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Solution of Inverse Problem for Wave Equation With Nonlinear Conditions in Regions With Moving Boundaries

927J0104C Moscow PRIKLADNAYA MATEMATIKA I MEKHANIKA in Russian Vol 55 No 6, Nov-Dec 91 (manuscript received 22 Mar 90) pp 1058-1062

[Article by V. S. Krutikov, Nikolayev; UDC 532.5:534.222.2]

[Abstract] A spherically symmetric compressible medium with an arbitrary initial radius and a surface which moves at an arbitrarily varying velocity is considered. The subject of concern is the solution of the inverse problem for the wave equation which describes the motion of that surface. The inverse problem, with supplementary boundary conditions stipulated not at the moving surface but at some fixed point within the region of wave motion, is solved by determining the relation between values of the sought function $\varphi(r,t) = (_1/r\rho)\text{Int}_0^t f(\xi)dt$ (r - radial space coordinate of point within wave region, t - time, ρ - constant) at the moving surface and at other points with respective time delays taken into account. The problem for linear supplementary boundary conditions is solved by unilateral Laplace transformation of the wave equation and subsequent inverse Laplace transformation, the $f(\xi)$ function then being approximated with a Lagrange polynomial. The problem for a nonlinear supplementary boundary condition $P(r,t) = \rho\varphi_t = -\rho(\varphi_t + \varphi_r^2/2)\}_{r-r1}$ is solved with use of the same Lagrange polynomial making it reducible to a single algebraic equation. As a practical example of a thus solvable inverse problem is considered controlling the expansion of a cavity in a compressible medium. Figures 1; references 9.

Instability of Shock Wave Under Transverse Perturbations in Viscous Medium

927J0119C Leningrad PISMA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 17 No 14, 26 Jul 91 (manuscript received 18 May 91) pp 20-21

[Article by Yu. N. Zayko]

[Abstract] Conditions for development of instability of a shock wave under transverse perturbations in a viscous liquid or gas are established, a shock wave in such a medium being described by the solution to Burgers' equation for weakly nonlinear one-dimensional perturbations. This equation is derived from the system of nonlinear one-dimensional Navier-Stokes equations describing waves in such a medium and is supplemented by the equation of state $p - p_0 = a(n - n_0) + b(n - n_0^2)$ (p - pressure, n - concentration, a,b - constant coefficients). Following a generalization of Burgers' equation for a longitudinally flowing main stream, with all variables and coordinates expanded into series, a stability analysis of the solution to this equation yields the condition when the stability limit is exceeded and instability develops. References 4.

Decay of Shock Front Perturbations During Richtmayer-Meshkov Instability

927J0119D PISMA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 17 No 14, 26 Jul 91 (manuscript received 14 Apr 91) pp 1-4

[Article by A. N. Aleshin, S. G. Zaytsev, and Ye. V. Lazareva]

[Abstract] An experimental study was made involving interaction of a refracted plane shock wave and a perturbation of contact made between two gases with different densities upon rupture of a diaphragm separating them, this interaction resulting in perturbation of the shock front. The experiment was performed in a square shock tube with a 72 x 72 mm^2 cross-section, its low-pressure channel being split by a thin dacron film into two compartments holding a lighter gas and a heavier gas respectively. The mass of that film prior to its rupture was equivalent to the mass of a less than 1 mm thick layer of subsequently mixing gases. The experiment was performed with three pairs of gases with correspondingly different values of the Atwood number: 1) Ar and Xe ($N_{At} = 0.45$), 2) He and Ar ($N_{At} = 0.77$), 3) He and Xe ($N_{At} = 0.92$). The initial pressure was 0.5 atm and the Mach number of the incident shock wave was controlled so as to make the refracted shock wave attain a Mach number $N_{Ma} \approx 4$. A periodic two-dimensional strain pattern $x = x_0 + a_0\sin(ky)$ had been inscribed in the diaphragm film by a special device so as to induce an analogous pattern of its subsequent rupture and attendant gas-to-gas contact perturbation ($a_0 = 5$ mm, $k = 2\pi/\lambda$, y - longitudinal coordinate, x - transverse coordinate, λ - wavelength of contact and shock wave perturbation). Tests were performed with three such patterns: 1) $\lambda = 24$ mm, 2) $\lambda = 36$ mm, 3) $\lambda = 72$ mm. The process in the shock tube was tracked visually with an IAB-451 instrument and recorded on the film of a ZhFR-3 instrument at high speeds of 80,000-120,000 frames per second, a Q-switched ruby laser serving as the light source. The toeplerograms and the pressure readings reveal an attenuation of shock front perturbations attending the interaction of a strong refracted shock wave and a sinusoidal gas-to-gas contact perturbation as the shock front passes from one gas to another, specifically from the lighter gas to the heavier one, upon rupture of a sinusoidally distorted diaphragm. They also indicate attendance of secondary shock waves in the process. A theoretical analysis of the process as a one-dimensional problem of decaying discontinuity confirms these findings, moreover indicating that the perturbations at the shock front are attenuated by transversely propagating secondary shock waves. According to the results of pressure measurements, the amplitude of these perturbations fluctuates while decreasing to zero and they decay faster when the Atwood number is larger. According to the results of angle and displacement measurements, the intensity of secondary shock waves at the instant of their formation is higher when the initial curvature of the refracted shock wave is larger. Figures 2; tables 1; references 2.

Reflection of a Wave Front on an Acoustically Stimulated Nonlinear Surface

927J0189 Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 38 No 2, Mar-Apr 92 (manuscript received 16 May 91) pp 304-307

[Article by V. V. Zosimov and A. V. Panasyuk, N. N. Andreyev Acoustic Institute, Russian Academy of Sciences; UDC 534.222]

[Abstract] While wave front reflection is widely used in acoustic studies, it is little used in the acoustics of liquids, primarily due to the lack of natural media with the appropriate characteristics. This article examines the effect of reflection of the wave front of an acoustic wave falling from a liquid onto a nonlinear surface stimulated by an external source. The surface has a high coefficient of nonlinearity and has resonant properties. It is shown that when the characteristics of this system are matched, the effectiveness of reflection can reach 10 percent at a pumping power of 170 W/m^2 and a signal frequency of 13 kHz. The signal, reflected and conjugated waves are of the same frequency while the pumping wave is twice the frequency. An equation describing the interaction is exactly solved. A variant method of implementing this system and calculating its characteristic parameters is proposed. A schematic of the system is given and its operation outlined. Figures 1; references 5: 4 Russian, 1 Western.

New Types of Structures in Random Antiferromagnetic Material With Easy Plane and Hexagonal Crystal Lattice

927J0094F Moscow ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 100 No 6(12), Dec 91 (manuscript received 8 Aug 90, revised version received 11 Jan 91) pp 2068-2073

[Article by S. S. Aplesnin, Institute of Physics imeni L. V. Kirenskiy, Siberian Department, USSR Academy of Sciences]

[Abstract] A random magnetic material having a hexagonal crystal lattice with uniaxial easy-plane anisotropy and with exchange fluctuations is analyzed for new types of magnetic states and sequences of phase transitions which the theory of spin glasses and disorders does not predict. The analysis is based on the classical Heisenberg model, assuming an anisotropy field much weaker than the exchange field so that quantum effects are negligible and can be disregarded in the Hamiltonian. All relevant quantities (energy, heat cacpacity, temperature, magnetization, magnetic susceptibility, distance along a hexagon axis and in the basis plane) have been normalized and constrained by periodic mirror boundary conditions. They have then been calculated by the Monte Carlo method on an 18x18x18 grid and on a 24x24x24 grid. Also the Edwards-Anderson parameter, the spin-spin correlation functions along the crystal axes, the local field distribution function, and the Fourier transform of the spin which corresponds to the wave vector of the structure have been evaluated, considering that the noncollinear configuration of spins is characterized by a chiral vector. The results reveal an antiferromagnetic state with modulation of the transverse spin components, the modulation period varying, and two spin-glass states with breaking of chiral symmetry and spin symmetry respectively. The antiferromagnetic material has, when disordered, a domain structure and two phase transitions at different temperatures: the first one at temperature T_{N1} involving breakdown of the random nonhomogeneous structure with respect to the y(x)-component of the spin and the second one at temperature T_{N2} caused by breaking of the periodic spin order with respect to the x-component. The heat capacity of this antiferromagnetic material peaks to a lower maximum at T_{N1} and to a higher maximum at T_{N2}. The antiferromagnetic material has only one phase transition when it is weakly disordered, inasmuch as breaking of the discrete chiral symmetry and breaking of the continuous spin symmetry with respect to temperature coincide here. Its heat capacity peaks to a maximum which, because of ferromagnetic impurity bonds, spreads over a narrow temperature range about the phase transition point. All these structures are realizable in a $Fe(Cl_xBr_{1-x})_2$ solid solution with a hexagonal crystal lattice, possibly also in Gd compounds of the ABX_3 which have planes with triangular lattices. Figures 5; references 8.

Nonlinear Surface Waves in Ferrite-Ferroelectric Structure

927J0108A Leningrad FIZIKA TVERDOGO TELA in Russian Vol 33 No 6, Jun 91 (manuscript received 18 Apr 90, final version received 19 Sep 90) pp 1635-1639

[Article by A. G. Glushchenko, Kuybyshev Institute Electrical Communication Engineering; UDC 539.2]

[Abstract] Surface waves in a binary ferrite-ferroelectric structure are considered, the nonlinearity of properties of the ferroelectric material being accounted for by describing them as that of the polarization vector P_N in accordance with the Grimalskiy-Koshevaya model (V.V. Grimalskiy and S.V. Koshevaya; PISMA V ZHURNAL TEKHNICHESKOY FIZIKI Vol 13 No 17, 1987) and the ferrite material treated in the linear approximation. From the wave equation for H (H_x,H_y,E_z) waves in the ferroelectric material interacting with magnetostatic waves in the ferrite material is obtained a fundamental equation of wave dynamics in the y-direction for the $E_z(y,t)$ function and its Fourier transform $(1/4\pi^2)\text{IntInt}_{-\infty}^{\infty} E(\omega,k)e^{i(\omega t - ky)d\omega dk}$. Convolution then yields a nonlinear integrodifferential equation for $\text{IntInt}_{-\infty}^{\infty} Y(y - y',t - t')E(y',t')dy'dt'$, Y(y,t) representing the linear part of the structure's impulse response. The solution to this equation is sought analytically in the form of a pulse which satisfies the condition of a slowly varying amplitude, a soliton. For a polarization vector $P_N(E)$ expandable into a power series of even-order (2,4,...) nonlinearity terms the equation reduces to a nonlinear partial differential one of the nonlinear Schroedinger kind. An analysis of solutions obtained by taking into account odd-order (3,5,7,...) nonlinearity terms and dispersion of the even-order nonlinearity terms shows that the dispersion characteristics just as the nonlinearity characteristics may ensure existence of multistable states, as demonstrated by simultaneous solution of the dispersion equation for up to fourth-order nonlinearity terms and the equation for soliton velocity. Figures 1; references 12.

Nonlinear Radiation Absorption and Ultrafast Excitation Relaxation in Thermally Colored $SrTiO_3$ Crystals

927J0108B Leningrad FIZIKA TVERDOGO TELA in Russian Vol 33 No 6, Jun 91 (manuscript received 18 Jul 90, final version received 5 Dec 90) pp 1735-1739

[Article by M. I. Demchuk, V. P. Mikhaylov, V. S. Konevskiy, N. V. Kuleshov, P. V. Prokoshin. and K. V. Yumashev, Scientific Research Institute of Problems in Physics imeni A. N. Sevchenko, Minsk; UDC 621.373]

[Abstract] An experiment with $SrTiO_3$ crystals excited by a $YAlO_3$:Nd^{3+}-laser has revealed a saturation of radiation absorption and an ultrafast relaxation of excitation in them. Single crystals for this experiment, 0.3-10 mm thick and 20 mm in diameter, were grown by the Verneuil method and absorption centers then induced in them by annealing at 1000°C in a reducing atmosphere

sufficiently long for point defects to spread from the polished surface over the volume. Absorption of the infrared radiation covering the 0.395-10 μm range of wavelength was recorded with SPECORD M-40/61-MIR/75-IR spectrophotometers. The clearing process was tracked and the relaxation of absorption centers was timed by a picosecond spectrometer with a passively mode-locked $YAlO_3:Nd^{3+}$-laser. The experimental data are evaluated by correlating them with theoretical ones based on the two-level model of a radiation absorber and on a radiation relaxation time comparable with duration of the excitation pulse, the system of two balance equations for the concentration of absorption centers and the population difference between levels having been solved numerically for an excitation pulse with a Gaussian waveform in both time and space. The results indicate three-photon absorption, with the relative amounts of absorbed infrared radiation and 13,400 cm^{-1}-band radiation depending on the annealing process parameters. The results reveal, moreover, a phototropy of thermally colored $SrTiO_3$ crystals under excitation of 10^8 - 10^{10} W/cm^2 intensity. Figures 3; tables 1; references 10.

Nonlinear Steady Nuclear-Magnetic Resonance in Easy-Plane Antiferromagnetic Materials

927J0108C Leningrad FIZIKA TVERDOGO TELA in Russian Vol 33 No 6, Jun 91 (manuscript received 27 Dec 90) pp 1805-1808

[Article by M. I. Kurkin, Institute of Metal Physics, Ural Department, USSR Academy of Sciences, Sverdlovsk]

[Abstract] Steady nuclear-magnetic resonance in antiferromagnetic materials, found to be nonlinear in the presence of nuclear spin waves and to be anomalous in easy-plane antiferromagnetic materials ($MnCO_3$, $CsMnFe_3$) is analyzed on the basis of a model of an indirect interaction through electronic spins, whether spin waves or magnons much stronger than direct dipole interaction of nuclear magnetic moments. While ordering of nuclear spins or spin waves and correlations in their oscillations are manifested at much higher temperatures in magnetic materials than in weakly magnetic ones, these effects have been observed in easy-plane antiferromagnetic materials at 4.2 K and lower temperatures already. Forced transverse oscillations of the nuclear magnetization are evaluated on this basis in terms of the dependence of their amplitude on the frequency of the exciting field. While in the absence of a dynamic frequency shift the amplitude-frequency characteristic resembles that of a mechanical system with one degree of freedom and viscous damping, in the presence of a dynamic frequency shift due to correlations. It resembles that of a mechanical system with one degree of freedom and a continuously stiffening spring. It is demonstrated that excitation of nuclear spin waves with nonzero wave numbers k does not influence the stability of a saturated state. In a homogeneous material, therefore, saturated and nonsaturated states can coexist only outside a frequency interval limited on both sides, because relaxation stabilizes a nonsaturated state only when deviations from it are small. Transition from an unsaturated state to a saturated one and transition from a saturated one to an unsaturated one are examined from this standpoint, but taking into account the presence of inhomogeneities in the material and that, because a saturated state is more stable than an unsaturated one, inhomogeneities influence those transitions differently. Although these transitions have not yet been studied experimentally, they are shown to be experimentally verifiable under certain conditions. Figures 1; references 8.

Anisotropy of Hole Dispersion Law on $GaAs_{1-x}Ga$-Al_xAs Quantum Well Plane

927J0183B Kiev UKRAINSKIY FIZICHESKIY ZHURNAL in Russian Vol 37 No 3, Mar 92 pp 442-448

[Article by V. L. Denisenko, Sumy Physical Technology Institute; UDC 621.315.592]

[Abstract] The laws of dispersion on the energy layer plane and Landau levels of valence subbands in semiconductor heterostructures are discussed and GaAs-$Ga_{0.7}Al_{0.3}As$ valence subband anisotropy on the quantum well layer plane due to the difference in Luttinger's γ_2 and γ_3 parameters is taken into account. The section of the holes' equal-energy surface by the k_xk_y plane perpendicular to the [0,0,1] direction is investigated. The spatial course of the upper edge of the valence band with a transition from the $Ga_{1-x}Al_xAs$ layer to the GaAs layer are plotted. It is shown that anisotropy is significant for the ground valence subband of heavy holes but is insignificant for the remaining bands. It is stressed that the anisotropic dispersion laws of valence subbands on the quantum well layer plane in GaAs-GaAlAs are found by direct numerical calculations. The authors are grateful to V. I. Sugakov, S. V. Shiyanovskiy, and S. A. Yatskevich for constructive discussions and valuable remarks. Figures 3; tables 2; references 22: 7 Russian, 15 Western.

