towards the corresponding values of the pure solvent.

$D = \alpha/\chi_T$ is the mass diffusion coefficient of the mixture, where χ_T is the osmotic compressibility and α a transport coefficient. Typical values for liquids are

$$\Lambda/\rho C_p \simeq 10^{-3}\ \mathrm{cm^2\ sec^{-1}}, \quad D \simeq 10^{-5}\ \mathrm{cm^2\ sec^{-1}};$$

so the linewidth of the spectrum originating from density fluctuations is of the order of 100 times greater than that corresponding to concentration fluctuations.

First we investigated the Rayleigh central component for pure CS_2, using a heterodyne photon beating apparatus already described.[3] In this case, the central component is a single Lorentzian curve whose linewidth

$$\Gamma_d = 1.1\times 10^{-3} K^2\ \mathrm{sec^{-1}}$$

is in good agreement with the formula (1), where the values Λ, ρ, and C_p have been taken from static measurements.

Without any change in the experimental setup, 10% in volume of acetone was then added into the scattering cell. After dissolution, the spectrum was found significantly different from that of pure CS_2. Figure 1 shows the results obtained for a scattering angle of 1.05° ($K = 2.89\times 10^3$ $\mathrm{cm^{-1}}$). For both curves the range 0-300 Hz was scanned with a 3-Hz bandwidth and the range 300-10 000 Hz with a 50-Hz bandwidth, using a General Radio Company Model No. 1900A spectrum analyzer.

The broad density-fluctuation Lorentzian curve of CS_2 is only slightly modified by the addition of 10% of acetone. However, an additional narrow curve is evidently present in this last case. This line has already been observed by Aref'ev et al.[4] for greater scattering angles, but the linewidths appear to be quite different.

The existence of two curves was confirmed by

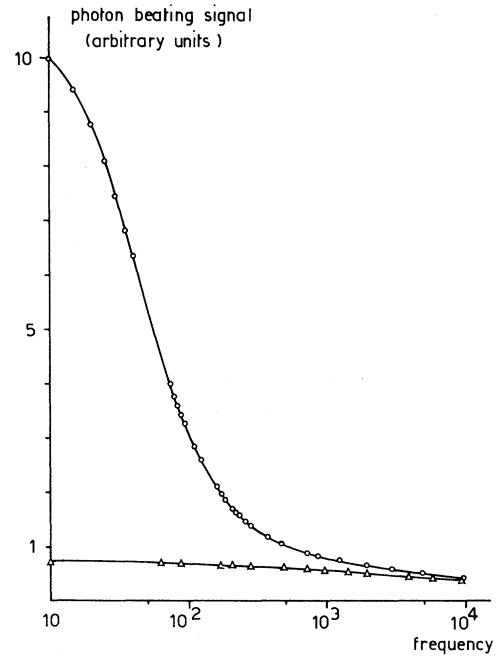

FIG. 1. Comparison of the heterodyne photon beating spectrum of light scattered by pure CS_2 (triangles) and by a mixture of ≃10% acetone in CS_2 (circles). The results shown are the best-fit curves of the experimental results (measurement conditions: laser power 55 mW at 6328 Å, $\theta = 1.05°$, and room temperature).

a computer fit using a two-Lorentzian program which gave very satisfactory results, while all attempts to fit the experimental data by a single Lorentzian curve were unsuccessful.[5]

For a 10%-acetone mixture and for a scattering vector $K = 2.9\times10^{3}$ cm^{-1}, we obtain the following parameters for the two Lorentzian curves (at room temperature):

$$\Gamma_c/2\pi = 31\pm2 \text{ sec}^{-1}, \quad I_c(\omega=0) = 1030\pm60;$$

$$\Gamma_d/2\pi = 1590\pm140 \text{ sec}^{-1}, \quad I_d(\omega=0) = 70\pm2;$$

where $I(\omega=0)$ is the rms spectral density at $\omega = 0$ (arbitrary units).

This permits us to calculate

$$D = 2.32\times10^{-5} \text{ cm}^2 \text{ sec}^{-1},$$

$$\Lambda'/\rho' C_p' = 1.2\times10^{-3} \text{ cm}^2 \text{ sec}^{-1}.$$

This last value should be compared with the corresponding value for pure CS_2 given above.

To our knowledge this is the first time that the complete Rayleigh central component of a binary mixture has been observed. This simultaneous observation of the two Lorentzian curves permits us to evaluate directly the ratio of the total integrated intensities of the light scattered by concentration and density fluctuations. We find for a $\simeq$10% concentration of acetone

$$I_c/I_d \sim 2.$$

More sophisticated experiments are now under way with variable concentrations and scattering angles.

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[4]I. M. Aref'ev et al., Zh. Eksperim. i Teor. Fiz. —Pis'ma Redakt. 5, 438 (1967) [translation: JETP Letters 5, 355 (1967)].

[5]We are greatly indebted to Dr. M. Tournarie for designing the programs and for many stimulating discussions.

REMOTE FEEDBACK STABILIZATION OF COLLISIONAL DRIFT INSTABILITY BY MODULATED MICROWAVE ENERGY SOURCE*

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The collisional drift instability is remotely feedback stabilized by irradiating the plasma with microwaves to heat the electrons locally, by upper-hybrid resonance absorption, at interior plasma locations. The phase and amplitude of the feedback-modulated heating necessary for stabilization agree qualitatively with a linear theory, which includes a feedback-controlled heat source.

Recent work,[1-6] using feedback elements immersed in or in contact with plasmas, has demonstrated feedback stabilization of plasma instabilities and concomitant improvement in plasma confinement. Specifically, the collisional drift instability[7] in the oscillatory regime has been feedback stabilized[6] by immersing electrostatic probes to draw current from the plasma, in agreement with a linear theory which includes feedback-controlled particle sources. The feasibility of feedback control of thermonuclear plasmas, however, depends critically on the availability of remote detection and suppression methods. The present work describes such a remote feedback-suppression method for the collisional drift instability, employing modulated microwaves, and presents a theory which includes a feedback-controlled energy source.

The experiment was performed in the cesium plasma of the Q-1 device ($n_e \simeq 5\times10^{10}$ cm^{-3}, $T = 2800$°K, $B \simeq 4$ kG), with a Langmuir probe as detector and a half-wave dipole antenna (located ~2 cm outside the plasma column, at its midplane) as suppressor. The amplified and phase-shifted ion saturation-current instability signal modulates the microwave source so that its output power is proportional to the instability amplitude. The microwave irradiation heats the electrons,[8,9] by resonance absorption, at interior plasma locations selected by adjusting the microwave frequency to the local upper hybrid frequency $[(f_{ce}^2+f_{pe}^2)^{1/2} \simeq 11$ GHz$]$; correct frequency dependences on both density and magnetic field were measured. Localized heating (deter-