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BATANOV, V. A.; BUNKIN, F. V.; FROKHOROV, A. M.; FEDOROV, V. B. (Lebedev Physics Institute, USSR Academy of Sciences)

"Evaporation of Metallic Targets by Intense Optical Radiation"

Moscow, Zhurnal Eksperimental'noy i Teoreticheskoy Fiziki; August, 1972; pp 586-608

ABSTRACT: A theory of evaporation of metals subjected to intense optical radiation is developed on the basis of the liquid-vapor phase transition. A method for the approximate solution of the Clapeyron-Clausius equation is suggested which permits one to determine the temperature of the surface of a target as a function of the incident radiation intensity I with accuracy sufficient for experimental purposes. It is shown that when a certain critical value of the intensity $I_{md} \sim 10^7-10^8 \text{ w/cm}^2$ is exceeded, a new effect -- a "transparency wave" -- arises as a result of the loss of metallic properties by the target: in the front of the wave the liquid metal changes into a liquid dielectric. For $I > I_{md}$ vaporization begins to take place at the surface 1/2.

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BATANOV, V. A., et al., Zhurnal Eksperimental'noy i Teoreticheskoy Fiziki; August, 1972; pp 586-608

of the "transparent" (dielectric) layer, the temperature T_{md} of which ceases to increase and remains below the critical value. This layer is separated from the metal by the front of the transparency wave propagating into the target. This transparency effect is accompanied by the appearance of a number of other effects which may serve for its observation: viz., a sharp drop of the target reflection coefficient, a considerable change in the dependence of the evaporation front velocity on I , and, finally, the appearance of a maximum followed by a monotonic decrease in the dependence of the specific recoil momentum on I . The latter effect was experimentally observed in the present investigation. The results obtained are presented in the paper.

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APOLLONOV, V. V., BARCHUKOV, A. I., KONYUKHOV, V. K., and PROKHOROV, A. M.,
Physics Institute imeni P. N. Lebedev, Academy of Sciences USSR

"Thermoelastic Deformation of the Surface of a Solid Under the Action of a
Laser Beam"

Moscow, Pis'ma v Zhurnal Eksperimental'noy i Teoreticheskoy Fiziki, Vol 15,
No 5, 5 Mar 72, pp 248-250

Abstract: The article describes the behavior of the surface of a solid under the action of a continuous laser beam, where the result is distortion of the surface profile through thermoelastic deformations rather than surface failure. A continuously operating unimodal CO₂ laser was used as the radiation source, and the target was a fused quartz disk. It was found experimentally that under the action of laser radiation there is buckling of the surface of the irradiated solid at the place where the beam strikes. The authors thank F. V. BUNKIN and the late V. I. DANILOVSKAYA for valuable discussions.

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ASNIN, V. M., ZUBOV, B. V., MURINA, T. M., PROKHOROV, A. M., ROGACHEV, A. A.,
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USSR

"Radiative Recombination of Biexcitons in Germanium"

Moscow, Zhurnal Eksperimental'noy i Teoreticheskoy Fiziki, Vol 62, No 2, Feb
72, pp 737-745

Abstract: The article describes results of a study undertaken to obtain additional data on the nature of the long-wave recombination radiation line in germanium, as well as to determine the binding energy of biexcitons. Some preliminary findings were published in previous articles by the authors. Experiments were performed on samples of pure n- and p-type germanium with a total impurity center concentration on the order of $5 \cdot 10^{13} \text{ cm}^{-3}$. Two methods of excitation were used; viz., surface and volume. Data were obtained at $T = 4.2^\circ \text{ K}$ in a wide range of excitation level variations showing the dependence of the intensity of an exciton line with a quantum energy $h\nu = 0.713 \text{ ev}$ on the intensity of a biexciton line with $h\nu = 0.708 \text{ ev}$. A quadratic

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ASNIN, V. M., et al., Zhurnal Eksperimental'noy i Teoreticheskoy Fiziki, Vol 62, No 2, Feb 72, pp 737-745

dependence is observed up to concentrations $n_b \approx 3 \cdot 10^{14} \text{ cm}^{-3}$, while at higher excitation levels there is a linear dependence, which can be explained by the effect of nonequilibrium phonons produced when the excitons are bound into biexcitons. The energies E_b (dissociation energy of an exciton molecule) and ΔE ("recoil" energy which a biexciton receives during phonon emission) were found to be 3.6-3.8 Mev and 2.0-2.2 Mev respectively. The energy of the phonon produced during formation of the biexciton is 1.6 Mev. The experimental results prove the biexciton nature of the 0.708 ev line in germanium. Regarding the shape of this line and its energy position, it is suggested that there is a recombination process in which annihilation of one exciton is accompanied by acceleration of another as a whole.

The authors thank L. V. KELDYSH and S. N. RYVKIN for a useful discussion of a number of questions touched upon in the article.

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ALEKSANDROV, V. I., VORON'KO, YU. K., MIKHALEVICH, V. G., OSIKO, V. V.,
PROKHOROV, A. M., Academician, TATARINTSEV, V. M., UDOVENCHIK, V. T., and
SHIPULO, G. P., Physics Institute imeni P. N. Lebedev, USSR Academy of
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"Spectroscopic Properties and Generation of Nd^{3+} in Crystals of ZrO_2 and HfO_2 "
Doklady Akademii Nauk SSSR, Vol 199, No 6, 1971, pp 1282-1283

Abstract: The spectroscopic properties of Nd^{3+} are known in various crystals and glasses. Materials such as crystals of $\text{V}_3\text{Al}_5\text{O}_{12}$ and silicate glasses activated with neodymium have been widely used in lasers. The authors of this article first describe the spectroscopic properties and generation of Nd^{3+} in cubic crystals of ZrO_2 and HfO_2 . These materials have a fluorite type crystal lattice in which the Nd^{3+} ions replace the tetravalent ions of zirconium or hafnium. In addition to the Nd^{3+} the crystals contained impurities of CaO or V_2O_3 for the purpose of stabilizing the cubic structure of the ZrO_2 and HfO_2 . The authors describe the experiment and give 1 figure and 1 table to illustrate the results. The figure graphically shows the optical spectra of $\text{HfO}_2\text{-Nd}^{3+}$ crystals, including the spectrum of absorption, the

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absorption group, and the spectrum of luminescence transition. The table gives two structural types of crystals with their properties. The article contains 1 figure, 1 table, and 9 bibliographic entries.

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BUNKIN, F. V., KRASYUK, I. K., MARCHENKO, V. M., PASHININ, P. P., BROKHOROV,
A. M., Physics Institute imeni P. N. Lebedev, Academy of Sciences, USSR

"Investigation of the Structure of a Spark Produced in the Focussing of a Pico-second Laser Pulse in Gases"

Moscow, Zhurnal Eksperimental'noy i Teoreticheskoy Fiziki, No 4, 1971, pp 1326-1331

Abstract: Research is conducted on the formation of points of strong nonlinear scattering of laser radiation and breakdown in air, nitrogen, and argon due to the focussing of a ruby laser radiation pulse with a duration of 20 -- 100 picoseconds and a power of about 2×10^9 watts. The mechanism of this phenomenon, which is linked to the self-focussing of laser radiation in a gas, is discussed. An analysis is given of the results of determination of the breakdown thresholds by means of short-focus and long-focus lenses. The part played by the self-focussing of laser radiation in the development of breakdown at optical frequencies is assessed. 3 figures. 16 bibliographic entries.

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LUGOVOY, V. N., PROKHOROV, A. M., Physics Institute imeni P. N. Lebedev,
Academy of Sciences USSR

"On the Possibility of Generating Ultrashort Light Pulses in Lasers With a
Low Luminescence Line Width of the Laser Material"

Moscow, Pis'ma v Zhurnal Eksperimental'noy i Teoreticheskoy Fiziki, Vol. 15,
No. 1, 5 Jan 72, pp 70-72

Abstract: A connected laser-resonator system is proposed in which the generation frequencies of the laser are automatically selected close to the natural frequencies of the particular resonator. The system consists of a ring or axial resonator R_0 inside which there is a selector for transverse types of oscillations, an active laser material, material active in the induced Raman emission spectrum or in the Mandelstam-Brillouin spectrum, a wide-band nonlinear absorber, and a plane-parallel resonator R_1 . To avoid generation due to reflections from the resonator R_1 , one can use a Faraday cell or set the resonator R_1 with a deflection with respect to the direction of the beam in the laser. In this case those types of oscillations of the
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LUGOVOY, V. N., PROKHOROV, A. M., Pis'ma v Zhurnal Eksperimental'noy i Teoreticheskoy Fiziki, Vol. 15, No. 1, 5 Jan 72, pp 70-72

resonator R_0 have the greatest Q for which the coefficient for passage through the resonator R_1 is a maximum. In turn, the coefficient for passage through the resonator R_1 has sharp maxima corresponding to its natural frequencies. The resonator R_1 therefore simultaneously fills the role of a highly effective selector of axial or longitudinal types of oscillations in the resonator R_0 and selects the generation frequencies close to its natural frequencies. Two cases are considered: (1) the material active in the induced Raman emission spectrum is located in the resonator R_1 , and in the Resonator R_0 there is only active laser material, a nonlinear absorber generally being absent; (2) the material active in the Mandelstam-Brillouin stimulated emission spectrum and the nonlinear absorber, just as the active laser material, are located in the resonator R_0 , and the resonator R_1 is filled with a linear medium. It was found that in both cases the generation of ultrashort pulses with a spectral width exceeding the width of the luminescence line of the active laser material is possible, apparently without lowering the laser efficiency.