Nonlinear Packet Dynamics of Strong Electromagnetic Field in Plasma With Linear or Parabolic Density Barrier

927J0094A Moscow ZHURNAL EKSPERIMENTALNOY ITEORETICHESKOY FIZIKI in Russian Vol 100 No 6(12), Dec 91 (manuscript received 22 Jun 91) pp 1785-1796

[Article by Ye. M. Gromov, V. M. Nakaryakov, and V. I. Talanov, Institute of Applied Physics, USSR Academy of Sciences]

[Abstract] An analysis of the dynamics of a strong electromagnetic field in a nonhomogeneous plasma with a linear or parabolic barrier-forming density profile and with an ion-acoustic kind of nonlinearity reveals the existence of a new class of dynamic phase-conjugate and frequency-tunable dynamic states, electromagnetic wave packets, in such a plasma. The analysis rests on the Schroedinger equation $-2i(\delta\varphi/\delta t) + \delta^2\varphi/\delta x^2 - n\varphi + (-x)^p\varphi = 0$ in dimensionless variables where $\delta^2 n/\delta t^2 - \delta^2 n/\delta x^2 = \delta^2(|\varphi|^2)$, which describes the evolution of a one-dimensional wave field $\varphi(z,t)$ in a medium with a linear ($p = 1$) or parabolic ($p = 2$) density barrier and an ion-acoustic kind of nonlinearity. A plasma with plane-laminar stratification and with an ion-acoustic kind of nonlinearity is considered, the wave vectors of the electromagnetic waves being parallel to its density gradient. Perturbations of the plasma concentration N_s by the electromagnetic field are assumed to be of a scale much smaller than that of inhomogenieties in the quiescent plasma. From the equation of the field envelop $E_0(z,t)$ and the equation of plasma concentration perturbations are derived equations of motion for electromagnetic wave packets with a slowly varying frequency in such a plasma, these wave packets representing the electric field $E(z,t)$ of electromagnetic waves. Solutions to the equation for $p = 1$ (linear density barrier) describe reflection of packets by the barrier, characterized by mirror symmetry with respect to time $t = 0$ and corresponding to coupled dynamic states. Solutions to the equation for $p = 2$ (parabolic barrier) describe packet reflection by the barrier or packet passage through the barrier, or the in-between mode of packet pull-up to and slide-down from the top of the barrier, depending on the initial conditions. The evolution of packet parameters is analyzed separately for each case. In the case of packet pull-up it is analyzed for depth of field penetration in such a plasma and for absorption of the packet energy by such a plasma near the top of its density barrier. Considering that heat losses during packet reflection or passage are negligible when absorption of the packet energy by the plasma takes a longer time than return of the packet frequency to the initial one and that heat losses during packet pull-up are not negligible, it is demonstrated that the main energy of a packet during its pull-up in a dense supercritical plasma could be absorbed by the latter as the packet approaches the top of the density barrier. Figures 3; references 11.

Instability and Formation of Regular Structures During Chilling of Gas-Saturated Liquids and Solids

927J0094D Moscow ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 100 No 6(12), Dec 91 (manuscript received 9 Jan 90) pp 1860-1872 [Article by S. K. Zhdanov, Ye. Yu. Zhdanova, and B. A. Trubnikov, Institute of Atomic Energy imeni I. V. Kurchatov]

[Abstract] Propagation of the solidification front during growth of crystals from melts is referred to Stefan's problem with Mullins-Severka instability of that front due to supercooling of the liquid ahead of it (W.W. Mullins and R.F. Severka; JOURNAL OF APPLIED PHYSICS: Vol 34, 1963; Vol 35, 1964), considering also that impurities in the melt as well as the temperature drop below its freezing point play a role in that instability and in formation of known regular crystal structures. Formation of such structures is analyzed on the basis of a "surface" mechanism, according to a "unilateral model" (J.S. Langer; REVIEW OF MODERN PHYSICS Vol 52 No 1, 1980) for a plane solidification front moving at a constant velocity v_z into a supercooled liquid saturated with a gaseous impurity. This model derives from two equations: 1) equation of heat conduction $\rho c_p(dT/dt) + \text{div } q^{(T)} = 0$ for the temperature field T (q^T - heat flux) with the boundary condition of a regularly matched step change of heat flux at the solidification front; 2) equation of impurity diffusion $dn/dt + \text{div } q_n = 0$ for the impurity concentration field n (q_n - mass flux) without a step change of impurity mass flux at the solidification front and instead with a boundary condition for the impurity concentrations of the two phases which implies equal, though differently concentration-dependent, chemical potentials at the solidification front. The system of these equations is simplified by assuming that the liquid and and the solid have the same density ρ, specific heat c_p, and thermal conductivity k. The surface of the perturbed solidification front is described by an only numerically solvable integrodifferential equation $z = z_f = a(x,y,t)$, the front quiescing in the $z = 0$ plane and its pattern then being obtained from the steady-state solution to that system of equations. Although this model is a tentative rather than precise one, inasmuch as the steady-state temperature of a supercooled liquid and thus the velocity of a solidification front do not necessarily remain constant and the temperature of the solid phase not always coinciding exactly with its freezing point, it is quite adequate for stability and structurization analysis. Assuming then a solid phase without temperature fluctuations and a liquid phase with temperature fluctuations, one can reduce the model system of equations to a complete system of nonlinear differential equations for the temperature fluctuation correction and then simplify this system so that it will yield an integral equation with a rather simple Green's function for the surface of the solidification front. Only an approximate analytical solution of this equation is possible and is obtained here, after all terms of smallness orders higher than the second

have been discarded and the equation thus reduced to the $a = \Delta a^2$ form. The solution to this equation describes steady-state pattern formed by that "surface" mechanism on a moving solidification front, namely "parquet floor with hexagonal tiles" patterns leading to pencil-like dendritic crystal structures. The theoretical results based on this model are comparable with the results of experiments involving solidification of liquid CBr_4 (K. Jackson; SOLIDIFICATION, American Society for Metals, Metal Park 1971). The "surface" mechanism may possibly but not necessarily be adequate when applied to solidification of volcanic lava and, therefore, a "bulk" mechanism is proposed to explain its cleavage into palisade rock formations. In this case, unlike in crystal growth, an essential factor is escape of dissolved gases (essentially water vapor and SO_2) from the magma. This process is described by an analogous equation of heat conduction with inclusion of heat transfer by the gases and an analogous equation of molecular diffusion with a temperature-dependent diffusion coefficient, taking into account the fact that supercooling of a magma is unlikely unless caused by Raoult's concentration effect. Instability of nonlinear heat and gas fluxes which leads to their threading is now described on the basis of this "bulk" model. The model, with numerical estimates of basalt and typical lava properties, is then applied to such rock formations as on Cape Stolbchatyy (Palisade) of the Kunashir Island. The authors thank S. A. Fedotov, N. A. Zharinov, P. P. Firstov, A. N. Khrenov, and V. V. Vladimirov for helpful comments. Figures 2; references 24.

Second Harmonic in Longitudinal Nonlinear Response of Cubic Ferromagnetic Material in Vicinity of Curie Temperature

927J0094E Moscow ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 100 No 6(12), Dec 91 (manuscript received 17 Jun 91) pp 1964-1979

[Article by A. V. Lazuta, I. I. Larionov, and V. A. Ryzhov, Leningrad Institute of Nuclear Physics imeni B. P. Konstantinov, USSR Academy of Sciences]

[Abstract] The response of a cubic ferromagnetic material to superposition of a harmonically alternating magnetic field $h(t) = h_0 \sin \omega t$ on the parallel to its constant magnetic field H_d at temperatures within the paramagnetic range of fluctuations $T - T_C$ about the Curie point is considered, of interest being the second harmonic in the induced longitudinal (parallel to h) nonlinear magnetization M_2 of the material. Theoretical analysis of the nonlinear response is based on the relation $M_2(t) = -h_0^2[\chi_2(\omega)e^{-2i\omega t} + \chi_2^*(\omega)e^{2i\omega t}]/2$. Here the second-order dynamic magnetic susceptibility $\chi_2(\omega)$ characterizes the longitudinal nonlinear response, expressible in terms of Green's even spin function of the material, and $\chi_2^*(-\omega) = \chi_2(\omega)$ by virtue of the response being a real quantity. A nonlinear response of a magnetic material is among others due to the field dependence of the spin relaxation time, according to theory in the one-frequency approximation, and addition of an alternating magnetic field to the constant one causes the spin relaxation rate Γ in the magnetic material to depend on the instantaneous magnitude of the resultant magnetic field $H(t) = H_d + h(t)$. An experiment was performed with two specimens of $CdCr_2Se_4$, a cubic ferromagnetic material with a Curie point at approximately 129 K, one single crystal and one monolayer of single microcrystals on the surface of a quartz substrate. It was performed within the $4\pi\chi(H,T) < 1$ exchange range of field and temperature. It was performed by the electron-paramagnetic resonance method sensitive to small signals. Testing was done with signals of only one frequency $\omega = 15.7$ MHz sufficiently low for the linear response to fit the Lorentz relation. It was done with the intensity of the constant magnetic field H_d, first 1.5 kOe and then 3 kOe, modulated with a constant and about 70 Oe wide ΔH sweep. The temperature was varied from $T_C = 129.5$ K ($\Delta T = 0$) to T = 146 K ($\Delta T = 16.5$ K) and measured with a Cu-Constantan thermocouple having one junction at 0°C. On the basis of the test data has been evaluated the dependence of Re $\Delta M_2/\Delta H = \Delta M_2^{cos}/\Delta H$ and of Im $\Delta M_2/\Delta H = \Delta M_2^{sin}/\Delta H$ on ΔT over the 0-16, 5 K range, also the dependence of Re M_2 on H over the -300-(+300) Oe range. The results are analyzed for a correlation with theory, the absolute temperature increment ΔT being replaced with the relative one $\tau = \Delta T/T_C$. Inasmuch as for such an analysis is needed an expression describing the field and temperature dependence of the longitudinal (parallel to H) spin relaxation rate $\Gamma_l(H,\tau) = \Gamma_1(H,\tau) - \Gamma_2$ which will apply to both weak and strong magnetic fields, an interpolation formula is used which accounts for the anisotropy of fluctuations in a magnetic field. The formula does so by including the also (H,τ)-dependent longitudinal static magnetic susceptibility $\chi_l(H,\tau)$ and transverse static magnetic susceptibility $\chi_t(H,\tau)$. Taken into consideration is the fact that the part of the dynamic susceptibility due to the field dependence of the spin relaxation rate has no static limit, only its part due to nonlinearity of the magnetization curve M(H) having one. The authors thank S. V. Maleyev and B. P. Toperverg for helpful discussion, V. M. Gelfand, V. A. Bikineyev, Ye. I. Zavatskiy, V. A. Solovyev, and G. V. Stabnikova for assistance, V. N. Fomichev for interest and support. Figures 7; references 13.

Characteristics of Radiation Emission During Mutual Radiation Phase Conjugation by Two Independent Lasers in Medium With Local Response

927J0106A Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 18 No 10, Oct 91 (manuscript received 3 Jun 91) pp 1150-1151

[Article by I. M. Beldyugin, N. I. Beldyugina, M. V. Melkumov, and K. A. Sviridov, Scientific-Industrial Association "Astrofizika", Moscow; UDC 621.373.826]

[Abstract] Mutual radiation phase conjugation by two independent lasers in two separate nonlinear media each with a local response is evaluated, following an analysis of the dynamics of four-wave interaction and attendant emission of reversed radiation in a scheme which includes an additional internal amplifier. The two input signals are assumed to have different frequencies, which is shown to be essential. Interaction of four fields $E_{1,2,3,4}$ with respective wave numbers $k_{1,2,3,4}$ and slowly varying amplitudes $A_{1,2,3,4}$ is considered, assuming for simplicity that fields E_1,E_2 have equal intensities $|E_1|^2 = |E_2|^2$ and that their additional amplification is prevented by use of polarizing devices. The system of three equations describing the dynamics in the two nonlinear media, based on a length of time for phase grating relaxation much shorter than the length of time for radiation transfer from one medium to the other, is in the approximation of given field $E_{1,2}$: $\delta A_3/\delta z = i\gamma n A_2$, $\delta A_4/\delta z = -i\gamma n A_1$, and $\delta n/\delta t + n/T = \beta(A_2^* A_3 + A_1^* A_4$ (n - amplitude of phase grating in nonlinear medium, T - relaxation time, γ,γb - constants characterizing the nonlinear interaction, z - space coordinate along optical axis, t - time). The noise radiation emission from which stimulated radiation emission evolves is, moreover, assumed to take place at the boundary z = L of medium I. With all initial and boundary conditions established accordingly, this system of equations is solved by the method of Laplace transformation. The result indicates that the necessary condition for emission of reversed radiation evolving from the noise is an exponential buildup of either amplitude A_3 or amplitude A_3 and that there exists a threshold for mutual phase conjugation in the given scheme. It also indicates that a phase difference between the two input signals is the determining factor here: emission of reversed radiation will not be stimulated by the addition when $\Delta k \Delta s = (k_1 - k_2)(s_1 - s_2) = 0$ ($s_{1,2}$ - lengths of optical paths traversed by the two laser beams 1 and 2 respectively) but can be stimulated without the additional amplifier when $\Delta k \Delta s$ is not zero. Figures 1; references 4.

Pulsed CO_2-Laser With Preionization by Soft X-Rays and Pumping by Self-Sustained Electric Volume Discharge

927J0106B Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 18 No 10, Oct 91 (manuscript received 18 Jan 91) pp 1173-1175

[Article by A. G. Gordeychik, A. G. Maslennikov, A. A. Kuchinskiy, V. A. Rodichkin, V. A. Smirnov, V. P. Tomashevich, I. A. Shestyakov, and Ye. G. Yankin, Scientific-Industrial Association "Elektrofizika", Leningrad; UDC 621.373.826.038.823]

[Abstract] A pulsed wide-aperture CO_2-laser with preionization by soft X-rays and pumping by self-sustaining electric volume discharge has been developed and tested. Preionization is provided by stable operation of an electron gun under an accelerating voltage of 60 kV and with a burst-emission cathode made of carbon-graphite cloth, discharge current pulse of 1.5 μs total duration and with 1.5 kA peaks exciting a 0.2 mm thick aluminum foil into emission of soft X-rays through a 30x60 cm size window. The active volume of the lasing medium, a CO_2-N_2-He mixture under atmospheric pressure, is 19 dm^3. An easily ionizable additive, triethylamine, is for some tests injected under a pressure of 2 mm Hg. The optical cavity, 3 m long, is formed by a plane germanium plate 190 mm in diameter and a concave copper mirror with a 12 m radius of curvature. For performance tests and energy measurements, a certain fraction of emitted laser radiation was deflected by means of a BaF_2 mirror into a bank of calorimeters. Electric discharge for pumping the active medium was produced by two methods: 1) conventionally by voltage pulses with a short rise time from a four-stage 0.125 μF Arkadyev-Marx generator through a cable of adjustable length regulating the time delay from incidence of a voltage pulse to emission of a preionizing pulse; 2) by voltage pulses with a long rise time from a generator connected to the discharge chamber through an 18 μH inductance, a noninductive 0.1 μm capacitor being connected in parallel across the electrodes. The test results and their comparison with preionization by ultraviolet radiation indicate that optimization of the X-ray source and of the pumping circuit will make a pulsed wide-aperture CO_2-laser more efficient than one preionized by ultraviolet radiation. Figures 3; references 16.

Nonlinear Model of Thermal Effects in Laser Crystals of YAG:Nd Kind

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[Article by A. G. Rozanov, Scientific-=Research Institute "Polyus" (Pole), Moscow; UDC 621.373.825.038.825]

[Abstract] Considering that the linear model of a YAG:Nd^3-laser based on the linear equation of heat conduction does not adequately explain fracture of the active medium (a long circular rod) under a thermal power far below the threshold power for mechanical fracture but only during laminar flow of the coolant, a nonlinear model of thermal effects in such laser crystals is constructed which accounts for the temperature dependence of thermal conductivity and for the consequently nonuniform temperature distribution. With the temperature dependence of thermal conductivity of a YAG:Nd crystal above 200°C closely approximated by

the hyperbolic relation k(T) = k/T, the model is based on the corresponding one-dimensional equation of steady-state heat conduction and on the equations of thermoelasticity for thermal stresses in a circular rod. This model is applied to a numerical analysis of the thermal lens, dependence of its optical strength on the pump power and on the cooling rate as well as on the thermal surface stress. Calculations have been made for a YAG:Nd rod 125 mm long and 6.3 mm in diameter placed inside a 36 cm long optical cavity and cooled with distilled water, the Reynolds being varied over the 4300-22,000 range. These calculations have also yielded the dependence of the maximum allowable rate of heat generation in a YAG:Nd crystal on the thermal resistance $1/r_0\alpha$ (r_0 - radius of rod, α - heat transfer coefficient). The proposed nonlinear model not only fits experimental data but also explains the experimentally established aberration of the thermal lens, namely its having greater optical strength along the axis than around the periphery. The authors thank A. E. Lukin for participating in the experiments and Yu. D. Golyayev for helpful discussions. Figures 2; references 14.

