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[9]On the basis of this theory, one would expect that

$$\lim_{k\to 0}[NV(k)/m+2\overline{T}_i(0)/m]^{1/2}\simeq \lim_{k\to 0}[NV(k)/m]^{1/2} \simeq c(0)=239 \text{ m/sec}$$

for He II, which is the value for $c(0)$ to which we have normalized our data. The commonly used phenomenological potentials for helium cannot be expected to yield this value for the phonon velocity because they do not adequately represent the interaction for values of $\vec{r}$ significantly smaller than the equilibrium interatomic separation, nor are they intended to. For example, the familiar 6-12 potential does not even possess a Fourier transform because of its highly singular character at small r, a very unphysical characteristic. However, based on work in progress, we have shown that it is possible to impose a constraint on the phenomenological potential so that the correct experimental value is realized for $c(0)$, and the resulting potential $V(r)$ still agrees with experimental data to within 5% in the vicinity of the equilibrium interatomic separation and at large interatomic separations, which are the only regions where the potential is well known anyway. Thus, it is not unlikely that our results are compatible with known experimental data for $V(r)$ and that all that is required for a complete treatment is a more realistic form for the potential at small $\vec{r}$.

There is, however, another possible interpretation for the quantitative success of this theory. That is, we have in effect actually chosen an effective potential $V_{\text{eff}}=V(k)$, where V_{eff} is such as to yield the observed phonon velocity $c(0)$. This is equivalent to arguing that the short-range correlations which are neglected in the RPA are such as to change $V(k)$ from being simply the Fourier transform of $V(r)$ to that of an effective potential V_{eff}. As to which interpretation is the more correct, it remains to be seen.

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COLLECTIVE SCATTERING OF LASER LIGHT BY A PLASMA

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Several authors[1-5] have reported experiments on the scattering of laser light from electrons in a laboratory plasma. The profiles of the scattered light show a nearly Gaussian distribution, indicating little or no collective effect between the ions and the electrons. It is of interest to observe this collective effect, on the one hand to verify the theory[6,7] which predicts satellite peaks approximately at the plasma frequency, and on the other hand to develop a useful technique for the diagnostics of plasmas. This paper reports an observation of the scattering of light from a pulsed ruby laser by a plasma jet. The profile of the scattered light shows unambiguously the distinct satellite peaks on both sides of the central frequency, indicating strong collective effects between the ions and the electrons.

A plasma jet is used because it is fairly simple to obtain a reproducible plasma with an electron density of 10^{16} to 10^{17} cm^{-3} and an electron temperature of 1 or 2 eV.[8] These conditions make it possible to observe the satellites at a scattering angle of 45°. It is much easier to reduce the stray light when making observations at this large angle as compared to small forward-scattering angles. In addition, since the jet is operated at atmospheric pressure, we need no windows or walls in the neighborhood of the plasma.

The jet is mounted vertically. It draws 280 A at 15 V from a battery and rheostat power supply. The diameter of the jet nozzle is 5 mm. The flow of the argon gas is controlled at a steady velocity of 15 m sec^{-1}.

A TRG giant-pulse ruby laser, with peak power of 10 MW and a pulse duration of 50 nsec, is used. The light from the laser is focused onto a pinhole, and this is then focused with a second lens at the center of the plasma. The light from the laser is monitored with a photodiode. Suitable light baffling and light traps are provided so that the stray light being reflected into the detector system is less than

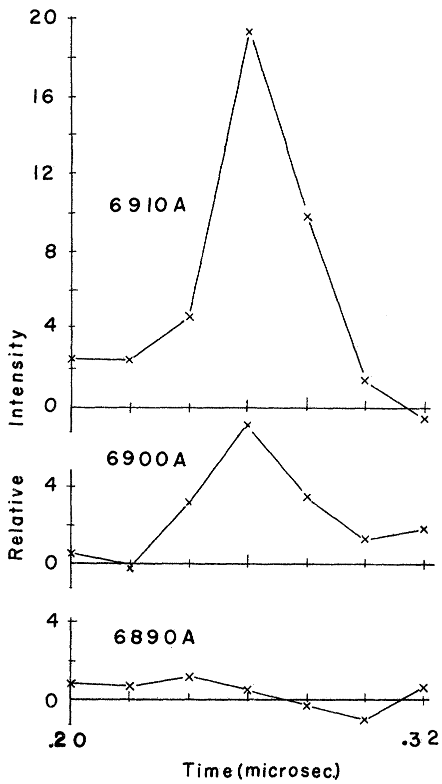

FIG. 1. The average of 10 scope traces, indicating a clear signal at 6910 Å. The laser pulse (λ = 6943 Å) occurs at 0.26 μsec.

10^{-12} of the incident light. The stray light background of the monochromator has been studied carefully to rule out any instrumental effect and, in the range of wavelengths which we are scanning, is negligible compared to the observed scattered signal.

The scattered light was observed at 45° in the forward direction with a Jarrell-Ash 82-010 monochromator and a Philips CVP150 photomultiplier. The outputs of the photomultiplier and of the photodiode monitoring the laser were recorded on a Tektronix 551 dual-beam oscilloscope. The instrument width of the monochromator was set at 8 Å, and the dimensions of the observed plasma were approximately 2 mm × 0.5 mm × 0.5 mm.

