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JPRS 82015

19 October 1982

# USSR Report

PHYSICS AND MATHEMATICS

No. 81

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ACOUSTICS

UDC 534.2

EFFECT OF RANDOM PHASE AND AMPLITUDE ERRORS ON IMAGE QUALITY IN ACOUSTIC HOLOGRAPHY

Novosibirsk AVTOMETRIYA in Russian No 2, Mar-Apr 82  
(manuscript received 6 Mar 81) pp 30-35

GIK, L. D., Novosibirsk

[Abstract] Acoustic holography with one source of a harmonic probing signal and  $N$  receivers in the observation plane is considered for an object lying below the signal source at a distance from the observation plane much larger than the distances from receivers to source. The distances of all points of the object from the observation plane are assumed to be of the same order of magnitude. The holographic image is in this case reconstructed not in the form of a Kirchhoff integral but as the sum of signals recorded by the receivers and with phases referred to a point. Assuming that the image is reconstructed correctly in the absence of phase and amplitude errors, first the effects of phase errors alone and then the effects of amplitude errors alone on the statistical characteristics of the signal vector are analyzed with the signal vector resolved into its sine and cosine components. The results indicate that the phase errors can be compensated by increasing the number of receivers and that, with basic linearity and stability requirements satisfied, the effect of amplitude errors is negligible. Figures 4.

[202-2415]

ACOUSTOOPTICAL MEASUREMENT OF MULTIPASS NOISE AMPLIFICATION IN  $n$ -InSb

Leningrad FIZIKA TVERDOGO TELA in Russian Vol 24, No 5, May 82  
(manuscript received 16 Nov 81) pp 1302-1307

DOMARKAS, A. , D'YAKONOV, A. M. and CHIPLIS, D., Physico-Technical Institute imeni A. F. Ioffe, USSR Academy of Sciences, Leningrad

[Abstract] Multipass amplification of acoustoelectric noise in  $n$ -InSb occurs, in absence of a magnetic field, as a result of conversion of acoustic modes

during their reflection at crystal boundaries. An effective acoustooptical method utilizing diffraction of light by sound has been developed for determining the spectral and modal content of acoustic noise in such semiconductor devices. Application of this method in the middle infrared range is difficult, because the diffraction efficiency of noncoherent sound is inversely proportional to the fourth power of the optical wavelength and is thus much lower for 10.6  $\mu\text{m}$  radiation than for visible light. The long wave of infrared radiation also sets an upper limit on the frequency range of acoustic noise measurable by this method. The optical part of the equipment includes an He-N<sub>2</sub>-CO<sub>2</sub> laser operating in the pulse mode at a 50 Hz repetition rate, delivering pulses of 10 W power and 2-3 ms duration. The pulses are reflected by a 45° mirror and then chopped by a rotating disk into 200  $\mu\text{s}$  pulses. A beam splitter divides these light pulses along two paths to the InSb specimen: one beam is reflected by another 45° mirror before passing through a diaphragm and a lens, the other beam passes through a polarizer before being reflected by a rotating mirror and then passing through a lens. From the InSb specimen light passes through another lens to an HgCdTe photoresistor. Acoustoelectric instability in the specimen is excited by means of a drift-pulse generator, the latter triggered by the chopper through a trigger-pulse generator and a repetition-rate divider. The equipment includes also a microwave bias-voltage generator for heterodyning and a 30 MHz amplifier followed by an oscillograph at the output of the HgCdTe photoreceiver. Specimens were cut from an nInSb ingot with electron concentration  $n = 5 \cdot 10^{13} \text{ cm}^{-3}$  and electron mobility  $\mu = 6.8 \cdot 10^5 \text{ cm}^2/\text{V}\cdot\text{s}$ , their dimensions 19 [110] x 4 [ $\bar{1}\bar{1}0$ ] x 4 [001] mm. Intensity of the transverse noise component was measured at various distances from and various angles to the anode. Each noise component decayed after the drift field had been turned off, the nonpiezoactive slow transverse component almost according to normal lattice attenuation and the piezoactive fast transverse component much faster. The authors thank V. V. Lemanov and Yu. V. Ilisavskiy for helpful discussion, I. L. Drichko for assistance, also V. V. Shein and V. A. Yankovskaya for preparing the specimens. Figures 5, table 1, references 5: 3 Russian, 2 Western.

[226-2415]

#### FILM LENSES FOR SURFACE ACOUSTIC WAVES

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 8, No 11,  
12 Jun 82 (manuscript received 3 Mar 82) pp 673-676

BORODIY, Yu. N., GRANKIN, I. M., GONCHAROV, A. D. and KOBA, S. I., Kiev Polytechnic Institute imeni Semicentennial of Great Socialist October Revolution

[Abstract] Focusing plane surface acoustic waves on an isotropic substrate requires transformation of their front to a cylindrical one, which can be

achieved by means of a laminate structure. An experimental study was made of acoustic lenses consisting of 1.1-3.6  $\mu\text{m}$  thick ZnO films deposited on fused-quartz substrates by ion-plasma sputtering in an Xe-Ar atmosphere and oriented with their c-axis perpendicular to the substrate surface. A plane surface acoustic wave with a parallel front was, upon reaching the base of such a lens, indeed focused according to calculations. Such a lens (3.6  $\mu\text{m}$  thick film on 18 mm thick substrate) was tested with a nonapodized interdigital transducer (20 prong pairs, 17.5 mm aperture, 70  $\mu\text{m}$  period, ZnO coating and shielding electrode) for focusing surface acoustic waves with velocities of 3410 and 3165 m/s at a distance of 35 mm. Amplitude measurements revealed an almost sinusoidal distribution in the focal plane. Phase measurement revealed a plane front inside the lens and a cylindrical one outside the lens, also an almost plane front in the focal region. Measurements were made with a laser probe. Such acoustic lenses were also tested with small-aperture transducers underneath and found to be capable of focusing only waves propagating near the acoustic axis. Figures 2, references 4: 3 Russian, 1 Western.  
[227-2415]

#### THEORY OF SOUND ABSORPTION BY LATTICE IN 'DIRTY' CRYSTALS

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 82, No 5, May 82 (manuscript received 14 Oct 81) pp 1551-1561

GULYAYEV, Yu. V. and KOZOREZOV, A. G., Institute of Radio Engineering and Electronics, USSR Academy of Sciences

[Abstract] A theory is constructed for sound absorption in real dielectric crystals, with impurities and defects, which covers a wide frequency range and in which the "clean" crystal Akhiezer (low-frequency) and Landau-Rumer (high-frequency) mechanisms appear as special cases. Perturbation of the phonon system by acoustic waves is described on the basis of Boltzmann kinetics with the absorption coefficient, in the linear approximation with respect to wave amplitude, proportional to the real part of the nonequilibrium increment added by acoustic waves to the phonon distribution function. The latter is calculated with aid of the phonon-phonon collision integral. The frequency dependence of the absorption coefficient is determined by the role of phonon-phonon interaction and diffusion processes, the former at thermal energy levels predominant in the low-frequency range and the latter predominant in the high-frequency range. There is an intermediate range within which the frequency dependence of the absorption coefficient weakens and vanishes before the Akhiezer mechanism becomes operative again. The authors thank V.L. Gurevich for valuable comments. Figure 1; references 14: 9 Russian, 5 Western.  
[225-2415]

## CRYSTALS AND SEMI CONDUCTORS

### EFFECT OF GAMMA IRRADIATION ON OPTICAL CHARACTERISTICS OF RUBY AND RUBY LASERS WITH GALLIUM AND TITANIUM IMPURITIES

Yerevan IZVESTIYA AKADEMII NAUK ARMYANSKOY SSR: FIZIKA in Russian Vol 17, No 2, Mar-Apr 82 (manuscript received 1 Nov 80) pp 91-96

ATABEKYAN, R. R., VOSKANYAN, R. Ye., GEVORKYAN, V. A., YERITSYAN, G. N., YEZOYAN, R. K., SARKISOV, V. Kh. and SAKANYAN, A. G., Yerevan Institute of Physics and Kirovakan Chemical Plant

[Abstract] An experimental study was made to determine the effects of  $\gamma$ -radiation on  $\alpha$ - $\text{Al}_2\text{O}_3$  crystals with Cr, Cr+ Ga, Cr+ Ti impurities (0.05 wt.%  $\text{Cr}_2\text{O}_3$ ,  $10^{-4}$ - $10^{-3}$  wt.%  $\text{Ti}_2\text{O}_3$ , 1-2.5 wt.%  $\text{Ga}_2\text{O}_3$ ). All specimens were heat treated at  $1950^\circ\text{C}$  in vacuum and  $1250^\circ\text{C}$  in oxygen. Optical anisotropy and optical uniformity were measured with an IPL-452 conoscope and a universal Twyman interferometer respectively. Absorption spectra were recorded with an SF-8 spectrophotometer and emission characteristics were measured in an L-1 laser setup with an IFP-600 xenon flash lamp in a 600  $\mu\text{F}$  - 100  $\mu\text{H}$  circuit, before and after irradiation from a  $\text{Co}^{60}$   $\gamma$ -source. The results indicate that the emission efficiency of crystals with gallium impurity is higher than that of "pure" crystals. They are also gamma resistant, inasmuch as after irradiation they are restored by flashes from a xenon lamp without supplementary heat treatment. Figure 1, tables 1, references 16: 6 Russian, 10 Western.  
[199-2415]

### OPTICAL AMPLIFICATION IN ZnTe SINGLE CRYSTALS

Leningrad FIZIKA TVERDOGO TELA in Russian Vol 24, No 5, May 82 (manuscript received 13 Jun 81, final edition received 11 Jan 82) pp 1431-1433

BALTRAMEYUNAS, R. and KUOKSHTIS, E., Vilnius State University imeni V. Kapsukas

[Abstract] An experimental study was made of optical amplification in cubic ZnTe single crystals. Specimens were grown from melt and then excited with

third-harmonic emission from a YAG:Nd<sup>3+</sup> laser. The wavelength spectra of gain were measured by the "thin strip" method at 4.2 and 77 K. The results indicate predominance of radiative processes in electron-hole drops, but only in very pure specimens, distortions in form of cutoff at the short-wave edge being caused by absorption in the interdrop space. In defective specimens there occurs no radiative recombination in electron-hole drops and radiative processes in dense exciton gas predominate. Here the gain has four peaks, two of them in the long-wave range attributable to radiative transitions I-LO (annihilation of bound exciton with emission of one optical phonon) and A-LO (first phonon repetition of free exciton) respectively. The other two peaks in the short-wave range are difficult to identify, but they probably correspond to exciton-exciton interaction and to a bound exciton respectively. The spectra of gain at 77 K indicate strong absorption at the short-wave edge and reveal two peaks, a longer wave peak exactly within the range of exciton annihilation with emission of two phonons and a shorter-wave peak which apparently corresponds to break-even between competing emission and absorption processes. Figures 2, references 14: 7 Russian, 7 Western.

[226-2415]

#### DEFECTS IN ION-IMPLANTATION LAYER OF FERRITE-GARNET FILMS

Leningrad FIZIKA TVERDOGO TELA in Russian Vol 24, No 5, May 82  
(manuscript received 16 Nov 81) pp 1308-1312

LINKOVA, D. Ye., OSUKHOVSKIY, V. E., RUDIK, Ye. I., YUDINA, L. A., VETER, V.V.,  
CHIRKIN, G. K. and MILYAYEV, Yu. K., Far-Eastern State University, Vladivostok

[Abstract] A morphological study was made of (EuTmCa)<sub>3</sub>(FeGe)<sub>5</sub>O<sub>12</sub> ferrite-garnet films with ion-implantation layer. Single-crystal films of this material were deposited on GGG [expansion not given] substrates by the liquid-phase epitaxial process. Specimens were irradiated with 100 keV H<sub>2</sub><sup>+</sup> ions in doses of 1.10<sup>16</sup>-7.5.10<sup>16</sup> cm<sup>-2</sup> and then etched with orthophosphoric acid (1.85 g/cm<sup>3</sup>) at 130°C. While the etching rate of plain films is 33 Å/s and constant, the etching rate of films with ion implantation was found to be much higher and proportional to the concentration of radiative defects. The depth of the implantation layer was 0.45 μm regardless of the irradiation dose. The surface reliefs were examined under an MBI-6 optical microscope and a JSM-IZ scanning electron microscope. Experimental data, supported by theoretical analysis of collisions between impinging ions and atoms of the film material with attendant competing generation and annihilation of point defects, indicate that the mean (statistical) size of etching pits increases proportionally with the irradiation dose but their volume concentration increases nonlinearly to a maximum at the irradiation dose of 2.5.10<sup>16</sup> cm<sup>-2</sup>. Coalescence of vacancies under higher irradiation doses appears to result in formation of pores (three-dimensional defects) rather than dislocation loops. Figures 5, references 13: 7 Russian, 6 Western.