Possibility of Decreasing Laser Beam Divergence

927J0106D Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 18 No 10, Oct 91 (manuscript received 31 May 91) pp 1209-1211

[Article by A. V. Yurkin, Institute of General Physics, USSR Academy of Sciences, Moscow; UDC 621.373.826]

[Abstract] A new kind of mirror for optical cavities, consisting of several inclined reflector plates or wedges, has been proposed by the author as a means of minimizing the nonuniformity and the divergence of a laser beam. Two schemes are described which demonstrate the advantages of such a mirror. The basic configuration is one plane high-reflectance mirror perpendicular to the cavity axis with its center on that axis and an exit mirror consisting of 12 identical flat reflector plates arrayed 30° apart around a circle with the center on the cavity axis in a plane also perpendicular to it. All these plates are inclined at the same angle to the cavity axis and the clearances between adjoining plates are smaller than the length of the optical cavity. The trajectories of light rays in this cavity are analyzed as a basis for cavity design and laser beam optimization. The performance of laser leaving such a cavity in the free-emission mode is demonstrated on the image of its spot on some surface in the far-field region. The second scheme, a modification of the first, replaces the single plane high-reflectance mirror with two such mirrors symmetrically apart but not necessarily parallel to one another and therefore adjustable. In this case there exists a simple relation between the angle of laser beam divergence and the angle between the two mirrors. Figures 3; references 5.

New Possible Emission Channels in Praseodymium Laser Crystals

927J0112A Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 319 No 4, Aug 91 pp 870-872

[Article by A. A. Kaminskiy, Institute of Crystallography imeni A. V. Shubnikov, USSR Academy of Sciences; UDC 548.0+535.35]

[Abstract] New emission channels associated with Pr^{3+} ions have been discovered in six kinds of anisotropic dielectric laser crystals containing this impurity: $^3P_0 \rightarrow {}^3H_6, {}^3F_4$ channels in $LiYF_4$ crystals, $^3P_0 \rightarrow {}^3H_6$ channel in $LiLuF_4$ crystals, $^3P_0 \rightarrow {}^3F_2, {}^3F_4$ channels in BaY_2F_8 and $LuAlO_3$ crystals, $^1D_2 \rightarrow {}^3F_4$ channel in $CaWO_4$ and $Ca(NbO_3)_2$ crystals. The crystals for the experiment leading to this discovery were grown from melts: the oxide crystals by the Bridgman-Stockbarger with 1-1.5 atom.% Pr^{3+} concentration and Na^+ or Ti^{4+} compensator ions, the fluoride crystals by the Czochralski method with 0.6-0.7 atom.% Pr^{3+} concentration. Active elements in the form of 45 mm long rods 6 mm in diameter with plane-parallel end faces were cut out of the crystals, their lasing axes variously oriented relative to the crystallographic ones. These active media at a 300 K temperature were pumped with radiation pulses of 25-30 μs duration, the radiation source being an ISP-250 Xe flash lamp surrounded by a light-yellow filter inside an elliptic luminaire with a silver-coated active surface. Such pumping of the crystal rods was found to stimulate pulsed emission of visible or near-infrared radiation. A confocal optical cavity was formed by interchangeable mirrors each having a 500 mm radius, different mirrors being used for radiation of different wavelengths so as to ensure an R = 0.99 reflection coefficient in each case and thus the necessary selectivity. The emission spectra were analyzed by the photoelectric method, using an MDR-3 diffractometric monochromator and a cooled InSb photoresistor or a Ge avalanche photodiode with the appropriate electronics. There are two major obstacles to practical usefulness of these lasers, one of them being the very narrow active-absorption band (0.43-0.48 μm) of Pr^{3+} ions so that pumping with wide-spectrum radiation of Xe flash lamps is very inefficient and another one being the very short life (10-50 μs) of the initial $^3P_0$ lasing state. One way to increase the pumping efficiency would be the use of a fluorescence converter which will convert ultraviolet pumping radiation into radiation of wavelengths within the active-absorption band of Pr^{3+} ions. Another way would be lifting the ground state. An additional problem with the oxide crystals is that pumping with short-wave radiation generates color centers. The author thanks A. V. Pelevin, A. G. Petrosyan, K. L. Ovanesyan, and T. V. Uvarova for growing the laser crystals. Article was presented by Academician B. K. Vaynshteyn on 14 May 1991. Tables 1; references 13.

Dielectric Cerenkov Maser as Ultrawide-Band Microwave Power Amplifier

927J0121A Leningrad PISMA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian, Vol 17 No 19, 12 Oct 91 (manuscript received 15 Aug 91) pp 4-10

[Article by K. A. Chirko and A. S. Shlapakovskiy]

[Abstract] A principle of a dielectric Cerenkov maser and its performance as ultrawide-band microwave power amplifier are analyzed. An estimation of its widest attainable amplification band depends on both electron beam and waveguide structures. First is considered the simplest theoretical model of a magnetized relativistic solid electron beam passing through an all-solid dielectric waveguide, in which case the dispersion equation can be reduced to the characteristic equation for a Cerenkov traveling-wave tube. Its solution yields the amplification band in relation to the dimensionless quantity $\zeta = (\varepsilon\beta^2 - 1)\varepsilon\gamma^3(pv)^2/4\Omega^2$ (ε - dielectric permittivity of waveguide filler, $\beta = v/c$, v - velocity of electrons, c - speed of light, $\gamma = (1 - \beta^2)^{-1/2}$, p - transverse wave number, $\gamma = (1 - \beta^2)^{-1/2}$, Ω - plasma frequency). The absolute amplifier bandwidth increases as ζ decreases from $\zeta >> 1$ (one-particle mode) with the electron velocity approaching the Cerenkov limit and becomes maximum when $\zeta = 1/4$. It also depends on the beam current and, at any fixed electron velocity, is maximum at some optimum intermediate current level. The relative amplifier bandwidth decreases as ζ increases from $\zeta << 1$ (collective mode) with the electron velocity approaching the Cerenkov limit and becomes minimum when $\zeta = 1/4$, then remaining constant as ζ increases further. Next is considered the more practical model of a magnetized thin tubular relativistic electron beam passing through a shielded circular waveguide with a dielectric insert only, for which case the dispersion equation in Bessel functions has been solved numerically. The results show that here the absolute bandwidth increases as the clearance between the electron beam and the dielectric surface is narrowed, also that it depends on the beam current and is maximum at some optimum intermediate current level. Increasing the beam energy without changing its radius and thickness can, moreover, increase the relative amplifier bandwidth and maximize it at some higher current level. Another interesting feature is that the amplifier bandwidth decreases to zero gradually toward its upper frequency limit and abruptly at its lower frequency limit. Such dielectric Cerenkov maser with 300-800 keV electron beams carrying currents of 1-10 kA can operate as amplifiers with an up to 40 dB maximum gain and a 40-50 percent relative bandwidth at 10 GHz and even higher frequencies. The authors thank G. P. Fomenko, N. S. Veringorov, and A. S. Sulakshin for helpful discussions. Figures 3; references 11.

Transient Scattering of Laser Radiation in Nonlinear Medium

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[Article by Yu. V. Korobkin, I. V. Romanov, and V. B. Studenov, Moscow Institute of Radio Engineering, Electronics, and Automation]

[Abstract] Transient scattering of laser radiation by charged particles passing through electrooptically nonlinear fluid media such as a Kerr liquid was studied in an experiment, the theoretical "medium-particle-particle track" system being simulated in a coaxial cylindrical capacitor 200 mm long with a 60 mm outside diameter. Its inner electrode was a taut wire 100 μm in diameter simulating the particle track and benzene served as the Kerr liquid ($\varepsilon_2 = \Delta\varepsilon/E^2$ cgs units: $\Delta\varepsilon$ - component of dielectric permittivity due to nonlinearity of the medium, E - electric field intensity due to light wave. Each end of the cylindrical tube was covered by a window made of optical-grade glass, for passage of a laser beam along the cylinder axis. An extremely high electric field intensity of up to about 10 MV/m and a linear charge density of up to 6×10^{-7} C/m on the wire electrode, at a potential of 25 kV, were attained in this configuration. A permittivity wave in the medium was produced by injection of a wave of intense 1.07 μm light coming from a YAl_3:Nd^{3+} laser, passive mode locking of this laser ensuring maximum transient scattering in terms of energy. The laser emitted pulse trains of 0.3-0.5 J energy and 100 ns duration, with 20 pulses of 30 ps duration in each train. A high-voltage pulse of approximately 3 ms duration was applied to the capacitor in synchronism with incidence of a light pulse. An analysis of the radiation spectra in the visible region reveal a superwidening of these spectra up to red wavelengths, owing to phase self-modulation of the laser wave. In the absence of an electric field there was found polarized cooperative radiation scattering into the second laser harmonic. Upon application of an electric field there occurred transient radiation scattering with a polarized component in a direction dependent on the phase velocity of the permittivity wave, in accordance with the Cerenkov criterion. The authors thank V. A. Davydov for fruitful discussion. Figures 1; references 3.

Manifestation of "Matrix Memory" in Electronic Spectra of Compound Molecules Adsorbed by Nonhomogeneous Surface

927J0121D Leningrad PISMA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 17 No 19, 12 Oct 91 (manuscript received 15 Aug 91) pp 83-86

[Article by V. N. Beger and A. V. Sechkarev]

[Abstract] An experimental study was made concerning the spectral characteristics of dye molecules precipitating from a solvent onto porous adsorbing glass, the results indicate that their spectra do not change after removal of the solvent from the pores. The results are analyzed taking into consideration several factors: 1) Absorption and fluorescence bands of a molecule can shift either hypsochromatically or bathychromatically during its passage from solution to substrate; 2) A shift within its electronic spectrum is due to changing interaction of the molecule and its local environment, the interaction energy not being the same for an excited molecule and for an unexcited one; 3) Nonhomogeneity of a surface is caused by polydispersity of pore size as

well as by "roughness" and thus by polydispersity of local curvature, the radius of surface curvature determining the energy of van der Waals adsorbent-adsorbate interaction. Intermolecular interaction during adsorption of a molecule by a porous surface, which in the case of adsorbate molecules in solution includes also solvent-adsorbent interaction, should obviously result in a nonuniform widening its spectra. This and retention of spectral shifts after removal of the solvent was confirmed by a spectrum analysis of oxazine-17 molecules adsorbed from various solvents (ethanol, toluene, hexane) by porous glass and then remaining on "dry" glass. Figures 1; references 8.

Wide-Aperture 1 GW KrF-Excimer Laser With Electron Beam Pumping

927J0128A Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 18 No 4, Aug 91 (manuscript received 12 Apr 91) pp 902-904

[Article by N. G. Basov, V. G. Bakayev, Ye. A. Grigoryants, Ye. O. Danilov, V. D. Zvorykin, P. V. Kobelev, G. Ye. Metreveli, S. V. Polyanskiy, I. V. Proleyko, A. F. Suchkov, and G. V. Sychugov, Institute of Physics imeni P. N. Lebedev, USSR Academy of Sciences, Moscow; UDC 621.373.826.038.823]

[Abstract] An excimer laser set, "Harpun," has been built with a ternary F_2-Kr-Ar mixture as active medium occupying a volume of 18x20x100 cm^3 and bilaterally pumped by two electron beams in pulses of 1-1.1 kJ energy and 100 ns duration . The electron beams, 12 cm thick and 100 cm wide with a current density of 25-27 A/cm^2, were generated in vacuum diodes upon application of 400 kV voltage pulses across the latter. They were injected into the laser cell through a 25-40 μm thick Ti foil each. Pinching of the electron beams by their intrinsic azimuthal magnetic fields was prevented and scattering of electrons in the active gas was minimized by means of two solenoids, each having 200 turns and generating a collinear pulsed magnetic field so as to ensure a uniform distribution of current density over the cross-section of the electron beams. The laser cell with the active medium was at one end mounted on a flange and at the other end covered by a LiF window slanting at a 15° angle. The optical cavity for the active medium was formed by a concave opaque mirror with a 6 m radius of curvature mounted on the same flange and a plane or concave exit mirror facing the window at the other end. Various plane exit mirrors were used so as to vary the reflection coefficient and various concave exit mirrors with different base diameters were used so as to vary the magnification, the length of the optical cavity being varied over the 2-2.5 m range by varying the distance between mirrors. Active media containing 0.1-0.3 % F_2 + 5-10 % Kr with Ar as the buffer gas were tested, the total pressure being varied over the 1-2 atm range. The best performance was obtained with 0.1-0.15 % F_2, the emission energy then not significantly depending on the Kr concentration but still depending on the pressure and reaching its maximum under about 1.25 atm. A maximum emission energy of about 40 J per pulse was attained by having the active medium inside a stable resonator cavity, with a plane-parallel quartz plate transmitting 92 percent of incident radiation as the exit mirror, and pumped by electron beams with an average intensity of about 0.5 MW/cm^3. An emission pulse then lagged a pump pulse by about 40 and its energy therefore peaked toward the end of the pump pulse. Raising the amplitude of voltage pulses across the diodes to 430 kV raised the emission energy of the optimum KrF-laser to 60 J per pulse, with the power peaking to a maximum of about 1 GW. With the active medium inside an unstable resonator cavity, at an M = 3 or M = 4 magnification the laser emission power was only slightly lower than that maximum but at an M = 6 magnification and thus minimum beam divergence it was two-thirds to one-half of that. The authors thank I. V. Kholin for designing the laser apparatus, V. G. Zarudin, S. I. Sagitov, G. M. Chumak for assisting in the setup, and E. I. Molodykh and his staff for valuable discussions. Figures 2; references 4.

Generating Squeezed States of Electromagnetic Field With Nonlinearly Coupled Quantum Oscillators

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[Article by O. V. Lukashina, A. N. Orayevskiy, and I. Ye. Protsenko, Institute of Physics imeni P. N. Lebedev; UDC 621.373.826]

[Abstract] A scheme for squeezing light in a gaseous medium is described, namely nonlinearly coupled quantum oscillators such as polyatomic molecules resonantly absorbing and re-emitting infrared radiation in multiple-frequency vibrational modes. The mechanism is demonstrated on a gas of particles each consisting of two nonlinearly coupled almost harmonic small-amplitude quantum oscillators: one with dipole moment μ_0 oscillating at a frequency ω_0 and one with dipole moment μ_p oscillating at a frequency $\omega_p \simeq \omega_0/2$. Let the ω_0-oscillator be resonantly excited by a given "classical" external traveling electric field $E_0\sin(2\omega t-kz)$ whose frequency is $2\omega \simeq \omega_0$ and amplitude E_0 is constant. Such a field can be produced by passing a reference signal $E_r\sin(\omega t-kz)$ through a second-harmonic generator. As some energy of this oscillator is being transferred through the nonlinear coupling to the other oscillator, the latter will emit radiation. Let particles of this kind fill a container inside the cavity of a ring resonator with a natural frequency $\omega \simeq \omega_p$ so that its natural mode matches the wave vector $2k = 2\omega/c$ of the external field. This configuration simplifies the calculations, inasmuch as radiation emission in other than that mode becomes negligible and can be disregarded. Assuming further that a volume element $\delta V << k^{-3}$ of the container contains sufficiently many such particles for making the gas macroscopically dense, the Hamiltonian for such a

system of particles is formulated by averaging over the volume element and summation over the particles within the volume of the resonator mode. From the Hamiltonian is then derived an equation for the amplitude A_0 of the pumping oscillator. The solution to this equation yields a squeezed field component and an unsqueezed one. The squeezed one being of interest, its rate of buildup and its dispersion are calculated as a basis for experimental verification of the proposed mechanism and numerical estimation of the system performance characteristics. There exist several polyatomic molecules which have two vibrational modes fitting this scheme with $\omega_0 \cong 2\omega_p$: CF_2Cl_2, CCl_3F, and N_2H_4 can be pumped by an infrared laser such as an Er^{3+}-laser ($\lambda \leq 3.5$ μm), an HF-laser ($\lambda = 2.7\text{-}3.3$ μm), a CO_2-laser ($\lambda \simeq 10$ μm), or any semiconductor lasers emitting $\lambda \approx 15$ μm radiation. Figures 6; references 20.

Nonlinear Light Transfer in Coupled Rb:KTR Waveguides

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[Article by K. S. Buritskiy, Ye. M. Dianov, V. A. Maslov, V. A. Chernykh, and Ye. A. Shcherbakov, Institute of General Physics, USSR Academy of Sciences, Moscow; UDC 621.372.8.029.7]

[Abstract] Nonlinear light exchange between coupled Rb:KTR (KTR = potassium titanyl phosphate) channel waveguides was achieved in an experiment with a nonlinear directional coupler consisting of two identical tunnel-coupled waveguides in a KTR crystal. The waveguides, both 6 μm wide and about 5 μm thick, were 7 mm long and oriented parallel to the Y-axis 4 μm apart. They had been formed by transfer of Rb^{3+} ions from a melt of $RbNO_3$ salt to a Z-cut KTR substrate at a 350°C temperature, the process lasting 15 min. They were single-mode waveguides for 1.06 μm light polarized parallel to the X-axis. The light source was a Q-switched and mode-locked Quantronix-116 laser emitting pulse trains of 200 ns duration with a 100 MHz repetition rate and a 500 kW maximum peak power within each train, the duration of individual pulses not exceeding 20 ps. Light from this source was transmitted by an anisotropic single-mode optical fiber to one of the waveguides through a set of two microobjective lenses with 20x magnification before the polished face of the Rb:KTR crystal. Measurements on the exit side were made with a photodiode and an oscillograph. In the linear mode, with a small optical input signal, most of the luminous output power was found to be coming from the excited waveguide and only 10 percent of it coming from the other one. In the nonlinear mode, increasing the input signal power resulted in a phase mismatch of the two waveguides and in a transfer of increasingly more luminous power from the excited waveguide to the other one: up to 40 percent of it as the power of the input signal was raised to 5 kW. The authors thank V. P. Konyayev and Yu. V. Kurnyavko for producing the waveguides, also A. B. Grudinin for assistance. Figures 2; references 8.