Because the Thompson-scattering cross section for electrons is extremely small, the expected scattered signal is small, and its detection is ultimately limited by the shot noise in the photomultiplier due to the plasma radiation. The signal-to-noise ratio is about 1.5 and so we found it necessary to use a sampling technique.

At each of the 14 selected wavelength settings of the monochromator 10 shots were taken, and the oscilloscope trace of photomultiplier output and photodiode output were photographed. The vertical scope deflection for each of the shots were measured at seven horizontal points near the time of occurrence of the laser pulse and the 10 readings were averaged. Figure 1 shows some typical average traces. It is easily seen that there is a good signal at 6910 Å

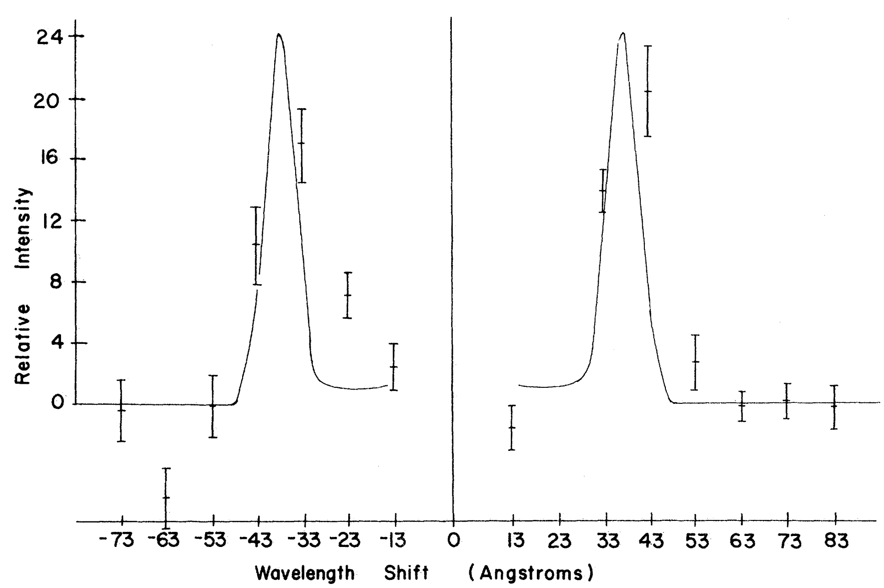

FIG. 2. The scattered signal as a function of wavelength. Also shown is the theoretical curve for 13 500°K, an $\alpha = 4.4$, an instrumental width of 8 Å, and an intensity chosen arbitrarily.

but not at 6890 Å.

The relative intensity of scattered radiation as a function of wavelength is plotted in Fig. 2, where the vertical bars represent the standard deviation for the 10 experimental values. It is readily seen that satellites occur at about ±38 Å. The experimental point at ±23 Å is purposely omitted because the argon line at 6965 Å saturates the photomultiplier making it impossible to obtain a signal.

We attempted a least-squares fit of the theoretical curves to our experimental points but were unable to obtain a good fit because the observed linewidth is much wider than that predicted by the theory. The discrepancy may be accounted for by a variation of temperature in the plasma we observe. According to Ahlborn,[8] the temperature changes from 13 500 to 11 500°K in a distance of 1 mm. This leads to a decrease in electron density of one-half, if we assume local thermal equilibrium, and a spread of peak frequencies of the satellites of about 12 Å. This agrees very well with the width of the line observed.

If we use Ahlborn's value of 13 500°K for the temperature of the center of the plasma jet and estimate α (defined in Ref. 6) to be 4.4, we obtain a theoretical curve whose peaks coincide with the experimental peaks as shown in Fig. 2. This value of α leads to an electron density of 6.3×10^{16} cm^{-3}, in good agreement with the assumption of local thermal equilibrium.

We wish to acknowledge the enthusiastic support of our many colleagues in the Plasma Physics Group. In particular, we wish to thank Dr. J. H. Williamson for his service in programming the theoretical best fits.

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MODULATED F-CENTER ABSORPTION IN KCl

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The possibility of existence of higher excited states of the F center at energies corresponding to those of the conduction band has recently stimulated a great deal of theoretical investigation.[1-4] The occurrence of localized states of relatively long lifetime into a continuum of levels raises, in fact, a number of problems for the theory of solids.[5] The suggestion that optical transitions to higher excited states from the fundamental level of the F center were responsible for the absorption of the L bands in alkali halides was made by Lüty[6] on the basis of proportionality among L, K, and F bands. However, the proportionality between the F and K bands has been at times doubted,[7] and the ratio between the height of F and L bands in crystals x rayed at low temperature is only approximately equal to that found in additively colored crystals.[8] Doubts have also been raised in connection with the controversial value of the yield for photoionization into the L bands, and a different model for the L and the K "centers" has even been suggested.[9-11]

In this Letter we present direct experimental evidence that the L and K absorption bands in KCl are caused by transitions starting from the fundamental state of the F center. The results are obtained by use of a method of "modulated optical absorption" which is capable of being applied to other problems of current research in the field of color centers.

The principle of the method is the following: A crystal of additively colored KCl is exposed, at low temperature, to an intense beam of F light whose intensity varies with time at a frequency ν_0. As a result of this excitation, both