[226-2415]

## LONGITUDINAL PROPAGATION OF MAGNETOPLASMA SURFACE WAVES OF SEMICONDUCTOR-METAL INTERFACE

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 16, No 4, Apr 82  
(manuscript received 27 Aug 81) pp 712-714

ZAKHAROV, V. A., Sverdlovsk Branch, All-Union Scientific Research Institute  
of Metrology imeni D. I. Mendeleev

[Abstract] Existence of magnetoplasma surface waves on a semiconductor-metal interface and their propagation in the direction of the magnetic field are analyzed, specifically for an n-type semiconductor, assuming first no collisions and a correspondingly zero frequency of carrier momentum relaxation  $\nu_r$ . Solution of the dispersion equation reveals that the frequency range of such waves is not simply  $0 < \omega < \omega_c$  ( $\omega_c$  - cyclotron frequency) but  $\omega < \min(\omega_c, \omega_p)$  ( $\omega_p$  - plasma frequency) and thus also determined by the plasma frequency. Attenuation of such waves depends on the relative magnitudes of the three frequencies  $\omega_c$ ,  $\omega_p$ ,  $\nu_r$  in the semiconductor, according to the expression obtained for the longitudinal component of the wave vector, it becomes weaker as  $\nu_r$  decreases and as  $\omega_c$  increases (stronger magnetic field). When  $\omega_c \gg \omega_p$ ,  $|\omega + j\nu_r|$  the ratio of imaginary part to real part of the longitudinal wave vector component increases with increasing magnetic field intensity almost proportionally to the ratio  $\omega_p/\omega_c$  at any ratio  $\nu_r/\omega$ . References 11: 3 Russian, 8 Western.  
[214-2415]

## ABSORPTION OF ELECTROMAGNETIC WAVES BY TWO-DIMENSIONAL PLASMONS IN THIN FILMS

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 16, No 4, Apr 82  
(manuscript received 29 Apr 81) pp 625-629

VITLINA, R. Z. and CHAPLIK, A. V., Institute of Semiconductor Physics, Siberian  
Department, USSR Academy of Sciences, Novosibirsk

[Abstract] A theory is constructed describing absorption of electromagnetic waves by two-dimensional plasmons in a quantum film or inversion channel of an MOS structure with two populated subbands. Electrons are assumed to be scattered by impurities only, which has been verified experimentally in silicon MOS structures and in GaAs thin films in GaAs/GaAlAs structures at liquid-helium temperatures. The equation of kinetics of the Poisson equation are solved exactly for the case of scattering by short-range centers, the field

term in the equation of kinetics including not only the external electric field but also the field of a plasma wave. For the more general case of an arbitrary scattering potential, with the probability of scattering assumed to depend on the angle difference only, the collision term in the equation of kinetics is integrated with respect to electron acceleration and the probability of scattering is resolved into cylindrical harmonics for an approximate solution. The authors thank L. I. Magarill and I. A. Gilinskiy for helpful comments.

References: 4 Western.

[214-2415]

UDC 621.315.592

#### PROPERTIES OF CHROMIUM-DOPED SILICON

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 16, No 4, Apr 82  
(manuscript received 23 Dec 80) pp 582-586

MUMINOV, R. A., DZHULIYEV, Kh. Kh., MAKHKAMOV, Sh. and MAMADALIMOV, A. T.,  
Physico-Technical Institute imeni S. V. Starodubtsev, UzSSR Academy of Sciences,  
Tashkent

[Abstract] Energy levels produced in n-type and p-type silicon by doping with chromium were studied by several methods. Specimens of n-Si and p-Si with electrical resistivity  $\sigma = 3-100 \text{ ohm}\cdot\text{cm}$  were doped with chromium by slow diffusion under vacuum at  $1000-1250^\circ\text{C}$  for 0.15-14 h, with subsequent oil quench. The electrical resistivity of doped n-Si had not changed, that of doped p-Si had increased to  $10^5 \text{ ohm}\cdot\text{cm}$ . Capacitance-voltage characteristics of n-si < Cr > and p-Si < Cr > diodes were measured at 77 K, with reverse 8 V bias and after irradiation with light  $\nu \gg E_g$  from the side opposite to the p-n junction. The temperature dependence of the rate of thermal emission from deep levels was measured by the method of isothermal relaxation of dark capacitance and photo-stimulated capacitance. The energy spectra of photoconduction (impurity photoconduction) were measured at 4.2 K with 6 V bias. The results indicate formation of donor levels with ionization energy  $E_c - 0.22$ ,  $E_c - 0.55$ ,  $E_v + 0.39$  eV in n-Si and  $E_v + 0.31$  eV in p-Si. The different levels in the two types of silicon are due to different interactions of chromium with fine acceptor and donor impurities, these interactions depending on the N/M ration (N- concentration of fine levels, M- concentration of deep levels). The authors thank A. A. Lebedev for providing the facilities for measurement of photoconduction spectra at liquid-helium temperature and for helpful suggestions. Figures 4; references 18: 14 Russian, 4 Western.

[214-2415]

## DIFFERENCES BETWEEN RADIATIVE DEFECTS PRODUCED IN GaAs DURING IMPLANTATION OF PHOSPHORUS AND ALUMINUM IONS RESPECTIVELY

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 16, No 4, Apr 82  
(manuscript received 15 Dec 80) pp 577-581

DAVIS, J., TASHLYKOV, I. S., and THOMPSON, D. A., Chalk River Nuclear Laboratory, Canada; Scientific Research Institute of Applied Problems in Physics imeni A. N. Sevchenko, Belorussian State University, Minsk; McMaster University, Canada

[Abstract] A study was made, by the backscattering method, of radiative defects (ternary compounds) produced in GaAs crystals by  $P^+$  and  $Al^+$  ions channeling through during their implantation. In the experiment  $P^+$  and  $Al^+$  ions with 60 keV energy were implanted in GaAs single crystals in doses of  $1.2 \cdot 10^{12}$ - $8 \cdot 10^{16}$  ions/cm<sup>2</sup>, at 40 K and at room temperature. Backscattering spectra of 1 MeV  $He^+$  ions were measured in the same target chamber, a surface-barrier detector with 15 keV resolution recording  $He^+$  ions backscattered at a  $150^\circ$  angle. These spectra and the trend of defectiveness buildup with increasing implantation dose reveal that this buildup proceeds in two stages at 40 K (number of defects first increases at same rate near unity with  $P^+$  and  $Al^+$  ions, but the cumulative number of defects remains always somewhat lower with  $Al^+$  ions than with comparable dose of  $P^+$  ions, then with  $5 \cdot 10^{13}$  cm<sup>-2</sup> ions of either kind the implantation layer becomes completely disordered) and in three stages at room temperature (number of defects first increases at different rates, slower with  $Al^+$  ions up to  $1 \cdot 10^{15}$  cm<sup>-2</sup> than with  $P^+$  ions up to  $2 \cdot 10^{14}$  cm<sup>-2</sup>, then very fast at almost same rate with  $Al^+$  ions up to  $4 \cdot 10^{15}$  cm<sup>-2</sup> as with  $P^+$  ions up to  $3 \cdot 10^{14}$  cm<sup>-2</sup>, when the implantation layer becomes completely disordered, then further still as the amorphized layer becomes thicker). Figures 2, references 16: 6 Russian, 10 Western.  
[214-2415]

## EFFECT OF ELECTRIC FIELD ON BUILDUP OF RADIATIVE DEFECTS IN GALLIUM ARSENIDE

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 16, No 5, May 82  
(manuscript received 29 Jun 81, after final revision 18 Nov 81) pp 912-914

MAMONTOV, A. P. and PESHEV, V. V.

[Abstract] A study was made of the kinetics of radiative defects within the space-charge region and within the bulk of gallium arsenide irradiated by  $\gamma$ -quanta. Diode structures of this semiconductor were produced on epitaxial layers with carrier concentration of  $(1-5) \cdot 10^{15} \text{ cm}^{-3}$  on GaAs substrates with carrier concentration  $(1-3) \cdot 10^{18} \text{ cm}^{-3}$ , Schottky barriers then built in by deposition of titanium. The diodes were irradiated from a  $\text{Co}^{60}$  source with doses from  $3.2 \cdot 10^{16}$  to  $2 \cdot 10^{17}$  quanta/ $\text{cm}^2$  at room temperature. The dependence of defect concentration on  $\gamma$ -quanta dose was measured by the method of non-stationary capacitive spectroscopy of deep levels. Measurements in the space charge region were made with a 40 V reverse bias voltage across the diode to ensure that  $z \geq h_2$  ( $z$ - width of space-charge region from semiconductor surface to intersection of electronic Fermi quasi-level and valence band,  $h_2$ - width of space-charge region due to charge redistribution at deep levels). Measurements in the semiconductor bulk were made without bias voltage. The condition  $h_2 \gg h_1$  ( $h_1$  - width of space-charge region due to contact potential difference) was also satisfied during measurements. The results reveal that E2 and E3 centers build up at different rates: E2 centers faster in space-charge region than in bulk, E3 centers faster in bulk than in space-charge region, and E2 centers everywhere faster than E3 centers. Figures 2, references 4:

2 Russian, 2 Western.

[216-2415]

ION IMPLANTATION OF IMPURITIES IN  $n\text{-Hg}_{0.8}\text{Cd}_{0.2}\text{Te}$ , PART 1: GROUP-II IONS  
 $\text{Mg}^+$ ,  $\text{Zn}^+$ ,  $\text{Cd}^+$ 

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 16, No 5, May 82  
(manuscript received 20 Apr 81) pp 782-788

VODOP'YANOV, L. K., KOZYREV, S. P. and SPITSYN, A. V., Institute of Physics  
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[Abstract] An experimental study was made of ion implantation in  $n\text{-Hg}_{0.8}\text{Cd}_{0.2}\text{Te}$  as means of producing planar semiconductor structures with controllable properties. The raw material was  $n\text{-Hg}_{0.8}\text{Cd}_{0.2}\text{Te}$  wafers 1 mm thick with  $E_g = 0.1 \text{ eV}$

and  $n < 10^{16} \text{ cm}^{-3}$  at 85 K, mechanically treated and then etched in methanol solution of bromine. Ions of group-II elements (100 keV  $\text{Mg}^+$ , 300 keV  $\text{Zn}^+$ , 300 keV  $\text{Cd}^+$ ) were implanted in them with a "High Voltage Engineering Europa" heavy-particle accelerator in doses ranging from  $3 \cdot 10^{12}$  to  $1 \cdot 10^{15} \text{ cm}^{-3}$  at an ion current smaller than  $0.30 \mu\text{A}/\text{cm}^2$  so as to avoid heating of a crystal by more than  $10^\circ\text{C}$ . Group-II elements had been selected because isomorphic substitution does not result in formation of electrically active centers and because they form continuous solid solutions  $\text{Hg}_{1-x}\text{Zn}_x\text{Te}$  and  $\text{Hg}_{1-x}\text{Cd}_x\text{Te}$  respectively over the entire  $0 \leq x \leq 1$  range. Physical properties of the subsurface implantation layer associated with free electrons were measured by infrared reflection spectroscopy, assuming Gaussian depthwise distribution of impurity ions. The results indicate a V-form dependence of carrier concentration on implantation dose, with the carrier concentration in the implantation layer first decreasing and then increasing to saturation as the implantation dose reaches  $1 \cdot 10^{15} \text{ cm}^{-3}$ . This trend is hypothetically attributed to "pinning" of the Fermi level by the resonance level of radiative defects within the conduction band. The properties of the implantation layer in  $n\text{-Hg}_{0.8}\text{Cd}_{0.2}\text{Te}$  thus depend largely on radiative defects. Annealing was found to produce some quantitative changes. Figures 5, tables 2, references 16: 2 Russian, 14 Western.

