effects (say impurity atoms). However, unlike the latter (compare with quasilocal oscillations [6]), the singularities (4) and (5) become clearly manifest even if the case when the fall in the region of the continuous spectrum of the matrix $(0, \omega_{0max})$; ω_{pI} is only limited in that it must not belong to the region (1) (when $f_{\parallel} = f_{\parallel cr}$), which in general is much narrower than the band $(0, \omega_{0max})$.

Singularieties of type (4) or (5) should obviously be possessed by the functions of the state density of elementary excitations of arbitrary type, if localized states near extended defects are possible for these excitations.

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FORMATION OF ULTRASHORT PULSES OF COHERENT LIGHT

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1. Considerable progress was made recently towards the production of ultrasound pulses of coherent light by amplification in the nonlinear regime [1], and especially by linear absorption [2]. The laser of De Maria et al. [2] represents essentially a two-component laser medium, in which (unlike the two-component medium of [1]) the nonlinearly-absorbing component (saturable solution) effects compression of the pulse, and the amplifying component (neodymium glass) compensates for the unavoidable losses and allows generation to develop from the level of spontaneous noise. The purpose of the present letter is to examine the dynamics of the compression of the light pulses at maximum pulse-compression rate. Our results also describe the dynamics of light-pulse compression in a laser with self-phasing of modes by nonlinear absorption [2].

2. We shall consider the propagation of a light pulse in a two-component medium made of two-level absorbing and amplifying particles. The parameters of the medium and of the pulse satisfy the following conditions (the indices 1 and 2 pertain to the amplifying and absorbing particles, respectively):

$$T_1^{(1)} >> \tau_p >> T_1^{(2)}, T_2^{(1)}, T_2^{(2)}, \tag{1}$$

$$E_s^{(1)} >> E_s^{(2)}, E, \tag{2}$$

where τ_p and E are the duration and energy (in photons/cm^2) of the pulse, $E_s^{(1)} = \hbar\omega_0/2\sigma_i$

the gain or absorption saturation energy, σ_i the cross section of the radiative transition, $T_1^{(i)}$ the spontaneous lifetime of the particles at the upper level, and $T_2^{(i)}$ the time of transverse relaxation of the particles (i = 1, 2). Under conditions (1) and (2) the amplification remains unchanged, and the absorption follows in quasi-stationary manner the intensity of the pulse. Then the change of the waveform of the pulse $I(\tau, x)$ ($\tau = t - x/c$, x is the propagation direction, x = 0 is the boundary of the medium, and c is the velocity of light in the medium) is described by the equation

$$\frac{\partial P(x, \tau)}{\partial x} = P(x, \tau)\left(\alpha - \frac{\gamma}{1 + P(x, \tau)}\right), \tag{3}$$

where $P(\tau, x) = 2\sigma_2 T_1^{(2)} I(\tau, x)$ is the dimensionless intensity, and α and γ are the initial gain and absorption coefficients per unit length. Inasmuch as the absorption decreases with increasing intensity, the vertex of the pulse is absorbed less than the leading and trailing fronts and, consequently, the light pulse becomes compressed upon propagation.

It is easy to obtain a solution of (3), but it cannot be expressed in explicit form. It is therefore more convenient to operate with the rate of compression of the pulse, $W = d\tau_p/dx$, which can be obtained from the relation $P(x, \tau_p) = (1/2)P_m$, where $P_m = P(x, 0)$ is the intensity of the pulse at the maximum, and with Eq. (3):

$$\frac{d\tau_p}{dx} = -\frac{\gamma P_m^2}{2(1+P_m)(2+P_m)}\left(\frac{\partial P}{\partial \tau}\Big|_{\tau=\tau_p}\right)^{-1}. \tag{4}$$

For pulses with gradual fronts we have

$$\frac{\partial P}{\partial \tau}\Big|_{\tau=\tau_p} \simeq \frac{1}{2}\frac{P_m}{\tau_p}$$

and consequently the following differential equation holds for the duration of such pulses:

$$\frac{d\tau_p}{dx} = -\tau_p \frac{\gamma P_m}{(1+P_m)(2+P_m)}. \tag{5}$$

It follows from (5) that the rate of compression of the pulse is maximal when $P_m = \sqrt{2}$ and tends to zero in limiting cases of small and large intensities.

3. In a laser with self-phasing of the modes, the intensity of the initial pulse is $P_0 \ll 1$, and the compression process is quite slow:

$$\tau_p = \tau_p^0 \exp\left\{-\frac{\gamma}{2}\frac{P_0}{(\alpha-\gamma)}[\exp(\alpha-\gamma)ct - 1]\right\}, \tag{6}$$

where $P_m = P_0 \exp[(\alpha - \gamma)ct] \ll 1$ and τ_p^0 is the initial duration of the pulse. Considerable compression of the pulse starts from the instant when the pulse intensity reaches the value $P_m = (\alpha - \gamma)/\gamma$ and continues until P_m grows to a value $\simeq 1$. Starting with this instant, a rapid growth of the power begins, due to the strong saturation of the absorption (automatic

Q-switching), which is accompanied, according to (5), by a decrease in the rate of pulse compression when $P_m \gg 1$. During the time the dispersion of the medium is capable of leading to broadening of the pulse. When the excess of initial gain over threshold is sufficiently small

$$\left(\frac{a-\gamma}{\gamma} \ll \left(\frac{T_1^{(2)}}{r_p^0}\right)^2\right),$$

the pulse duration at the instant τ_{pm} of Q-switching becomes comparable with $T_1^{(2)}$. Then further narrowing of the pulse is already limited by the fact that the saturating component does not have time to "collapse" on the trailing edge of the pulse. The foregoing picture of the generation explains the main features of the operating regime of the laser of De Maria et al. [2,3].

