Changing from summation over ν in ln $w_{i\to 0}$ to integration with respect to the energy ε_ν, we readily get the estimate

$$w_{i\to 0} \approx \exp[-\rho\Delta(\pi - 2)]. \quad (6)$$

It is seen from (5c) that the phonon transition probability contains the factor $\overset{o}{u}_\lambda v_\lambda - \overset{o}{v}_\lambda u_\lambda$, which is odd with respect to the Fermi boundary. Therefore $w_{i\to\omega}$ will be very small if the coefficients $A_{\lambda\lambda}$ do not contain an analogous factor. Out of all the known vibrational excitations, this property is possessed only by the coefficients $A_{\lambda\lambda}$ of the pair-oscillation phonon [3]. Estimates show that in this case $w_{i\to\omega}$ is of the order of the transition to the ground state (5a).

Thus, it follows from our results that the energy spectrum of the particles emitted by a compound nucleus should have a maximum in the region $E_f \sim E_i - (\rho\Delta/2)\Delta$, with a width $\Gamma \sim \Delta$. The "fine structure" of this resonance is described by formulas (5). The experimental data are in qualitative agreement with these predictions. However, the quantitative comparison with experiments requires a clear-cut separation of the contribution of the direct processes, and more detailed assumptions concerning the form of the wave function of the intermediate state $|i\rangle$.

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SELF-SIMILAR THERMAL WAVE IN A TWO-TEMPERATURE PLASMA HEATED BY A LASER PULSE

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When a plasma is heated by a powerful laser pulse, an important role is played by the electronic thermal conductivity. For the case of ultrashort pulses, the thermal wave connected with the electronic thermal conductivity is the main mechanism of energy transfer to the interior of the target during the initial stage of the process [1, 2]. Then, as the electrons become cooled, the thermal wave attenuates rapidly and the principal role is assumed by energy transfer connected with the hydrodynamic motion.

In the case of longer pulses one can no longer expect, in general, such a separation of the process into a thermal-wave stage and a mass-motion stage. An analysis of the process of plasma heating entails considerable difficulties in this case, and has not yet been performed completely.

It is shown in this paper that the problem of heating and motion of a two-temperature plasma with allowance for the electron-ion relaxation and the electronic thermal conductivity admits of a self-similar solution in the case when the energy flux absorbed by the plasma increases linearly in time. Since a linear function is a reasonable approximation for the initial part of a real laser pulse, this self-similar solution can be used in an analysis of plasma heating in laser experiments. The solution presented here makes it possible, in particular, to determine the qualitative features of the plasma-heating process at different values of the pulse duration and of the absorbed energy.

The system of equations describing the plasma motion is given in [3]. We confine ourselves to the one-dimensional case, neglect the viscous forces, and assume that the plasma is quasineutral (this is permissible under conditions typical of laser experiments). The self-similar solution is of the form

$$\begin{aligned} v(x,t) &= Q^{2/9} n_0^{-2/9} \tau^{-4/9} \beta^{-1/9} t^{1/3} V(\xi), \\ T_e(x,t) &= Q^{4/9} n_0^{-4/9} \tau^{-8/9} \beta^{-2/9} t^{2/3} f(\xi), \\ T_i(x,t) &= Q^{4/9} n_0^{-4/9} \tau^{-8/9} \beta^{-2/9} t^{2/3} g(\xi), \\ n(x,t) &= n_0 N(\xi), \\ \xi &= Q^{-5/9} n_0^{5/9} \tau^{10/9} \beta^{-2/9} x t^{-4/3}. \end{aligned} \qquad (1)$$

Here Q is the absorbed energy (per unit surface), τ the pulse duration, n_0 the unperturbed ion density, $\beta = \varepsilon(Z)/e^4 n_0 m_e^{1/2} \ln\Lambda$ the coefficient in the formula for the temperature conductivity of the plasma (the function $\varepsilon(Z)$ is given in [3], $\varepsilon(1) = 0.95$, and $\ln \Lambda$ is the Coulomb logarithm). It is readily seen that formulas (1) are valid when the light flux absorbed by the plasma is given by $q = q_0(t/\tau)$, and the energy absorbed when the instant t is reached is Qt^2/τ^2.