[216-2415]

#### LIGHT-STIMULATED TRANSFORMATION OF MOLECULES: NEW KIND OF 'GIGANTIC' OPTICAL NONLINEARITY IN LIQUID CRYSTALS

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 82, No 5, May 82 (manuscript received 26 Nov 81) pp 1475-1484

ODULOV, S. G., REZNIKOV, Yu. A., SOSKIN, M. S. and KHIZHNYAK, A. I., Institute of Physics, UkSSR Academy of Sciences

[Abstract] A new anomalous "gigantic" cubic nonlinearity in nematic liquid crystals such as MBRA (p-methoxybenzylidene-p-butylaniline) is examined on the basis of diffraction by light-induced dynamic holographic gratings. Formation of such gratings on molecules transformed by light is analyzed theoretically, considering two coherent light beams of intensities  $I_1$  and  $I_2$  which intersect at angle  $2\theta$  so as to produce a resultant space distribution of intensity  $I_0^{\circ,e}(x) = I_0^{\circ,e}(1 + m \cos \frac{2\pi x}{\Lambda})$  ( $I_0 = I_1 + I_2$ ,  $m = 2\sqrt{I_1 I_2}/(I_1 + I_2)$ ), period of diffraction grating  $\Lambda = \lambda/2\sin\theta$ ,  $\lambda$ -wavelength,  $x$ -space coordinate,  $o$ - ordinary polarization,  $e$ - extraordinary polarization). Molecules transformed by photostimulation can either spontaneously transform to ordinary ones or diffuse anisotropically, both processes resulting in erasure of the refraction grating. An experiment was performed in recording holograms with light from He-Cd and Ar

lasers so as to cover the  $\lambda = 0.44-0.488 \mu\text{m}$  range of wavelengths. Measurements have revealed that the diffraction efficiency is proportional to the intensity ( $I_0$ ) squared. It increases as the grating period increases, first at an increasing rate in the range of small periods and then at a decreasing rate toward saturation as the period becomes larger. The cubic nonlinearity index ( $\epsilon_2$ ,  $\text{cm}^3/\text{erg}$ ) as well as the absorption coefficient ( $\alpha$ ,  $\text{cm}^{-1}$ ) and the birefringence ( $n_e - n_o$ ) are very large near the edge of intrinsic absorption

( $\epsilon_2 \approx 5 \cdot 10^{-2} \text{ cm}^3/\text{erg}$  at  $\lambda = 0.44 \mu\text{m}$  with  $\Lambda = 13 \mu\text{m}$  for MBBA) but decreases very fast as the wavelength increases. The authors thank I. P. Il'chishin and Ye. P. Sukhenko for helpful discussions and assistance. Figures 6, references 19: 15 Russian, 4 Western.  
[225-2415]

UDC 532.783

STRUCTURAL ORDERING AND TRANSLUCENCE OF NEMATIC LIQUID CRYSTALS: EXPERIMENTALLY OBSERVED REORIENTATION OF MOLECULES IN LASER FIELD, LIGHT-INDUCED STABILIZATION OF FLUCTUATIONS

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 52, No 5, May 82  
(manuscript received 12 May 80, final edition received 9 Jun 81) pp 909-914

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[Abstract] Effects of a laser field on nematic liquid crystals, namely reorientation of the molecular director with attendant improvement of structural ordering (light-induced translucence), are examined theoretically in terms of molecule kinetics and dynamics. These effects were observed directly in experiments with  $50 \mu\text{m}$  thick layers of MBBA (p-methoxybenzylidene-p'-butylaniline) at room temperature in a linearly polarized low-intensity laser field. Scattering of light was measured as a function of time and of incident radiation power, from a few to several hundred  $\text{kW}/\text{cm}^2$ , from a helium-neon laser ( $\lambda = 0.633 \mu\text{m}$ ) and an argon laser ( $\lambda = 0.488 \mu\text{m}$ ) operating in the continuous mode. Translucence was found to increase monotonically with time to a stabilization level, the role of thermal processes increasing at higher power levels. After the low-power laser beam was "instantaneously" cut off crystals became turbid and returned to their original state with strong scattering of light. Similar reorientation in nematic liquid crystals was also observed in the field of a high-power ( $10 \text{ MW}/\text{cm}^2$ ) YAG:Nd<sup>3+</sup> Q-switched laser and will be reported separately. The authors thank B. Ya. Zel'dovich and A. S. Karayan for discussion of problems and valuable comments. Figures 3, references 9: 7 Russian, 2 Western.  
[219-2415]

## ELECTRICITY AND MAGNETISM

### DIGITAL-COMPUTER SIMULATION OF FILTRATION OF TWO-DIMENSIONAL SIGNAL FROM MULTIPLICATIVE INTERFERENCE

Yerevan IZVESTIYA AKADEMII NAUK ARMYANSKOY SSR: FIZIKA in Russian Vol 17, No 2, Mar-Apr 82 (manuscript received 15 May 81) pp 83-86

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[Abstract] The problem of nonlinear filtration of a two-dimensional signal from multiplicative interference due to a turbulent atmospheric layer, the mixture describable as  $A(x,y) = A_0(x,y)e^{\chi(x,y)}$ , can be solved by means of a space filter representing the two-dimensional analog of an optimum Wiener filter. Such a filter can be simulated on a digital computer with the algorithm of fast two-dimensional discrete Fourier transformation and inverse Fourier transformation. The procedure has been programmed on an M4030 computer, assuming both signal  $A_0(x,y)$  and interference  $\chi(x,y)$  to be real rather than complex, the latter having a normal distribution with  $\langle \chi(x,y) \rangle = 0$  and fully described by the correlation function  $B_\chi(\rho) = \langle \chi^2 \rangle b_\chi(\rho)$  ( $\rho$  - distance between two points in the receiver aperture,  $b_\chi(\rho)$  determined by refractive index distribution, thickness of turbulent layer  $L$ , and wavelength of radiation  $\lambda$ ). Computations for a typical  $0.3 \times 0.3$  m aperture and  $\lambda L = 10^{-2} \text{ m}^2$  indicate that the algorithm is efficient, fast and accurate. Figure 1, references: 1 Russian. [199-1862]

### ELECTROMAGNETIC SHOCK WAVES IN MAGNETIZED VACUUM

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 82, No 5, May 82 (manuscript received 22 Oct 81) pp 1366-1374

ZHELEZNYAKOV, V. V. and FABRIKANT, A. L., Institute of Applied Physics, USSR Academy of Sciences

[Abstract] Equations are derived which describe the dynamics of weakly nonlinear electromagnetic waves propagating through magnetized vacuum, with a correction

term for radiation in the Lagrangian. Solution of these partial differential equations is feasible in the one-dimensional case, in which it yields nonlinearly coupled TE and TM modes propagating in the same direction within a small solid angle. Locking and interaction of these modes is impossible, because of their different phase velocities and polarizations, and only TE modes remain nonlinear. The evolution of simple TE waves involves formation of step discontinuities evolving into a shock wave, inasmuch as the high-frequency dispersion of low-order (long-wave) harmonics is negligible. Figures 2, references 7: 5 Russian, 2 Western.  
[225-2415]

UDC 534.222

#### THEORY OF PARAMETRIC RECEIVER ANTENNA

Moscow VESTNIK MOSKOVSKOGO UNIVERSITETA, SERIYA 3: FIZIKA, ASTRONOMIYA  
in Russian Vol 23, No 3, May-Jun 82 (manuscript received 26 Dec 80) pp 60-63

DEVYATERIKOVA, Ye. A. and ZAREMBO, L. K., Chair of Acoustics, Moscow University

[Abstract] In a parametric receiver antenna for maritime applications the low-frequency acoustic signal interacts with a high-frequency reference signal. Assuming an axisymmetric wave beam, the two-dimensional nonlinear wave equation for the velocity potential in a heat conducting viscous medium is solved in the first approximation of a quasi-planar reference wave and then in the second approximation of a combination wave having the same transverse distribution as the reference wave. The radiation pattern of such an antenna in such a medium is calculated on this basis, with diffraction subsequently taken into account in the quasi-optical approximation. The results are applicable to optimization of the antenna design, which must also consider intrinsic noise due to a finite-width spectrum of the reference wave and interference due to sea noise interacting with the reference wave and its harmonics. The authors thank I. P. Chinchuzov for helpful suggestions. References 7: 4 Russian, 3 Western.  
[222-2415]

## BIPLANAR ELECTROSTATIC LENSES

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 52, No 5, May 82  
(manuscript received 12 Mar 81) pp 945-949

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Academy of Sciences, Leningrad

[Abstract] Biplanar electrostatic lenses with two planes of symmetry parallel to each other and to the optical axis are considered as means of correcting spherical aberration. The three-dimensional distribution of electric potential in such a lens is calculated from its distribution in a transverse plane near the center, far from the edges, with geometrical symmetry and electrode "influence" functions taken into account for a typical single lens with three electrodes in each plane. The problem is generalized by disregarding field symmetry and seeking the solution to the appropriate Laplace equation. Biplanar lenses have very flexible electrically controllable optical properties, are highly technological and, unlike crossed lenses, do not require tedious adjustment of electrodes. They can be used for focusing with deflection, in which case there appears a sextupole regular field component needed for correcting aberrations. Figure 2, references 3: 1 Russian, 2 Western.  
[219-2415]

UDC 553.9.12

## FORMATION OF LARGE-APERTURE HIGH-CURRENT ELECTRON BEAMS

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 52, No 5, May 82  
(manuscript received 12 Jan 81, final edition received 4 Jun 81)  
pp 929-934

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Sciences, Tomsk

[Abstract] Vacuum diodes for electron accelerators have been designed which form ribbon-like electron beams for excitation of gas lasers. Dimensions and spacing of the two cylindrical electrostatically focusing electrodes were calculated to ensure sufficient width of a parallel or tapering electron beam with minimum electric field intensity at their surface, roughly in accordance with the  $3/2$ -power law for flat diodes. The number of cylindrical emitter elements is sufficiently small to minimize mutual shielding, their dimensions

and spacing calculated to ensure uniform beam current density within a well defined cross section. There is no severe requirement here regarding stability of the beam current, inasmuch as the duration of beam pulses for pumping a gas laser need not exceed 10  $\mu$ s. Actual dimensions of two such diodes are given one diode forming a 19(13)x140 cm 300 keV - 1 A/cm<sup>2</sup> electron beam for CO<sub>2</sub> lasers and one diode forming a 10x140 cm 300 keV - 8 A/cm<sup>2</sup> electron beam for XeCl lasers. These diodes were tested, voltage and current transients were measured, beam traces were recorded on photographic film. The diode impedance remains constant during the entire beam pulse period, which facilitates efficient energy transfer from tank circuit to beam. The authors thank S. A. Belomyttsev for performing the numerical calculations. Figures 4, references 6: 5 Russian, 1 Western.

[219-2415]

## ASYMPTOTIC BEHAVIOR OF SOLUTION TO PROBLEM IN THEORY OF WAVES ON SURFACE OF THIN STRATIFIED FLUID LAYER

Moscow ZHURNAL VYCHISLITEL'NOY MATEMATIKI I MATEMATICHESKOY FIZIKI in Russian Vol 22, No 3, May-Jun (manuscript received 3 Jun 80) pp 690-699

VARLAMOV, V. V. and GABOV, S. A., Moscow

[Abstract] The problem of linear waves on the surface of an infinitely large plane layer of stratified fluid is solved with consideration of the earth's curvature in the vicinity of the equator. The asymptotic behavior of the Green's function is examined in the case of a layer thickness much smaller than the radius of curvature. The corresponding equation of motion for small oscillations is split into two, according to the Boussinesq approximation, so as to eliminate compressibility and acoustic waves with the density of the fluid not constant except along the trajectory of a particle. These equations are supplemented with an Euler equation. An auxiliary eigenvalue problem is solved by separation of variables, with aid of three lemmas and a basis system of eigenfunctions. The original boundary-value problem is then reduced to a double integral of the Green's function. The asymptotic behavior of the latter is established on the basis of two theorems pertaining to "local" and "integral" estimates of the function. The authors thank A. G. Sveshnikov and I. A. Shishmarev for helpful suggestions. References: 5 Russian. [213-2415]

## STEADY-STATE CIRCULATION IN SHALLOW SEA WATER

Moscow VESTNIK MOSKOVSKOGO UNIVERSITETA, SERIYA 3: FIZIKA, ASTRONOMIYA in Russian Vol 23, No 3, May-Jun 82 (manuscript received 10 Jul 79, final edition received 26 Oct 81) pp 66-69

SHEIKOVNIKOV, N. K., NOVOCHINSKIY, S. M. and RAKITINA, I. S., Chair of Physics of Sea and Inland Water, Moscow University

[Abstract] A model study was made to determine, under laboratory conditions, the flow pattern in shallow sea water in shelf regions during wind-induced tides. Experiments were performed in a 14 m long aerohydrodynamic channel with a 2.5x1.23 m cross section. The water level was 0.3 m above the bottom and a 0.35 m long wedge fitting into the channel simulated a sloping shore. Wind was produced along the channel with a velocity of 8.1 m/s at an altitude of 0.3 m above the still water surface and with a vertical velocity profile logarithmic up to 0.7 m above the water level. Vertical profiles of mean velocity in the drift-flow zone (upper layer) and in the gradient-counterflow zone (lower layer) as well as fluctuations of longitudinal and vertical velocity components in the gradient zone, also wave parameters at the surface, were measured at various distances from the water edge on the shelf.