He-(Xe,Kr,Ar) Lasers With Electron Beam Pumping

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[Article by A. Yu. Dudin, D. A. Zayarnyy, L. V. Semenova, N. N. Ustinovskiy, I. V. Kholin, and A. Yu. Chugunov, Institute of Physics imeni P. N. Lebedev, USSR Academy of Sciences, Moscow; UDC 621.373.826:038.823]

[Abstract] An experimental study of high-pressure He-Ar and He-Kr lasers with transverse high-current electron beam pumping was made concerning their spectral and energy characteristics, a known He-Xe laser serving as reference for comparison. The experiment was performed in the "Tandem" facility, where the active medium occupied a volume of 10 dm^3 in a laser chamber with a 10x10 cm^2 square aperture. An electron gun with a pin cathode under vacuum, when energized by an Arkadyev-Marx generator consisting of five stages with a 0.65 μF capacitor in each, formed a 10 cm thick and 100 cm wide beam of electrons with up to 320 kev energy in pulses of about 5 μs total duration at a current density slightly higher than 1 A/cm^2 in pulses of about 5 μs total duration. Such a beam was extracted from the vacuum of the electron gun and injected through a 20 μm thick Ti foil transversely to the optical axis into the laser chamber, the current density behind the foil reaching 1.7 A/cm^2 and the beam energy reaching 1.5 kJ in a pulse. The pressure of the active mixtures was varied over the 1-3.5 atm range in search of the optimum level. The active media were placed in a stable optical cavity between a gold-coated opaque plane mirror and a parallel to the dielectric plane exit mirror, various dielectric mirrors being interchangeably used so as to vary the transmission coefficient for 1.27-3.65 μm radiation over the 0.20-0.80 range. The dielectric mirror with a 0.75 transmission coefficient for 2 μm radiation was found to be the optimum one for all lasers in terms of maximizing the energy extraction from the cavity. The emission energy characteristics, namely total output energy Q in a pulse and physical efficiency η, were optimized by varying both the composition and the pressure of the active mixtures. The optimum mixtures were found to be He:Kr = 1000:1 under the top pressure of 3.5 atm only (Q = 20 J, η = 1.8 %), and He:Ar = 100:1 under any pressure within the 1-3.5 atm range (Q = 1.95 J under 3.5 atm, η = 1.6 %). As to the He-Xe mixtures, He:Xe = 1000:1 was also optimum under the top pressure of 3.5 atm and He:Xe = 100:1 was optimum under any lower pressure. An analysis of the emission spectra indicates that population of the upper lasing is effected not by recombination of heteronuclear ions and electrons but more likely by dissociative recombination of dimer ions and electrons with attendant formation of dimer atoms. This kinetic model of lasing transitions needs to be

verified to account for collisional relaxation of atomic states under higher pressure and its effect on the pattern of luminescence. The experimental data reveal also the dynamics of light amplification within the duration of an emission pulse corresponding to the dominant transitions in the various media under optimum pressure. The results indicate that the energy characteristics of Xe,Kr,Ar lasers with He as the buffer are not as favorable as those of Ar-Xe lasers. Figures 5; references 15.

Numerical Analysis of Characteristics of Laser With Mixing of H_2 and HCl Components During Electroionization Pumping of Molecular Hydrogen

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[Article by V. A. Vostryakov, P. P. Kirmusov, and A. M. Starik, Central Institute of Aircraft Engine Design; UDC 533.6.011+536.14]

[Abstract] A continuous-wave H_2-HCl laser is considered where HCl molecules become excited by nonresonant V-V' exchange as they mix with H_2*(v) hydrogen molecules excited by electroionization in a nonself-sustaining discharge. A stream of molecular hydrogen alone or of H_2-Ar mixture is first excited in the flow-through discharge chamber without appreciable heating and then expands in a supersonic nozzle while it mixes with HCl also injected into the nozzle. The spectral and energy characteristics of this infrared laser are analyzed theoretically in the approximation of one-dimensional flow of a nonviscous and thermally nonconducting gas, assuming also instantaneous mixing of its components and microscopic discontinuity between them. Because both gas temperature and gas pressure are high both within the supersonic zone of the nozzle and inside the optical cavity, a thermodynamic equilibrium between all translational and rotational degrees of freedom may be assumed to prevail in both regions so that spontaneous transitions are much slower than collisional ones. The gas relaxation dynamics on both sides of the discontinuity can then be described by the same system of ordinary differential equations interrelating gas velocity u, gas density ρ, gas pressure p, and their gradients as well as the temperature gradient dT/dx, with the ratio R/μ (R - gas constant, μ - molecular mass of lasing mixture) proportional to the temperature gradient and to the sum 5/2 plus the molar fractions of all H_2-Ar-HCl or H_2-HCl mixture components. Vibration of H_2 molecules both before and past the mixing surface is regarded as that of a harmonic oscillator. Vibration of HCl molecules is treated as that of a Morse oscillator. Taken into account are one-quantum and two-quantum transitions. The model of local vibrational temperatures is used for describing nonequilibrium flow of H_2 or H_2-Ar mixture in both subsonic and transonic zones in the nozzle but not in the supersonic zone, because this model does not account for the effect of anharmonism on the reversible H_2 (v') + HCl(v") $\rightarrow$ HCl(v" + 1) + H_2(v' - 1) reaction in that zone. Calculation of the emission spectrum and energy is based on the integral law of same energy loss and gain loss per lasing transition per mirror-to-mirror passage through optical cavity. A numerical analysis of this system indicates that such a laser can be an effective converter of electric energy into coherent radiation, into fundamental 3.8-4.2 μm radiation with a 9.2 percent efficiency or into second-harmonic 1.9-2.2 μm radiation with a 6.6 percent efficiency. Figures 5; references 12.

Temperature Dependence of Threshold of Brittle Fracture by Pulsed Dense Electron Beam

927J0090A Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 320 No 5, Oct 91 pp 1107-1111

[Article by A. L. Bardenshteyn, S. P. Bugayev, corresponding member, USSR Academy of Sciences, and D. I. Vaysburd, Institute of Electronics, Siberian Department, USSR Academy of Sciences, Tomsk; UDC 539.2:620.16:534.14]

[Abstract] Brittle fracture of solids by superstrong radiative action of dense electron beam is considered, of concern being the lowest of all energy threshold of fracture by pulsed action of such an electron beam relative to the energy thresholds of electric breakdown, melting, and boiling. It had been established in an earlier article (D.I. Vaysburd et al.; DOKLADY AKADEMII NAUK SSSR Vol 297 No 3, 1987) that fracture of a solid by a pulsed electron beam is associated not only with a compression pulse whose waveform and amplitude are temperature-dependent but also with tensile mechanical stresses. Three kinds of stresses being involved here: dynamic ones in the load relaxation wave, quasi-static ones including thermoelastic ones, and dynamic ones in the natural acoustic modes. The temperature dependence of those dynamic and quasi-static mechanical stresses preceding brittle fracture is now analyzed and evaluated, taking into account heat conduction by the material. A specific case is considered about an electron beam normally incident on the solid surface (along the z-axis of coordinates) so that the displacement vector and the stress tensor have only one nonzero component each, u_z and σ_{zz} respectively. The relation between them is expressed by Newton's law and Hooke's law, together yielding the wave equation: $\delta^2u/\delta t - \delta[C^2\delta u/\delta z]/\delta z/ = -\delta L/\rho\delta z$ with $L(z,t) = \mathrm{Int}_{t0}^{T(z,t)} \beta(T)K(T')dT'$ (T_0 - initial temperature of solid, T(z,t) - temperature field produced by electron bombardment, C(T) - speed of longitudinal sound wave, β - coefficient of cubical thermal expansion, K(T) - bulk compression modulus, t - time). The temperature field satisfies the equation of transient heat conduction $\delta T/\delta t - \delta[k(T)]/C_V(T)\ \delta T/\delta z] = \rho D(z)F(t)/C_V(T)$ (T - temperature, t - time, D(z) - distribution of absorbed bombardment dose, F(t) - bombardment pulse, k(T) - thermal conductivity, $C_V(T)$ - specific heat at constant volume). The solution to this equation must satisfy the initial condition $T(z,0) = T_0$ and the boundary condition $(\delta T/\delta z)_{z=0} = 0$. The two equations were solved by the method of finite differences. They were solved for three materials: cobalt single crystals, polycrystalline nickel, and quartz glass, each bombarded by an electron beam of the GIN-600 high-current miniaccelerator. Calculations for cobalt and nickel covered the 300-900 K temperature range, containing the 673 K α-Co $\rightarrow$ β-Co cobalt phase transformation temperature and the 527 K Curie point for nickel. The 673 K point of the calculations have yielded the temperature dependence of quasi-static and dynamic tensile stresses produced by heat of an electron beam, a temperature dependence without discontinuities. The results indicate that the ratio of maximum stress $-\sigma_{max}$ (MPa) to beam charge fluence per pulse $e\Phi$ ($\mu C/cm^2$) and thus the stress-producing efficiency of an electron passes through a simple wide peak about the phase transformation temperature in the case of cobalt and through a narrow peak between two valleys about the Curie point in the case of nickel. The temperature dependence of thermomechanical stresses in quartz glass, calculated over the 77-700 K range, follows an altogether different trend associated with two anomalies of this material: 1) its thermal expansion coefficient reverses sign at 190 K, 2) its modulus of elasticity and thus also the speed of sound increase very fast as the temperature rises above 60 K. In this material, unlike in the others, an electron-beam pulse generates a primary load relaxation wave in the form of a tension rather than compression pulse. The temperature dependence of the stress-producing efficiency of a pulsed electron beam remains in this case almost constant from 700 K to room temperature and then decreases down to a much lower level at about 190 K before increasing steeply to a much higher level at 77 K. The fracture threshold for quartz glass is evidently almost 10 times lower at 77 K than at room temperature. Figures 2; references 15.

New Efficient Method of Resonance Ionization Spectroscopy of Atoms With Short-Lived Nuclei

927J0119A Leningrad PISMA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 17 No 14, 26 Jul 91 (manuscript received 29 Apr 91) pp 39-42

[Article by G. D. Alkhazov, A. Ye. Barzakh, V. P. Denisov, K. A. Mezilev, Yu. N. Novikov, V. N. Panteleyev, A. V. Popov, E. P. Sudentas, V. S. Letokhov, V. I. Mishin, V. N. Fedoseyev, S. V. Andreyev, D. A. Vedeneyev, and A. N. Zyuzikov, Leningrad Institute of Nuclear Physics imeni V. P. Konstantinov, USSR Academy of Sciences]

[Abstract] A method of resonance ionization spectroscopy of atoms with far-from-stability range and thus short-lived nuclei is proposed, this method being more efficient and sensitive than optical spectroscopy of such atoms using tunable dye lasers. Two or three merging laser beams and atoms of such a species are injected into a cavity containing an ion source within a hot metal wall. Resonance ionization of these atoms is effected following their multistage excitation into autoionization states, a narrow-band laser with frequency scan being used for the first excitation stage. For both second and third excitation stages are used wideband lasers tunable to resonance with relevant atomic transitions, their emission frequency spectrum covering the hyperfine structure of these transitions and also possible isotopic shifts. The method is highly efficient, owing to multiple passage of atoms through the irradiation zone prior to their exit from the ion source through holes in the cavity wall and a consequently high probability of their becoming ionized. The ionized atoms, moreover, do not adhere to the cavity wall and thus do not become neutralized, because the hot metal wall emits so many electrons that the cavity inside becomes negatively

charged and an electric double layer forms around the ion source. The method was tested on isotopic shifts of the optical 555.6 nm wavelength in neutron-deficient Yb nuclides. Isotopes of this element were produced by nuclear reactions in a Ta target weighing 12 g, these reactions occurring during interaction of the target with a 1 GeV proton beam with 10^{12} s^{-1} intensity. Fast extraction of the reaction products was ensured by making the target 2300-2500°C hot. For the ion source, a 2000-2100°C hot 60 mm long Nb tube 2 mm in diameter was used. Into this tube were injected Yb atoms, from the target through a connecting tube, and two merging laser beams 0.5 mm in diameter. A narrow-band dye laser with an about 1.7 GHz wide tuning range was used for the first excitation stage. The same 580.9 nm dye laser with an about 30 GHz wide frequency range was used for both second and third excitation stages. Each laser was pumped with radiation pulses from a separate Cu-vapor laser at a repetition rate of 10 kHz. The ions of Yb isotopes were, upon leaving the source, accelerated to 30 keV energy, then passed into an electromagnetic mass-separator segregating them with a mass resolution of about 1000, and detected in the focal plane of that separator. The more numerous ^{160,162,164,166}Yb ions closer to the stability range were detected directly, with an electron multiplier. The less numerous ^{154,155,156}Yb ions farther from the stability range were detected indirectly, a surface-barrier Si-diode recording α particles emitted during α-decay of these isotopes within a 0.28π sector with an energy resolution of about 30 keV. Figures 1; references 3.

Fractal Kinetics of Self-Organization of Dissipative Structures During Mechanical Alloying in Attritors

927J0119B Leningrad PISMA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 17 No 14, 26 Jul 91 (manuscript received 7 Jun 91) pp 27-30

[Article by A. S. Balankin, V. S. Ivanova, A. A. Kolesnikov, and Ye. Ye. Savitskaya]

[Abstract] Synthesis of aluminides of transition metals by mechanical alloying is considered, this new technology having been tested experimentally on Ni-Al and Ti-Al alloys with stoichiometric compositions. These alloys were produced in an argon atmosphere in an attritor of 10 dm^3 capacity with forced cooling driven by a 4.5 kW motor. Analysis of the technological cycles has revealed that three groups of structures are forming in the process and facilitate energy dissipation at three different levels respectively. The turbulent dynamic macroscopic-scale dissipative structures facilitate effective redistribution of injected kinetic energy among the charge ingredients and the crushing balls, this being made possible by self-organization of the energy field which has been made highly nonuniform by interbedding. The dissipation regions form here a fractal structure with a Hausdorff dimensionality $d_f^{(1)}$ smaller than the dimensionality d of the enveloping space. The quasistatic mesoscopic-scale dissipative structures facilitate effective energy dissipation following comminution and attendant deformation of particles by the crushing balls. At this level such a mechanical treatment causes first their fragmentation and seizure of particle, then formation of multilayer composite particles as a result of welding and rolling action, and finally coagulation into a conglomerate of composite particles welding together without a preferential orientation. The fractal dimensionality of these mesoscopic dissipative structures $d_f^{(2)}$, which depends on the fractal dimensionality $d_f^{(1)}$, controls both adaptation and dissipation of energy at this level. The dynamic microscopic-scale dissipative structures facilitate effective mixing of the charge ingredients at the atomic level and subsequent formation of amorphous or quasi-crystalline clinkers of one kind. This is made possible by adaptation of the excess energy in regions which are not at equilibrium, the fractal dimensionality of these regions being $D_f > 3$. The effectiveness of energy adaptation at the atomic level is determined by that dimensionality D_f, which depends on the rate of deformation of the composite particles. The deformation rate here is in turn controlled by the intensity of energy dissipation at the mesoscopic level. On the basis of this fractal analysis is formulated a system of equations describing the coagulation kinetics of self-similar clusters which form metastable alloys with fractal dimensionalities $3 < D_f < 4$, useful for optimization of inertial or quasi-inertial control of this alloying process. The analysis is supplemented with experimental data on three alloys produced by this technology: 1) Ni + 25 atom.% Al, containing Ni_3Al and NiAl inclusions; 2) Ni + 50 atom.% Al, a mixture of amorphous and quasi-crystalline NiAl; 3) Ti + 48 atom.% Al, with a TiAl phase forming in the matrix. References 13.

Problem of Thermonuclear "Cluster" Fusion

927J0136A Leningrad PISMA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 17 No 18, 26 Sep 91 (manuscript received 20 Jun 91) pp 41-45

[Article by M. L. Aleksandrov, Yu. S. Kusner, V. I. Nikolayev, and P. N. Potapov, Institute of Analytical Instrument Design, USSR Academy of Sciences, St. Petersburg]

[Abstract] Concerning thermonuclear fusion by impact of an accelerated ion cluster on a solid target, an experiment was performed involving mass spectrometry of heavy-water ion clusters forming in a gasdynamic ion beam found to be a mixture of more $H^+(D_2O)_n(H_2O)_m$ ion-proton clusters and fewer $D^+(D_2O)_n(H_2O)_m$ ion-deuteron clusters. In the experiment D_2O was fed by a capillary tube with a 0.12 mm in diameter orifice through a corona discharge in air under atmospheric pressure at its tip to a divergent nozzle which then discharged a supersonic free jet of air and water vapor mixture at a rate of about 1 dm^3/min. Into the corona discharge had been injected both plain water (distillate) at a rate of 0.1 μl/min and, at about the same rate, NMR-grade heavy water containing 99 percent deuterium (made in Switzerland) or 99.8 percent deuterium

(made in the U.S.). A skimmer diaphragm behind the nozzle extracted from the jet a gasdynamic beam of ion clusters. This beam was passed successively through an electrostatic energy spectrometer and a magnetic mass spectrometer for analysis, the two analyzers forming a dee. The advantages of this arrangement were a high resolution, at least 1,000 clusters within an about 100 eV wide "energy window," its dee configuration which eliminated "jump over" of particles, and inclusion of energy-spectrum analysis indicating both the origin and the charge of cluster ions. The authors thank L. Friedman (Brookhaven National Laboratory, U.S.) and G. Fena (Yale University, U.S.) for helpful discussions, O. A. Mirgorodskaya and A. V. Podtelezhnikov (Institute of Analytical Instrument Design, USSR Academy of Sciences) for assistance in organizing the measurements, and V. I. Mamatyuk (Institute of General Chemistry, Siberian Department, USSR Academy of Sciences) for supplying the specimens of heavy water. Figures 3; references 4.