An important property of the process described by the solution (1) is that the propagation velocity of the small perturbations, $c \sim (T_e/m_i)^{1/2} \sim t^{1/3}$, and the velocity of the front of the thermal wave, $\dot{x} \sim t^{1/3}$, depend in like manner on the time. This means that, depending on the parameters of the problem, two different limiting modes of heat penetration into the plasma are possible: (i) a shock wave moves in the unperturbed medium and is followed by a thermal wave, and (ii) the front of the thermal wave propagates first and is followed by a rarefaction wave from the boundary with the vacuum. It can be shown that the ratio of the velocities of the thermal and shock waves is determined by the parameter

$$k = 3Z \left[\frac{\varepsilon(Z)}{m_i}\right]^{1/2} \left[\frac{n_0 \tau^2}{\beta Q}\right]^{1/3}.$$

The mode (i) is realized at large values of k and the mode (ii) at small values. The limiting value $k \sim 1$ corresponds (when $Z = 1$ and $n_0 = 5 \times 10^{22}$ cm^{-3}) to $Q\tau^{-2} \simeq 10^{32}$ $Oe/cm^2 sec^2$. The situation with the two modes is qualitatively the same as in the well-known solution of Marshak [4]. A detailed investigation of the properties of the solution (1) will be presented in a detailed article. We note here only that, in accord with (1), the depth of penetration of monochromatic radiation into the perturbed plasma increases in time more slowly than the dimension of the perturbed region, and therefore the influence of the absorption on the profiles of the variables can be neglected. At the same time, the Rosseland free path of the radiation turns out to be larger than the displacement of the front of the thermal wave, while the radiant transfer and the loss to radiation are small at $k \lesssim 1$.

We now consider in greater detail the case of small k, when the dimension of the heated region is much larger than the dimension of the region in which the substance moves. The problem reduces in this case to the solution of the equations for the electron and ion temperatures, which can be written, after transformation in accord with formulas (1), in the form

$$f - 2\xi f' = (f^{5/2} f')' - k^2 f^{-3/2}(f - g) ,$$
$$g - 2\xi g' = Z k^2 f^{-3/2}(f - g) , \qquad (2)$$
$$\frac{3}{2} \int_{-\infty}^{\xi_0} (Zf + g) d\xi = 1,$$

where ξ_0 is the dimensionless coordinate of the front of the thermal wave.

The approximate solution of the system (2) yields $\xi_0 \simeq 0.66Z^{-5/9}$ and an average dimensionless ion "temperature" $\bar{g} \simeq 0.5k^2 Z^{8/9}$. Turning to (1), we can readily see that the dimensional ion temperature in the thermal-wave regime decreases with increasing energy absorption[1], $T_i \sim Q^{-2/9}$. Since T_i has a maximum as a function of Q (for a given pulse duration). An estimate shows that the maximum of T_i is attained at $k^2 \simeq 1.4Z^{-4/3}$, corresponding to a case intermediate between (i) and (ii). The ion temperature is in this case approximately one-third the electron temperature.

It is of interest to note that the competition between the hydrodynamics and the heat conduction is determined by the same parameter as the ratio of the electron and ion temperatures. The thermal-wave mode corresponds to appreciable superheating of the electrons relative to the ions. The situation is qualitatively the same in the case of ultrashort pulses, where the hydrodynamic motion becomes noticeable after equalization of the electron and ion temperatures [2].

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MASS OPERATOR AND EXACT GREEN'S FUNCTION OF AN ELECTRON IN AN INTENSE FIELD

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As is well known, the radiative corrections to the motion of an electron in an external field can be described by the mass operator in the modified Dirac equation [1] and can be experimentally detected by the effects of scattering and level shifting. The mass operator has been considered in detail only for a Coulomb field in the lower orders in this field and in the radiation field.

Although the presently attained electromagnetic fields F are weak compared with the characteristic quantum-electrodynamics value $F_0 = m^2c^3/eh = 4.4 \times 10^{13}$ Oe, it is possible to obtain a field of the order of F_0 in the rest system of a high-energy electron moving in a field of high intensity. Regardless of the

[1]We refer here, of course, to the temperature reached during the time of action of the light pulse. After the end of the pulse, the process evolves qualitatively in the same manner as for an ultrashort pulse.