Figures 3, references: 2 Russian.

[222-2415]

USE OF FREE ELECTRON LASER FOR PRODUCING OPPOSED HIGH-ENERGY PHOTON BEAMS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 264, No 4, Jun 82  
(manuscript received 25 Jan 82) pp 849-852

KONDRATENKO, A. M., PAKHTUSOVA, Ye. V. and SALDIN, Ye. L., Institute of Nuclear Physics, Siberian Department, USSR Academy of Sciences, Novosibirsk

[Abstract] A scheme is proposed for producing opposed photon beams solely on the basis of accelerator technique without external light source. Electrons of a relativistic electron beam in an open undulator are made to interact through radiation fields so as to cause instability of certain harmonics of the electron concentration distribution, which results in electron bunching and in coherent radiation used for producing a dense light cluster. A typical device for this purpose includes an injector, an accelerator-discriminator, a high-frequency oscillator, and an undulator. The same electron beam is used for generation of coherent radiation and conversion to high-energy photons at various acceleration stages, which automatically solves the problems of phasing and bunch length optimization as well as the problem of required repetition rate. Its performance is calculated on basis of theoretical relations and numerical data for a relativistic cylindrical electron beam moving through a spiral undulator. With a sufficiently long undulator, shot noise in an electron bunch can serve as initial excitation for buildup of radiation instability. The authors thank Ya. S. Derbenev for his discussions, A. N. Skrinskiy for his interest in this study, also G. L. Kotkin, V. G. Serbo and V. I. Tel'nova for their comments. Article presented by Academician A. N. Skrinskiy 15 Jan 82. Figure 1, references 9: 6 Russian, 3 Western.  
[211-2415]

## FREE-ELECTRON MASERS WITH BRAGG RESONATORS

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian  
Vol 35, No 10, 20 May 82 (manuscript received 20 Apr 82) pp 418-420

BOTVINNIK, I. Ye., BRATMAN, V. L., VOLKOV, A. B., GINZBURG, N. S.,  
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[Abstract] An electrodynamic system for a maser has been designed according to a nonlinear theory which should simultaneously satisfy the two requirements of selective mode excitation and transportability of high-intensity electron flux. With proper improvement of the active medium, the parameters of the accelerator and of the electron-optical system were modified for operation either as ubitron with free electrons oscillating at bounce frequency or as maser at cyclotron autoresonance with high efficiency and low sensitivity to initial spread of electron velocities. The electron beam is 6 mm in diameter, it carries electrons of 350-600 keV energy in a current of 0.4-1.0 kA and 100 ns pulse duration. The initial spread of transverse velocities of electrons and of radii of driving centers is reduced by use of a double cathode in the magnetic field as large here as in the interaction space. A magnetic field modulated in space with a period of 2 cm pumps oscillation energy into the electron beam. The resonator is a waveguide segment with circular cross section and with two Bragg mirrors, two corrugated segments and a smooth one separating them. In an experiment with the device operating as autoresonance-cyclotron maser and as ubitron it was possible to achieve single-mode emission in the  $H_{1,1}$  mode at the 4.3 mm wavelength, with a power output of 6 MW at 4% efficiency and 2 MW at 1% efficiency respectively. The duration of emission pulses was 5-30 ns, the frequency conversion ratio was 3-4 and 5 respectively. The authors thank V. I. Belousov, A. V. Gaponov-Grekhov and A. Sh. Fiks for helpful discussions. Figures 2, references 11: 6 Russian, 5 Western.  
[208-2415]

## VARIABLE-BAND SEMICONDUCTOR LASER WITH OPTICAL PUMPING

Yerevan IZVESTIYA AKADEMII NAUK ARMYANSKOY SSR: FIZIKA in Russian Vol 17, No 2,  
Mar-Apr 82 (manuscript received 15 Jun 80) pp 87-90

MURADYAN, A. M., Yerevan Polytechnic Institute imeni Karl Marx, and  
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[Abstract] A laser with optical pumping for population inversion is described whose active medium consists of a uniform-band semiconductor region between two variable-band semiconductor regions with linearly increasing widths on both

sides. The threshold pumping power is calculated, assuming a Gaussian distribution of pump energy about some center frequency  $\omega_c > E_{g,act}/\hbar$  and using an experimentally established dependence of optical gain on semiconductor and dopant characteristics. For a typical p-Ga<sub>x</sub>Al<sub>1-x</sub>As/GaAs/Ga<sub>x</sub>Al<sub>1-x</sub>As structure it is found to be much lower than for a plain uniform-band active medium. When pumped with another laser, such a variband structure becomes an efficient converter of one coherent radiation to another. The authors thank V. M. Arutyunyan and R.A. Siris for discussing this study. Figure 1; references 8: 6 Russian, 2 Western.  
 [199-2415]

UDC 621.315.592

TEMPERATURE DEPENDENCE OF EMISSION THRESHOLDS OF DOUBLE HETEROSTRUCTURE InGaAsP/InP LASERS (WAVELENGTH 1.55 μm) WITH OPTICAL AND CURRENT EXCITATION OF EXCESS CARRIERS

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 16, No 5, May 82 (manuscript received 9 Oct 81) pp 848-851

GARBUZOV, D. Z., CHALYY, V. P., MISHURNYY, V. A., AKHMEDOV, D., AGAYEV, V. V. and YEVTIKHIYEV, V. P., Physico-Technical Institute imeni A. F. Ioffe, USSR Academy of Sciences, Leningrad

[Abstract] The temperature dependence of emission thresholds of double heterostructure InGaAsP/InP lasers (wavelength 1.5 μm) with either current (injection) excitation or optical excitation of excess carriers in the active region was measured on structures consisting of four layers (n-InP buffer layer, In<sub>0.56</sub>Ga<sub>0.44</sub>As<sub>0.93</sub>P<sub>0.07</sub> active layer, In<sub>0.78</sub>Ga<sub>0.22</sub>As<sub>0.5</sub>P<sub>0.5</sub> buffer layer, In<sub>0.78</sub>Ga<sub>0.22</sub>As<sub>0.5</sub>P<sub>0.5</sub>+0.2·10<sup>-3</sup> at.% Zn buffer layer) deposited on n-InP substrates by the liquid-phase epitaxial process, with second and third layers intentionally not doped and with the p-n junction shifted relative to the boundary between third and fourth layer toward the active one. The threshold current density in the case of current excitation was measured with laser diodes in the pulse mode (300-500 μm long resonator cavity, (Zn,Au) + Ag contact tabs on p-region, (Te,Au)+Ag contact tabs on n-region deposited and brazed in). Optical excitation was effected by means of a single-mode YAG:Nd<sup>3+</sup> laser (wavelength 1.06 μm) operating in the pulse mode with Q-switching. Spectra of threshold emission and also spectra of spontaneous emission were recorded for each mode of excitation. The thresholds were found to rise linearly with temperature, at a faster rate in the case of current (injection) excitation because of additional losses which also increase with higher

temperature. The authors thank A. T. Gorelenko and Ye. L. Portnoy for valuable consultations and discussions, S. G. Konnikov and V. M. Zheludev for performing x-ray microspectral measurements, also Zh. I. Alfërov for formulating the problem and taking interest in this study. Figures 2, table 1, references 10: 4 Russian, 6 Western.  
[216-2415]

UDC 621.315.592

INFLUENCE OF RE-RADIATION EFFECTS ON THRESHOLD CHARACTERISTICS OF DOUBLE HETEROSTRUCTURE InGaAsP/InP LASERS WITH OPTICAL PUMPING

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 16, No 5, May 82 (manuscript received 9 Oct 81) pp 844-847

GARBUZOV, D. Z., CHALYY, V. P., GORELENOK, A. T., AGAYEV, V. V. and MDIVANI, V. N., Physico-Technical Institute imeni A. F. Ioffe, USSR Academy of Sciences, Leningrad

[Abstract] Effects of re-radiation on the threshold characteristics of double heterostructure InGaAsP lasers (wavelength 1.3  $\mu\text{m}$ ) with optical pumping were studied on n-n-n structures consisting of an n-InP buffer layer, a  $\mu\text{m}$  thick  $\text{In}_{0.7}\text{Ga}_{0.3}\text{As}_{0.64}\text{P}_{0.36}$  active region, and an InP upper layer. Excess carriers in the active region were excited by means of a continuously pumped YAG:Nd<sup>3+</sup> laser (wavelength 1.06  $\mu\text{m}$ ) emitting pulses of 100 ns duration at a repetition rate of 2 kHz. Emission spectra of the double heterostructures were measured with and without an absorbing germanium layer on the InP surface. The data indicate that such an absorption layer raises the threshold pumping power, to levels up to twice as high at room temperature and less at higher temperature. Metal (nickel) layers serving as contact tabs have a similar effect, but to a lesser degree and not as consistent. The authors thank V. I. Skopin for depositing germanium layers, V. A. Mishurnyy and D. Akhmedov for supplying double p-n heterostructure-InGaAsP specimens, also Zh.I.Alfërov for helpful discussions. Figures 2, tables 2, references: 5 Russian.  
[216-2415]

CW GROWN-MESASTRIP InGaAsP/InP HETEROSTRUCTURE LASERS PRODUCED BY  
COMBINATION LIQUID-PHASE AND GASEOUS-PHASE EPITAXY

Leningrad PIS'MA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 8, No 11,  
12 Jun 82 (manuscript received 3 Mar 82) pp 680-684

ALFEROV, Zh. I., VASIL'YEV, M. G., GOLIKOVA, Ye. V., GORELENOK, A. T.,  
DURAYEV, V. P., IVANYUTIN, L. A., IL'INSKAYA, N. D., SINITSYNA, G. M.,  
TARASOV, I. S., USIKOV, A. S., TSYPLENKOV, I. N. and SHVEYKIN, V. I., Physico-  
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[Abstract] A hybrid technology has been developed for producing cw InGaAsP/InP lasers for use with fiber-optics communication lines, a reverse biased p-n junction in i-InP mesatrip providing the necessary optical and current limitation. The binary InGaAsP heterostructure is grown by liquid-phase epitaxy on n(p)-InP<Sn(Zn)>[100] substrate, the InP<Cr>mesastrip was grown by the chloride-hydride method of gas-phase epitaxy, and two contact tabs (one Au-Zn, one Au-Te) are vacuum deposited after removal of the SiO<sub>2</sub> mask. Specimens with up to 300 μm long Fabry-Perot resonators were sliced off and mounted through indium on copper heat sinks, for measurement of radiation spectrum, threshold current and its temperature dependence, power-current characteristic, also intensity distribution in the far field, under pulse and constant-current excitation. Misalignment of lattice parameters, as determined from the spectral dependence of linear polarization of spontaneous electroluminescence, was found to be within +0.05%. The threshold current at 285 K for a 5 μm wide mesastrip and a 250 μm long resonator was 110 mA under constant-current excitation and 150 mA under excitation by pulses of 1 μs duration at a 1 kHz repetition rate. Figures 3, references 9: 5 Russian, 4 Western.  
[227-2415]

SMALL CO<sub>2</sub> LASER WITH SEALED ELECTRON SOURCE

Leningrad PIS'MA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 8, No 11,  
12 Jun 82 (manuscript received 22 Sep 81, final edition received 4 Apr 82)  
pp 644-648

BYCHKOV, Yu. I., KURBATOV, Yu. A., MESYATS, G. A., ORLOVSKIY, V. M. and  
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[Abstract] It is possible to reduce weight and size of CO<sub>2</sub> pulse lasers with electrical ionization by use of sealed diodes for generating short-duration electron beams as external ionization source. A small prototype MIG-1 of such a laser has been built with standard MIRA-ZD X-ray equipment. The active zone

measures 0.6x1.5x6 cm and contains a CO<sub>2</sub>:N<sub>2</sub> = 1:1 gas mixture under pressure of 1-6 atm. The resonator is formed by a spherical gold mirror (radius of curvature 10 m, reflection coefficient 100%) and a plane germanium mirror with tellurium coating (reflection coefficient 80%). The electron beam was designed on basis of the equilibrium equation for electrons in the ionization-recombination model, namely  $t_n = 1.47/\sqrt{\beta\psi}$  ( $\beta = 10^{-6} - 10^{-7}$  recombination factor,  $\psi = jn/eN_0p\langle\sigma\rangle$ ,  $jn$ -current density,  $e$ - electron charge,  $p$ - pressure of gas mixture,  $N_0$ - concentration of particles under pressure  $p= 1$  atm,  $\langle\sigma\rangle$  average cross section for ionization of gas by fast electrons. Typically,  $p= 6$  atm and  $jn= 28$  A/cm<sup>2</sup> yield  $t_n = 4.2-13.6$  ns. Calculated performance characteristics, energy input to gas mixture and energy output from laser as functions of ratio  $E/p$  ( $E$ - electric field intensity,  $p$ - pressure) indicate the feasibility of maximizing the energy output with a 10 cm<sup>3</sup> active zone under  $p= 3$  atm and attaining an efficiency of 5% at a pulse repetition rate of 4 Hz. Figures 2, references 8: 7 Russian, 1 Western.  
[227-2415]