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KAYTMAZOV, S. D., MEDVEDEV, A. A., and PROKHOROV, A. M., Physics Institute
imeni P. N. Lebedev, USSR Academy of Sciences

"The Effect of a Magnetic Field at 400 kOe on the Plasma of a Laser Spark"

Moscow, Pis'ma v Zhurnal Eksperimental'noy i Teoreticheskoy Fiziki, Vol 14,
No 5, 5 Sep 71, pp 314-316

Abstract: The possibility that a magnetic field has an active influence on the geometry of a laser spark is due, in the authors' opinion, to the necessity of simultaneously satisfying two conditions: the magnetic pressure must be greater than the gas-kinetic pressure of the plasma, and, consequently, the relationship between field and temperature of the plasma is determined by the condition $T < H^2/8 \pi nk$. In order to eliminate any significant diffusion of the plasma into the field, the skin-layer must not exceed the radius of the spark (r). This leads to the relationship $T > 6.3 \cdot 10^8 r^{2/3} r^{-4/3}$ (where r is the time constant of the spark), since the skin layer $d = c \sqrt{r/2 \pi \gamma \lambda}$, and the electrical conductivity of the plasma $\lambda = 10^7 T^{3/2}/z$. Unless the first condition is satisfied, the plasma is dispersed, squeezing out the magnetic field; if the second condition is not satisfied, it diffuses into the field.

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Thus, for the magnetic field to have any significant effect on the geometry of the spark it must be so high that, with lowering of the pressure of the plasma to the level of the magnetic pressure, its temperature is sufficiently high that no plasma diffuses into the field. This leads to the conclusion that a threshold value of the magnetic field must exist, beginning from which the field actively influences the separation of the spark. This results in finding a value of 300 kOe for the threshold value of the magnetic field. Bearing this in mind, the authors investigated a laser sample in fields of 400 kOe and built special equipment to carry out the investigation. The significant influence which the magnetic field exerts on the geometry of the spark in these investigations permits the authors to independently evaluate the lower boundary of the plasma temperature. The characteristic parameters of the spark are $r = 0.1$ cm, $\tau = 3 \cdot 10^{-7}$ sec, whence it follows that the plasma temperature is more than $6 \cdot 10^5$ oK. The article contains 2 illustrations and 5 bibliographic entries.

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KARLOV, N. V., KONEV, YU. B., and PROKHOROV, A. M., Physics Institute imeni P. N. Lebedev, Academy of Sciences, USSR

"Using Lasers for the Selective Breaking of Chemical Bonds"

Moscow, Fis'ma v Zhurnal Eksperimental'noy i Teoreticheskoy Fiziki, Vol 14, No 3, 5 Aug 71, pp 178-181

Abstract: The authors propose using two-stage photoexcitation for the selective breaking of previously chosen molecular chemical bonds. They find that one serious obstacle in solving the problem of selective bond breaking by using laser radiation is the anharmonic oscillations of the molecules. The authors discuss the necessary parameters of the lasers based on a system of equations which is easy to solve but whose solution is difficult to foresee. As a result of their research and computations, the authors find that the photoexcitation of molecular oscillations can substantially increase the rate of photodissociation from wide-band sources of visible light because of the increase in the number of photodissociation channels. The article contains 8 bibliographic entries.

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DOBZHANSKIY, G. F., KITAYEVA, V. F., KULEVSKIY, L. A., POLIVANOV, YU. N.,
POLUEKTOV, S. N., PROKHOROV, A. M., SOBOLEV, N. N., Physics Institute imeni
P. N. Lebedev of the Academy of Sciences USSR

"Spontaneous Parametric Radiation of the α -HIO₃ Crystal"

Moscow, Pis'ma v Zhurnal Eksperimental'noy i Teoreticheskoy Fiziki, No. 11,
5 Dec 70, pp 505-508

Abstract: The first observation of spontaneous parametric radiation in the biaxial crystal α -HIO₃ belonging to class 222 of the rhombic system is recorded. It is noted that if a crystal having quadratic nonlinearity is exposed to a laser beam, there is a probability of a laser photon with frequency ω_H spontaneously decaying into two photons: a photon of the signal frequency ω_1 and a photon of an additional frequency ω_2 so that

$$\omega_H = \omega_1 + \omega_2.$$

The frequencies of the spontaneous parametric radiation ω_1 and ω_2 are determined by the dispersion characteristics of the crystal, since the process is effective if

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ROBRZHANSKIY, G. F., et al, Pis'ma v Zhurnal eksperimental'noy i teoreticheskoy fiziki, No. 11, 5 Dec 70, pp 505-508

the following condition is fulfilled:

$$k_H = k_1 + k_2,$$

where k_H , k_1 , and k_2 are the wave vectors of the pumping and of the signal and additional waves. The phenomenon is termed particularly interesting, since it is observed even at pumping powers too small to excite parametric generation, and in the absence of a resonator it can be used to obtain angular, temperature, and electrooptical curves of active media suitable for use in parametric generators of light. The α -HIO₃ crystal was transparent in the region 0.4-1.4 μ and had high nonlinear constants. No optical inhomogeneities were observed in the refractive index under the action of optical radiation of high power density, a feature very important in developing parametric generators of light. A continuous argon laser with wavelengths $\lambda_{H_1} = 4880 \text{ \AA}$ and $\lambda_{H_2} = 5145 \text{ \AA}$ with an output power of up to 1 w on each of the wavelengths was used for pumping. Parametric radiation arising in the crystal and polarized along the Y-axis was recorded in the direction of pumping propagation. Typical spectrograms of the spontaneous parametric radiation signal are given which illustrate the dependence of the signal frequency ω_1 on the direction of propagation of pumping in the crystal. It was noted that such crystals can be used as a material to produce both pulsed and continuous parametric generators tuned in the region 0.6-1.3 μ .

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UDC: 621.375.029.67

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BARCHUKOV, A. I., KONEV, Yu. B., PROKHOROV, A. M., TERIN, V. S.

"A 10.6 Micron Laser Amplifier With Periodic Structure of the Amplified Beam"

Moscow, Radiotekhnika i Elektronika, Vol. 16, No 6, Jun 71, pp 996-1004

Abstract: An experimental study is made of a single-mode CO₂ laser amplifier based on a 90-meter quasioptical mirror transmission line. An estimate is made of the effect which errors in alignment of the line correctors and amplitude-phase distortions have on beam degradation. Basic design data and characteristics are presented for the laser. The output power is more than 500 watts. The study showed that the proposed design could be competitive with the telescopic amplifier described by P. Miles and W. Lotus (IEEE J. Quantum Electronics, 1968, QE-4, 11, 811). The principal advantage of the gas laser studied in this work is the fact that the phase correctors in the line are simpler devices than the telescopes in the Miles-Lotus laser. These correctors provide periodic focusing of the beam, thus reducing broadening due to non-linearity of amplification. Calculations show that cells no more than 20-25 mm in diameter should be used to simplify matching between the line and the optical laser, shifting the matching itself to the laser. The total experimentally measured losses in amplification were too high to allow any appreciable increase in output power.