Formation of Defect Centers in Metals During High-Energy Ion Implantation

927J0136B Leningrad PISMA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 17 No 18, 26 Sep 91 (manuscript received 26 Jul 91) pp 50-55

[Article by V. V. Kostin, V. A. Skvortsov, and V. Ye. Fortov]

[Abstract] Surface treatment of metals and alloys by pulsed implantation of large doses of light or heavy high-energy (1-10 MeV) ions resulting in formation of sufficiently thick and uniformly impregnated insulating layers is considered for diverse purposes such as protection against chemically aggressive media or attainment of record high superconducting transition temperatures, a major problem with this treatment being the initiation of defects by it. This problem is analyzed here on the basis of two-dimensional equations of hydrodynamics describing transient flow of a continuous medium. These equations, supplemented with a wide-range equation of state which accounts for elastoplasticity of the material, taking into account the Bragg peak attending action of a beam of protons with higher than 1 MeV energy on such a target. As a specific example for numerical analysis has been selected a solid cylindrical proton beam with a 0.1 cm radius and a Gaussian radial distribution of the current density, up to 5 kA/cm^2 at the axis, bombarding a 1 mm thick aluminum plate in pulses of 100 ns duration with protons of up to 10 MeV energy. The resulting plane state of stress in the plate has been calculated for two conditions: 1) both proton energy and current density constant at their maximum levels, and 2) both varying sinusoidally in time. The patterns of stress distribution and discontinuity distribution after 500 ns are presented in the form stress (kbar) isolines and specific volume (cm^3/g) isolines respectively. Figures 3; references 10.

Experimental Study of Streamer Corona Between Grounded Surface and Charged Aerosol Cloud

927J0136C Leningrad PISMA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 17 No 18, 26 Sep 91 (manuscript received 2 Aug 91) pp 80-83

[Article by K. V. Antsupov, I. P. Vereshchagin, L. M. Makalskiy, N. I. Petrov, and V. S. Sysoyev, All-Union Institute of Electrical Engineering imeni V. I. Lenin]

[Abstract] An experimental study of a positive streamer corona between a grounded plate and a negatively charged aerosol cloud was made concerning its form and characteristics. The cloud of charged aerosol particles in the 0.1-0.5 μm size fraction was produced by a high-voltage water aerosol generator underneath the 18 m square plate. The aerosol was rising (through a hole in the plate) into the air under normal atmospheric conditions, forming a cloud in the shape of a 3-4 m high diverging vertical cone. With the generator drift current within the narrow 100 +/- 5 μA range, discharge was taking place from the lateral surface of that conical aerosol cloud to the grounded plate. The discharge was confined within a 0.5-0.8 m long conical tube bending downward while converging within an angle of about 30° from a wide base at the aerosol surface to a bright spot about 1 cm in diameter on the grounded plate-electrode. Within this diffusely glowing corona tube there appeared several brighter filaments representing streamer channels. The discharge retained this form in a stable state for a period longer than 10 s, while the drift current maintained the aerosol charge by also balancing the leakage of charge to other grounded objects as well as the loss of charge owing to electrostatic repulsion and to recombination. The corona tube vanished when the drift current was dropped below 95 μA. The corona tube shrunk into a spark channel when the drift current was raised above 105 μA, but recovered its original form 1-5 s later. As the charge of the aerosol cloud reached 60-80 μC, a pulsed streamer discharge began developing at inhomogeneities on the grounded plate. Further increase of the drift current resulted in a higher repetition rate of individual corona pulses. As the charge of the aerosol cloud was increasing from 80 to 90 μC, these pulses were being replaced by packets of 15-30 streamer corona pulses riding on the discharge current component: Their amplitude becoming almost three times larger and that d.c. component increasing from 0.02 to 0.06 A. Further buildup of space charge in the aerosol cloud was attended by an eventual complete transition of the streamer corona to a leader discharge, the latter having begun at a 10-20 μC/m threshold of linear charge density and thus indicating that the stable streamer corona discharge from the aerosol cloud was only a part of a broader leader discharge to begin with. Figures 2; references 5.

Thermal States of Copper Target Cooled During Intense Local Heating

927J0137B Moscow TEPLOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 29 No 1, Sep-Oct 91 (manuscript received 13 Jun 90) pp 941-948

[Article by V. V. Kharitonov, A. A. Plakseyev, V. V. Voskoboynikov, and D. Yu. Tarutin, Moscow Institute of Engineering Physics; UDC 536.24]

[Abstract] An experimental study was made concerning the thermal states of copper targets cooled by various methods during intense local heating by an electron beam. Two copper disks 100 mm in diameter were on the one smooth side bombarded with an electron beam 9-10 mm in diameter, so that the incident thermal flux could be varied over the 2-43 MW/cm^2 density range, and on the other side cooled with running water. One disk was milled on that other side so as to leave a 1.4 mm thick heat-sensing wall covered by a brush-like "chessboard" pattern of obliquely oriented (45°) bristle-like 3 mm long square fins around which the cooling water with a 20°C initial temperature then meandered. One disk had a smooth surface on the other and thus formed a 1.5 mm thick heat-sensing wall, but onto that surface was soldered on a 10 mm thick layer of highly porous "Porinvar" material through which the cooling water with a 5°C initial temperature then passed. Tests were performed with beam-plasma discharge in a magnetic field. The beam power was varied and measured as the product of the accelerating potential difference and the current flowing through the target. The radial temperature profile on the cooled disk side was measured with 0.1 mm Constantan thermocouple wires along and across the water stream, using one common copper wire. The water filtration rate was varied over the 0.1-1.0 m/s range and the corresponding loss of pressure head was measured with a differential U-manometer. A theoretical analysis of the results based on the Kuzmin-Kharitonov relation for the radial profile of the wall temperature (TEPLOFIZIKA VYSOKIKH TEMPERATUR Vol 24 No 5, 1986) indicates that while boiling of the water (on the cooled side) intensifies heat dissipation and thus tends to lower the wall temperature, local stalling of the heat transfer at the affected spot (on the heated side) impedes heat exchange and thus tends to raise the wall temperature. The interplay of these two opposing effects explains the almost linear dependence of the temperature at the center of the cooled surface on the thermal flux density within the affected spot on the heated surface. Local stalling of heat transfer is further analyzed by considering extreme conditions of a dry spot forming on the cooled side as its temperature reaches the Leidenfrost point (300-310°C).The results of this analysis, supported by experimental data from this and other known studies, indicate that boiling of water after its passage through a porous structure where it had only been heated up does not significantly intensify the cooling of the entire target (wall) to its surface temperature (250-300°C). A dry spot produced by local stalling of heat transfer on the cooled side may then cause a temperature redistribution over the target volume so that this spot will, in turn, increase to a size comparable with the size of the affected spot on the heated side and the temperature at the center of that affected spot will climb stepwise. Figures 5; references 10.

New Method of Accounting for Polarization Effects in Calculation of Probabilities of Atomic Transitions

927J0165A Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 71 No 3, Mar 91 (manuscript received 12 Feb 90) pp 395-397

[Article by A. V. Glushkov and A. V. Tarchenko, Odessa Institute of Technology imeni M. V. Lomonosov of Food Industry; UDC 539.182.01]

[Abstract] Calculation of the probabilities of radiative transitions in atoms and in multiple-charge ions using the universal and consistent S-matrix formalism is considered; adequate precision requiring that not only relativistic effects but also polarization effects be accounted for, is of interest. These effects are most consistently accounted for in the quantum-electrodynamic method, however, this method is so unwieldy that just as theoretically consistent but more computer-economical method is being proposed. In this variant of S-matrix method the probability of a radiative transition in an atom or ion with one electron outside the full shells is described by the expression $\Gamma_{ij} = 4\omega^3 V_{ijkl}^{|\omega|}/3hc^3(2j - 1)$ in standard notation (ω - frequency of transition, c - speed of light, h - Planck constant), where $V_{ijkl}^{|\omega|}$ includes the Dirac matrix $\alpha_{1,2}$. As the physical mechanism of polarization effects is considered to be virtual, polarization of a medium by a bare Coulomb potential e^2/r_{12} and subsequent shielding of this potential by the polarization cloud while it converts into the potential of a weaker interaction. This latter potential is calculated in the approximation of random phases. In this approximation the potential of effective interaction in the q-space thus becomes $V_{eff}(q,\omega) = V_q/[1 + V_q\Pi_0(q,\omega)]$, where $V_q = 4\pi e^2/q^2$ is the Fourier transform of the Coulomb potential and $\Pi_0 = 6\pi n\varepsilon_F$ is the polarization operator (ε_F - Fermi energy, $q \rightarrow 0$ when $\omega = 0$). This procedure was tested on probabilities of several i-j dipole transitions between levels of $1s^22s^22p^63s$, 3p, 3d, 4s, 4p configurations in the isoelectronic NaI series, with n calculated on the basis of the Thomas-Fermi model. The gf-force of $3s^2S - 3p^2P$ transition and $3p^2P - 3d^2D$ transition oscillators in the Cl-VII ion was calculated by this and, for comparison, by several other methods: Hartree-Fock method ignoring and including polarization effects, method of 1/Z perturbations ignoring and including polarization effects, shielded Coulomb potential method, and conventional variant of S-matrix method including polarization effects. A comparison with experimental data indicates a close agreement with the proposed method. Tables 1; references 16.

Angular Anisotropy of Fission Fragments From ^{236}U by 0.375-7.22 MeV Neutrons

927J0182A Moscow YADERNAYA FIZIKA in Russian Vol 54 No 5, Nov 91 (manuscript received 23 May 91) pp 1209-1216

[Article by D. L. Shpak, Physical Energy Institute, Obninsk]

[Abstract] The multi-angle "track" method (fragments recorded by cylindrical glass detectors) is used to make detailed measurements of the angular distributions of fragments of ^{236}U fission and the energy dependence of the ratio of the fission cross-section of ^{236}U to the fission cross-section of ^{235}U with 0.375-7.22 MeV neutrons. A statistical law, $W(\theta) = 1 + a \cos^2 \theta$, is insufficient to describe the angular distribution of fission fragments in this neutron energy range; a higher cosine power is needed. In the entire studied neutron energy range, significant irregularities of angular anisotropy were detected near the threshold for even-even target nuclei. For all target nuclei with mass number 236, independent of Z, the angular distributions of fission fragments exhibited a sharp change in the shape of $W(\theta)$ and a large-scale change in angular anisotropy. Data was obtained for 10 angles and 132 neutron energies. Figures 2; references 24: 17 Russian, 7 Western.

Positron-Nucleus Resonances in Electric and Magnetic Fields

927J0182B Moscow YADERNAYA FIZIKA in Russian Vol 54 No 5, Nov 91 (manuscript received 7 Mar 91) pp 1225-1231

[Article by A. V. Sergeyev, State Optical Institute]

[Abstract] This article studies the resonant states of a positron in the Coulomb field of the nucleus and in parallel homogeneous electric and magnetic fields. In the framework of a classical description, the positron oscillates along the symmetry axis, in turn reflecting from the nucleus and from the anode. The magnetic field does not permit the positron to go around the nucleus and to fly away to the cathode, thus stabilizing the resonance. The nucleus is considered infinitely heavy, and the problem is reduced to a one-particle Schroedinger equation. Perturbation theory, 1/n expansion and quasi-classical theory are used to determine the energies and widths of the resonances. The cases of a weak electric field and a strong magnetic field are considered. The methods agree well with each other. The conditions for the decay of positron resonances due to quantum tunneling are described. Figures 2; references 4: Russian.

Nonstationary Processes in the Elastic Layer in High-Speed Shock-Wave Loading of Its Surface in a Limited Region

927J0191 Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 27 No 10, Oct 91 (manuscript received 29 Jan 90) pp 38-45

[Article by V. A. Galazyuk and A. K. Chumak, Lvov University; UDC 539.3]

[Abstract] This article examines the problem of the propagation of nonstationary waves in a plane-parallel layer consisting of a linearly-elastic homogeneous isotropic material. It is assumed that the source of nonstationary processes in a layer which is initially immobile is a shock wave at the surface boundary. One can describe with good approximation the effect on the surface by a broad spectrum of real force factors. The example of a wave process in an elastic layer of alloyed steel is presented. It is found that the greatest level of stress is reached in the first few moments and then attenuates quickly. The amplitude of oscillations decreases as one gets further away from the point of impact. The contributions of radial and peripheral stresses are discussed. Stretching stress is also considered. Solution of the problem is based on the use of Chebyshev-Laguerre integral transformation over time. The problem is reduced to a sequence of boundary value problems with a set of common differential equations. Numerical results are presented. Figures 4; references 7: Russian.

Quantum Fluctuations Do Not Annihilate Optical Soliton

927J0088A Moscow PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 54 No 10, 25 Nov 91 (manuscript received 3 Oct 91, revised version 22 Oct 91) pp 566-568

[Article by D. Yu. Kuznetsov, Institute of Physics imeni P. N. Lebedev, USSR Academy of Sciences, Moscow]

[Abstract] Propagation of quasi-monochromatic light pulses through nonlinear fibers with dispersion is considered, this quantum theoretical problem having been treated as pertaining to a one-dimensional gas with local interaction of particles (Y. Lai and H. Haus; PHYSICS REVIEW A Vol 40, 1989) and solved exactly. The conclusion that quantum fluctuations annihilate an optical soliton (A.V. Belinskiy, PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI Vol 53, 1991), based on the spatial distribution of the mean photon concentration at successive instants of time, is disproved by demonstrating that "quantum fluctuations" only widen the quantum indeterminacy of the location of its center of mass. Following a clarification of terminology, the problem is re-examined on the basis of the quantum Hamiltonian of light in a nonlinear fiber with dispersion and on exact solutions to the Schroedinger equation in Hamiltonian and momentum eigenfunctions. The soliton solution with definite phase and amplitude is constructed as a linear combination of those solutions and thus represents coupled states. Quantum fluctuations are shown to "diffuse" the matrix element which characterizes not the relative position of photons but their spatial distribution. Stability of such a soliton is established by a test involving the soliton intensity correlator. The argument is supported by a theorem stating that if the Hamiltonian eigenvalues are uniquely determined by the number-of-particles and momentum eigenvalues, then this correlator remains constant while the superposition of the number-of-particles, Hamiltonian, and momentum eigenfunctions evolves. The author thanks V. A. Andreyev, A. V. Belinskiy, R. M. Herman, and Y. Lai for assistance and discussions. References 4.

Amplitude and Phase Self-Modulation of Higher-Order TE-Modes in Optical Fibers

927J0091A Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 321 No 1, Nov 91 pp 83-87

[Article by M. Yu. Glotova, M. A. Zuyev, I. N. Sisakyan, and A. B. Shvartsburg, Central Engineering Office for Design of Unique Devices at USSR Academy of Sciences, Moscow; UDC 535.39]

[Abstract] Propagation of a polarized array of higher-order TE-modes through optical fibers is considered, their amplitude and phase self- modulation upon selective excitation of such waveguide modes being analyzed on the basis of the nonlinear Kerr effect $\Delta n \simeq \alpha|E|^2$ and the applicable system of Maxwell field equations. Into account is taken the fact that the field evolution in higher-order waveguide modes involves not only self-modulation of differently polarized components but also their cross-modulation. The analysis is applied to a fiber optic waveguide with a dielectric permittivity which consists of a constant part ε_0 and an increment $\Delta\varepsilon$ dependent on the electric field intensity $\Delta\varepsilon = \alpha|E|^2$. When $\mathrm{div}(\varepsilon E) = 0$, then a gradient term appears in the equation of nonlinear field dynamics which describes cross-modulation of polarization components. This interaction, usually weak as long as the waveguide effect remains weak and therefore usually ignored in the nonlinear Schroedinger equation, can become appreciable in this particular case. The analysis reveal that the phase leads $\varphi_{1,2}$ of both E_x, E_y field components are positive and the phase difference $\varphi_2 - \varphi_1$ between them depends on the waveguide geometry, being either positive or negative in a rectangular waveguide depending on the ratio of sides and zero in a square one. This is demonstrated by numerical analysis of the TE_{11}-mode evolution in a fiber with an a = 2 μm x b = 1 μm cross-section transmitting a 1.5 μm radiation wave and in a fiber with an a = 0.5 μm x b = 1 μm cross-section transmitting a 1.06 μm radiation wave. An unusual feature of self-modulation in such waveguides is a nonmonotonic dependence of the phase lead of one field component on the evolution path so that the path will include a segment with a negative slope (rate of change of phase) $\delta\varphi/\delta\delta\tau < 0$ despite a positive nonlinear Kerr effect. Figures 2; references 2.

