where

$$\cos\theta = \frac{1}{n} + \frac{\hbar\omega}{2E}\left(n - \frac{1}{n}\right), \quad \omega_m = \frac{2pc}{(n+1)\hbar},$$

E is the initial energy of the particle, and $E_0 = mc^2$ is the rest energy.

For a medium with a refraction index close to unity ($\cos\theta \approx 1$, $\sin\theta \approx 0$), we obtain from (7):

$$W = \frac{13\,e^2E^2}{1024\,cE_0^4}\int\limits_0^{\omega_m}\omega(E - \hbar\omega)^2\,d\omega, \quad \omega_m = \frac{pc}{\hbar}. \tag{8}$$

If the energy of the emitted quantum is significantly smaller than the energy of the particle ($\hbar\omega \ll E$), then $\cos\theta = 1/n$, and we have for the radiation energy, from (7),

$$W = \frac{13}{1024}\,\frac{e^2}{c}\left(\frac{E}{E_0}\right)^4\int\limits_0^{\omega_m}\omega d\omega, \tag{9}$$

where only $\omega_m = 2pc/(n+1)\hbar\,(n \gg 1)$ depends on the index of refraction.

A specific feature of these results is the unlimited increase of the radiation energy with growing initial energy of the particle. This is in agreement with the latest experimental data on the intensity of the Cerenkov radiation caused by the particles of the cosmic radiation. Jelley notes[6] that Bassi and his co-workers have established, in a series of experiments on the changes in the intensity of the Cerenkov radiation of cosmic-ray particles, that the yield of light increases with increasing energy for very high particle energies. Jelley's view[6] is that this increase of radiation for high energies cannot be explained by knock-on electrons, nor by any other cause, and that the results of these experiments confirm the conclusions of Budini, who predicted a logarithmic increase of the radiation of the particles at extremely relativistic energies in dense media, in analogy to the increase of the ionization losses at such energies.

I express my sincere gratitude to Prof. F. I. Fedorov for valuable advice.

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DISAPPEARANCE OF THE ISOTHERMAL JUMP AT LARGE RADIATION DENSITY

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THE theory of finite disturbances in gas, based on the differential equations of hydrodynamics without supplementary assumptions, leads, in the complete absence of dissipative factors and continuous initial conditions, to absurd triple-valued flow parameters.[1] To eliminate this difficulty, Stokes and Riemann postulated a flow discontinuity that satisfies the boundary conditions.[2] Rankin and Rayleigh,[3] staying within the framework of a continuum, examined a heat-conduction mechanism by which "jumps" can be realized, and considered the results of Stokes, Riemann, and Hugoniot as a trivial neglect of the dissipation mechanism. Rayleigh observed here that the heat-conduction structure of a compression wave with a profile that remains unchanged in time can be continuous only if

$$p_{+\infty}/p_{-\infty} \leqslant (\varkappa+1)/(3-\varkappa) \equiv (i+1)/(i-1). \tag{1}$$

Waves of greater amplitude experience an "overturn" similar to the Riemannian overturn of adiabatic wave. The "isothermal jump" (see reference 4) resolves the Rayleigh paradox, although the meaning of such a solution again reduces somehow to ignoring, within the scope of the stated problem, dissipative factors other than heat conduction (such as viscosity and diffusion). In this solution one has in mind a radiant heat conduction, but the radiation density is neglected, and the conclusion is that the structure of a wave of amplitude (1), with the inequality sign reversed, includes the isothermal jump.

Considering, as before, the gas to be a continuous heat-conducting medium that retains local thermodynamic equilibrium, we shall show that the isothermal jump vanishes in a sufficiently hot gas.