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PASHININ, P. P., PROKHOROV, A. M., Physics Institute imeni P. N. Lebedev, Academy of Sciences USSR

"Producing a High-Temperature Dense Plasma Under Laser Heating of a Special Gas Target"

Moscow, Zhurnal Eksperimental'noy i Teoreticheskoy Fiziki, No. 5, May 71, pp 1630-1636

Abstract: The problems of using lasers to produce a dense plasma of thermonuclear temperatures are discussed in connection with quantum electronics and the increasing interest in controlled thermonuclear fusion. Four types of plasma heating through the use of lasers are considered. The first version discussed is the focusing of high-intensity laser radiation on the surface of a semi-infinite target of a solid or liquid mixture of heavy isotopes of hydrogen or tritium. In the second version, the target is a small condensed particle introduced to or slowly entering a vacuum through the laser radiation focusing region. The third version assumes the use of a gas medium in which, under the focusing of laser radiation, there occurs optical breakdown and further heating of the plasma. The fourth is

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PASHININ, P. P., PROKHOROV, A. M., Zhurnal eksperimental'noy i teoreticheskoy fiziki, No. 5, May 71, pp 1630-1636

based on the application of a CO₂ laser with a wavelength $\lambda = 10.6 \mu$ which, in principle, permits heating of the plasma with a density of 10^{19} cm^{-3} . In this case in the field of thermonuclear temperatures, one can speak of magnetic containment of a plasma with magnetic fields that can be technically achieved in the foreseeable future. This last version, however, is very difficult to discuss now, since the experimental base is in the very initial stages of development, although in addition to the above it is also very attractive in view of the possibility of producing appropriate lasers with a fairly high efficiency of 10-20%. The first two approaches are said to be the most promising, since they involve the use of an ultrahigh density plasma with $n \sim 5 \cdot 10^{22} \text{ cm}^{-3}$. It is noted that the use of a superhigh-density plasma makes it possible to considerably lower the volume of matter but that this, in turn, leads to a too rapid cooling of the plasma upon expansion in a vacuum, requiring lasers with a pulse length of $\leq 10^{-9}$ sec. It is also pointed out that a final evaluation of the promise of these two versions is still very indeterminate due to the inadequacy of knowledge concerning the interaction of intense laser radiation with a superdense plasma, electron heat conductivity in a dense plasma with a

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No 5, May 71, pp 1630-1636

considerable temperature and density gradient, and many other problems. It is pointed out that, by optimistic estimates, to obtain a positive yield of thermonuclear energy with respect to the energy in the laser beam for these versions it is necessary to have a laser with a pulse energy of 10^6 joule with a pulse duration of 10^{-9} sec, under the assumption that all of the laser energy goes into the plasma. Since the upper boundary of energy for such glass lasers with neodymium predicted for the next 5-10 years is in the range 10^4 - 10^6 joule, it is suggested that the other versions be given more attention, particularly the third version in which a gas target is used. It is shown that in using a magnetic field of the order of 10^6 oe it is necessary to use a laser pulse of length $\sim 10^{-7}$ with an energy of $3 \cdot 10^5$ joule to obtain a positive energy yield with respect to laser radiation in a thermonuclear fusion reaction in a mixture of deuterium and tritium isotopes. It is noted, in conclusion, that if an ultrastrong retardation of laser beams in a

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No 5, May 71, pp 1630-1636

dense plasma is observed in experiments with electron beams due to collective effects, targets with radial inertial containment, magnetic thermal insulation, and longitudinal gas flow into the vacuum can be used in this method of heating of plasma; one more parameter of the initial target -- the density of the gas -- can also be controlled by the experiment through a change in pressure in the channel.

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VORON'KO, Yu. K., OSIKO, V. V., PROKHOROV, A. M., and SHCHERBAKOV, I. A.,
Physics Institute imeni P. N. Lebedev, Academy of Sciences USSR

"Study of the Mechanism of an Elementary Act of Excitation Energy Transfer
Between Rare Earth Ions in Crystals"

Moscow, Zhurnal Eksperimental'noy i Teoreticheskoy Fiziki, Vol 60, No 3,
Mar 71, pp 943-954

Abstract: The micromechanism of the interaction of impurity ions in crystals with one another and with the crystal lattice matrix is investigated. The variation with temperature of the probability of excitation energy transfer between rare earth ions was studied using doubly activated fluorite to exclude the effect of energy migration along donor ions. It is shown that the transfer process varies directly with temperature, even in the case of the absence of spectral resonance of electron transitions of the donor and acceptor. It is concluded that the results indicate that the probability of excitation energy transfer in the absence of overlapping of donor and acceptor spectra is determined by the density of phonon states in the frequency region corresponding to the Stokes resonance detuning. The mechanism of temperature activation is associated with the population of the phonon state
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VORON'KO, Yu. K., et al, Zhurnal Eksperimental'noy i Teoreticheskoy Fiziki,
Vol 60, No 3, Mar 71, pp 943-954

corresponding to the acoustical branch of the dispersion diagram. It is noted that these effects also appear in the infrared absorption spectra as a function of temperature, both of crystals of the flucrite type and of crystals of alkali-halide and other compounds.

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KRASYUA, I.K., KULEVSKIY, L.A., PASHININ, P.P., and PROKHOROV,
A.M., Physics Institute imeni P.N. Lebedev, Academy of Sciences,
USSR

"Application of Picosecond Ruby Laser Pulses for Measuring
Damping Time of the Luminescence Band of the First Phonon Re-
petition of Exciton A in CdS"

Moscow, Zhurnal Eksperimental'noy i Teoreticheskoy Fiziki, Vol 59,
No 2(8), 1970, pp 346-349

Abstract: The object of this paper was to determine experimen-
tally the attenuation time of a luminescence band in CdS ge-
nerated as a result of radiation recombination of a free exci-
ton with a simultaneously emitted photon and one longitudinal
optical phonon. A previously described ruby laser generating
picosecond pulses was used as a source of double-photon exci-
tation in CdS. The ruby laser generated a series of picosecond
pulses from which, by means of a special gate, a single pulse
was discriminated. The discriminated pulse was directed at the

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KRASYUK, I. K., et al., Zhurnal Eksperimental'noy i Teoreticheskoy Fiziki, Vol 59, No 2(8), 1970, pp 346-349

CdS sample mounted in a cryostat at a temperature of 77°K . The CdS luminescence induced by the ruby laser was directed at the ELU-F7 photomultiplier the electric signal from which was recorded by means of one of the beams of the 6LOR-02 high-speed oscillograph. The oscillograph also recorded, simultaneously, the generated radiation pulse, a portion of which was directed at a coaxial photoelement FEK-15. A portion of CdS radiation was focused on the slit of a ISP-51 spectrograph. By placing a proper filter before the photomultiplier it was possible to observe green radiation from CdS or a blue band of the first phonon repetition of exciton A. The experimental value of the attenuation time was 1.3 nanosec. It is concluded that the use of picosecond laser pulses for investigating relaxation processes in solids will make it possible to obtain a series of new data.

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UDC: None

ZLENKO, A. A., PROKHOROV, A. M., SYCHUGOV, V. A., and SHIPULO, G. P.

"Exciting $\text{LaF}_3\text{-Nd}^{3+}$ Crystals with Monochromatic Light"

Moscow, Zhurnal Eksperimental'noy i Teoreticheskoy Fiziki, Vol 59, No 9, 1970, pp 785-789

Abstract: The relaxation time of the particles from the 0.53μ absorption band of Nd^{3+} ions at the $4F_3/2$ level is determined, and the transverse cross section of the induced radiation in $\text{LaF}_3\text{-Nd}^{3+}$ crystals is measured in lasers pumped with monochromatic light. The determination of this time is important since it has a definite effect on the operation of the laser. The results of a numerical solution of the problem of exciting laser oscillations in a four-level system with the relaxation time taken into account, pumped by a light pulse lasting 50 ns, are obtained. These results are found from a curve showing the laser radiation as a function of time, through the use of a computer. Formulas are derived to determine the relaxation time from measurements of the time interval between the first two peaks of the laser radiation curve after the pumping pulse. The authors express their gratitude to M. V. Dmitruk and to V. V. Osiko for the $\text{LaF}_3\text{-Nd}^{3+}$ crystals, and to Ye. M. Dianov for his comments and discussion.