#### SPIN MODES OF SUBLIMATION OF SOLID UNDER LASER RADIATION

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 82, No 5, May 82 (manuscript received 5 Nov 81) pp 1604-1606

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[Abstract] sublimation of solids under laser radiation is considered in terms of surface evaporation of condensate and kinetics of phase-transition front in a temperature field describable by the equation of heat conduction with appropriate boundary conditions. The three-dimensional problem can, without loss of essential characteristics, be reduced to the two-dimensional one of a thin hollow cylinder coaxial with a laser beam and solved by numerical methods. Calculations reveal a behavior varying with the radiation intensity. At radiation intensities not much above threshold level the initial additive cluster of many modes of approximately equal amplitudes evolves into a quasi-steady evaporation wave with curvilinear front and with a fundamental period corresponding to the maximum linear instability increment. At radiation intensities sufficiently high above threshold level the range of positive instability increments becomes so wide as to encompass harmonics of the initial perturbation with a resulting unsteady evaporation wave. As the radiation intensity increases beyond the critical level, there appear vibrational and spin modes until the temperature field becomes stochastic. An analogous pattern is known

in the theory of combustion. The authors thank V. K. Gryaznov for assisting in numerical calculations and B. A. Malomed for helpful discussions, also E. N. Sobol' for referring to article by W. W. Duley and W. A. Young in JOURNAL OF APPLIED PHYSICS Vol 44, 1973 p 4236. Figures 2, references 8: 7 Russian, 1 Western.

[225-2415]

UDC 621.373.826:53

BREAKDOWN OF AIR BY LASER RADIATION AT  $\lambda \sim 10 \mu\text{m}$  WAVELENGTH

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 52, No 5, May 82  
(manuscript received 11 Jun 81) pp 901-903

GRIGOR'YEV, F. V., KALINOVSKIY, V. V., KORMER, S. B., LAVROV, L. M. and MISHUCHKOV, G. A.

[Abstract] An experimental study was made pertaining to breakdown of air by laser radiation and, particularly, effect of self-focusing on the threshold radiation intensity. Laboratory air was irradiated by 100-200 nanosecond pulses from a DF-CO<sub>2</sub> chemical laser with pumping from a xenon lamp, at the single wavelength  $\lambda = 9.55 \mu\text{m}$  (most intense) extracted from the spectrum, with beam divergence within  $(6-8) \cdot 10^{-4}$  rad and power increased up to 250 MW. The focal volume was a cylinder of diameter  $d = f\theta$  and length  $L = (\sqrt{2} - 1)f^2\theta / (D - f\theta)$  equal to the length of the caustic ( $f$ - focal length of spherical mirror,  $\theta$ - divergence of laser beam,  $D$ - diameter of laser beam at entrance to focusing system). The results indicate that the threshold power density of laser radiation causing breakdown decreases with increasing focal volume (length of caustic) until it reaches the threshold  $q = (1-3) \cdot 10^8 \text{ W/cm}^2$  for thermal breakdown of aerosol and dust, after which it remains almost constant at this level as the focal volume increases further beyond  $0.5 \text{ cm}^3$ . When the breakdown threshold is governed by thermal breakdown of particles in suspension, the average threshold radiation intensity varies with the focal volume according to the empirical relation  $\langle I_{\text{thr}} \rangle = (3-10) \cdot 10^9 (2/Vn)^{1/(\beta-1)} \text{ W/cm}^2$  ( $V$ - focal volume,  $n = 10^5-10^6 \text{ cm}^{-3}$  concentration of atmospheric aerosol,  $\beta = 5$  factor characterizing the size distribution of aerosol). Figures 2, references 5: 2 Russian, 3 Western.

[219-2415]

## HEATING OF LASER DIODES

Leningrad PIS'MA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 8, No 12,  
26 Jun 82 (manuscript received 24 Mar 82) pp 750-754

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[Abstract] Heating of a laser diode and the activation energy for defect formation during its gradual degradation can be estimated, for reliability analysis, on basis of calculated power dissipation and known thermal parameters of the heterostructure layers. The characteristic activation parameter needed for such an estimate depends on the conditions of diode testing, usually accelerated testing, and on the method of measurement so that it can only serve as indicator of sensitivity of degradation processes to temperature changes. In the case of testing at fixed ambient temperature the degradation rate  $\gamma$  depends on the thermal resistance of the diode  $R_T$  and on the temperature of the active region, which yields an exponential (Arrhenius-law) relation. The degradation rate can be taken as the rate at which the pumping power (current) at the emission threshold increases with time. The activation parameter is, accordingly, determined from the slope of the almost straight line representing the  $\gamma(R_T)$  relation in semilog coordinates. The diode life is then determined upon extrapolation of the degradation rate to the operating temperature. The degradation rate is also proportional to the probability of defect formation and to the square of the concentration of injected electrons, both depending on the temperature, with the constant of nonoptical transition as proportionality factor. Typical calculations are shown for a GaAs heterostructure with the difference between acceptor and donor concentrations in the active region normalized to  $N_0 = 10^{18} \text{ cm}^{-3}$ . Figure 1, references 10: 5 Russian, 5 Western. [228-2415]

## STOCHASTIC MODE OF TITANIUM HEATING BY LASER RADIATION

Leningrad PIS'MA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 8, No 12,  
26 Jun 82 (manuscript received 22 Feb 82) pp 744-747

BUZYKIN, O. G. and BURMISTROV, A. V.

[Abstract] Experiments performed by other authors (V. A. Bobyrev, F. V. Bunkin, N. A. Kirichenko, B. S. Luk'yanchuk and A. V. Simakin, PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI Vol 32, 1980 p 608) with heating of titanium specimens by continuous sharply focused laser radiation have revealed complex stochastic fluctuations of the heating rate. The original hypothesis of a "strange attractor" heating mode produced by surface oxidation and thermal conductivity effects is here discarded in favor of another hypothesis, namely that

melting (which does not occur during heating by uniformly distributed laser radiation) causes such fluctuations. This hypothesis is supported by numerical solution of the equation of heat conduction for a symmetric cylindrical specimen for appropriate boundary conditions at the surface, taking into account radiative and convective losses and not only melting but also recrystallization. The presence of respective phase transition fronts has been included through solution of the Stefan problem and the  $\text{TiO}_2$  film has been assumed to build up exponentially. The hypothesis can be verified experimentally by the method of transient heating. The possibility is allowed that changes in the absorption capacity of titanium oxide can also contribute to those fluctuations.

Figures 1, References: 11 Russian.

[228-2415]

#### HETEROLASER WITH DISTRIBUTED FEEDBACK PRODUCED BY INTERFERENCE LASER IGNITION

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 8, No 13,  
12 Jul 82 (manuscript received 19 Apr 82) pp 769-772

ALFEROV, Zh. I., KALANDARISHVILI, K. G., KOVAL'CHUK, Yu. V., PORTNOY, Ye. L.  
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[Abstract] A report on experimental realization of heterolasers with distributed feedback produced by interference laser ignition of epitaxial layers of heterostructures InGaAsP/InP. The width of the forbidden band of the quaternary compound was 1.08 eV. The output of a Q-switched neodymium glass laser on a wavelength of 1.06  $\mu\text{m}$  with pulse duration of about 60 ns was split into two coherent beams interfering on the surface of the semiconductor material. The spatial frequency of the interference pattern was controlled by the angle at which the interfering beams came together. This frequency was selected from the condition of distributed feedback in fourth order of interaction of the waveguide mode with periodic optical inhomogeneity. The energy density of laser radiation was 0.7 J/cm<sup>2</sup>, which was sufficient to change the luminescence properties of the specimen at antinodes of the interference pattern without damaging its surface. Specimens were studied at 95 K under conditions of pumping by an LGI-40 xenon laser with output focused in strips perpendicular to the grating lines. Lasing lines identified with the proposed heterolaser corresponded to modes with index of refraction  $N_m = \frac{\lambda}{\alpha} \pm \sin \alpha_m$ , where  $\alpha_m$  is the

angle of radiation output through the corrugated surface of a waveguide with corrugation spacing  $\alpha$ . The identified lines were a shortwave line with  $\lambda = 1.1556 \mu\text{m}$  corresponding to mode  $N_2 = 3.341$ , and a long-wave line with  $\lambda = 1.1616 \mu\text{m}$  corresponding to the hybrid mode  $N_{1,2} = 3.358$ . Results show that Bragg

lines arise on the long-wave section of the amplification band. Lasers of this type should be useful in microelectronics for producing hybrid integrated circuits that contain electronic and optical components. Figures 2, references: 4 Russian.

[240-6610]

#### FEASIBILITY OF EXCIMER LASERS WITH IONIZATION BY NUCLEAR REACTOR RADIATION

Leningrad PIS'MA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 8, No 13,,  
12 Jul 82 (manuscript received 9 Apr 82) pp 789-791

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[Abstract] Research is done on diagnosing the plasma produced in the emission field of a steady-state nuclear reactor in laser mixtures  $^3\text{He} + \text{Xe} + \text{NF}_3$  and  $^3\text{He} + \text{Xe} + \text{CCl}_4$ . The concentration of charge carriers was determined from current-voltage characteristics of a steady-state semi-self-maintained discharge. The experiments were done on a VVR-K reactor in the thermal neutron flux density range of  $10^{10}$ - $10^{14}$  n/cm<sup>2</sup>s. The discharge chamber contained two coaxial cylindrical electrodes 102 and 140 mm in diameter and 100 mm long. Analysis of electron concentration as a function of neutron flux shows that for fluxes of thermal neutrons of about  $10^{12}$  n/cm<sup>2</sup>s or more, ion concentration is more than  $10^{10}$  cm<sup>-3</sup>, and electron concentration is more than  $10^8$  cm<sup>-3</sup>. Figures 2, references 8: 6 Russian, 2 Western.

[240-6610]

#### CONTINUOUS LASING IN INJECTION LASER WITH RING CAVITY

Leningrad PIS'MA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 8, No 13,  
12 Jul 82 (manuscript received 18 Mar 82) pp 799-803

BOGATOV, A. P., YELISEYEV, P. G., OKHOTNIKOV, O. G., PAK, G. T.,  
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[Abstract] Experiments are done to determine conditions for getting single-frequency cw lasing in a ring cavity where coupling between opposed waves is minimized. The active elements studied were AlGaAs heterolasers with optical region about 0.2  $\mu\text{m}$  thick and strip contact width of about 10  $\mu\text{m}$ . The ring

cavity was formed by objective lenses, two opaque aluminum mirrors, a flat reflective diffraction grating with 600 lines/mm and a Fabry-Perot etalon. The path was closed for first-order diffraction, and the output was produced by the zero-order and second-order diffractions of the beams. An FD24K photocell was used for measuring the power of waves propagating in both directions in the cavity. The spectrum was observed by an MDR-4 monochromator. The spectrum showed simultaneous excitation of about 20 longitudinal modes of the ring cavity. Insertion of the Fabry-Perot etalon makes the output single-frequency. The proposed arrangement minimizes coupling between opposed waves. A mode close to traveling-wave operation is observed at a luminous flux density of about  $2 \cdot 10^5$  W/cm<sup>2</sup>. Further studies should be done with a nonreciprocal device that will enable spectral splitting between the opposed waves.

Figures 2, references: 2 Russian.