Ultraviolet Luminescence of CsI Excited by Electrons in Subnanosecond Pulses

927J0098A Leningrad FIZIKA TVERDOGO TELA in Russian Vol 33 No 5, May 91 (manuscript received 11 Nov 90) pp 1591-1593

[Article by M. S. Abdrakhmanov, V. V. Gavrilov, R. G. Deytch, A. P. Kuyanov, and S. A. Chernov, Institute of Physics, LaSSR Academy of Sciences, Salaspils; UDC 535:548.0]

[Abstract] Rapidly decaying ultraviolet luminescence of CsI crystals upon their excitation by electrons in pulses of subnansecond duration was observed in an earlier experiment, CsI crystals pure or with point defects in the lattice having been excited by a 0.3 MeV electron beam with a current density of 20 A/cm^2 in pulses of 5 ns duration. The wavelength of maximum luminescence within the emission band was found to depend on the nature of the crystal: pure crystals luminescing maximally at the 306 nm wavelength, the intensity increasing with increasing vacancy concentration; CsI:Br crystals luminescing maximally at the 320 nm wavelength and CsI:Cl crystals luminescing maximally at the 340 nm wavelength. It has been proposed on the basis of these facts that some exciton-like state localized in the vicinity of a lattice defect is responsible for such an ultraviolet luminescence. In a subsequent experiment, performed for verification, CsI crystals were excited by a 0.25 MeV

electron beam with a current density of 100 A/cm^2 in pulses of 50 ps duration. Measurements were made in an "Agat-SF" electronic-optical chamber, luminescence bands being extracted by means of a monochromator or a light filter. At a temperature of 77 K, a spectrum was recorded consisting of two luminescence bands with maxima at the 290 nm wavelength and at the 337 nm wavelength respectively, the 337 nm luminescence decaying within approximately 900 ns. At room temperature a luminescence band was recorded with a maximum at the 306 nm wavelength. Luminescence within the 305-320 nm band rapidly decaying after electronic excitation of CsI crystals in nanosecond pulses had been recorded earlier at temperatures from 150 K up, its intensity increasing with rising temperature up to room temperature and then remaining almost constant up to 440 K. The most likely mechanism of rapidly decaying ultraviolet luminescence at such high temperatures is generation of a free exciton and its subsequent capture into regions of the crystal perturbed by a lattice defect. Such a localization of free excitons in the vicinity of either intrinsic or impurity defects may bring about self-localization of exciton states not realizable under normal conditions. Figures 2; references 12.

Fundamental Properties of Compressed Light

927J0100A Moscow USPEKHI FIZICHESKIKH NAUK in Russian Vol 161 No 10, Oct 91 (manuscript received 6 Dec 90, revised version received 26 Jun 91) pp 145-173

[Article by V. P. Bykov, Institute of General Physics, USSR Academy of Sciences]

[Abstract] A theoretical description of compressed light and its physical properties is given, beginning with the concept of a harmonic quantum oscillator and the probability distribution of its coherent state among numerous other possible nonclassical ones. Next is considered the probability distribution of a stationary state with arbitrary initial conditions, that probability distribution of the coherent state being a Gaussian one with a dispersion equal to the dispersion of the vacuum state. Analysis of the evolution of a state having also a Gaussian probability distribution but with different parameters leads to the concept of an oscillator whose frequency is not only different but also complex and then to the concept of a compressed state. Evolution of such a state of an electric field is analyzed further, by comparing the oscillations and the indeterminacy of an electric field in such a state with those in the coherent state and with those in compressed vacuum. Excitation into a compressed state is a problem, the simplest method seeming to be parametric excitation of a harmonic oscillator and its effectiveness depending largely on the initial state. Possible practical applications for compressed light are suppression of noise in a Mach-Zehnder interferometer, a role in nonlinear optics as, for example, nonlinear polarization of a substance in a compressed electric field, and a role in communication systems. The author thanks A. M. Prokhorov, F. V. Bunkin, N. V. Karlov, V. I. Tatarskiy, A. A. Rukhadze, N. B. Delone, S. A. Akhmanov, B. M. Bolotovskiy, V. A. Shcheglov, V. I. Manko, A. V. Masalov, V. P. Karasev, I. I. Tugov, and Yu. Ya. Yushin for discussions and cooperation. Figures 11; references 18.

Manifestations of Quantum Fluctuations in Optical Solitons: Comment on Earlier Article

927J0101A Moscow PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 54 No 10, 25 Nov 91 (manuscript received 23 Sep 91) pp 569-570

[Article by A. V. Belinskiy, Moscow State University imeni M. V. Lomonosov, Moscow]

[Abstract] Evolution of the second moment of the field N[x,t] during propagation of an optical soliton through an ideally transmitting optical fiber was analyzed by the author (A.V. Belinskiy; PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI Vol 53, 1991), using the exact soliton-like solution, the quantum-mechanical Schroedinger equation. This analysis has led to the conclusion that the average soliton envelope N[x,t] eventually becomes diffuse, apparently owing to gradual degradation of the soliton. Broadening of the average envelope however, could also be caused by indeterminacy of the soliton location (inasmuch as quantum averaging is done over the ensemble of solitons). For the purpose of establishing which of the two mechanisms is actually responsible for diffuse broadening of the average soliton envelope, the author now calculates the soliton intensity correlator $K(x',t) = \text{Int } M(x,t) N[x+x',t]dx$. This correlator is not a function of the x-coordinate and thus does not depend on the indeterminacy of the soliton location. It has at $x' = 0$ or any other x' a finite value which remains constant in time t for any optical soliton with an average number of photons $n_0 >> 1$. Evidently, therefore, no degradation of a soliton takes place and broadening of the average soliton envelope is caused solely by quantum indeterminacy of the soliton location. It has been assumed here that there are no lateral maxima of K(x'), which would only indicate "breakup" of a soliton into localized photon clusters with peak intensities higher than the initial soliton intensity at its peak. This is an unlikely situation and the assumption is therefore valid. The author thanks D. N. Klyshko, D. Yu. Kuznetsov, I. V. Sokolov, and A. S. Troshin for discussions, which have made him reinterpret the results of his original analysis. References 3.

Attenuation and Scattering of Light by Randomly Oriented Ensemble: Exact Solutions in T-Matrix Method

927J0123A Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 71 No 1, Jul 91 (manuscript received 13 Dec 90) pp 151-153

[Article by N. G. Khlebtsov, Institute of Biochemistry and Physiology of Plants and Microorganisms, USSR Academy of Sciences, Saratov; UDC 375.36]

[Abstract] Attenuation and scattering of light by an ensemble of randomly oriented scatterers is considered from the standpoint of quantum mechanics and T-matrix theory. Three tensors are averaged over orientations of scatterers for a determination of all physical characteristics of scattering. The first one, the averaged T-matrix, yields the noncoherent attenuation by a randomly oriented ensemble and is used in the theory of multiple scattering. The second one, the averaged Hermitian tensor T^+T, yields the cross-section for scattering. The third one, the averaged tensor product $T_{\nu\nu'}T_{\mu\mu'}$, yields the elements of the Mueller matrix in the transform of Stokes parameters. Averaging is done by a method based on the quantum theory of angular momentum, rotation of the system of coordinates transforming the T-matrix in the standard manner with the aid of Wigner matrices. Subsequent integration of that transform over the Euler angles yields an expression for the average-over-orientations $T_{\nu\nu'}$-matrix in terms of the trace Sp_m of the $(T_{\tau nm,\tau' nm})$-matrix, this relation representing the analog of the generalized Wigner-Eckart theorem applicable to this particular problem, with index $\nu = \tau nm$ for complex solutions to the Helmholtz vector equation; $\tau = 1,2$ for the two transverse solutions of the first kind and of the second kind respectively; n,m-standard indices characterizing spherical vectors or isotropic rank-1 spin tensors. Completely analogous treatment of the Hermitian tensor T^+T yields an expression for its average-over-orientations in terms of the sum of squares of T-matrix elements, more precisely of their moduli, with index μ structurally analogous to index ν. The tensor product $T^*_{\nu\nu'}T_{\mu\mu'}$ is averaged by first expanding T into a Klebsch-Gordan series of the sum of irreducible isotropic $t^*_{JM(\rho,\tau')}$ rank-J tensors and then averaging the product of two irreducible isotropic tensors $t^*_{J(1)M(1)}t_{J(2)M(2)}$ according to the same rules which apply to transformation of the T-matrix by rotation. References 12.

Form of Scattering Line Associated With Scattering of Light by Particles in Brownian Motion

927J0123B Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 71 No 1, Jul 91 (manuscript received 2 Jul 90) pp 144-150

[Article by S. N. Bagayev, V. A. Orlov, and V. P. Chebomayev, Institute of Thermophysics, Siberian Department, USSR Academy of Sciences, Novosibirsk; UDC 575.76]

[Abstract] Scattering of light by particles performing Brownian movements in liquids was observed, the form of the scattering line having been for the first time recorded with a 0.1 Hz frequency resolution by an unconventional new method, namely by probing the medium with two linearly polarized light beams each having a different frequency. The two incident light beams entering the liquid medium were oriented at some angle to each other, so that their polarizations and wave vectors as well as those of the scattered light were all in vertical planes and parallel to the gravitational acceleration vector. Light scattered by particles within the region of the intersection of light beams was picked up by a square-wave photodetector. The apparatus of the new spectrometer included two He-Ne lasers emitting 0.63 μm radiation with a power of about 1 mW. The two lasers were synchronized in phase within 0.01 rad by means of an electronic high-speed automatic frequency-phase control system. The frequency difference between the two lasers was equal to the approximately 1 MHz frequency of a reference oscillator whose relative frequency stability was maintained within 10^{-8}. Both laser beams entered into the test cell converging, after passage through a focusing lens, and exited from the test cell diverging but then intercepted by a diaphragm which passed light coming from the region of their intersection. This portion of the light was focused by another lens into an optical fiber transmitting it with very low background noise to a photomultiplier for spectrum analysis. The spectrum analysis was performed using a 42 Hz resonance filter with bandwidth regulation over the 0.1-1.0 Hz range, an $f_0 \simeq 42$ Hz signal being synthesized by mixing the $f_1 \approx 1$ MHz photomultiplier output signal with the $f_2 = 1$ MHz output signal of a quartz oscillator. The spectrum of this signal was recorded with an XY-plotter on the filter output side and its frequency was tuned to resonance within the filter passband by slowly varying the frequency of the reference oscillator within the +/- 100 Hz range with the aid of a sawtooth-voltage generator. The theoretical power spectrum of the photodetector output signal depends on the correlation function of the scattering intensity and thus implicitly on the resultant electric field of scattered light, the form of that correlation function being quite simple for dilute solutions with negligible interaction of particles. The resultant electric field is calculated in the approximation of identical particles as the sum of additive elementary scattered fields with correspondingly equal amplitudes, disregarding effects due to multiple scattering and assuming independent interaction of each particle with the two light beams. The probability distribution of finding a particle at a point in space R at an instant of time τ is then calculated on the basis of the Fokker-Planck equation, taking into account drift of precipitating particles in the terrestrial gravitational field. Experiments were performed first with a monodisperse system of spherical latex particles 0.12 μ in diameter in distilled water, then with erythrocytes in human donors' blood for a study of the dynamics of their sedimentation. The wide spectral line of scattering in blood cannot be attributed to Brownian motion of erythrocytes alone. Tests performed with and without erythrocytes in the blood plasma revealed a spectrum with a narrow peak on top of a wide pedestal in both cases. Tests with pure blood plasma were performed with the probing light beams at various angles, the peak in this case evidently representing an orientational line widening of about 0.5 Hz independent of that angle between probing light beams and characteristic of translational diffusion within a 53 rad wide scattering sector. Addition of erythrocytes to the blood plasma was found to cause a Doppler shift of the spectrum with an additional line widening proportional to the velocity and thus also to

the mass of precipitating erythrocytes. The additional line widening associated with sedimentation of erythrocytes is probably caused by interaction of erythrocytes and their clusters with finer blood particles. Tests with erythrocytes in a physiological solution revealed a scattering of light close to theoretically evaluated scattering by erythrocytes in Brownian motion. An opposite effect was detected in milk cream diluted with distilled water: a Doppler shift in the opposite sense, evidently caused by upward drift of fat particles. This was confirmed by absence of such a shift in skimmed milk. The authors thank Ye. A. Titov for helpful discussion of the results and A. E. Om for setting up the electronic apparatus. Figures 4; references 5.

Nonlinear Radiation Conversion in Resonantly Absorbing Media

927J0123C Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 71 No 1, Jul 91 (manuscript received 6 Feb 91) pp 163-170

[Article by Yu. I. Geller, O. A. Ryabov, and K. V. Senchenko, Institute of Physics imeni L. V. Kirenskiy, Siberian Department, USSR Academy of Sciences; UDC 535.42]

[Abstract] Nonlinear mutual conversion of decaying waves upon their interaction during propagation through a radiation absorbing medium is analyzed in the four-dimensional vector formalism so as to allow use of Lorentz transformations and thus facilitate classification of all possible conversion modes, the Lorentz parameter L being defined by the relation $L/(1 + L^2) = [h \times h]/(h^2 + d^2)$. The basic reference are two planarly polarized waves with different frequencies ω_1 and ω_2 propagating along the z-axis of an absorbing medium, the conversion coefficient in terms of intensities being defined accordingly. Just as interaction of waves with only slightly different frequencies depends on their phase relation at the entrance to the medium, so does nonlinear conversion of waves with widely different frequencies. The analysis of their nonlinear conversion is therefore generalized to cover arbitrary phase relations between them, and in the course of this analysis is established the invariance of radiation conversion with respect to the Lorentz group in the space of effective vectors d and h. Accordingly, the same conversion coefficients correspond to different interaction parameters when the boundary conditions are appropriately stipulated. The general criteria of optimum conversion are established on this basis without referring to specific interaction parameters, the conditions for propagation of two such waves without their conversion and the conditions for their anomalously weak absorption by the medium as two extreme cases also being thus established. The conversion mode is shown to depend on the quantitative relation between d' and h', also the absorption coefficient α: oscillatory conversion taking place when $h' >> \alpha >> d'$ and quasi-steady conversion taking place when $d' >> h'$. Universality of the four-dimensional vector formalism is then demonstrated on two examples. The first one is conversion of infrared radiation into visible or ultraviolet radiation involving resonant four-wave summation of frequencies $\omega_c = 2\omega_1 + \omega_2$ at discrete energy state transitions in a medium, a typical case being conversion of P(34)-line radiation of a CO_2-laser in sodium vapor. The second one is conversion of a radiation into one with a continuous spectrum at energy state transitions in the absorbing medium. The authors thank V. P. Timofeyev and N. P. Makarov for helpful discussions. Figures 4; references 12.

Relativistic Multiconfigurational Time-Dependent Theory of Self-Consistent Field for Molecules

927J0185A Tomsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA in Russian Vol 34 No 10, Oct 91 pp 29-34

[Article by A. V. Glushkov, Odessa Technological Institute imeni M. V. Lomonosov; UDC 539.186]

[Abstract] The importance of developing consistent relativistic methods of molecule analysis is noted and an attempt is made to formulate relativistic multiconfigurational time-dependent (TD) Dirac-Fock (DF) self-consistent field formalism for molecules which unifies the corresponding multiconfigurational Hartree-Fock (KhF) formalism. A new nonempirical approach to analyzing molecules—the Liouville-Dirac-Fock method which has a number of advantages over other traditional *a priori* methods—is proposed. The time variations of the multiconfigurational Dirac-Fock wave function, the relativistic response function for a multielectron molecule, and the Liouville-Dirac-Fock formalism in the theory of multielectron molecules are considered. The equivalence of the results of relativistic analyses of oscillator and molecule forces in terms of length and velocity is demonstrated. It is stressed that solution for a multielectron molecule is gauge invariant but this factor may be helpful for developing optimized chemical bases. References 14: 2 Russian, 12 Western.

