had in this case the same density as at 20°K.

The procedure for the principal measurements consisted of successive determination of the counting rate from the target filled with liquid hydrogen, at two positions of the appendix. These two positions corresponded to measurement of the effect from the hydrogen when the appendix is removed from the effective volume, and measurement of the background when the appendix replaces the effective volume of the hydrogen.

The backgrounds from the appendix walls and from the helium were determined in supplementary tests.

In determining the cross section, several computational corrections were introduced, principal among which were the corrections for the electron admixture, for pions with energy below the registration threshold, and for the difference between the "effective" volumes of the hydrogen at 90° and 60°.

As a result of the measurements and of all the corrections, we obtained the differential cross section for the summary production of $\pi^{\pm}$ mesons at 90° in the l.s.

$$\left(\frac{d\sigma}{d\Omega}\right)^{\pi^+}_{90^\circ} + \left(\frac{d\sigma}{d\Omega}\right)^{\pi^-}_{90^\circ} = (1.34 \pm 0.16) \times 10^{-28}\ \text{cm}^2/\text{sr}. \tag{2}$$

The corresponding value of the total cross section is

$$\sigma^{\pi^+}_{np} + \sigma^{\pi^-}_{np} = (2.70 \pm 0.35) \times 10^{-27}\ \text{cm}^2/\text{sr}. \tag{3}$$

The errors indicated in the cross section constitute essentially those arising in the absolute normalization of the cross section and the uncertainty in the values of the calculated corrections.

The cross section obtained is in agreement with the measurements of [1,2].

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OPTOCALORIC EFFECT (AMPLIFICATION OF THE ATOMIC INTERACTION AND COOLING OF THE MEDIUM) IN A LASER BEAM

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It is customarily assumed that the laser beam heats the medium and causes disordering of the atoms. It is shown in the article that in some cases amplification of the interaction of the atoms and pulsed or periodic cooling of transparent media can be produced by switching on a laser beam.

1. The interaction between atoms placed in a strong light field can be appreciably altered. The additional interaction potential of the atoms that become polarized in the electric field is produced by two types of interaction: (i) the interaction of two dipoles produced by the external field, $U_{pp} \simeq (\vec{p}\cdot\vec{E}_p) \simeq (p^2/R^3)(1 - \cos^2\theta) \simeq \beta(\vec{E}_0\cdot\vec{E}_p)$, where $\vec{p} = \beta\vec{E}_0$ is is the dipole moment of the atom polarized in the external field $\vec{E}_0$, $\vec{E}_p = \nabla(\vec{p}\cdot\vec{R}/R^3)$ is the electric field of this dipole, and θ is the angle between the direction of the dipoles and of the radius vector joining them (it is easily seen that atoms arranged along $\vec{E}_0$ are attracted and those transverse to $\vec{E}_0$ are repelled); (ii) the atom, as a dielectric, is pulled into the field of another atom - the dipole $U_{ap} \simeq \beta E_p^2$, where β is the polarizability of the atoms ($\beta \simeq a^3$, where a is the diameter of the atom). Although $U_{pa}/U_{pp} \sim E_p/E_0 \sim (a/R)^3$, the results due to the two types of interaction can become noticeably different when averaged over different collisions.

Let us consider an illustrative mechanism for the change in the kinetic energy of quasi-elastic atoms colliding in a growing homogeneous magnetic field. We assume that the duration of the collison is many times longer than the period of the optical oscillations, so that the interaction potential can be averaged over the high frequency, but the slower potential variations connected with the modulation of the electromagnetic field amplitude are retained.

On the average, the electric field increases the attraction of the molecules. If the electric field amplitude E_0 varies with time (say, increases) then the work done by the interaction force between two colliding molecules prior to their encounter will be smaller in absolute value than the work done by the interaction force between the atoms, and the net decrease in the kinetic energy during each passage is $\Delta W_1 \simeq -(\partial U_{av}/\partial t)t_{coll}$, where the collision time is $t_{coll} \simeq R/V_a$. The decrease of the kinetic energy of the molecule as the field grows to E_0 is therefore $\Delta W \simeq \Delta(kT) \simeq (2\pi/3)\beta^3 E_0^2 n_A/R_{min}^3 \simeq \beta^2 E_0^2 n_A$, where n_A is the number of atoms per unit volume. We see from the obtained formula that the more molecules per unit volume and the larger the polarizability of the molecules, the larger the decrease in temperature. For example, for $\beta \simeq a^3 \simeq 10^{-24}$ cm^3, $n_A \sim 3 \times 10^{22}$ cm^{-3}, and $E_0 \simeq 3 \times 10^7$ V/cm we obtain for Δt_1 a value of the order of several degrees.