[240-6610]

## SCINTILLATION CHARACTERISTICS OF GADOLINIUM-BEARING PHOSPHATE GLASSES

Leningrad FIZIKA I KHIMIYA STREKLA in Russian Vol 8, No 3, May-Jun 82  
(manuscript received 3 Jun 81) pp 345-347

PALVANOV, V. P., VIKTOROV, L. V., SLEPUKHIN, V. K., SHUL'GIN, B. V. and  
SHTIN, A. P., Ural Polytechnic Institute imeni S. M. Kirov and Institute of  
Chemistry; Ural Science Center, USSR Academy of Sciences, Sverdlovsk

[Abstract] Feasibility of building scintillators with gadolinium-bearing phosphate glasses was studied, operation in the current mode being more convenient for circuit design and measurements than operation in the counting mode. Phosphate glasses of compositions  $K_2O \cdot (1-x)Y_2O_3 \cdot 4P_2O_5 \cdot xGd_2O_3$  ( $0 \leq x \leq 1$ ) close to that of crystalline binary phosphates of rare-earth elements were tested, all four glasses ( $x = 0.1, 0.3, 0.5, 1$ ) remaining colorless. Their radioluminescence spectrum falls within the ultraviolet range and does not depend on the gadolinium content; but the intensity peaks when  $x = 0.3$  (5 mol.%  $Gd_2O_3$ ). The spectral content of  $\alpha$ -scintillation is identical to that of X- and photoluminescence, with characteristics typical of compounds with  $Cd^{3+}$  ions. The temperature dependence of scintillations was measured in a special-purpose cryostat by the one-photon autocorrelation method. Photoluminescence spectra were measured with an MDR-2 monochromator by the photoelectric method. The glasses were found to have a high scintillation yield, up to 9% relative to CsI-Tl, and a high chemical stability. They are nonhygroscopic and suitable for miniature radiation detectors over the 0.01-10 MeV energy range. Figures 2, table 1, references: 5 Russian.

[224-2415]

## SET OF STANDARD PROGRAMS FOR SOLUTION OF PROBLEMS IN NONLINEAR OPTICS

Moscow ZHURNAL VYCHISLITEL'NOY MATEMATIKI I MATEMATICHESKOY FIZIKI in Russian  
Vol 22, No 3, May-Jun 82 (manuscript received 1 Jul 80) pp 756-758

AMOSOV, A. A., BORISOV, A. B., VALEDINSKIY, V. D., VLADIMIROV, M. V.,  
SHILEYKIN, Ya. M., ZLOTNIK, A. A. and KUZ'MINA, M. A., Moscow

[Abstract] A set of standard programs has been compiled at the Scientific Research Computer Center of Moscow State University for solving problems in nonlinear optics. There are two groups of programs here, one for numerical calculations pertaining to propagation of light beams through nonlinear media and one for numerical calculations pertaining to nonlinear interaction of three light waves coming from different directions. The basis is the fundamental equation of propagation of electromagnetic waves through a nonlinear medium  $\Delta v + k^2 v = f(|v|^2)v$ , which, after extraction of the slow part of the solution, is replaced with its "parabolic" approximation. The programs include difference schemes ND1F1-4,5,7-9 and fast Fourier transformation FFT. The problem of wave interaction is solved by a finite-difference scheme, with a SERV1 program of most convenient data presentation. Another program PG facilitates the design of quantum-electronic devices with distributed feedback. All programs are written in FORTRAN for BESM-6 and YeS (Unified System) computers. References 14: 13 Russian, 1 Western.  
[213-2415]

UDC 534.6

## DYNAMIC CHARACTERISTICS OF ADAPTIVE MIRROR

Moscow VESTNIK MOSKOVSKOGO UNIVERSITETA, SERIYA 3: FIZIKA, ASTRONOMIYA in Russian  
Vol 23, No 3, May-Jun 82 (manuscript received 15 Jun 81) pp 83-85

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[Abstract] A controllable optical mirror is described which consists of two solid piezoceramic disks, one of them having a polished surface with an aluminum coating which serves both as mirror and electrode. The disks are bonded together so that their polarizations coincide and a control voltage applied to the inner electrode (the two outer electrodes grounded), through a hole in one disk, causes the plane structure to bend into a spherical one

with the diameter of one disk increasing and the diameter of the other one decreasing. The curvature of this mirror is controlled by the magnitude of the voltage. The dynamic characteristic of such a mirror, namely dependence of the vibration amplitude at its center on the frequency of the control voltage, was measured over the 0.05-20 kHz range with an interferometer. A noise generator was used for excitation, its output voltage adjusted to ensure an rms displacement of the mirror not larger than a quarter wavelength of light and thus a linear relation between mirror displacement and interferometer signal. The electric signal from the interferometer was preamplified for both recording and spectral analysis. The interferometer included a light beam splitter with full compensation of losses and two photoreceivers, with provisions for formation of an auxiliary interference pattern next to the main one on the second photoreceiver. Figures 3, references 3: 2 Russian, 1 Western. [222-2415]

UDC 535.417

SPECIAL EFFECTS INVOLVED IN RECORDING AND INTERPRETING SPECKLE INTERFEROGRAMS OF SHIFTING OBJECTS

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 52, No 5, May 82  
(manuscript received 19 Jul 80, final edition received 8 Dec 80) pp 896-900

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[Abstract] New features of speckle interferogram recording have been discovered in an experimental study pertaining to double exposure of speckle photographs of shifting objects. In the case of objects shifting longitudinally in direction of the lens axis the contrast of speckle interferograms subsequently produced by space filtration and illumination with a collimated laser beam was found to depend largely on the aperture of the optical system. It increases from zero at fully open lens to magnitudes of the order of 0.5 as the lens closes, and with it the aperture angle decreases, becoming smaller with increasing displacement of the object. This effect is attributable to objectivity of speckle patterns recorded when object shifts during second exposure, with the conditions of "correlation" no longer prevailing. A decrease of the aperture results in an increase of the focusing depth and thus also of the critical distance at which the recorded field still retains subjectivity. The problem of decreasing aperture angle can be solved by use of an annular aperture with large outside diameter. In the case of transverse shifting of the object, the displacement consisting of a uniform component (parallel transfer) and a nonuniform component (rotation of object in its own plane), sufficient information is obtained by illumination of speckle photographs with an undivided

laser beam at several characteristic spots. The authors thank Yu. V. Bezzubov for assisting with the experiments. Figures 3, references 8: 4 Russian, 4 Western.  
[219-2415]

CONVERSION OF SMOOTHLY TUNABLE RADIATION TO NEAR AND MIDDLE INFRARED BY MEANS OF STIMULATED RAMAN SCATTERING

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 8, No 12, 26 Jun 82 (manuscript received 21 Jan 82) pp 740-743

APANASEVICH, P. A., BATISHCHE, S. A., GANZHA, V. A., GRABCHIKOV, A. S., KAMACH, Yu. E., KOZLOVSKIY, Ye. N., MALEVICH, N. A., MOSTOVNIKOV, V. A., OVCHINNIKOV, V. M. and ORLOVICH, V. A., Institute of Physics, BSSR Academy of Sciences, Minsk

[Abstract] An experimental study was made to produce radiation smoothly tunable over the  $\lambda = 1.03-8.11 \mu\text{m}$  range by conversion of radiation from dye lasers to the second Stokes component of stimulated Raman scattering in compressed hydrogen. A dye laser was operated in three modes: first with a spectrum  $2.2 \text{ cm}^{-1}$  wide produced with a Fabry-Perot etalon and a 1200 lines/mm diffraction grating in the resonator cavity, next with the spectrum narrowed down to  $9 \text{ cm}^{-1}$  with only the diffraction grating in the resonator cavity, then with the spectrum narrowed down to  $200 \text{ cm}^{-1}$  with no tuning device in the resonator cavity. The radiation was focused through a lens (focal length 100 cm) onto the center of a cell containing gaseous hydrogen under a pressure of 40 atm. The second Stokes component was extracted by means of interference-type filters or a prism-type monochromator. The energy was measured with a photoreceiver and a conversion efficiency was calculated as a function of pumping radiation energy for various line widths. Conversion to the second Stokes component was found to be 5-7 times more efficient than conversion to the first component and was nearly independent of a change of the latter from  $2.2$  to  $200 \text{ cm}^{-1}$  resulting in a decrease of conversion efficiency by a factor of 2.12 only. This is only slightly worse than the decrease by a factor of 1.36 in the case of conversion to the first Stokes component. The frequency conversion by means of stimulated Raman scattering was further optimized by better focusing of the pumping radiation onto the cell and by suppression of all attendant (at least four) anti-Stokes components. Figure 1, table 1, references 7: 6 Russian, 1 Western.  
[228-2415]

CHARACTERISTICS OF MANDEL'SHTAM-BRILLOUIN MIRROR WITH NANOSECOND DRIVING PULSE

Leningrad PIS'MA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 8, No 12, 26 Jun 82 (manuscript received 6 Apr 82) pp 735-740

GALAGAN, B. I., GOL'BERG, S. M., MATYUSHIN, G. A., PODGAYETSKIY, V. M. and TRIBEL'SKIY, M. I., Scientific Research Institute of Organic Semi-Products and Dyes

[Abstract] Characteristics of a nonlinear Mandel'shtam-Brillouin mirror with a nanosecond driving pulse are analyzed from the standpoint of general application of such a device as means for shortening the duration and increasing the contrast of laser pulses. The system of three equations describing Mandel'shtam-Brillouin stimulated scattering in any medium, gaseous or other, are formulated in the approximation of plane waves with appropriate initial and boundary conditions. They are solved for the ranges of dimensionless space coordinate  $0 \leq x \leq 1$  and time  $t \geq 0$ . Calculation of the intensity of back-scattered radiation  $J_1(0,t) = J_1(x,t)|_{x=0}$  with an intensity of incident radiation

typically  $J_0(0,t) = f(t)|_{x=0} = \begin{cases} \sin^2(\pi t/2), & 0 \leq t \leq 2 \\ 0, & t > 2 \end{cases}$  reveals that both ampli-

tude and duration of the reflected signal are determined by four parameters: the three coefficients in the equations of scattering and the amplitude of acoustic waves produced by thermal fluctuations at room temperature. The solution to these equations depends most strongly on the coefficient of  $\partial J_{0,1}/\partial t$

and the coefficient of  $\sqrt{J_0 J_1}$ . The former represents the dimensionless length of the interaction space and should be small for appreciable pulse shortening, the latter governs the intensity of scattered radiation and should be large. Therefore the most effective media will be those with a large refractive index and thus a large coefficient of nonlinear coupling. The authors thank B. Ya. Zel'dovich, V. S. Starunov and I. L. Fabelinskiy for discussion of results and helpful comments. Figures 2, references 7: 6 Russian, 1 Western. [228-2415]

MANDEL'SHTAM-BRILLOUIN STIMULATED SCATTERING AND WAVEFRONT REVERSAL IN OPTICAL FIBERS

Leningrad PIS'MA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 8, No 12, 26 Jun 82 (manuscript received 3 Mar 82) pp 729-732

PETROV, M. P. and KUZIN, Ye. A., Physico-Technical Institute imeni A. F. Ioffe, USSR Academy of Sciences, Leningrad

[Abstract] An experimental study was made of Mandel'shtam-Brillouin stimulated scattering and wavefront reversal in multimode optical fibers. Fundamental frequency and second-harmonic emission from a YAG:Nd laser operating in a single mode with a line not wider than  $10^{-2}$  cm<sup>-1</sup> and a pulse duration of 30 ns was used for pumping, a Gaussian beam formed by means of a lens (focal length 200 mm) and a pinhole (diameter 150 μm) as space filter. Light was coupled into optical fibers through another lens (focal length 40 mm) with 100% efficiency. The fibers, made of phosphosilicate glass, were 30 μm in diameter with 0.15 aperture and 0.3-10 m long. Wavefront reversal was recorded photographically. Efficiency of conversion of pumping wave to reflected wave was measured as a function of pumping power. A conversion efficiency of 50% was reached at a pumping power equal to 300% of the threshold level. In order to increase the efficiency, it was necessary to stabilize the Mandel'shtam-Brillouin stimulated scattering process by use of pumping pulses of duration an order of magnitude longer than the phonon lifetime and thus lower the threshold pumping power. The latter was lower with fundamental-frequency pumping (1 kW) than with second-harmonic pumping (1.5 kW). Figures 2, references 5: 3 Russian, 2 Western.  
[228-2415]

CONTROLLING DIFFRACTION EFFICIENCY OF DENISYUK'S REFLECTION HOLOGRAMS BY 'TURNING ON' GYROTRROPY DURING RECORDING

Leningrad PIS'MA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 8, No 12, 26 Jun 82 (manuscript received 12 Feb 82) pp 713-716

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[Abstract] Recording of reflection holograms of plane waves in gyrotropic media by the Denisyuk method of three-dimensional holography is analyzed from the standpoint of controllable diffraction efficiency. The latter as a function of product  $\beta d$  is calculated by the method of coupled waves ( $d$ - thickness of gyrotropic layer,  $\beta = \frac{2\pi}{\lambda} \frac{\alpha}{\cos \varphi_r}$ ,  $\lambda$ -wavelength,  $\alpha$ -gyration parameter,  $\varphi_r$ -refraction angle), with gyrotropy "turned on" during recording and "turned off" during reconstruction. Such a control can be achieved by respectively

turning on and off a magnetic field or by turning on a compensating magnetic field during reconstruction. Calculation of the magnetic field intensities corresponding to unity and zero diffraction efficiency for fixed layer thickness involves solution of a transcendental equation. A comparison of diffraction efficiency as function of  $\beta$  at fixed  $d$  and as function of  $d$  at fixed  $\beta$  with analogous characteristics without gyrotropy demonstrates the feasibility of control by this method. Figures 2, references 14: 13 Russian, 1 Western. [228-2415]

