oscillations of the lead lattice.

As can be seen from Fig. 3b, the presence of lattice defects broadens the maximum of $\alpha^2(\omega)F(\omega)$ near 8.5 mV by a factor of more than 2. Since the electron mean free path* even in the most deformed sample is $\ell >> 1/q$, this change cannot be attributed to the function $\alpha^2(\omega)$. The broadening of the maxima is obviously due to the smearing of the Van Hove singularities in the strongly distorted lattice. Such a result follows qualitatively also from a theoretical analysis of the spectrum of the disordered system [7]. The most significant change is experimenced by the function $\alpha^2(\omega)F(\omega)$ in the region of low energies, where a more intense smearing of the maxima takes place down to $\omega \to 0$, and where, in addition, an increase takes place in the function $\alpha^2(\omega)F(\omega)$. It is obvious that such a change in the function $\alpha^2(\omega)F(\omega)$ should lead to a change in such characteristics of lead as the specific heat or the electron effective mass, and to an increase in the ratio $2\Delta_0/kT_c$. The presence of the latter effect follows from the foregoing experimental data. These effects will be examined in greater detail after the reconstructed function $\alpha^2(\omega)F(\omega)$ is established more precisely.

The increased role of oscillations with large energies in the electron-phonon interaction, observed in the case of lead condensed at helium temperature, is apparently typical for metals with a crystal lattice distorted to the limit.

The author is grateful to P. L. Kapitza for continuous interest in the work, to A. R. Yaroshenko for taking part in the initial stage of the work, and to B. D. Yurasov for the performance of the complicated glass-blowing work.

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*The electron mean free path was 3×10^{-7} and 5×10^{-7} cm respectively for samples condensed at 1.6°K and annealed to 80°K. For samples annealed to 300°K, the mean free path ranged from 1.4×10^{-6} to 5×10^{-6} cm.

NONLINEARITY OF MEDIA DUE TO INDUCED DEFORMATION OF MOLECULES, ATOMS, AND PARTICLES OF A MEDIUM

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Submitted 6 June 1967
ZhETF Pis'ma 6, No. 5, 672-674 (1 September 1967)

The appearance of powerful laser sources of light makes it urgent to investigate new mechanisms effecting the change of polarizability of a medium in powerful beams. Such phenomena can cause self-focusing (see [1-4] and a number of succeeding papers), nonlinear beam interaction, etc. In this article we consider new nonlinear effects whereby the polarizability of a medium is increased by induced defromation of molecules or particles.

1. Deformation and Increase in Polarizability of a Molecule in a Strong Light Field

The averaged electric pressure $P_{el} = E^2/8\pi$ in a laser beam can reach hundreds of thousands of atmospheres, making appreciable deformation of the molecules possible (even at ten thousand atmospheres, the compressibility is connected with compression of the molecules, since the density of matter exceeds the molecular density at low temperature). The anisotropy of the electric pressure [for example, the electric field pressure on the surface of a conducting sphere, $P_{el} \approx (9/8\pi)E_0^2 \cos^2\theta$ is maximal in the field direction] produces strong deformation even in those cases when the changes of the volume are small. Since estimates of the polarizability of atoms and molecules are frequently obtained by using the model of "metallic" spheres (the polarizability of an atom is close in magnitude to the polarizability of a conducting sphere having the same radius), we shall henceforth use that model to estimate the field pressure deforming the molecule.

The polarizability of a conducting spheroid is $\alpha_x = V/4\pi n_x$, where V is the volume and n_x the coefficient of depolarization (see, for example, [5]). If the spheroid is close to a sphere, then $n_x = 1/3 - (4/15)(a - b)/R$, where a and b are the major and minor semiaxes of the spheroid and R is the radius of the deformed sphere. The change in the polarizability of a molecule, due only to a change in its shape,

$$\Delta\alpha_1 \simeq \frac{3V}{5\pi}\frac{(a-b)}{R} \simeq \frac{4}{5}\alpha_0\frac{(a-b)}{R},$$

as well as that due only to a change in its volume, $\Delta\alpha_2 \approx \alpha_0(\Delta V/V)$, result in a nonlinear increment $\Delta\varepsilon \approx 4\pi N_A \Delta\alpha$ to the dielectric constant (neglecting the corrections for the internal field), N_A being the particle concentration per unit volume of the medium.