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KRASYUK, I. K., PASHININ, P. P., and PROKHOROV, A. M., Physics Institute imeni P. N. Lebedev, Academy of Sciences USSR

"Experimental Observation of Induced Compton Absorption of Laser Emission in a Spark"

Pis'ma v Zhurnal Eksperimental'noy i Teoreticheskoy Fiziki (Letters to the Journal of Experimental and Theoretical Physics), Vol 12, No 9, 5 Nov 1970, p 439-442

Abstract: The first experiments of the observation of induced Compton absorption (ICA) of laser emission by a plasma are reported. The total number of radiated quanta remains constant, but the radiation energy is transferred to the electrons in the plasma by the change in frequency of the scattered quanta. The spectrum of the radiation that has passed through the plasma should, owing to the ICA, be shifted in the longwave direction. The experimental equipment, shown in a diagram, consists basically of a ruby laser that produces picosecond pulses (50 nsec), an optical amplifier, a plasma chamber with associated filters and optical elements, and a spectrograph. A beam splitter diverts part of the energy to a high-speed oscillograph. The energy density at the focus of the lens system was 2×10^{14} watt/cm², which is considerably greater than a spark in helium. Half

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KRASYUK, I. K., Pis'ma v Zhurnal Eksperimental'noy i Teoreticheskoy Fiziki, Vol 12, No 9, 5 Nov 1970, p 439-442

of the pulse energy is passed through the plasma, is collimated, and enters the top half of the spectrograph slit. The other half is diverted around the chamber to the lower half of the spectrograph slit. An arc spectrum of iron was photographed simultaneously for reference. Spectra obtained for helium and aluminum foil plasmas exhibit longwave shifts and short-wave absorption. Part of the energy is absorbed across the entire spectrum. Normalizing the curves for bremsstrahlung absorption in helium, the integral absorption for the spectrum is $1.3 (\pm 0.3) \times 10^{-5}$, and the mean absorption is $0.26 \times 10^{-2} \text{ cm}^{-1}$. Similar results are obtained when aluminum foil is placed at the focus in the plasma chamber. The authors conclude that the spectrum shift is due to induced Compton scattering. Other possible mechanisms are ruled out because of time considerations. The effect, therefore, can play a dominant role in plasma heating by electromagnetic radiation and under given conditions can greatly exceed the classical bremsstrahlung absorption, which is weakened by nonlinear effects in strong fields. Effective quantities of energy can be injected into the plasma only if the emission spectrum width is comparable to the radiation frequency. The authors thank F. V. Bunkin for discussions. Orig. art. has 2 figs. and 7 refs.

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KOROBKIN, V. V., MALYUZHIN, A. A., and PROKHOROV, A. M., Physics Institute imeni P. N. Lebedev of the Academy of Sciences USSR

"Phase Self-Modulation and Self-Focusing of the Radiation of a Neodymium Laser Under Self-Synchronization of Modes"

Moscow, Pis'ma v Zhurnal Eksperimental'noy i Teoreticheskoy Fiziki, Vol. 12, No. 5, 5 Sep 70, pp 216-220

Abstract: Detection of the phenomenon of self-focusing and phase self-modulation of radiation in the active element of a neodymium laser operating in a self-synchronization mode is reported. It is shown that these effects have a considerable influence on the nature of the generation of this laser. The nonlinear changes in the index of refraction of the active element of the laser arising under self-modulation and self-focusing are evaluated. A laser with a ring resonator ($T = 8.5$ nsec) was used in the experiments. The length of the active element was 30 cm and dye number 3955 dissolved in nitrobenzene was used as a Q-modulator. Pictures show a considerable redistribution of radiation intensity under large fields in the resonator, while the intensity distribution in a free generation regime was uniform. Phase self-modulation is thus said to explain to a considerable degree the structure of the radiation spectrum of a laser with self-synchronization.

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KONYUKHOV, V. K., MATROSOV, I. V., PROKHOROV, A. M., SHALUNOV, D. T., and SHIROKOV, N. N., Physics Institute imeni P. N. Lebedev, Academy of Sciences USSR

"Continuous Gasdynamic Laser With a Mixture of Carbon Dioxide, Nitrogen, and Water"

Moscow, Pis'ma v Zhurnal Eksperimental'noy i Teoreticheskoy Fiziki, Vol. 12, No 10, 20 Nov 70, pp 461-464

Abstract: This article reports that in a supersonic wind tunnel to which a heated mixture of carbon dioxide and nitrogen with a small quantity of water was blown there was observed an amplification of infrared radiation, and after installation of an optical resonator in the working portion of the tunnel a generation effect was obtained. Studies of the amplification coefficient of a supersonic flow ($M = 4-5$) were made in a wind tunnel described previously by the authors, with the difference that the gas expanded in a wedge-shaped nozzle with an angle of opening of 13° and a length of the supersonic portion of 5 cm. The stagnation temperature was 1000°K , the stagnation pressure was 5 atm, and the dimensions of the critical cross section were 1.5×100 mm. The probing ray of a single-mode, single-frequency CO_2 laser was directed parallel to the greater dimension of the

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USSR

KONYUKHOV, V. K., et al, Pis'ma v Zhurnal Eksperimental'noy i Teoreticheskoy Fiziki, Vol 12, No 10, 20 Nov 70, pp 461-464

critical cross section and intersected the gas flow at the point of emission from the nozzle. A study of the change in the absorption coefficient and the amplification of the signal of the CO_2 laser with time showed that absorption in the gas flow decreases to zero and then amplification appears. Introduction of water molecules causes accelerated relaxation of the CO_2 molecules from the lower laser level as the gas flows in the supersonic portion of the nozzle. The amplification coefficient was measured as a function of water content in the mixture. Measurement of the amplification coefficient in this gas mixture was made at a frequency of 947.73 cm^{-1} and showed that inversion in the supersonic flow exists for the pair of levels $(00^01)-(10^00)$ but the amplification coefficient amounts to $6 \cdot 10^{-4} \text{ cm}^{-1}$ for a water concentration of 2.1%.

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USSR

KONYUKHOV, V. K., and PROKHOROV, A. M., Physics Institute imeni P. N. Lebedev,
Academy of Sciences USSR

"On the Possibility of Producing an Adsorption-Gasdynamtic Laser"

Moscow, Pis'ma v Zhurnal Eksperimental'noy i Teoreticheskoy Fiziki, Vol. 13,
No 4, 20 Feb 71, pp 216-218

Abstract: It is shown that nonequilibrium expansion in a supersonic jet of a two-phase gas-aerosol system can be accompanied by population inversion with respect to oscillatory levels of multiatomic anisotropic molecules, due to oscillatory relaxation of molecules in the adsorbed state on the surface of aerosol particles. It is noted that surface relaxation considerably broadens the choice of molecular gases in which it is possible to obtain population inversion by the gasdynamic method. It is assumed that the dependence of the average lifetime of a molecule in a two-phase gas-aerosol system on the type of oscillatory level at which the molecule is located is explained by the joint action of three factors: (1) a molecule on being adsorbed is oriented in a certain way relative to the surface of the adsorbent; (2) the damping of different oscillatory modes of the molecule depends on its orientation in the adsorbed state; (3) the time of stay on

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USSR

KONYUKHOV, V. K., and PROKHOROV, A. M., *Fis'ma Zhurnal Eksperimental'noy i Teoreticheskoy Fiziki*, Vol. 19, No. 4, 20 Feb 71, pp 216-218

the surface also depends on the orientation of the molecule. Expressions are derived for the time of stay of a molecule in the adsorbed state as a function of its orientation; and the damping of different oscillatory modes of a molecule, as a function of its orientation on the surface. The ratio of the lifetime τ_b of a CO_2 molecule in a two-phase system on the surface laser level to the average lifetime τ_H on the four lower levels is also obtained and shows that the lifetime of molecules on the lower levels is $1/\eta$ times shorter than the lifetime on the surface laser level. It is noted that in supersonic wind tunnels and in gasdynamic lasers there is a common reason for which flow in the supersonic portion becomes two-phase: the reason is the voluminal condensation of vapors of those substances which are contained in the form of small admixtures in the gas and which have considerable vapor pressure in comparison with the total pressure of the gas. The presence of aerosol particles in a gas flow then causes attenuation of the infrared radiation due to absorption and scattering by small particles.

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1/2 028 UNCLASSIFIED PROCESSING DATE--13NOV70
TITLE--SELF FOCUSING FILAMENTS AS A RESULT OF THE MOTION OF FOCAL POINTS
-U-
AUTHOR--(04)-KORDBKIN, V.V., PROKHOROV, A.M., SEROV, R.V., SHCHELEV, M.YA.
COUNTRY OF INFO--USSR
SOURCE--JETP LETTERS (USA), VOL. 11, NO. 3, P. 153-7 (FEB. 1970)
DATE PUBLISHED----FEB70
SUBJECT AREAS--PHYSICS
TOPIC TAGS--ELECTRON-OPTICS, FLUID PROPERTY
CONTROL MARKING--NO RESTRICTIONS
DOCUMENT CLASS--UNCLASSIFIED
PROXY REEL/FKAME--3005/1784 STEP NO--US/0000/70/011/003/0153/0157
CIRC ACCESSION NO--AP0133689

UNCLASSIFIED

2/2 028

UNCLASSIFIED

PROCESSING DATE--13NOV70

CIRC ACCESSION NO--AP0133689

ABSTRACT/EXTRACT--(U) GP-0- ABSTRACT. USING AN ELECTRON OPTICAL CONVERTER TO INVESTIGATE THE KINETICS OF SELF FOCUSING IN LIQUIDS, THE AUTHORS SHOW THAT FILAMENTS PRODUCED ARE THE RESULTS OF MOTION OF INDIVIDUAL FOCAL POINTS. (15 REFS.).

FACILITY: USSR ACAD.
SCIS.