#### INFLUENCE OF GLASS SBS MIRROR BREAKDOWN ON WAVEFRONT REVERSAL

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 8, No 13, 12 Jul 82 (manuscript received 1 Feb 82) pp 816-819

BAL'KYAVICHYUS, P. I., DEMENT'YEV, A. S., LUKOSHYUS, I. P., MALDUTIS, E. K. and TARULIS, V. P., Institute of Physics, LiSSR Academy of Sciences, Vilnius

[Abstract] An investigation is made of the effect that damage to K-8 glass and KSG quartz glass has on the efficiency of subsequent stimulated Brillouin scattering and wavefront reversal. The second harmonic ( $\lambda = 0.53 \mu\text{m}$ ) of a neodymium glass laser was used. Beam divergence was  $5 \cdot 10^{-4}$  rad, intensity distribution over the beam cross section was near gaussian, and pulse duration at half-amplitude was 20 ns. The glass SBS mirror under conditions of breakdown was characterized by the energy reflectivity and by the Stokes fraction of the energy propagating in a given angle. For KSG quartz glass it was found that the length of the damaged region increases toward the lens with each succeeding pulse, and SBS develops effectively only until the damaged region has approximately filled the entire length of the focus. The fraction of Stokes energy is weakly dependent on angle, about half the energy of the Stokes component being concentrated in the angle of pumping divergence regardless of the reduction of reflectivity with increasing dimensions of the damaged region at large numbers of pulses. Behavior is similar for K-8 glass except that reflectivity decreases much faster with increasing pulse number for the same focal lengths of lenses and pumping energies. Figures 2, references: 10 Russian. [240-6610]

WAVEFRONT FORMATION BY TWO-DIMENSIONALLY PERIODIC STRUCTURES

Leningrad PIS'MA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 8, No 13,  
12 Jul 82 (manuscript received 22 Mar 82) pp 823-827

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[Abstract] It is shown on the example of acoustic surface waves that such waveforms can be generated at different angles on a two-dimensionally periodic interdigital transducer by varying the frequency of the controlling electric voltage. An analysis is made of the way that conditions of acoustic surface wave generation arise in two-dimensionally periodic structures of line and point type, and the consequences of such waves are considered. It is shown that at a fixed frequency the acoustic surface wave radiation pattern may contain several lobes, and as the frequency changes, not only the direction, but also the number of lobes will change. Figures 2, references 6: 4 Russian, 2 Western.  
[240-6610]

## USE OF SPACE-TIME LIGHT MODULATORS IN OPTICAL DATA-PROCESSING SYSTEMS

Novosibirsk AVTOMETRIYA in Russian No 2, Mar-Apr 82  
(manuscript received 8 Feb 80, in final version 26 Mar 81) pp 6-12

NAGAYEV, A. I., PARYGIN, V. N. and PASHIN, S. Yu., Moscow

[Abstract] An electron-beam space-time light modulator using a DKDP crystal is considered from the standpoint of new applications such as transmission of holograms over a television channel. As the active element of a phase mask or adaptive optics, it must both deflect the light beam and straighten the front of a plane wave passing through a rectangular phase grating. Inscription of a ramp or equivalent sawtooth voltage in the electrooptic crystal by means of an electron beam is sufficient for deflection of the light beam. Attendant scattering of light determines the phase distortions and correction of the excessive ones depends on the crystal characteristics. Dependence of the light loss on the period of the sawtooth voltage and on the diameter of the inscribing electron beam was calculated on a computer and the loss was found to increase at a decreasing rate with increasing voltage period. The loss remains low as the diameter of the electron beam increases up to 40  $\mu\text{m}$  and increases fast as the diameter increases further. The performance characteristics of such a modulator were also measured in an experiment with a DKDP crystal at its phase transition temperature ( $-52^{\circ}\text{C}$ ) and an electron beam 80  $\mu\text{m}$  in diameter inscribing a sawtooth voltage profile with the optimum amplitude as well with amplitudes deviating by 10 and 20% from optimum. The corresponding light intensity distributions in the Fraunhofer zone produced by diffraction of a plane wave were also recorded, as were the light intensity distributions in the diffraction pattern of a predistorted wave and of the reconstructed wave. Experiments with transmission of holograms over a television channel indicate that reconstruction of images by this method requires that the band of space frequencies match the resolving power of the television channel and that the light modulator operate as amplitude modulator with suppressed constant component in the light beam. Figures 5, references 5 Russian.

[202-2415]

DEPENDENCE OF APPLICABILITY OF INJECTION LASERS IN MAGNETOOPTICAL DEVICES  
ON THEIR ENERGY AND NOISE CHARACTERISTICS

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 8, No 11,  
12 Jun 82 (manuscript received 12 Jan 82) pp 688-692

KUPRIYANOVA, N. G., MOROZOV, V. N., NIKITIN, V. V., POPOV, Yu. M.,  
SEMENOV, G. I. and CHERVONENKIS, A. Ya., Institute of Physics imeni  
P. N. Lebedev, USSR Academy of Sciences, Moscow

[Abstract] Energy and noise characteristics of four heterostructure-injection lasers ( $\text{YFeO}_3$ ,  $\text{Nd}_{0.8}\text{Pr}_{0.2}\text{FeO}_3$ ,  $\text{Y}_2\text{BiFe}_{3.8}\text{Ga}_{1.2}\text{O}_{12}$ ,  $\text{Tm}_2\text{BiFe}_{3.8}\text{Ga}_{1.2}\text{O}_{12}$ ), both room lasers ( $\lambda = 0.81 \mu\text{m}$ ) and those with one channel emitting linearly polarized light ( $\lambda = 0.85 \mu\text{m}$ ), are reviewed from the standpoint of applicability in magneto-optic data processing devices. These characteristics such as sensitivity, efficiency, signal-to-noise ratio depend on several parameters which have been measured: Faraday rotation modulus, optical absorption coefficient, degree of radiation depolarization by magnetized specimen, optical contrast in image of domain structure, and optical efficiency. The magneto-optic properties are excellent, optical efficiency is low but can be improved by increasing the thickness of structures to the optimum for near infrared radiation (orthoferrites 150-200  $\mu\text{m}$ , garnets 100  $\mu\text{m}$ ), noise immunity requires much smaller power fluctuation and much lesser radiation depolarization. Figures 2, table 1, references 6: 5 Russian, 1 Western.

[227-2415]

## SUPERCONDUCTIVITY

### SUPERCONDUCTIVITY OF $CeCu_2Si_2$ COMPOUND

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian  
Vol 35, No 10, 20 May 82 (manuscript received 14 Apr 82) pp 435-438

ALIYEV, F. G., BRANDT, N. B., LUTSIV, R. V., MOSHCHALOV, V. V. and  
CHUDINOV, S. M., Moscow State University imeni M. V. Lomonosov

[Abstract] An experimental study was made of  $CeCu_2Si_2$  single crystals and polycrystalline  $CeCu_2Si_2$ , the only known variable-valence compound with superconductor characteristics. Their electrical properties were measured over the 0.05-300 K temperature range in a magnetic field of up to 20 kOe and under pressures from 0 to 8 kbar. The temperature dependence of the electrical resistivity was measured as well as the pressure dependence of the superconductive transition temperature and dependence of the critical intensity of a longitudinal parallel magnetic field on the superconductive transition temperature. In the case of polycrystalline specimens under zero pressure the electrical resistivity was found to dip slightly at 70 K and to drop sharply but not to zero at 0.5 K. In the case of single crystals there were no dip at 70 K and no superconductive transition under zero pressure, no dip at 70 K but a superconductive transition at 0.05 K under normal pressure (5.4 kbar). Under pressures above 2.5 kbar there seems to appear another modification of the compound with a superconductive transition temperature less dependent on the pressure and, in the case of single crystals, with an anomalously high ratio of critical magnetic field intensity to superconductive transition temperature. The authors thank R. I. Yasnitskiy for synthesizing  $CeCu_2Si_2$  single crystals, S. G. Freyman for assisting with measurements at cryogenic temperatures, also D. I. Khomskiy and A. I. Buzdin for discussing the results. Figures 3, references 6: 1 Russian, 1 Polish, 4 Western.  
[208-2415]

STIMULATION OF SUPERCONDUCTIVITY IN S-N-S JUNCTIONS BY MICROWAVE FIELD

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 82, No 5, May 82 (manuscript received 4 Dec 81) pp 1671-1677

ASLAMAZOV, L. G. and LEMPITSKIY, S. V., Moscow Institute of Steel and Alloys

[Abstract] Stimulation of superconductivity in S-N-S junctions by a microwave field is analyzed in terms of delayed and advanced Green functions in the equation of diffusion and their integrals with respect to an energy variable. The current density as a function of time, in the case of short mean free path of electrons, is expressed as the trace of matrices with elements made up of Gor'kov functions and ordinary Green functions. The critical current in a junction is calculated, and found to depend on the junction length (length of normal metal weak link) according to an inverse power law rather than exponentially. Calculations are based on weak electron-phonon interaction and zero order parameter in normal metal, with appropriate boundary conditions at the superconducting edges. Solution of the equation of kinetics according to perturbation theory confirms that the nonequilibrium component of the critical current is principally due to electrons with energy of the order of  $\hbar D/d^2$  ( $\hbar$ - Planck constant,  $D$ - diffusion coefficient,  $d$ - length of normal metal weak link). The conclusions are valid for microwave frequencies higher than the reciprocal of the diffusion time  $D/d^2$  and not excessively high microwave radiation power. The authors thank A. A. Abrikosov, K. K. Likharev and A. I. Larkin for valuable comments and discussion of results. References 16: 11 Russian, 5 Western.

[225-2415]

THERMODYNAMICS

UDC 536.422.1

DYNAMICS OF CRATER FORMATION BY HIGH-CURRENT CHARGED PARTICLE BEAMS IN METAL BARRIER

Minsk DOKLADY AKADEMII NAUK BSSR in Russian Vol 26, No 6, Jan 82  
(manuscript received 2 Oct 81) pp 496-499

ROMANOV, G. S. and SUZDENKOV, M. V., Scientific Research Institute of Physics Application Problems imeni A. N. Sevchenko

[Abstract] The dynamics of action of a relativistic charged particle beam on an absorbing metal plate in an ambient cold gas (vapor), and the resulting crater formation, are analyzed on the basis of three equations of hydrodynamics and one equation of electrothermohydrodynamics in Euler variables. This system of equations is closed with an equation of state containing  $\log P$  ( $P$ - pressure) and  $\log \mathcal{K}_R$  ( $\mathcal{K}_R$ - radiative thermal conductivity) in region of multiple ionization, both obtained from solution to the Saha equation and tabulated. These equations have been solved numerically on a computer, by the method of large particles, for an  $E_0 = 0.5$  MeV  $54$  GA/m<sup>2</sup> electron beam with 1 mm radius and 50 ns pulse duration striking a 0.95 mm thick aluminum plate. The profile of energy lost by a particle along its path was determined from tables based on the Monte Carlo method. The results yield the integral transient characteristics of crater formation parameter and the crater profile. They compare fairly closely with experimental data reported elsewhere. The authors thank A. V. Teterev for assisting in development of the calculation procedure. Article was presented by Academician M. A. Yel'yashevich, BSSR Academy of Sciences. Figures 2, references 13: 11 Russian, 2 Western.  
[200-2415]

## ESTIMATING COMPONENTS OF THERMAL FLUX FROM SEA TO ATMOSPHERE

Moscow VESTNIK MOSKOVSKOGO UNIVERSITETA, SERIYA 3: FIZIKA, ASTRONOMIYA  
in Russian Vol 23, No 3, May-Jun 82 (manuscript received 13 Apr 81) pp 72-74

ANDREYEV, Ye. G. and PYRKIN, A. Yu., Chair of Physics of Sea and Inland Water,  
Moscow University

[Abstract] A method is proposed for estimating the heat of evaporation of sea water which utilizes the fact that heat transfer from sea to atmosphere occurs principally through evaporation and effective radiation, contact heat transfer being an order of magnitude smaller than the heat of evaporation and therefore negligible. It is thus merely necessary to synchronously record the total thermal flux and the effective radiation flux, the difference between them yielding the heat of evaporation. The accuracy of this method depends on the accuracy of recording instruments and on the actual magnitude of contact heat transfer. Such measurements were made on board a research vessel moving at a constant speed of 20 cm/s, with a copper-constantan thermocouple (response lag time not exceeding 1.5 ms) probing a 30 cm thick air layer above the water surface and penetrating 30 cm deep into the water. The thermocouple signal, after preamplification in a LUT-401 microcircuit, was recorded with an S8-9A memory oscillograph. These measurements were made during August and September in the 1977-79 period. The total thermal flux averaged  $260 \text{ W/m}^2$  over 24 hours,  $180 \text{ W/m}^2$  from 9 PM to 8 AM and  $300 \text{ W/m}^2$  from 8 AM to 9 PM, while the radiative flux averaged  $45 \text{ W/m}^2$  over 24 hours. Accordingly, the heat of evaporation was estimated at  $220 \text{ W/m}^2$  or approximately 80% of the total thermal flux. Figure 1, references: 4 Russian.