Ball Lightning as Quantum Condensate

927J0141A Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 320 No 5, Oct 91 pp 1103-1106

[Article by A. V. Kulakov, corresponding member, USSR Academy of Sciences, and A. A. Rumyantsev, Leningrad State Technical University; UDC 537.52]

[Abstract] A ball lightning and the physical state of its substance are analyzed from the standpoint of quantum mechanics, formation of such a lightning being attributed to action of long-range quantum forces in a dense and cold, but not degenerate plasma. As the plasma temperature decreases, the de Broglie wavelength of thermal electrons becomes much smaller than the interionic distance. Attendant interference of force centers results in an overlap of the wave functions of these electrons. The action of quantum forces generated by this overlap results in a collective "cohesion" of particles and eventual formation of a plasma condensate with characteristics of a liquid, which include surface tension. The energy of such a system decreases in the process, as the excess energy is being emitted, but the electromagnetic plasma interactions are retained. This mechanism of a ball lightning is demonstrated on a model system of N potential wells as force centers with a U_0 deep rectangular potential profile and a spherical geometry, each with a radius ρ, forming an array with a mean center-to-center distance b. Each well is assumed to be sufficiently shallow to cover only a continuous energy spectrum, without discrete energy levels when isolated from other wells. The entire array of force centers and particles subject to them is assumed to reside within a sphere with a radius $R >> \rho$. Each electron is assumed to be in an s-state, while also being in the state of a continuous spectrum with a wave number $k < 1/b$. Considering that the state of each particle in any one force center is influenced by the other N-1 centers, their action on it is treated as a perturbation. In accordance with the requirement that the wave vector of the system have commutative symmetry, the interparticle interaction energy is then described by the expression E^1 = (Ψ/V circumflex over V/Ψ)/(Ψ) (Ψ = A[circumflex over A]Φ, A[circumflex over A]-symmetrization operator which extracts some Young scheme for the coordinate part of the state vector, $\Phi = \Pi_i \psi(r_i)$-direct product of wave functions associated with each potential well, r_i-distance from i-th center, V[circumflex over V] = $\Sigma_{k \text{ not } i}{}^{N} u(r_k)$, $u(r_k$-potential at the k-th center). This energy consists of two parts: $E_d^{(1)} \approx -2NV_{U0}n\rho^3$ representing direct interaction and $E_e^{(f)} = -NU_0(\rho/b)^6 nv_m$ representing exchange interaction (N - number of force centers, V - volume of sphere, n = N/V, $v_m = 4\pi(2\pi\lambda)^3/4$, de Broglie wavelength $\lambda = 1/k$). The criterion for exchange interaction predominating over direct interaction is accordingly $(2\pi\rho\lambda/b^2)^3 > 1$ (λ - de Broglie wavelength), which reduces to $\pi\lambda > b$ when the potential wells are contiguous to one another so that $b = 2\rho$. These relations are applied to a plasma which is not degenerate but satisfies this inequality, whereupon the state of the lightning plasma is estimated on the basis of observations. Measurements have yielded, after statistical analysis, the following average values of plasma parameters: temperature about 1000 K, ion charge $z \geq 1$, particle concentration $n = 2x10^{19}$ cm^3, de Broglie wavelength $\lambda = 1$ nm, mean interionic distance $d = 3$ nm. According to these data, the plasma of a ball lightning plasma can exist in the state of a quantum condensate. References 6.

Nonlinear Packet Dynamics of Strong Electromagnetic Field in Plasma With Linear or Parabolic Density Barrier

927J0094A Moscow ZHURNAL EKSPERIMENTALNOY ITEORETICHESKOY FIZIKI in Russian Vol 100 No 6(12), Dec 91 (manuscript received 22 Jun 91) pp 1785-1796

[Article by Ye. M. Gromov, V. M. Nakaryakov, and V. I. Talanov, Institute of Applied Physics, USSR Academy of Sciences]

[Abstract] An analysis of the dynamics of a strong electromagnetic field in a nonhomogeneous plasma with a linear or parabolic barrier-forming density profile and with an ion-acoustic kind of nonlinearity reveals the existence of a new class of dynamic phase-conjugate and frequency-tunable dynamic states, electromagnetic wave packets, in such a plasma. The analysis rests on the Schroedinger equation $-2i(\delta\varphi/\delta t) + \delta^2\varphi/\delta x^2 - n\varphi + (-x)^p\varphi = 0$ in dimensionless variables where $\delta^2 n/\delta t^2 - \delta^2 n/\delta x^2 = \delta^2(|\varphi|^2)$, which describes the evolution of a one-dimensional wave field $\varphi(z,t)$ in a medium with a linear ($p = 1$) or parabolic ($p = 2$) density barrier and an ion-acoustic kind of nonlinearity. A plasma with plane-laminar stratification and with an ion-acoustic kind of nonlinearity is considered, the wave vectors of the electromagnetic waves being parallel to its density gradient. Perturbations of the plasma concentration N_s by the electromagnetic field are assumed to be of a scale much smaller than that of inhomogenieties in the quiescent plasma. From the equation of the field envelope $E_0(z,t)$ and the equation of plasma concentration perturbations are derived equations of motion for electromagnetic wave packets with a slowly varying frequency in such a plasma, these wave packets representing the electric field E(z,t) of electromagnetic waves. Solutions to the equation for $p = 1$ (linear density barrier) describe reflection of packets by the barrier, characterized by mirror symmetry with respect to time $t = 0$ and corresponding to coupled dynamic states. Solutions to the equation for $p = 2$ (parabolic barrier) describe packet reflection by the barrier or packet passage through the barrier, or the in-between mode of packet pull-up to and slide-down from the top of the barrier, depending on the initial conditions. The evolution of packet parameters is analyzed separately for each case. In the case of packet pull-up it is analyzed for depth of field penetration in such a plasma and for absorption of the packet energy by such a plasma near the top of its density barrier. Considering that heat losses during packet reflection or passage are negligible when absorption of the packet energy by the plasma takes a longer time than return of

the packet frequency to the initial one and that heat losses during packet pull-up are not negligible, it is demonstrated that the main energy of a packet during its pull-up in a dense supercritical plasma could be absorbed by the latter as the packet approaches the top of the density barrier. Figures 3; references 11.

Polarization of Acoustic Soliton in Paramagnetic Crystal

927J0098B Leningrad FIZIKA TVERDOGO TELA in Russian Vol 33 No 5, May 91 (manuscript received 3 Dec 90) pp 1596-1567

[Article by G. T. Adamashvili, Tbilisi State University imeni Iv. Dzhavakhishvili; UDC 621.385]

[Abstract] As the basis for analysis of an acoustic soliton in a diamagnetic crystal containing a small amount of paramagnetic impurities, a linearly polarized transverse plane acoustic wave is considered to be propagating through such a crystal in the direction of a constant external magnetic field. All dextro(+)polarized and levo(-)polarized components of its strain tensor satisfy the equation of a polarization ellipse, and the dispersion relation for each is obtained by solving the system of Bloch and elasticity equations. The expressions for those tensor compnents then yield the two parameters characterizing the polarization of an acoustic soliton: length ratio of minor to major semiaxes of the polarization ellipse and angle of rotation of the polarization plane. In the linear limit this angle increases to a maximum as the frequency of the wave components approaches resonance and decreases to zero for a soliton as its time delay approaches zero. Accordingly, no rotation of the polarization plane takes place under conditions of a self-induced acoustic window. In the nonlinear limit the rotation angle depends on the pulse time delay. The expression for the ratio of the semiaxes indicates that linear and nonlinear linearly-polarized transverse acoustic waves transform into elliptically polarized ones as they propagate through the crystal, a linear wave then becoming a circularly polarized one. All these relations apply to an acoustic pulse propagating in the soliton mode without attendant transition processes in a crystal where, moreover, the time delay is small so that a spatial separation of dextropolarized and levopolarized components of linearly polarized transverse acoustic waves takes place. An experimental study of this problem was made using MgO:Ni^{+} crystals. References 4.

Automation of Microwave Interferometers With Frequency Modulation

927J0192A Moscow FIZIKA PLAZMY in Russian Vol 18 No 2, Feb 92 (manuscript received 27 Feb 91) pp 242-244

[Article by S. P. Gubarev, A.I. Skibenko, O. S. Pavlichenko, V. S. Taran, A. A. Utkin, and I. P. Fomin, Kharkov Physicotechnical Institute; UDC 621.317.7: 621.3.029.65]

[Abstract] This article examines two types of microwave interferometers with hardware for recording and processing. The first interferometer uses a Wharton scheme with raster indication. It operates at $\lambda = 4$ mm. The band of frequency tuning $\Delta\varphi_0 = 10^8$ Hz is achieved by supplying a saw-toothed voltage of 30 V with a period of 0.1, 0.25, or 0.5 ms to the klystron reflector when the difference in the legs is 15 mm. At the output one observes a change in phase shift in a modulation period governed by the equation $\Delta\varphi = 2\pi\Delta f$. The detector isolates phase beats, which are recorded by the measurement equipment. The second interferometer is a Fabry-Perot interferometer mounted in an Uragan-3M assembly. It operates at $\lambda = 8$ mm. The source of electromagnetic oscillations exciting the resonator is a klystron generator operating at 37 GHz in frequency modulation mode. Saw-toothed pulses 0.1, 0.25, 0.5, and 1.5 ms long are generated with smooth regulation of amplitude from 0 to 50 V. Shifts in resonant frequency are measured and known laws are used to determine the distribution of electron density. Both interferometers have identical measurement channels. The amplifiers have a bandwidth of up to 500 kHz. The measurement channels meet the CAMAC standard. A MERA-60 microcomputer is used to control modules, and the MERA-60 is connected to a MERA-125 minicomputer through a serial asynchronous DL interface. Figures 2; references 3: Russian.

Nonlinear Dispersion Interferometer in Equipment for Thermonuclear Studies

927J0192B Moscow FIZIKA PLAZMY in Russian Vol 18 No 2, Feb 92 (manuscript received 27 Feb 91) pp 264-266

[Article by P. A. Bagryanskiy, V. P. Drachev, and Yu. I. Krasnikov, Institute of Nuclear Physics and the Institute of Thermal Physics, Siberian Division of the USSR Academy of Sciences; UDC 533.9.082.5]

[Abstract] A dispersion interferometer has been developed to measure linear density with a sensitivity of about $10^{13}cm^{-2}$ in a 100 kHz band of frequencies. It is compact and is only slightly sensitive to vibrations. No special vibration-insulating mounting is necessary. The device can be attached directly to the working chamber of plasma equipment. The working capability of the instrument is demonstrated in experiments in a gas dynamic trap. The sensing radiation of an yttrium-aluminum garnet laser with Nd ($\lambda = 1.06$ μm) is used. The waves from the interferometer are orthogonally polarized, so the interference signal of one of the photoreceptors is shifted by π relative to the other. This makes it possible to compensate for instability of the strengh of the second harmonic using the difference between the signals of the two photoreceptors. Sensitivity is determined by the instability of the strength of the second harmonic and the noise in the photoreceptors. Differential recording yields a relative noise level of $1.5x10^{-4}$ in a 100 kHz band. The spatial resolution of the interferometer was 1 mm. Figures 2; references 5: 3 Russian, 2 Western.

Structure and Superconducting Characteristics of R-Ba-Cu-Al-O (R = Y,Gd,Eu) Single Crystals

927J0098D Leningrad FIZIKA TVERDOGO TELA in Russian Vol 33 No 5, May 91 (manuscript received 16 Nov 90) pp 1434-1442

[Article by A. A. Levin, Yu. I. Smolin, Yu. F. Shepelev, L. M. Sapozhnikov, P. P. Syrnikov, Ye. I. Golovenchits, and V. A. Sanina, Institute of Silicate Chemistry imeni I. V. Grebenshchikov and Institute of Engineering Physics imeni A. F. Ioffe, USSR Academy of Sciences, Leningrad; UDC 538.945:548.736]

[Abstract] An experimental study of $RBa_2Cu_{3-x}Al_yO_{6+x}$ (R = Y,Gd,Eu) 123-phase single crystals was made concerning their structural and superconductivity characteristics. Two groups of such crystals were grown from melts of R_2O_3-BaO-CaO) solutions in crucibles made of pure Al_2O_3: one group by melting and crystallization in the same crucible, one group with melting-dissolution and crystallization in separate but interconnected crucibles so as to ensure better access for oxygen during crystallization. All crystals except Gd-Ba-Cu crystals grown by the second method were annealed at 450°C in an oxygen stream for 70 h and then slowly cooled. Four crystals with the most representative "extreme" superconductivity characteristics were selected for analysis and evaluation: 1. Y-Ba-Cu crystal grown by the first method (T_{cO} = 60 K and ΔT = 1 K after annealing), 2. Y-Ba-Cu crystal grown by the second method (T_{cO} = 60 K and ΔT = 5 K before annealing, T_{cO} = 90°C and ΔT = 1 K after annealing), 3. Gd-Ba-Cu crystal grown by the second method (T_{cO} = 50 K and ΔT = 3 K without annealing), 4. Eu-Ba-Cu crystal grown by the second method (no superconductivity before and after annealing). Phase and lattice structure analysis in an X-ray diffractometer revealed twins in the Y-Ba-Cu crystal 1 (first method) even after annealing, no twins in the Y-Ba-Cu crystal 2 (second method) after annealing, and no twins in the Gd-Ba-Cu crystal 3 (second method). X-ray microanalysis with the CAMEBAX-301 apparatus revealed presence of aluminum in all crystals: Al:Cu = 0.78 in Y-Ba-Cu crystal, 0.086 in Gd-Ba-Cu crystal, 0.173 in Y-Ba-Cu crystal). The results of further quantitative crystallographic analysis indicate formation of endless clusters from chemically equivalent Cu-O-Cu chains, depending on the degree of defectiveness of both cationic and anionic sublattices. Formation of weak links in the absence of twins is probably attributable to chemical nonequivalence of Cu-O-Cu chains in a CuO_3 layer, caused by presence of Cu atoms with different valencies in an adjacent CuO_x layer and this in turn resulting oxygen deficiency in that layer. Figures 1; tables 4; references 18.

Thermal Conductivity, Electrical Conductivity, and Seebeck Thermo-E.M.F. Coefficient of Two Bi-Sr-Ca-Cu-O Materials

927J0108D Leningrad FIZIKA TVERDOGO TELA in Russian Vol 33 No 6, Jun 91 (manuscript received 11 Dec 90) pp 1762-1768

[Article by T. B. Zhukova, L. S. Narfenyeva, V. V. Popov, B. T. Melekh, I. A. Smirnov, and Kh. M. Kholmedov, Institute of Engineering Physics imeni A. F. Ioffe, Leningrad; UDC 536.21]

[Abstract] Two high-T_c superconductor materials of the Bi-Sr-Ca-Cu-O system, $BiSrCaCu_2O_x$ and $Bi_{1.82}Sr_{1.73}Ca_{1.25}Cu_{2.2}O_x$, were studied in an experiment in which their thermal conductivity, electrical resistivity, and Seebeck thermo-e.m.f. coefficient were measured at temperatures covering the 3-300 K range. Cast specimens of both materials with a density of 6.2 g/cm^3 were produced from a mixture of extra-pure Bi_2O_3, $SrCO_3$, $CaCO_3$, and CuO by induction melting in air and spontaneous crystallization in a cold crucible. The raw ingots were not superconducting at temperatures down to 4.2 K (liquid helium), but heat treatment at 830°C in air for 60 h raised the critical superconducting transition to about 86 K on the basis of electrical resistivity, magnetic susceptibility, and Seebeck coefficient measurements. The orthorhombic phase, their principal component was characterized by a c = 2.46 nm lattice parameter. Measurements were made not only on "fresh" specimens of $BiSrCaCu_2O_x$ specimens containing about 25 percent CuO and about 20 percent (Sr_2CuO_3 + $Ca_5Bi_{14}O_{26}$) and of $Bi_{1.82}Sr_{1.73}Ca_{1.25}Cu_{2.2}O_x$ containing about 10 percent (CuO + tetragonal phase) but also on specimens of $BiSrCaCu_2O_x$ after storage under vacuum (with about 20 percent CuO only) and on specimens of $Bi_{1.82}Sr_{1.73}Ca_{1.25}Cu_{2.2}O_x$ after storage in air (pure orthorhombic phase). The ingots of both materials had a distinct grain orientation, having been grown perpendicularly to the preferential direction of the crystallographic C-axis and 8 mm long bars with a 2.5x4 mm^2 cross-section having been then cut out some parallel and some perpendicularly to that axis. Electrical resistivity was measured by the standard voltage-current method with a direct current of about 2 mA at each temperature. Thermal conductivity was measured in a steady thermal flux at each temperature. Both of these and thermo-e.m.f. were measured simultaneously, contact tabs (In, Ag paste) having been deposited on each specimen for this purpose. The temperature was measured with carbon resistance thermometers over the 3-60 K range and with Cu-Constantan thermocouples over the 50-300 K range. The results of this study reveal how the thermal conductivity of both highly grain-oriented materials compares with that of single crystals, the magnitude of thermal conductivity of almost the same in the case of $BiSrCaCu_2O_x$ when heat flows in the direction of the C-axis. They also reveal the effect of "aging" on the phase composition and in this way on the properties of these materials: a strong effect on the magnitude and the temperature dependence of their thermal conductivity, a slight effect on the magnitude of their electrical resistivity of their Seebeck coefficient, no effect on the temperature dependence of their electrical resistivity and Seebeck coefficient. The electrical resistivity and the Seebeck coefficient of the $Bi_{1.82}Sr_{1.73}Ca_{1.25}Cu_{2.2}O_x$ particularly were, moreover, found to have a strongly anisotropic temperature dependence. Figures 5; tables 1; references 11.

