splitting of the spin levels due to the crystalline field and let R be the distance at which J(R) = D. A small number of particles, for which $r < R$, form pairs. For an overwhelming number of particles $r > R$ and in this case the exchange forces, while not altering the spectrum of the particles, should change the width of the resonance lines. This effect of the exchange forces was apparently observed long ago in ruby and in other crystals in which a concentration dependence of line width is observed but cannot be explained at $C < 0.2\%$ by dipole-dipole interactions.[8,9]

Spin-lattice relaxation due to exchange forces $J < D$ will, firstly, depend strongly on the concentration C and, secondly, will be practically independent of the field H, since the matrix element of the interaction $\mathcal{H}$ is proportional to $D/g\beta H$. The probability of a relaxation transition of a particle from level i to level j can be calculated from the equation (see [10])

$$A_{ij} = \frac{8\pi^3}{3h^4}\frac{1}{\rho v^5}\sum_{r>R} r^2\left(\frac{\partial J}{\partial r}\right)^2 \times \sum_{k,l}\frac{E^3_{ik,\,jl}}{1-\exp\left(E_{ik,\,jl}/kT\right)}\left|\langle i,k\,|\,\mathrm{SS}'\,|\,j,l\rangle\right|^2.$$

Here ρ is the density of the crystal, v is the speed of sound, and $E_{ik,jl}$ is the change in energy of the pair of particles in the transition $i, k \rightarrow j, l$. Detailed calculations were carried out for ruby. In order to obtain agreement between the calculated and measured values for the spin-lattice relaxation times for concentration $C \sim 0.1\%$, it is necessary to take $J(\bar{r}) \approx 10^{-3}\ \mathrm{cm}^{-1}$ ($\bar{r} = 27$ Å, the mean separation between the particles). If it is recalled that at $r \sim 6$ Å the magnitude of $J \sim 0.5\ \mathrm{cm}^{-1}$,[6] then our value for the exchange integral is acceptable, the more so since it does not contradict the data on the resonance line width. If for crystals oriented perpendicular to the magnetic field one numbers the spin levels of Cr^{3+} from the bottom upwards, then for the transitions 2—4, 1—2, 2—3, 3—4, the ratios of the relaxation times at 20.3°K are 10:6:8:4, according to measurements.[7] Our calculations give for these ratios 10:6:8.6:7.2.

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401

PRESSURE ON EVAPORATION OF MATTER IN A RADIATION BEAM

G. A. ASKAR'YAN and E. M. MOROZ

P. N. Lebedev Physics Institute, Academy of Sciences, U.S.S.R.

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RECENTLY the use of lasers has given high concentrations of light capable of causing intense evaporation even of heat-resistant materials. Equally well-known and widely used in practice are the heating and evaporation of materials by intense beams of charged particles (electronic and ionic cutting of metals, cathodic and anodic sputtering of electrodes, etc.). Strong energy fluxes concentrated over small areas (the attainable dimensions of a focus spot of a laser beam or an electron beam used in cutting amount to only several microns) are capable of producing such intense evaporation that in estimating the pressure on the surface it is necessary to allow for the strong recoil pressure during evaporation.

We shall estimate the recoil pressure for steady-state evaporation: $p \approx \alpha I v_f/\lambda$, where I is the energy density flux in the beam, v_f is the final velocity of vapor flow, $\lambda \approx \lambda_0 + \frac{1}{2}v_f^2$ is the specific energy of evaporation and acceleration of the vapor, α is the portion of the energy used in evaporation (at high beam densities α is close to unity for absorbing substances). The ratio of the recoil pressure to the pressure p_1 of the beam itself is $p/p_1 \approx v_1 v_f/2\lambda$ for a beam of particles of nonrelativistic velocity v_1, and $p/p_1 \approx cv_f/\lambda$ for a beam of light. Even for $v_f \gtrsim 10^5$ cm/sec and $\lambda \approx 10^3$ cal/g = 4×10^{10} erg/g we find $p/p_1 \gtrsim 10^4$—10^5 for electron or light beams.

These estimates show that the recoil pressure on evaporation may be several orders of magnitude greater than the beam pressure, and this was experimentally observed for the focused beam of a ruby laser.

We shall consider some of the possible applications of this effect.

1. ACCELERATION OF PARTICLES OF MATTER IN A LASER BEAM

Particles or droplets placed in a concentrated laser beam will suffer one-sided evaporation. With such evaporation the particles may acquire a velocity $u = v_f \ln[M_0/M(t)]$. At high concentrations of the light energy in the beam a relative change of the particle mass $M_0/M \gg 1$ may be obtained even after short durations of acceleration (the duration of evaporation is $\tau \approx a\rho\lambda/E^2c < 1\ \mu$sec for an initial particle dimension $a < 1$ mm and field intensity in the beam $E > 10^5$ V/cm). The short duration of the process of acceleration tends to produce a strong nonuniformity of the evaporation from the particle surface. By this method we can accelerate the remaining portions of the particles to velocities $u \gtrsim 10^7$ cm/sec. This range of velocity is of interest, for example, in the simulation of the action of micrometeorites on the surfaces of bodies, for the formation of a high-velocity gas stream, etc.

2. GENERATION OF ULTRASOUND AND HYPERSOUND

The amplitude of the evaporation pressure may reach high values up to, for example, hundreds of thousands of atmospheres for an electron beam pressure $p_1 \approx mv_1 j/e \approx 10$ atm with current densities at the focus of an electron-beam cutter of $j \approx 10^6$ A/cm^2, and even higher pressures are obtainable in a laser beam. When the beam intensity is modulated the evaporation pressure also becomes modulated and volume oscillations of the medium of intensity $I_s \approx p_m^2/2\rho c_s$ are excited. The coefficient representing transformation of the beam energy into the energy of volume oscillations is

$$k = \frac{I_s}{I} \approx \frac{I v_f^2}{\lambda^2 2\rho c_s} \sim 1$$

for an acoustical impedance of the medium $\rho c_s \approx 10^6$ g-cm/sec, $v_f \approx 10^5$ cm/sec, $\lambda \approx 10^3$ cal/g and $I \approx 3 \times 10^{17}$ erg-cm^{-2} sec^{-1} (which corresponds, for example, to a beam power of 3 kW and a focus-spot cross-section area of $\approx 10^{-7}$ cm^2). In the case of intense evaporation the inertia of the evaporation pressure oscillations will not affect the results right up to high modulation frequencies of $\lesssim 1$ kMc. Consequently, modulation of a beam focused on a surface should generate intense ultrasonic and hypersonic vibrations and increase the fragmenting and cutting action of the beam.

Concluding, we note the possibility of the appearance of these effects in outer space as a pressure on the dust particles of a comet, on the surfaces of space vehicles, meteorites, etc. The direct pressure of solar radiation on space vehicles, may displace their orbits quite considerably (up to ≈ 1 km per day). Therefore, these effects may be useful, for example, for trajectory control by varying the evaporation pressure at the surface of such objects (by the use of special coatings, focusing of solar radiation to intensify evaporation, venetian blinds for control of the intensity of evaporation, etc.).

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402

MELTING CURVE OF TELLURIUM UP TO 23,000 kg/cm²

N. A. TIKHOMIROVA and S. M. STISHOV

Crystallography Institute, Academy of Sciences, U.S.S.R.

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It is known that at extremely high pressures all substances should undergo transition to the metallic state. Many authors relate the sharp change in