[222-2415]

## UNAMBIGUOUS DETERMINATION OF HEAT SOURCE ON BASIS OF INDIRECT DATA

Moscow VESTNIK MOSKOVSKOGO UNIVERSITETA, SERIYA 3: FIZIKA, ASTRONOMIYA in  
Russian Vol 23, No 3, May-Jun 82 (manuscript received 10 Jul 80) pp 12-15

GLASKO, V. B., KONDORSKAYA, Ye. Ye. and BIDZINOV, Sh. M., Chair of Mathematics,  
Moscow University

[Abstract] The problem of unambiguously and correctly determining a heat source on basis of indirect data and regardless of a specific model is considered first in the case of a point source in a plane. The temperature field is described by the equations:

$\alpha^2 \Delta T - \frac{\partial T}{\partial t} = f(t) \delta(x - x_0)$  ( $\alpha$ - thermal diffusivity,  $T$ - temperature,  $t$ - time,  $f(t)$ - intensity of source,  $x_0$ - space coordinate of the source location), which yields  $T(x,t) = \int_0^t G(x-x_0, t-\tau) f(\tau) d\tau$ . There are three problems possible: 1)

determine location  $x_0$  of heat source when its intensity  $f(t)$  is known, 2) determine intensity  $f(t)$  of heat source when its location  $x_0$  is known, 3) determine both  $x_0$  and  $f(t)$ . Unique determination of  $f(t)$  (first problem) requires knowing the temperature at three points not on one straight line, assuming that  $f(t)$  is a continuous non-negative function. Unique determination of  $x_0$  (second problem) requires knowing the temperature as a function of time at one arbitrary point, assuming that  $f(t)$  is a continuous bounded function, with the additional constraint that the temperature at any given time be a function of the space coordinate. Unique determination of  $x_0$  and  $f(t)$  requires knowing the temperature at three points not on one straight line, as a function of time at one point, and only at some arbitrary instants of time at the other two. On this basis both parameters can be determined simultaneously by an appropriate iteration process. Analyticity of  $f(t)$  in both problems 2) and 3) can be established by asymptotic analysis. In the case of a finite heat source the problem can be solved according to several successively more complex models, the first one being a source localized within a given volume  $g$  with uniform intensity distribution  $f(x,t)$  so that

$$\alpha^2 \Delta T = \frac{\partial T}{\partial t} = \begin{cases} -f(t), & x \in g \\ 0, & x \notin g \end{cases}, T|_{t=0} = (x).$$

Figures 2, references 5 Russian.  
 [222-2415]

NONAUTONOMOUS PROBLEM OF EVASION

Moscow AVTOMATIKA I TELEMEXHANIKA in Russian No 6, Jun 82  
(manuscript received 2 Jul 80) pp 81-86

OSTAPENKO, V. V.

[Abstract] The nonautonomous problem of differential evasion games is analyzed for a dynamic system describable by the equation  $\dot{z} = f(z, u, v, t)$  ( $z \in E^n$ ,  $u \in U$ ,  $v \in V$ ,  $E^n$   $n$ -dimensional Euclidean space,  $U$  and  $V$  compacts in Euclidean spaces), with the terminal set depending on time and with function  $f(z, u, v, t)$  continuous in  $z, u, v$  and summable in  $t$ . With  $u$  and  $v$  replaced by  $u(t)$  and  $v(t)$  respectively, there exists a solution to that equation for any arbitrary initial state  $(z_0, t_0)$  and this solution can be continued along the entire  $(t_0, \infty)$  semiaxis.

The sufficient conditions for evasion are formulated in terms of two assumptions about function  $f(z, u, v, t_0, \dots, t_k)$  and two assumptions about functions  $\epsilon_0$  and  $\epsilon_j$  ( $j=1,2$ ) respectively. A theorem states that evasion is possible when the first two and one of the other two assumptions are met. This theorem is proved here for both cases. The outcome of the game is demonstrated on two examples of pursuer and evader dynamics. References 12 Russian.

[221-2415]

NONPARAMETRIC SIGNAL ESTIMATION ON BASIS OF INCOMPLETE INFORMATION ABOUT NOISE DISTRIBUTION

Moscow PROBLEMY PEREDACHI INFORMATSII in Russian Vol 18, No 2, Apr-Jun 82  
(manuscript received 15 Jun 81) pp 44-60

TSYBAKOV, A. B.

[Abstract] Nonlinear estimators, nonparametric analogs of  $M$ -estimators consistent in large classes of functions, are proposed for restoration of a signal

$f(x)$  on basis of  $n$  observations  $(x_i, y_i)$ , where  $y_i = f(x_i) + \xi_i$  ( $i = 1, 2, \dots, n$ ) and  $\xi_i$  is a noise with infinite dispersion ( $x_i$ - independent random vectors with identical distributions,  $\xi_i$ - independent quantities with identical distributions and independent of  $x_i$ ). The value of the signal in each estimate is

defined as  $f_n(x) = \arg \min_{f^- \leq t \leq f^+} \sum_{i=1}^n F(y_i - t) K\left(\frac{x_i - x}{h_n}\right)$ , where  $F(u)$  is a regular convex

function of a real variable and  $K$  is a regular Parzen kernel with  $h_n > 0$  a number depending on the sample size. These estimators and their approximations are tested for convergence with the aid of two theorems, whereupon the lower bounds for the corresponding risk are established on basis of a third theorem and two corollaries. The estimators are then optimized in the sense of fastest convergence by proper selection of  $K$ ,  $h_n$  and  $\psi(u) = F'(u)$  in accordance with three other theorems, each followed by a corollary. Application of such estimators is demonstrated on four classes of noise distributions: with finite dispersion, with overall zero median, with distorting distribution symmetric to the main one, and single (exactly known) distribution. The author thanks B. T. Polyak and R. Z. Khas'minskiy for taking interest in this study.

References 22: 13 Russian, 9 Western.

[201-2415]

UDC 621.391.15:519.28

#### QUASI-OPTIMUM METHODS OF CORRELATIONAL RECEPTION FOR REED-SOLOMON CODES

Moscow PROBLEMY PEREDACHI INFORMATSII in Russian Vol 18, No 2, Apr-Jun 82  
(manuscript received 27 Apr 79, after revision 25 Sep 79) pp 12-21

NEMIROVSKIY, E. E.

[Abstract] Quasi-optimum methods simpler than parallel correlational reception are proposed for decoding Reed-Solomon codes in a Gaussian channel. One method involves comparing, in Euclidean metrics, all possible  $C_n^{d-1}$  erasures of  $d-1$  symbols and their subsequent restorations, with most likely values serving as nonerased symbols and restored symbols constituting linear forms of nonerased ones. Another method is the "sliding subgraph" with a quasi-optimum modifications of the Viterbi asymptotically optimum algorithm. Three modifications have been tested experimentally by statistical simulation: "list" method algorithm with constant number of most likely states of Reed-Solomon coder, "threshold" method algorithm with random number of states deviating from current maximally likely one by not more than a preset threshold probability difference, and combination algorithm of threshold method with limited list.

Figures 5, references 9: 4 Russian, 5 Western.

[201-2415]

## METHOD OF ESTABLISHING LOWER BOUNDS FOR REDUNDANCY IN UNIVERSAL CODING

Moscow PROBLEMY PEREDACHI INFORMATSII in Russian Vol 18, No 2, Apr-Jun 82  
(manuscript received 16 Jan 81, after revision 14 Dec 81) pp 3-11

SHTAR'KOV, Yu. M.

[Abstract] Lower bounds for redundancy in universal coding of a source without memory and for efficiency of a code in the set of sources are established on the basis of rather rough estimates requiring few computations. An enabling theorem pertains to words generated by letters of a countable discrete alphabet and uses a lemma which pertains to the error of a decision rule for maximizing the code efficiency, proved with aid of the Chebyshev inequality and the estimate  $\log(1+z) \leq z$  ( $z > -1$ ). This method of establishing lower bounds is demonstrated on two examples, a stationary Poisson source and a Markov source, a theorem being proved for each pertaining to existence of asymptotically optimum codes of maximum probabilities. More accurate lower-bound estimates are obtained on the basis of appropriate a priori source distributions. The author thanks M. V. Burnashev for suggesting the possibility of simpler calculation and for helping with it. References 12: 9 Russian, 3 Western. [201-2415]

## OPERATOR METHOD OF SOLVING SYSTEM OF PAIRED INTEGRAL EQUATIONS RELATED TO MEIER-FOCK INTEGRAL TRANSFORMS

Kiev UKRAINSKIY MATEMATICHESKIY ZHURNAL in Russian Vol 34, No 3, May-Jun 82  
(manuscript received 29 Dec 80) pp 316-321

PONOMARENKO, S. P., Institute of Management of the National Economy, Kiev

[Abstract] An operator method is proposed for solving the system of paired integral equations

$$P^\mu[A_j(\tau)\Psi(\tau)] = f^{(j)}(x)$$

$P^\mu[\Psi(\tau)] = \int_0^\infty \rho_{-\frac{1}{2}+i\tau}^{-\mu} (\cosh x)\Psi(\tau)d\tau$  ( $0 \leq x < \infty$ ) operator of generalized Meier-

Fock integral transformation,  $\rho_{-\frac{1}{2}+i\tau}^{-\mu}$  ( $\cosh x$ ) associated Legendre function with

complex index,  $\mu$  real parameter,  $\Psi(\tau) \in L(0, \infty)$ ,  $\Psi(\tau)$  column matrix with components  $\Psi_k(\tau) \in L(0, \infty)$ . The method is based on properties of operator  $P^\mu$ , namely

its relations with operators of fractional integration and sine-cosine Fourier transformations. The algorithm of such a solution is constructed here and applied to two typical boundary-value problems. References 5: 3 Russian, 2 Western.  
[212-2415]

UDC 517.948.34

ASYMPTOTIC SOLUTION TO SYSTEM OF LINEAR INTEGRO-DIFFERENTIAL EQUATIONS OF RATIONAL RANK

Kiev UKRAINSKIY MATEMATICHESKIY ZHURNAL in Russian Vol 34, No 3, May-Jun 82 (manuscript received 15 Dec 80) pp 279-288

VORONOV, A. N., Kirovograd Pedagogical Institute

[Abstract] The problem is the system of linear integro-differential equations

$$\varepsilon \frac{k}{n} \frac{dx(\tau, \varepsilon)}{d\tau} = A(\tau, \varepsilon)x(\tau, \varepsilon) + \rho \int_0^1 K(\tau, \sigma, \varepsilon)x(\sigma, \varepsilon) d\sigma$$

$x(\tau, \varepsilon)$  unknown  $p$ -dimensional vector,  $\varepsilon > 0$  small parameter,  $k$  and  $n$  natural relatively prime numbers,  $\rho$  arbitrary real parameter,  $A(\tau, \varepsilon)$  and  $K(\tau, \sigma, \varepsilon)$  real square matrices of order  $p$  representable as asymptotic series in  $\varepsilon^r$ . The solution to this system depends on the roots of the characteristic equation

$$\det (A^{(0)}(\tau) - \lambda E) = 0 \quad (E - \text{unit matrix})$$

and on the solution to the degenerate equation

$$A^{(0)}(\tau)\varphi(\tau) + \rho \int_0^1 K^{(0)}(\tau, \sigma)\varphi(\sigma) d\sigma = 0 \quad (\varepsilon = 0)$$

A formal solution is obtained in the regular case of introduction of parameter  $\mu^n = (\mu > 0)$  and application of two theorems with a lemma pertaining to its existence and asymptotic properties. An asymptotic solution is obtained in the case of non-zero eigenvalue by reduction to the regular case on the basis of a third theorem. References 4: 3 Russian, 1 Western.  
[212-2415]

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