UNCLASSIFIED

1/2 051 UNCLASSIFIED PROCESSING DATE--20NOV70
TITLE--INVESTIGATION OF BREAKDOWN IN ARGON AND HELIUM PRODUCED BY A
PICOSECOND RUBY LASER LIGHT PULSE -U-
AUTHOR--(03)-KRASYUK, I.K., PASHININ, P.P., PROKHOROV, A.M. P
COUNTRY OF INFO--USSR
SOURCE--ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI, 1970, VOL 58,
NR 5, PP. 1606-1608
DATE PUBLISHED-----70

SUBJECT AREAS--PHYSICS

TOPIC TAGS--ARGON, HELIUM, RUBY LASER, PICOSECOND PULSE, IONIZATION

CONTROL MARKING--NO RESTRICTIONS

DOCUMENT CLASS--UNCLASSIFIED
PROXY REEL/FRAME--3002/0002

STEP NO--UR/0056/70/058/005/1606/1608

CIRC ACCESSION NO--AP0127652

UNCLASSIFIED

2/2 051

UNCLASSIFIED

PROCESSING DATE--20NOV70

CIRC ACCESSION NO--AP0127652

ABSTRACT/EXTRACT--(U) CP-0- ABSTRACT. THE THRESHOLD FLUX FOR BREAKDOWN IN ARGON AND HELIUM INDUCED BY A 50 PICOSECOND RUBY LASER PULSE IS INVESTIGATED. THE RESULTS SHOW THAT BOTH FOR ARGON AND HELIUM THERE EXIST PRESSURE RANGES IN WHICH BREAKDOWN OCCURS EITHER AS THE RESULT OF THE AVALANCHE MECHANISM OR AS A RESULT OF MULTIPHOTO IONIZATION OF THE GAS ATOMS IN THE FIELD OF A STRONG LIGHT WAVE. THE TWO MECHANISMS CAN BE DISTINGUISHED THANKS TO THEIR DIFFERENT DEPENDENCE ON GAS PRESSURE. THE MAGNITUDES OF THE MULTIPHOTON IONIZATION PROBABILITIES ARE ESTIMATED FOR THRESHOLD VALUES OF THE BREAKDOWN FLUXES. THE EXPERIMENTAL BREAKDOWN THRESHOLDS AND IONIZATION PROBABILITIES ARE COMPARED WITH THOSE CALCULATED ON BASIS OF THEORETICAL DATA AVAILABLE IN THE LITERATURE. FACILITY: FIZICHESKIY INSTITUT IM. P. N. LEBEDEVA, AKADEMII NAUK SSSR.

UNCLASSIFIED

1/2 039 UNCLASSIFIED PROCESSING DATE--04DEC70
TITLE--FINE STRUCTURE OF THE GIANT PULSE IN A CO2 LASER WITH TRANSVERSE
MODES -U-
AUTHOR-(03)-ARKELIAN, V.S., KARLOV, N.V., PROKHOROV, A.M.
COUNTRY OF INFO--USSR
SOURCE--RADIOTEKHNIKA I ELEKTRONIKA, VOL. 15, APR. 1970, P. 849-851
DATE PUBLISHED---APR70
SUBJECT AREAS--PHYSICS
TOPIC TAGS--CARBON DIOXIDE LASER, LASER PULSE, LASER Q SWITCHING
CONTROL MARKING--NO RESTRICTIONS
DOCUMENT CLASS--UNCLASSIFIED
PROXY REEL/FRAE--1996/1672 STEP NO--UR/0109/70/015/000/0849/0851
CIRC ACCESSION NO--AP0118650
UNCLASSIFIED

2/2 039

UNCLASSIFIED

PROCESSING DATE--04DEC70

CIRC ACCESSION NO--AP0118650

ABSTRACT/EXTRACT--(U) GP-0- ABSTRACT. DESCRIPTION OF EXPERIMENTS IN WHICH GIANT PULSES COMPOSED OF TRAINS OF MUCH SHORTER PULSES WERE OBTAINED IN A CARBON DIOXIDE LASER WITH MORE THAN ONE TRANSVERSE MODE. THE RESONATOR LENGTH WAS ONLY 160 CM WHICH PRECLUDED THE SIMULTANEOUS EMISSION OF SEVERAL LONGITUDINAL MODES. IT IS SHOWN THAT THE COMPETITION OF TRANSVERSE MODES RESULTS IN SEQUENCES OF SHORT PULSES DURING PASSIVE, ACTIVE, AND COMBINED PASSIVE AND ACTIVE Q SWITCHING. THE CHARACTERISTICS OF THE PULSE TRAINS DIFFER FOR EACH TYPE OF Q SWITCHING. FACILITY: AKADEMIYA NAUK SSSR, FIZICHESKII INSTITUT, MOSCOW, USSR.

UNCLASSIFIED

1/3 056 UNCLASSIFIED PROCESSING DATE--04DEC70
TITLE--FILAMENTS WHICH ARE SELFFOCUSING BY MOVEMENT OF FOCAL POINTS --U-
AUTHOR--(04)-KOROBKIN, V.V., PROKHOROV, A.M., SEROV, R.V., SHCHELEV, M.YA.
COUNTRY OF INFO--USSR *P*
SOURCE--MOSCOW, PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY
FIZIKA, VOL. 11, NO. 3, 5 FEB 70, PP 153-157
DATE PUBLISHED--05FEB70

SUBJECT AREAS--PHYSICS

TOPIC TAGS--OPTIC PROPERTY, ELECTRON OPTICS, IMAGE CONVERTER, SINGLE MODE
LASER, NITROBENZENE, CARBON DISULFIDE, LASER RADIATION, LASER SELF
FOCUSING EFFECT

CONTROL MARKING--NO RESTRICTIONS

DOCUMENT CLASS--UNCLASSIFIED
PROXY REEL/FRAME--1999/1463

STEP NO--UR/0386/70/011/003/0153/0157

CIRC ACCESSION NO--AP0123371

UNCLASSIFIED

2/3 056

UNCLASSIFIED

PROCESSING DATE--04DEC70

CIRC ACCESSION NO--AP0123371

ABSTRACT/EXTRACT--(U) GP-0- ABSTRACT. THE QUESTION OF WHETHER FILAMENT OF SELF FOCUSING IS THE RESULT OF MOVEMENT OF INDIVIDUAL FOCAL POINTS OR WHETHER IT EXISTS IN A STEADY STATE IS INVESTIGATED. TO CLARIFY THE PROBLEM OF WHICH THEORY IS VALID, THE AUTHORS INVESTIGATED THE KINETICS OF SELF FOCUSING IN LIQUIDS, USING AN ELECTRON OPTICAL IMAGE CONVERTER. THE RADIATION OF A SINGLE MODE LASER (ONE ANGULAR AND ONE AXIAL MODE) WAS PASSED THROUGH A CELL OF LENGTH 10 CM CONTAINING NITROBENZENE OR CARBON BISULFIDE. THE RADIATION AT THE INPUT TO THE CELL HAD A PLANE PHASE FRONT WITH AN APPROXIMATELY NORMAL TRANSVERSE DISTRIBUTION. THE DIAMETER OF THE INPUT BEAM WAS 0.25 MM AND THE POWER WAS UP TO 1.5 MW FOR A PULSE LENGTH OF SIMILAR TO 15 NSEC. A LIGHT FILTER WAS PLACED IN FRONT OF THE IMAGE CONVERTER WHICH TRANSMITTED ONLY LASER RADIATION. A TYPICAL PHOTOGRAPH SHOWS THAT AT THE OUTPUT OF THE VESSEL THE DIAMETER OF THE SELF FOCUSING SPOT IS APPROXIMATELY 5 MU, CORRESPONDING TO THE RESOLUTION OF THE RECORDING SYSTEM. THE SELF FOCUSING SPOT EXISTS SMALLER THAN 0.5 NSEC AND THEN DISAPPEARS; THEN A SUBSEQUENT SPOT APPEARS AFTER 1-2 NSEC AT THE SAME PLACE. SOMETIMES ANOTHER SELF FOCUSING SPOT APPEARS AT A DISTANCE OF SIMILAR TO 50 MU, BUT THIS IS OBSERVED VERY RARELY. UNDER THE CONDITIONS OF THIS EXPERIMENT THE MAXIMUM VALUE OF N EQUALS $E-E$ SUBCR CONGRUENT TO 7, WHERE E IS THE INPUT FIELD STRENGTH AND E SUBCR EQUALS 1-SQUARE ROOT OF N SUB2 (KA) PRIME2 (K IS THE WAVE NUMBER, A IS THE RADIUS OF THE INPUT BEAM, AND N SUB2 IS THE NONLINEAR INDEX OF REFRACTION).