We determine the equation of state

$$p_a + p_\gamma = \rho RT + a_0 T^4 / 3 = p; \ \rho \equiv 1/V \qquad (2)$$

and the enthalpy

$$H = c_p T + \frac{4}{3} a_0 T^4 V = \left(\frac{i+2}{2} p_a + 4p_\gamma\right) V \qquad (3)$$

with allowance for the radiation density. By virtue of the fact that in such a gas the isothermal velocity of sound increases relatively slowly,

$$a_T^2 \equiv (\partial p / \partial \rho)_T = (\partial / \partial \rho)_T (\rho RT + {}^1/_3 a_0 T^4) = RT = p_a V, \qquad (4)$$

the following relation is satisfied behind the shock wave at certain amplitudes

$$-V_{+\infty}^2 (p_{+\infty} - p_{-\infty}) / (V_{+\infty} - V_{-\infty}) = u_{+\infty}^2 > a_T^2 = -V_{+\infty}^2 (\partial p / \partial V)_{T,+\infty} \qquad (5a)$$

or

$$-(\partial p / \partial V)_{T,+\infty} = (p_{+\infty} - p_{\gamma,+\infty}) / V_{+\infty} \leqslant -(p_{+\infty} - p_{-\infty}) / (V_{+\infty} - V_{-\infty}),$$

which leads to the condition

$$(p_\gamma / p)_{+\infty} (V_{-\infty} / V_{+\infty} - 1) \geqslant (V_{-\infty} / V_{+\infty} - 2) + p_{-\infty} / p_{+\infty}. \qquad (5b)$$

It is easy to see, for example from the p-V diagram, that condition (5a) is equivalent to stating that the temperature is monotonic along the line of evolution of the heat-conducting gas within the shock wave:

$$-\frac{p_{+\infty} - p_{-\infty}}{V_{+\infty} - V_{-\infty}} = -\frac{dp}{dV} = j^2 \equiv (\rho u)^2 = \text{const}.$$

This is correct also for a non-radiating gas [in the latter case we obtain Eq. (1)]. For strong waves, from the conservation conditions for the flow of energy and momentum

$$j^2 (V_{-\infty}^2 - V_{+\infty}^2) = V_{+\infty} [(6 - i) p_{\gamma,+\infty} + (i + 2) p_{+\infty}],$$
$$j^2 (V_{-\infty} - V_{+\infty}) = p_{+\infty},$$

we get the total compression on the wave in the radiating gas:

$$V_{-\infty} / V_{+\infty} = i + 1 + (6 - i) p_{\gamma,+\infty} / p_{+\infty} \to 7 \quad \text{for } p_{\gamma,+\infty} / p_{+\infty} \to 1. \qquad (6)$$

Expressing $(p_\gamma/p)_{+\infty}$ in terms of $V_{-\infty}/V_{+\infty}$ in (5b) we obtain the inequality

$$(V_{-\infty} / V_{+\infty})^2 - 8 V_{-\infty} / V_{+\infty} + 13 - i \geqslant 0, \qquad (7)$$

which means that waves on which

$$V_{-\infty} / V_{+\infty} \geqslant 4 + \sqrt{3 + i} = 6.45 \ (\text{for } i = 3) \qquad (8)$$

(we disregard the second root, for we specified large amplitudes) have a monotonic temperature profile in the heat-conduction approximation. The equality corresponds to the transformation of the isothermal jump into isothermal sound.

In conclusion, I consider it my pleasant duty to express my indebtedness to my associates at the Institute of Chemical Physics, K. E. Gubkin, O. S. Ryzhov, and A. A. Milyutin, for valuable discussions.

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THE CONDUCTIVITY OF SEMI-CONDUCTORS IN AN ULTRASONIC FIELD

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In the literature there are several references to the effect of ultrasonics on the luminescence[1-4] and photoconductivity of semiconductors.[5]

We have examined the influence of ultrasonics on the conductivity of a number of semiconductors, and have studied specimens of selenium, cadmium sulphide, lead sulphide, cuprous oxide, stannic oxide and germanium, irradiated with 10 w/cm^2 of ultrasound at 600 Kcs. In all cases a change of conductivity was found on irradiation, but analysis of these changes shows that the ultrasound does not have a specific action on the conductivity, but that the effects follow from the heating of the specimen. The conductivity did not change immediately on switching on the ultrasound, but increased or decreased (depending on the sign of the temperature coefficient for the specimen) during the heating of the sample on irradiation. Simultaneous measurement of the temperature and conductivity shows that the latter varies as $\sigma = \sigma_0 \exp\{-E/kT\}$, i.e.,