The effect under consideration is connected with the internal interaction of the atoms in a quasihomogeneous electromagnetic field. In the edge zone of the field inhomogeneity, the atoms are acted upon by forces connected with the field gradients. The effect of these surface forces cannot be transmitted to the interior of the volume during the short duration of a powerful laser pulse, $T \sim 30$ nsec (the transmission time is $\tau \sim l_\perp/V_a \gtrsim 10^{-7}$ sec when the transverse dimension of the focus spot is $l_\perp \sim 10^{-2}$ cm and $V_a < 10^5$ cm/sec).

The pulsed temperature drop in the medium in the laser beam and the increase in the molecule interaction energy may become manifest by an appearance of pulsed quasicrystalline structures with preferred arrangement of the ordering planes along the field, by complexes of linked molecules, by a decrease in the speed of sound, etc., all of which can be recorded by x-ray diffraction and interferometry.

By repeatedly turning the light field on slowly and switching it off rapidly (within a time shorter than the time between collisions) it is possible to intensify the cooling effect repeatedly ($\Delta T_n \simeq n\Delta T_1$, where n is the number of cycles). Of particular interest is the jumpwise temperature drop in the region of low temperatures and its use for cryogenics.

It is possible that in the case of resonance polarizability the cooling effect may be sharply increased, since $\beta_{res} \simeq \beta_0 \omega^2_{res}\{(\omega^2_{res} - \omega^2) + \gamma^2\omega^2\}^{-\frac{1}{2}} >> \beta_0$ when $\omega \rightarrow \omega_{res}$.

The inverse effect is also of interest - a jumpwise heating by smoothly turning off a laser beam, when the decrease in the force of interaction between molecules increases their kinetic energy.

2. Under certain conditions [1-3] there is produced in the laser beam an intense hypersonic wave in the medium. Since the time of relaxation of the coherent phonons into thermal phonons can be rather large, the hypersonic wave leads to a periodic cooling and heating of the medium, with a repetition period $\sim 10^{-9}$ sec 1).

The amplitude of the pressure in the hypersonic wave is

$$\Delta p \simeq \rho \frac{\partial \epsilon}{\partial \rho} \frac{E^2_{st}}{4\pi},$$

where E_{st} is the amplitude of the standing light wave which produces the hypersonic pressure distribution by striction forces. Assuming a gaseous medium, we put $P \simeq \rho RT/M$ and

$$\frac{\Delta T}{T} \simeq \frac{1 - \gamma}{\gamma} \frac{\Delta P}{P} \simeq \pm \frac{1 - \gamma}{\gamma} \frac{E^2_{st}\beta}{kT};$$

where β is the polarizability of the molecules of the medium, k Boltzmann's constant, and γ the ratio of the specific heats. For example, for $(1 - \gamma)/\gamma \simeq 0.2$, $\beta \simeq 10^{-24}$ cm^3, and $E^{max}_{st} \simeq 2E_0$ we obtain a vlaue $\Delta T_{max} \simeq \pm E_0\beta/k \lesssim 10^2$ deg if $E_0 \simeq 3 \times 10^7$ V/cm. At the instant when the medium is cooled, virtual complexes and crystalline structures can also be produced periodically, and can be detected by their x-ray scattering, by nonlinear optical effects, etc. Such temperature changes can also be manifest by changes of the effective speeds of the sound waves in a wave train.

At low temperatures, noticeable optocaloric effects can arise also at lower field intensities in unfocused laser beams, passage of which will be accompanied by pulsed or periodic induced freezing of the medium.

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1) We note in passing that a pulse of dissipative hypersound can develop large destructive pressures in the direction of the light pressure.