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3/3 056

UNCLASSIFIED

PROCESSING DATE--04DEC70

CIRC ACCESSION NO--AP0123371

ABSTRACT/EXTRACT--THE STEADY STATE THEORY PREDICTS THE EXISTENCE OF ONLY SEVEN FOCAL POINTS FOR N EQUALS 7, WHICH IS FAIRLY CLOSE TO THE EXPERIMENTAL DATA OBTAINED IN THIS PAPER. THE VELOCITY OF THE FOCAL POINTS IS ALSO IN AGREEMENT WITH THIS THEORY. THE AUTHORS FEEL THAT THE EXPERIMENTAL RESULTS SUPPORT THE VALIDITY OF THE STEADY STATE THEORY OF SELF FOCUSING. FACILITY: PHYSICS INSTITUTE IMENI P. N. LEBEDEV, ACADEMY OF SCIENCES USSR.

UNCLASSIFIED

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USSR

UDC 621.378.325

DIANOV, YE. M., PROKHOROV, A. M., Academician, Physics Institute
imeni P. N. Lebedev of the Academy of Sciences USSR, Moscow

"Thermal Distortions of Laser Resonators in the Case of Active
Rods in the Form of Rectangular Plates"

Moscow, Doklady Akademii Nauk SSSR, Vol 192, No 3, 1970,
pp 531-533

Abstract: Thermal distortions of a laser resonator in the case
of a neodymium glass rod in the form of a rectangular plate are
analyzed. It is noted that many theoretical and experimental
studies have been devoted to thermal distortions of laser radia-
tors, but in all these papers the active elements were in the
form of circular rods. It is also pointed out that neodymium
glass is the basic laser material used for producing high radia-
tion intensity, so the problem of thermal distortions of the
resonator is a particularly pressing one; also, the possibility
of varying the physical properties of the glass material by
changing the composition of the glass makes it possible, in
principle, to produce a glass for which the different mechanisms
leading to thermal distortion of the resonator compensate one
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USSR

DIANOV, YE. M., et al, Doklady Akademii Nauk SSSR, Vol 192,
No 3, 1970, pp 531-533

$$\beta_{T,\lambda} = \partial n / \partial T; B_{\parallel} = \frac{n}{E} \left[\frac{1}{V} - 2\nu \frac{p}{V} \right]; B_{\perp} = \frac{n}{E} \left[(1-\nu) \frac{p}{V} - \nu \frac{q}{V} \right];$$

E is young's modulus; ν is the Poisson coefficient; q/V and p/V are photoelastic constants characterizing the change in the index of refraction as a function of deformation in a direction parallel to or perpendicular to the plane of polarization of the passing light. The path difference Δ' of the rays passing through the point $x = 0$ and $x = x'$ is given in the form

$$\Delta'_x = L \left[\beta_{T,\lambda} + \frac{\alpha E}{(1-\nu)} (2B_{\perp}) \right] T(x'). \quad (2)$$

Similar formulas for light polarized along the y-axis are

$$\Delta p_y(x) = L \left\{ \left[\beta_{T,\lambda} + \frac{\alpha E}{(1-\nu)} (B_{\perp} + B_{\parallel}) \right] T(x') + \left[\alpha(n-1) - \frac{\alpha E}{(1-\nu)} (B_{\perp} + B_{\parallel}) \right] \frac{1}{2h} \int_{-h}^{+h} T(x) dx \right\}, \quad (3)$$

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$$\Delta'_y = L \left[\beta_{T,\lambda} + \frac{\alpha E}{1-\nu} (B_{\perp} + B_{\parallel}) \right] T(x'). \quad (4)$$

USSR

DIANOV, YE. M., et al, Doklady Akademii Nauk SSSR, Vol 192, No 3, 1970, pp 531-533

another. An expression is derived for the change in the optical path length of a ray propagating along the x-axis through the point $x = x'$ produced by an applied temperature gradient (Fig. 1).

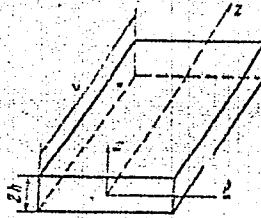


Fig. 1.

For light polarized along the x-axis this expression has the form

$$\Delta p_x(x') = L\{(n-1)\epsilon_{zz} + \beta_{T,\lambda}T(x') - B_{\parallel}\sigma_{xx} - B_{\perp}(\sigma_{yy} + \sigma_{zz})\}, \quad (1)$$

where $T(x')$ is the temperature difference between the points $x = x'$ and $x = 0$; ϵ_{zz} is the component of the deformation along the z-axis; σ_{ii} are the stress components; n is the index of refraction;

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USSR

DIANOV, YE. M., et al, Doklady Akademii Nauk SSSR, Vol 192
No 3, 1970, pp 531-533

Formulas (2) and (4) show that the condition for the absence of thermal distortions of the resonator for a thin rectangular plate with a symmetric temperature distribution along its thickness is independent of the specific form of the temperature distribution and is determined only by the parameters of the glass material. A comparison of various laser glasses shows that (1) glasses of the type KGSS-3 and KGSS-7 satisfy the condition of minimum thermal distortion better than others for light polarized along the y-axis and (2) LGS-41 glass is best for light with a polarization along the x-axis.

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USSR

UDC 535.02

KORNIYENKO, L. S., KVARTSOV, N. V., LARIONTSEV, YE. G.,
Academician PROKHOROV, A. M.

"Some Properties of a Solid-State Laser With Large Resonator Length"

Moscow, Doklady Akademii Nauk SSSR, Vol 193, No 6, 1970,
pp 1280-1282

Abstract: The laser dealt with in this article has a resonator whose length is of the order of several meters. With increasing resonator length, the ratio of the resonator band width to the frequency interval between the longitudinal modes can be significantly increased. With the ratio larger than unity, in turn, the band of the resonator can be significantly enlarged, and it can then be expected that the characteristics of such a laser will be close to those of a laser with non-resonant feedback. Resonator lengths can be increased to values of the order of a kilometer under laboratory conditions by introducing an optical delay line into the laser. A sketch of the scheme under which this can be done accompanies the article. Through the use of such a delay line, the diffraction losses as well as the dimen-
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USSR

KORNIYENKO, L. S., et al, Doklady Akademii Nauk SSSR, Vol 193,
No 6, 1970, pp 1280-1282

sions of the experimental arrangement can be essentially reduced. The authors find that they can draw certain qualitative conclusions concerning the large resonator length laser by considering the interaction of three longitudinal modes. Analysis of such triple-mode excitation shows that it depends only slightly on intermode coupling arising due to modulation of the inverse population and that the coupling strongly affects the intensity distribution of individual modes in the oscillation spectrum.

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1/2 052

UNCLASSIFIED

PROCESSING DATE--23OCT70

TITLE--PROPERTIES OF BORON TRICHLORIDE AND ITS USE IN THE CO SUB2 LASER

DESIGN -U-

AUTHOR--(02)-KARLOV, N.V., PROKHOROV, A.M.

COUNTRY OF INFO--USSR, UNITED STATES

SOURCE--IEEE J. QUANTUM ELECTRONICS (USA), VOL. QE,6, NO. 1, P. 3-4, JAN. 1970. 1969 IEEE CONFERENCE ON LASER ENGINEERING AND APPLICATIONS POST DATE PUBLISHED-----69

SUBJECT AREAS--PHYSICS

TOPIC TAGS--LASER Q SWITCHING, CARBON DIOXIDE LASER, BORON COMPOUND, TRICHLORIDE, LASER PULSE, LASER FREQUENCY, LASER RADIATION, CHEMICAL DECOMPOSITION

CONTROL MARKING--NO RESTRICTIONS

DOCUMENT CLASS--UNCLASSIFIED

PROXY REEL/FRA--1990/1319

STEP NO--US/0000/69/006/001/0003/0004

CIRC ACCESSION NO--AP0109403

UNCLASSIFIED

2/2 052

UNCLASSIFIED

PROCESSING DATE--23OCT70

CIRC ACCESSION NO--AP0109403

ABSTRACT/EXTRACT--(U) GP-0- ABSTRACT. ABSTRACT ONLY GIVEN SUBSTANTIALLY AS FOLLOWS. USING BCL SUB3 PASSIVE Q SWITCHING OF THE CO SUB2 LASER, TUNING OF THE LASER FREQUENCY, SHORTENING OF GIANT PULSES AT ACTIVE Q SWITCHING, AND SELF MODE LOCKING WERE OBSERVED. THE LIFETIME AND THE SATURATION FACTOR OF BCL SUB3 WERE MEASURED. DECOMPOSITION OF BCL SUB3 MOLECULES UNDER LASER RADIATION WAS OBSERVED. FACILITY: ACAD. SCI. USSR, MOSCOW.