4. The greatest speed of pulse compression can be obtained by maintaining constant the maximum intensity of the pulse $P_m = \sqrt{2}$. To this end, the gain and the absorption coefficients should be connected by the relation

$$a = \frac{\gamma}{1+\sqrt{2}} \tag{7}$$

i.e., the medium must be amplifying only at intensities $P_m \geq \sqrt{2}$. In this case the pulse compression obeys the law

$$r_p = r_p^0 \exp\left[-\frac{\gamma x}{(1+\sqrt{2})^2}\right] = r_p^0 K^{-(1/1+\sqrt{2})}, \tag{8}$$

where $K = e^{\alpha x}$ is the gain of the active component.

In practice, a two-component medium is a sequence of alternating amplifying and absorbing elements with gain ≈ 3 per element, such that the intensity of the P_m lies in the interval $P_m \simeq 0.8 - 2.5$. The gain of all the amplifying elements K should be connected with the absorption coefficient of all the absorbing elements $R = e^{\gamma x}$ by the relation $R = K^{1+\sqrt{2}}$. It is perfectly feasible to obtain $K \simeq 10^5$, and consequently to reduce the pulse duration by a factor 10^2. The intensity of the input pulse P_m should be on the order of $\sqrt{2}$. Substances suitable for use as amplifying and absorbing components are those used in lasers with self-phasing of modes [2].

The proposed method makes it possible, first, the shape single ultrasound pulses of light of large power from any given pulse with power $I_m \gtrsim (\sqrt{2}\,\sigma_2 T_1^{(2)})^{-1}\hbar\omega_0$ and, second, to regulate, by varying the length of the medium, the duration of the pulse in the range from the initial value to the limiting value $\sim T_1^{(2)}$; this is of interest in investigations of the interaction between powerful ultrasound light pulses and matter.

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CONCERNING ONE POSSIBLE MECHANISM OF NEGATIVE CONDUCTIVITY OF THIN FILMS IN A TRANSVERSE QUANTIZING MAGNETIC FIELD

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We consider a thin film placed in crossed electric and magnetic fields. Let the magnetic field be directed along the z axis, perpendicular to the plane of the film, and the electric field along the x axis. The conduction current is due to electron scattering. Scattering changes the potential energy of the electron by $-eE(X_2 - X_1)$ ($X_{1,2} = -L^2 k_{y1,2} + eE/m^*\omega_c^2$ are the coordinates of the center of the electron orbit before and after scattering, respectively; $L = (c\hbar/|e|H)^{1/2}$ is the magnetic radius; $\omega_c = |e|H/m^*c$ is the cyclotron frequency). This change of potential energy can be compensated by the following*: a - transition of the electron to another Landau level, b - absorption of emission of a phonon, c - a combination of processes a and b.

Let us assume that the follwing relations hold**

$$|\omega_0 - M\omega_c| \ll \omega_c, \quad |\omega_0 - M\omega_c| \gg \tau^{-1}, \tag{1}$$

where ω_0 is the limiting frequency of the optical phonons, τ is the relaxation time of the electron in the film, and M is a positive integer.

In addition, we shall assume that the electrons populate only the lower film level and do not go over to higher levels; this occurs when the following inequalities hold [1,2]:

$$\epsilon_0 \gg T, \quad \epsilon_0 \gg |e| EL, \quad n < \frac{10}{L_z^3}. \tag{2}$$

Here ϵ_0 is the energy of the first film level, T the temperature in energy units, n_0 the electron density, and L_z the film thickness.

In electric fields $E \ll \hbar\omega_c/|e|L$, which we shall consider, the current due to scattering by the impurities and acoustic phonons is negligibly small (see [2]). We shall therefore take only scattering by optical phonons into account. Since the conduction current is connected with migrations of the center of the electron orbit, we can write in this case

$$\begin{aligned} j \sim \frac{2\pi e}{\hbar} \sum_{N,\Lambda,q_x,q_y,k_1,k_2} & f_N(X_2 - X_1)\,|C_q|^2\,|(\exp iq_x x)_{N\Lambda}|^2 \times \\ & \times |(N_0+1)\,\delta[eE(X_2 - X_1) + \hbar(\Lambda\omega_c + \omega_0)]\,\delta_{k_{y1},k_{y2}+q_y} - \\ & - N_0\,\delta[eE(X_2 - X_1) - \hbar(\Lambda\omega_c - \omega_0)]\,\delta_{k_{y1},k_{y2}-q_y}|, \end{aligned} \tag{3}$$

where f_N is the number of electrons on the N-th Landau level, N_0 the number of optical