Depending on the type of the model used to describe the properties of the molecule, we obtain different expressions for the deformation. For example, the change in the volume is $\Delta V/V \approx 3E_0^2/8\pi K$ for a molecule; deformation of a solid sphere gives [5]

$$\frac{a-b}{R} \propto \frac{9E_0^2}{40\pi\mu},$$

where μ is the shear modulus; deformation of a drop gives $(a - b)/R \approx 9E_0^2R/16\pi\sigma$, where σ is is the surface tension, i.e., the change in the polarizability is $\Delta\alpha/\alpha \approx P_{el}/P_{mol} \approx E^2/8\pi P_{mol}$, where P_{mol} is the pressure required for a strong deformation of the molecule). We assume for this pressure a value $P_{mol} \approx 10^4 - 10^5$ atm, for at pressures on the order of tens of thousands of atmospheres the compressibility decreases greatly, and further compression of matter is the result of the compression of the molecules, as indicated by the kink in the compressibility and the fact that the density of the matter exceeds the values at low temperatures. (The deformation of atoms apparently requires higher pressures than the deformation of molecules.) Using this value of the molecular pressure, we obtain for the deformation-induced change of the polarizability $\Delta\alpha/\alpha \approx 10^{-12}E_0^2$, which is smaller by only several times than the maximum value of $\Delta\alpha/\alpha$ due to the orientation of very strongly elongated molecules in the case of the optical Kerr effect, for which $\Delta\alpha/\alpha \approx \alpha E^2/KT \approx 10^{-11}E_0^2$ for $\alpha \approx 10^{-24}$ cm^{-3} and $T \approx 300°$. the coefficient n_2 in the expansion of the refractive index $n = n_0 + n_2E^2$ is determined from the formula

$$n_2 \simeq \frac{\epsilon_2}{2n_0} \simeq \frac{4\pi N \Delta\alpha}{2n_0 E^2}, \qquad \frac{n_2^{\text{defor}}}{n_2^{\text{Kerr}}} \simeq \frac{\Delta\alpha_{\text{defor}}}{\Delta\alpha_{\text{Kerr}}} \simeq 0{,}1$$

for strongly elongated molecules, but for molecules with a small high-frequency Kerr effect the nonlinearity due to deformation may become predominant and fundamental.

The deformation time of molecules is exceedingly short ($t \leq 10^{-13}$ sec), and therefore the deformation sets in rapidly and quasistatically, and has time to follow the field even for different thermal motions of the molecules. Resonant increase of the deformation and the polarizability of molecules is possible by modulating the light intensity at a frequency close to the natural frequency of the molecules, i.e., by exciting the molecule [6]. Such processes are particularly plentiful in the presence of stimulated Raman scattering.

All this shows that even in those media in which the optical Kerr-effect constant is small or zero, high-intensity beams can increase the refractive index very rapidly as a result of the deformation of the molecules, and produce self-focusing conditions with a very short time lag, much shorter than the lag in the case of striction.

The strong deformation of polyatomic molecules in an intense light field can cause strong realignment of the atoms in the molecule. All this greatly expands the class of media in which rapidly occurring self-focusing is observed.

2. Artificial Media with Nonlinearities

The idea of producing artificial dielectrics, such as those widely used in radio, can be used to attempt to produce an artificial dielectric with strong nonlinear properties. The simplest analog of such a medium is one with suspended particles (suspensions, emulsions, colloidal solutions), whose polarizability changes when the field is turned on. This change in the polarizability can be connected with orientation of the particles (if they are not spherical), with their deformation under the influence of the field, with their thermal expansion, etc. In the case of media with anisotropic particles, the change in the polarizability of the medium is

$$\Delta\kappa \simeq N_{\text{part}} \Delta\alpha \simeq N_{\text{part}} \alpha \frac{\alpha E^2}{KT} \simeq \kappa_{\text{part}} \frac{\alpha E^2}{KT},$$

where κ_{part} is the maximum polarizability of the particles, and the factor $\alpha E^2/KT$ determines the disorienting action of the temperature. In view of the fact that the particle dimensions are many times larger than the molecule dimensions, this factor is much larger for particles than for molecules. Thus, strong nonlinear properties can be expected at much lower field intensities. The large particle dimensions facilitate their deformation (in the case of liquid particls, $\Delta\alpha/\alpha \approx E^2R/8\pi\sigma \sim R$ and $\Delta\alpha \sim R^4$), heating, thermal expansion (which gives $\Delta\alpha/\alpha \approx \Delta V/V \approx \chi\Delta T$, where χ is the coefficient of thermal expansion), etc. The transient time in the change of the properties of the medium cannot be very short, owing to the large particle dimensions, but such media with artificial nonlinearity can be used to study the self-focusing of not very powerful prolonged radiation fluxes, and to simulate various nonlinear processes. The properties of such media can be altered by external and magnetic field and can be controlled.

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ERRATA

In JETP Letters V. 6, No. 4, p. 101, 5th line from top:

read "data for hypersonic waves [4]."

On the same page, 4th line from the bottom:

read "In a strong light field, saturation occurs....