UNCLASSIFIED

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Acc. Nr:

AT0050267

Abstracting Service:
CHEMICAL ABST. 5-70

Ref. Code:

4R 0020

103301q Thermo-optical characteristics of glasses activated by neodymium. Buzhinskii, I. M.; Diabay, F. M.; Mamontov, S. K.; Mikhailova, L. M.; Prokhorov, A. M. (Piz. Inst. im. Lebedeva, Moscow, USSR). *Dokl. Akad. Nauk SSSR* 1970, 190(3), 558-61 [Phys] (Russ). A new method to measure the thermo-optical const. $W = a(n - 1) + \beta \tau \lambda$ is given, where a is the coeff. of linear expansion of a glass, n refractive index, and $\beta \tau \lambda$ the temp. coeff. of n . The measurement was done in the region 10-45° for wavelengths 0.63 and 1.15 μ , by using as a light source Ne-He laser LG-126. The temp. gradient, perpendicular to the light beam in the glass 10 x 60 x 130 mm, was produced by water baths, one of const. temp. at 10° and the other with temp. varying slowly 10-45°. A diaphragm with 2 holes (1 mm cross section) at 7 mm to sep. beams passing the glass through the zones with different temp. was used. By an optical system it was possible to follow the change of the optical path $\Delta L^p = \Delta N \lambda = L H \Delta T$, where ΔN is the no. of interference fringes shifted after the temp. gradient was formed in the glass.

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REEL/FRAME
19810195

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L was the length of the rod, λ wavelength of the light used, and ΔT the temp. difference. The values of W and $B_r \lambda$ were evaluated for a no. of laser glasses. Finally, the values of $B_r \lambda$ and W were evaluated, at which the distortion of the wave front of the wave passing the glass under the temp. gradient does not take place or is minimal. For W this was in the region $(-10$ to $+10) \times 10^{-7}$ /degree. The best glasses studied were those of the types KGSS-3 and LGS-41. J. Havel

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19810196

AP0008923

CHEMICAL ABST.

12/69 UR 0096

116427q Technological properties of weakly basic anion exchangers during the chemical desalination of water. Prokhorova, A. M. (Vses. Teplotekh. Inst., Moscow, USSR). *Khimiya i energetika* 1969, 10(9), 9-11 (Russ). New weakly basic anion exchangers AN-18 and AN-31 have been developed to replace the inefficient AN-2H resin. The tests revealed low capacity and inferior mech. properties of AN-18 which was taken from the production. The AN-31 resin has been tested in 10 power plants with different compns. of water. Its lab. tested capacity grows from 780 to 1230 and 1420 g. equiv./m.³ for the regeneration with 40, 52, and 70 g. NaOH/g. equiv.; when the resin is exhausted with 3.5 meq./l. HCl at 10; m./hr. In the plants, it is 960-1360 g. equiv./m.³ for a regeneration rate of 45-67 g. NaOH/g. equiv. and at the filtration rate of 10-15 m./hr. The capacity decreased to 300-400 g. equiv./m.³ in 3 plants after 62-279 cycles and passage of 30,000-105,000 m.³/m.³ of resin, owing to the adsorption of org. matter and to the increase of broken resin particles below 0.42 mm. to 40-57% which is due to the pH changes during the regeneration. This loss requires the replacement of 350 tons of AN-31 annually. An improved granulated resin AN-31G has only 2% of broken particles after 150 cycles. The GOST 13501-63 standard for testing of mech. properties which requires 2 hrs. of shaking of resin sample with condensed water should also include the alternating action of NaOH and HCl.

J. Palaty

19551249

MW 7

Acc. Nr: AP0043678

Ref. Code: UR 0056

PRIMARY SOURCE: Zhurnal Eksperimental'noy i Teoreticheskoy
Fiziki, 1970, Vol 58, Nr 2, pp 541-543

SINGLE MODE RUBY RING LASER

Korn'yenko, L. S.; Kravtsov, N. V.;
Naumkin, N. I.; Prokhorov, A. M.

Results of investigation of a ruby travelling-wave ring laser are presented. It is shown that such laser operates under regular oscillation conditions. The width of the radiation spectrum is measured. It is demonstrated that during the generation time the temperature drift of the radiation frequency is small (< 7 Mc).

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REEL/FRA
19770082

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Acc. Nr:

AT 0034841

Abstracting Service:

INTERNAT. AEROSPACE ABST. 4-70 UR 0020

Ref. Code:

A70-18720 #
SELF-FOCUSING OF INTENSIVE LIGHT BEAMS (O
SAMOFOKUSIROVKE INTENSIVNYKH SVETOVYKH PUCH-
KOV).

A. L. Dyshko, V. N. Lügovoï, and A. M. Prokhorov (Akademiia Nauk
SSSR, Fizicheskii Institut, Moscow, USSR).

Akademiia Nauk SSSR, Doklady, vol. 188, Oct. 1, 1969, p. 792-794.
In Russian.

Analysis of the self-focusing of strong light beams in media with
a quadratic Kerr effect, assuming that the light beams obtain a
spherical initial phase front after the passage through a condensing
lens. Numerical solutions to this problem are developed for several
1/R values other than zero. The practical advantages of obtaining a
self-focusing effect in lens-condensed light beams over obtaining it in
parallel light beams are indicated. V.Z.

M.T

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REEL/FRAME

19711554

E. M. Zolubov, A. M. Frolov, and V. Z. Pressley
Zhurnal Prikladnoi Spektroskopii, vol. 10, Feb. 1967, p. 230-235.

In Russian.

Investigation of the role of the 5_{16} level in the emission of optical radiation by stimulated $\text{CaF}_2:\text{Dy}^{2+}$ crystals, using a ruby laser for stimulation. An experiment in the identification of the absorption spectrum of stimulated $\text{CaF}_2:\text{Dy}^{2+}$ crystals is described. It is concluded that the 5_{16} level does not play the role in the emission mechanism of these crystals ascribed to it by Kiss (1965) and Pressley and Witke (1967).

V. Z.

AP9018434

IAA 6/69

CR/0368

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6/19

AA9-26618 # GENERATION IN ClF₂ Dy²⁺ [O] MEXHA-

AP9041416

INTERNAT. AEROSPACE ABST.
10-69

UR 0386

A69-38067

INVESTIGATION OF BREAKDOWN IN N₂ UNDER THE INFLUENCE OF A PICOSECOND RUBY-LASER PULSE.

I. K. Krasuk, P. P. Pashinin, and A. M. Prokhorov (Akademiia Nauk SSSR, Fizicheskii Institut, Moscow, USSR).

(ZHETF Pis'ma v Redaktsiu, vol. 9, May 20, 1969, p. 581-584.)

JETP Letters, vol. 9, May 20, 1969, p. 354-356. 9 refs. Translation.

Investigation of the dependence of the breakdown threshold in nitrogen gas on the pressure, at pressures ranging from 2 to 10,000 mm Hg. The results show that the experimental dependence of the breakdown threshold on the pressure is weaker than that predicted by theory. This is attributed to the total ionization of the gas particles at the threshold intensity values. Evidence is offered that the transition to picosecond pulse durations will make it possible to observe directly the photoionization that leads to breakdown in the field of a strong electromagnetic wave, in the region of relatively high pressures of the investigated gases.

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GORBENKO, B. Z., PROZHBIN, YU. A., KAYEMAZOV, S. D., ~~LEBEDEV, A. A.~~
~~PROKHOROV, A. M.~~, Academician, and TOLMACHOV, A. M., Physics Institute imeni
P. N. Lebedev, Academy of Sciences USSR, Moscow

"Investigation of Optical Breakdown in Air Caused by Ultrashort Pulses Using
High-Speed Photography With an Image Converter"

Moscow, Doklady Akademii Nauk SSSR, Vol. 187, No. 4, 1 Aug 69, pp 772-774

Abstract: The dynamics of spark development over the entire interval between laser pulses was examined in studying the breakdown in air caused by a series of ultrashort laser pulses, using high-speed photography of the plasmoids and the radiation pulses scattered by them. The distance between the points of breakdown was used to determine the average velocity of the propagation of the spherical shock wave in the plasma; analysis of the photography was also used to show that the maximum velocity may be considerably different from the average velocity. Photographs were taken every 10-15 nsec. Photographs are shown of the development of a spark over an interval of 100 nsec. The velocity of the plasma as measured from the photographs has a sharp maximum reaching $4 \cdot 10^7$ cm/sec over a time interval of 2 nsec, while the average velocity of the plasma was equal to $10 \cdot 10^6$ cm/sec. Since the time of flight of the hot plasma with a velocity $4 \cdot 10^7$ cm/sec occurred after cessation of the laser pulse, the tempera-

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GORBENKO, B. Z., et al, Doklady Akademii Nauk SSSR, Vol. 187, No. 4,
1 Aug 69, pp 772-774

$$T = 1.25 \cdot 10^{-2} v^2 / 7^{\circ}K,$$

giving an ion temperature $T = 6 \cdot 10^{60} K$. It is noted that the formula of a spark
by ultra-high light pulses is a complex physical process which will be dis-
cussed in further detail in a subsequent article.