Study of the Energy Characteristics of High-Temperature Ba-Y-Cu-O Superconductors

927J0178A Leningrad FIZIKA TVERDOGO TELA in Russian Vol 33 No 10, Oct 91 (manuscript received 16 May 91) pp 2970-2975

[Article by V. M. Yegorov, Yu. M. Baykov, V. A. Bershteyn, T. V. Gracheva, Yu. P. Stepanov, S. K. Filatov, and F. A. Chudnovskiy, A. F. Ioffe Physicotechnical Institute, USSR Academy of Sciences, Leningrad; UDC 538.945+536.7]

[Abstract] X-ray diffraction and other methods were used to study a number of $Ba_2YCu_3O_y$ systems with oxygen variation (y = 6.2-6.9) by thermal processing at 800-1200 K with subsequent hardening. During heating in a nitrogen atmosphere and with an unchanged oxygen content in the sample we detected in the course of calorimetric experiments an exothermic effect at 630-830 K. The size of the effect depends on the oxygen content, and is maximal at y = 6.5. The activation energy of the heat release process was Q = 1.5 eV, comparable with the activation energy of the process of oxygen diffusion in this system. The extreme nature of the dependence of the thermal effect on the oxygen concentration is apparently due to an optimal correlation between the concentration of atomic oxygen and the degree of nonequilibrium in the distribution of oxygen atoms after hardening. Figures 5; references 16: 11 Russian, 5 Western.

Effect of the Superconducting Transition on the Electron Drag of Dislocations and Deformational Hardening of Lead

927J0178B Leningrad FIZIKA TVERDOGO TELA in Russian Vol 33 No 10, Oct 91 (manuscript received 21 May 91) pp 2994-3000

[Article by V. P. Lebedev and V. S. Krylovskiy, A. M. Gorkiy Kharkov State University, Kharkov]

[Abstract] To study the effect of the state of the electron system on the mechanical characteristics of the superconductor, one can use deformation of the metal in only the normal or only the superconducting state, or during cyclical interchanging of states when the material is completely demagnetized. When the density and distribution of structural defects is independent of the state of the electron system, the difference in the deforming stress when the metal is stressed in only one state should exactly coincide with changes in stress due to cyclical activation and deactivation of the magnetic field. When metal with a fixed density of normal electrons is stressed, a higher level of stress was observed in the superconductor. The yield limit was higher in the normal state. The strength remained unchanged. In the superconducting state, when the force of electron drag of moving dislocations is decreased due to the removal of Cooper pairs from interaction with the crystal lattice, after lengthy deformation there is a substantial hardening of the pure metal (compared with the normal state). A comparison of the curves of deformational hardening for testing under various conditions with estimates of the distortion of the crystal lattice (according to residual electron resistance) made it possible to conclude that in rearrangement of the energy spectrum of electrons in the superconducting transition, there is a change in the force of dislocation drag that is not only due to a change in the viscosity of the medium, but also due to the formation of various defect structures. Figures 4; references 23: 18 Russian, 5 Western.

Temperature-Induced Anomalies of Piezo-Optic Coefficients in Barium-Strontium Niobate

927J0178C Leningrad FIZIKA TVERDOGO TELA in Russian Vol 33 No 10, Oct 91 (manuscript received 6 Mar 91) pp 2857-2860

[Article by B. G. Mytsyk, V. A. Romashko, and Ya. A. Seglinsh, Lvov Branch of the Kiev Scientific Research Institute of Hydraulic Instruments; UDC 537.226.33:53.092]

[Abstract] Piezo-optic and thermo-optic effects are studied in crystals of $Ba_xSr_{1-x}Nb_2O_6$ (x = 0.39), which has a very blurred phase transition. The coefficients of displacement of the phase transition point were determined under the effect of one-sided pressure. Contrast anomalies of the dependences of the piezo-optic coefficients on temperature were detected. These anomalies are explained in the framework of an earlier theory of piezo-optic coefficient anomalies and other pressure-induced effects. A good correlation between experimental and theoretical data makes it possible to extend the conclusions of the theory to other crystals with blurred phase transitions. Anomalies are due to spontaneous effects and anomalies of the coefficients of elastic ductility. Barium-strontium niobate crystals are well suited to the study of spontaneous effects because the contribution of the elastic term to the piezo-optic coefficients is increasingly small. Figures 2; references 13: 12 Russian, 1 Western.

Effect of Ultrasonic Treatment on Superconducting Properties of $YBa_2Cu_3O_{7-\delta}$

927J0183A Kiev UKRAINSKIY FIZICHESKIY ZHURNAL in Russian Vol 37 No 3, Mar 92 pp 403-406

[Article by B. M. Bulakh, Ya. M. Olikh, V. G. Onishchenko, K. I. Pokhodnya, V. G. Choni, M. K. Sheynkman, Semiconductor Institute at Ukrainian Academy of Sciences, Kiev; UDC 537.312.62]

[Abstract] The effect of ultrasonic treatment (UZO) on the superconducting properties of high-T_c ceramic superconductors (VTSP) characterized by the presence of weak bonds, i.e., "weak" superconductivity areas which

largely determine their superconducting (SP) properties is investigated. To this end, the ceramic and single crystal samples of $YBa_2Cu_3O_{7-\delta}$ manufactured by a series of successive annealing of a stoichiometric composition of the initial carbonates and oxides in an oxygen atmosphere with intermediate grinding and compaction are examined. A T_c shift toward higher temperatures in ceramic samples due to ultrasonic treatment is recorded; it is shown that ultrasonic treatment of single crystals at a wavelength commensurate with their transverse dimensions leads to a decrease in the T_c and changes the transition type. It is speculated that the areas (intersecting the lines of flow) in which the superconducting properties deteriorate or disappear altogether develop or grow in single crystals under the effect of ultrasonic treatment. In ceramics, the areas of intercrystalline grain bonds are strained by ultrasonic treatment thus reducing the number of weak bonds and increasing the number of percolation paths for the superconducting current. The need for further studies is stressed. Figures 2; references 6: 3 Russian, 3 Western.

Study of the Effect of Point Defects on the Stability of a B2 Lattice Using the Molecular Dynamics Method

927J0188A Tomsk IZVESTIYA VYSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA in Russian Vol 35 No 1, Jan 92 (manuscript received 21 Aug 91) pp 3-8

[Article by V. V. Kulagina and M. F. Zhorovkov, V. D. Kuznetsov Siberian Physicotechnical Institute at Tomsk State University; UDC 669.112.227.34]

[Abstract] The molecular dynamics method, which uses the Parinello-Rahman Lagrangian, is used to study the effect of point defects on the stability of the B2 lattice of a model TiNi alloy. Defects associated with deviation from stoichiometry and atomic disorder are examined. When there are low elasticity moduli the dislocation fields around the defects are long-lasting, which leads to cooperative interaction of defects and a decrease in the energy of the system when the defects are ordered. Depending on the symmetry of the dislocation fields which are created, the defects may stabilize the B2 structure or foster its instability and a martensitic transition. The calculation method is nontraditional in that it examines the change in size and shape of a modeled block, in the form of a cube. Periodic boundary conditions are used, which, for cells containing a defect, is equivalent to an examination of an infinite crystal with a superlattice of defects. It is assumed that structural change processes in all primitive cells of the superlattice occur synchronously. The concentration of defects in the B2 structure is less than 2 atomic percent. Five varieties of defects are examined. Figures 3; references 11: 3 Russian, 8 Western.

Mn-Doped $In_{1-x}Ga_xAs_yP_{1-y}$ Layers Grown by Liquid-Phase Epitaxy

927J0188B Tomsk IZVESTIYA VYSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA in Russian Vol 35 No 1, Jan 92 (manuscript received 19 Apr 91) pp 26-34

[Article by V. P. Germogenov, O. M. Ivleva, S. V. Ponomarev, L. S. Khludkova, and L. Ye. Epiktetova, V. D. Kuznetsov Siberian Physicotechnical Institute at Tomsk State University; UDC 621.315.592:548.554]

[Abstract] This article discusses the Mn doping of layers of $In_{1-x}Ga_xAs_yP_{1-y}$ ($0 < y < 1$) using liquid-phase epitaxy. The effect of the composition of the solid suspension and of the means of introducing the Mn into the suspension-melt on the electrophysical properties of the layers is studied, as well as the morphology of the surface, the edge of optical absorption and the lack of correspondence between the constants of the lattice of layers and the substrate. It is shown that the concentration of holes in the layers decreases as y decreases. The reasons for this are the decrease in the coefficient of distribution of the Mn acceptor (from 0.3 to 0.001), the increase in the degree of compensation of acceptors by donors (from 0.2 to 0.9), and an increase in the ionization energy of the acceptor. The composition of the InGaAsP:Mn layer and the morphology of its surface depend on the preparation of the melt, which is due to the strong interaction of Mn atoms with other components in the liquid phase. Figures 5; tables 1; references 19: 6 Russian, 13 Western.

Correct Accounting for the Mass, Anomalous Magnetic Moment, and Electric Dipole Moment of the Neutrino in a $\nu_1 - < \nu_1\nu_2\ \nu_2$ Reaction in an External Field

927J0188C Tomsk IZVESTIYA VYSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA in Russian Vol 35 No 1, Jan 92 (manuscript received 21 Oct 91) pp 101-105

[Article by V. V. Skobelev, Moscow State Correspondence University; UDC 539.12]

[Abstract] This article exactly calculates the probability of the $\nu_1 - < \nu_1\nu_2\ \nu_2$ process in the field of a two-dimensional wave in the general case, considering the mass, anomalous magnetic moment, and electric dipole moment of both types of neutrino. Special variants confirm earlier results. The symmetry of the expression of the total probability of an anomalous magnetic moment and electric dipole moment in the neutrino is analyzed. Given a nonzero mass, new information is obtained about the relative contributions of the anomalous magnetic moment and the electric dipole moment to the total probability. When one knows both moments for one type of neutrino, one can unambiguously determine the relative values of the two moments for the other type of neutrino. References 6: 4 Russian, 2 Western.

Power Supply Systems With MHD-Generators

927J0089A Moscow TEPLOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 29 No 4, Nov-Dec 91 (manuscript received 18 Dec 90) pp 1216-1223

[Article by A. V. Pisakin, N. L. Aitov, V. A. Zeygarnik, V. Yu. Rikman, O. G. Matveyenko, and Yu. P. Babakov, Institute of High Temperatures, USSR Academy of Sciences; UDC 621.362:537.84]

[Abstract] Various special-purpose power supplies for geophysical research have been and are being developed with the use of standard components of existing series "Pamir" and "Ural" MHD-plant (e.m.f. E = 1.0 kV, 2.6 kV; internal resistance R_i = 25 mΩ, 30 Ω; volume of MHD-channel V = 33 dm^3, 154 dm^3; consumption of combustion products Q = 25-30 kg/s, 70-100 kg/s; weight of power unit W = 8 tons, 14 tons). The "Pamir-1" modification, for electromagnetic probing of a mountain ridge (TaSSR) and prediction of earthquakes, consists of two "Pamir" power supplies connected in series and delivers up to 91. MW of power to matched loads at currents of up to 13.5 kA. The "Pamir-2" modification, for experimental and methodical oil exploration (Astrakhan anticline of Caspian Depression), has two "Pamir" MHD-generator channels connected in parallel during excitation of the magnetic system and then one channel connected across the load delivering to it up to 10 MW of power at currents of up to 15 kA. By utilizing wellbores, an electric dipole with a resistance of 0.1 Ω and an inductance of 30 nH has been constructed for delivery of currents up to 8 kA ("Pamir-1") and up to 5.3 kA ("Pamir-2") in pulses of up to 7 s duration. The "Sever-(North)-1" MHD-plant for electrical prospecting in the Krasnoyarsk Kray is a modification of the "Pamir-2" with an "Elektronika-60" computer, automatic controls, current cutoff with a 10-15 ms fall time, and a matching switch. The "Ural" MHD-plant, for down to 40 km deep probing of the rather homogeneous Ural region, has a single MHD-generator channel with extraction of current into a magnetic dipole (square frame with an area of 1x1 km^2 and a dipole moment of $4x10^{10}$ $A.m^2$). With the aid of seven A-600 aluminum cable conductors having a 4200 mm^2 total cross-sectional area and weighing 40 tons, a 25 mΩ dipole impedance ensured full matching of MHD-generator and load. The "Khibiny" MHD-plant is a pair of "Ural" plants with the plasma operating for up to 10 s long periods, the two generators connected in series during the excitation period and one of them then connected across the load while the other energizes the electromagnet. It is used for exploring the entire Kola peninsula as well as parts of Karelia and Finland, an extraordinarily large magnetic moment of 10^{14} $A.m^2$ having been attained in an experiment which utilized the uniquely shaped coastline of the Ribachi peninsula. The "Prognoz-1" MHD-plant is a modification of the "Ural", designed for operation with a low-resistance load (magnetic dipole, R ≈ 0.03 Ω) and with a high-resistance load (electric dipole, R ≈ 0.3-1.5 Ω). Further modifications of these MHD-generator power supplies are or will be available for specific purposes such as exploration of the earth crust with terraces and panels by probing its 30-100 km deep geoelectric profile, prediction of earthquakes by 15-30 km deep probing of mountain ranges, exploration of 3-8 km deep sedimentary top layers in search of oil deposits, exploration of 1-3 km deep rock layers in regions expected to have ore deposits, and exploration of 1-10 km deep continental shelves in search of useful minerals. Research and development plans for design optimization of MHD-generator power supplies include experimental and theoretical study of MHD braking in full-scale "Pamir" channels, of cooling processes in MHD-channels, and of processes in a radial MHD-generator, full-scale testing of plasma generators running on coal-dust fuel in an MHD-plant, experimental study of MHD-generators with plasma generators running on composite liquid fuels, experimental verification of theoretically evaluated electrodynamic and gasdynamic characteristics of a diagonal MHD-channel, including study of processes in its current-pickoff zones, and experimental verification of theoretically evaluated properties of promising new fuels. In one study kerosene was used as fuel in a mixture with oxygen, its combustion products were used as carrier gas, and mist of a molten eutectic alkaline-metals alloy (Na-K, Cs-Rb) rather than aluminum was injected into the MHD-channel so as to raise the electrical conductivity of the MHD medium without complicating the design of the plasma generator. The authors thank A. G. Blokh, M. F. Retinskiy, and B. G. Tkachenko at the Industrial Association "Nizhegorod Machine Manufacturing Plant," A. V. Zoltov, A. A. Yakushev, and A. Ye. Poltanov at the Institute of Atomic Energy imeni I. V. Kurchatov, G. Sh. Manukyan and V. A. Krylov at the Scientific Research Institute of Electrophysical Apparatus imeni D. V. Yefremov, R. K. Kuzmin, V. A. Polyakov, and M. I. Ralchenko at the Scientific Research Institute of Technology for collaboration; I. P. Bibelin and A. A. Khmelev at the State Institute of Applied Chemistry participated in the study on use of kerosene and eutectic alloys. Tables 2; references 15.

Fractal J-Integral in Fracture

927J0121C Leningrad PISMA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 17 No 19, 12 Oct 91 (manuscript received 20 Aug 91) pp 45-50

[Article by A. B. Mosolov, Institute of Problems in Mechanics, USSR Academy of Sciences, Moscow]

[Abstract] Cracking and fracture of solids are analyzed in terms of the line integral $J = \lim \mathrm{Int}_{\Gamma} (Wn_1 - \sigma_{ij} n_j u_{i,j} ds$ (W - work of internal stresses, σ_{ij} - stress tensor, u_i - displacement vector, n_j - unit normal vector) around a closed circular contour Γ circumscribing the tip of a crack and by treating the crack as a fractal surface. This integral usually represents the energy flux to the tip per unit surface area of that crack and the criterion for fracture is $J = J_c$ (J_c - constant characterizing the material). The integral is invariant for a crack with smooth edges, requiring integration over a small contour $\Gamma \rightarrow 0\Gamma$ around the tip. It is not invariant for a fractal crack within the mesoscopic range, requiring integration over successively larger contours $\lambda\Gamma > \Gamma$ around the tip, and particularly not for a fractal crack with fractal edges so that the elastic stress field contains singularities at all scale levels. The integral can also be regarded as representing the elastic energy to the tip of a crack per unit length of that crack, the invariant quantity then being not the J-integral but some quantity J_f proportional to $\lambda^{1-D} J(\lambda\Gamma)$. On the basis of this concept, a crack of fractal dimensionality D is shown to be "equivalent" to a V-notch with fractally rough sides and a vertex angle β such that $\zeta(\beta) = D/2$ (ζ - proportional to r^{1-D}, r - distance from the edge of the notch within mesoscopic range). The invariant integral for such a notch is $J_f = \lim \mathrm{Int}_{\Gamma \rightarrow 0\Gamma} (Wn_i - \sigma_{ij} n_j u_{i,1} \zeta ds$, and σ_{ij} is proportional to $r^{\zeta-1+(D-1)}$). This method of analysis can be applied to contact problems such as that of the pressure profile in the hole of a die under a punch with a fractally rough flat face. Figures 3; references 10.

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