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PULSED CO₂ LASER WITH DOUBLED FREQUENCY
N. V. Karlov, G. B. Monay, G. P. Kuzmin, and A. M. Prokhorov
(Akademia Nauk SSSR, Fizicheski Institut, Moscow, USSR)
IEEE Journal of Quantum Electronics, vol. QE-5, Mar. 1969, p. 137-
139. 7 refs.

Inversion kinetics for the pulse-pumped CO₂ laser, using Q-switching. The pump was synchronized with the Q-switching mirror. It was possible to obtain the Q-switch pulses at any phase of the pump pulse. The repetition rate was 50 Hz, and the pump pulse duration was 4 or 10 μ s. There is an optimum delay in switching the cavity Q-factor after the discharge started. The giant-pulse intensity increased several times after the discharge was switched from CW to pulses.

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PULSED CO₂ LASER WITH DOUBLE MODULATION
by MARY G. P. KRAMER and A. M. PROKOROV

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Exptl. E.P.R. investigation is described of Dy^{3+} ion in $LaCl_3$ in the wavelength range 1.7-2.35 mm. at $T = 4.2^\circ K$. on transitions between levels $E^{(1)}$ and $F_1^{(1)}$ of the 4I_5 term, detn. of the magnitude of the initial splitting between the levels $E^{(1)}$ and $F_1^{(1)}$, and also calcn. of the position of these levels and the wavefunctions depending on the magnitude and the direction of the const. magnetic field in the range 0-5 kOe. Graphics are given of the dependence of the levels of energy $E^{(1)}$ and $F_1^{(1)}$ on the magnetic field for $H_0 \parallel C_1$, $H_0 \parallel C_2$, and $H_0 \parallel C_3$, and also exptl. and theoretical graphs of the dependence of the wavelength of the transitions between these levels on the magnitude of the const. magnetic field ($H_0 \parallel C_1, C_2, C_3$). The magnitude of the initial splitting was 9.937 cm^{-1} .
A. Lisbeck/j

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... of ... ion in calcium fluoride, at

contribution in laser...
component of scattering. Laser produced surface damage (on
ruby and sapphire crystals are also described. A variable pulse duration but
ween 1-400 ns under normal laser operation and 30 ns (switched pulse) laser
operation has been employed in these experiments. Optical and structural
surface properties and their effect on a surface damage threshold have been
studied and mechanism of laser produced surface damage is discussed. (11
refs.)

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absorption band. Zhurnal Fiz. Khim. 1969, 43(1), 18-21. (Russ.)
 G. P. (Fiz. Inst. im. Lendeleva, Moscow, USSR). *Fiz. Tverd. Tela* 1969, 11(4), 988-91. (Russ). The time of the transition of excited Dy²⁺ from the red region (~14,400 cm⁻¹) absorption band to the metastable level is ~10 nsec. The lifetime to the 14,400 cm⁻¹ level of the absorption band is ≤0.5 nsec.

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43980c Lifetime in the dysprosium(II)-doped calcium fluoride
absorption band. Zelotov, M. M.; Frokhov, A. M.; Shipilov,
G. P. (Fir. Inst. im. Lebedeva, Moscow, USSR). Fiz. Tverd.
Tela 1969, 11(4), 533-51. (Russ). The time of the transition of

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... these crystals generated lines $\lambda_1 = 10,400$ and $\lambda_2 = 10,630$ A. at 70°K. But at 300°K. only λ_2 was generated. For isotropic crystals CaF_2 , YF_3 , G , and Nd^{2+} the temp. at which the threshold of generation frequencies ν_{41} and ν_{42} are equal is a function of the optical axis C and of the axis F of the active element.

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44321a Two-frequency lasing of neodymium
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25251 Pulse CO₂ lasers with double modulation and bleachable filters.
 N.V. Karlov, A.M. Prokhorov, P.N. Lebedev Physical Inst., Moscow, USSR.
IEEE J. Quantum Electronics (QSA), vol. QE-4, no. 5, p. 337 (May 1968).
 (1968 international quantum electronics conference, Miami, FL, USA, 14-17
 May 1968).

Abstract only given. Q-switching is used to investigate inversion kinetics. The pump was synchronized with the Q-switching mirror. It was possible to obtain the Q-switch pulses at any phase of the pump pulse. The repetition rate was 50 Hz and the pump pulse duration was 4 ms or 10 ms. It was found that there is an optimum delay in switching the cavity Q-factor after the discharge started. The giant pulse intensity increased several times after the discharge was switched from CW to pulses. The inversion rise time was 1-2 ms and its lifetime was strongly dependent on the discharge current, due to plasma heating during the current pulse. Increasing the helium percentage in the discharge prolonged the inversion lifetime because of high thermal conductivity of helium gas.

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BUNKIN, F. V., KONOV, V. I., PROKHOROV, A. M., and FEODOROV, V. B. (Physics
Institute imeni P. N. Lebedev, Academy of Science USSR)

"Laser Spark in 'Slow Burning' Mode"

47

Moscow, Pis'ma v Zhurnal Eksperimental'noy i Teoreticheskoy Fiziki, Vol 9,
No 11, 1969, pp 609-612

Abstract: During millisecond-pulse experiments with a neodymium glass laser the laser spark in the discharge space was noted to burn at a threshold below that of light breakdown. The process starts with an electrical breakdown in the discharge gap, where the ionized gas absorbs the laser radiation. This is followed by the burn, then the laser pulse. The axisymmetric spark along the beam axis is much longer than the initial region of ionization and burned many times longer than the duration of the electrical discharge, being governed by the duration of the generated pulse. The radiation intensity threshold of the effect is $\sim 10^7$ watt/cm²; that of the light breakdown at atmospheric pressure is 10^9 watt/cm².

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The spark in the 5-mm discharge gap, passing between two needle points charged to 6 kv by a 6.5 mf capacitor, is initiated by a laser pulse, which evaporates some metal from the needles. Details of the visible effect are given.

The threshold of the effect is 730 joules. The spark burning process is stationary and its average speed of development is 40 to 50 m/sec. The process is likened to slow burning of gas and differs from effects produced by giant laser pulses.

Orig. art. has 3 figs. and 5 refs.

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ABRAMOV, A. A., LUGOVOY, V. N. and PROKHOROV, A. M., Physics Institute imeni P. N. Lebedev, Academy of Sciences USSR

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"Self-Focusing of Ultrashort Laser Pulses"

Moscow, Pis'ma v Zhurnal Eksperimental'noy i Teoreticheskoy Fiziki, Vol. 9, No 12, 20 Jun 69, pp 675-679

Abstract: The propagation of "ultrashort" light pulses in a nonlinear medium, when the length of the pulse trains can be much less than (or of the order of) the width of the layer in which the self-focusing occurs, is discussed. This case is contrasted with previously considered cases when the length of the laser pulse is fairly great: i.e., the length of the light train is considerably greater than the width of the layer of the nonlinear medium through which the laser beam passes. Analysis of the field equations for this case shows that self-focusing of the light beam (with a maximum power greater than the ordinary critical power) occurs even in the case when the length of the corresponding light train is much less than the characteristic self-focusing length. It is noted that a basic feature here is the existence of a number

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of focal points, regions of very small dimensions and high energy concentration, on the axis of the beam. For ultrashort laser pulses these points arise at specific times and can split after forming. A method for determining the coordinates of all such focal points is given. It is shown that the longitudinal dimensions of the focal points in the self-focusing of very short pulses are much less than these dimensions for stationary self-focusing.

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26674 Optical homogeneity of ruby crystals and its connection with laser emission characteristics. Yu.K.Danileiko, V.Ya.Khaimov-Malkov, A.A.Manenkov, A.M.Prokhorov (P.N. Lebedev Physical Inst. Moscow USSR).

IEEE. J. Quantum Electronics (USA), vol.QE-4, no.5, p.391 (May 1968). (1968 international quantum electronics conference, Miami, Fl., USA, 14-17 May 1968).

Abstract only given. The optical homogeneity of the crystals was studied by observing the interference and birefringence patterns and the far-field intensity distribution using, as a probe light source, the Ne-He laser with the uniform plane wavefront beam. Good correlation was found between the laser characteristics and the optical properties of the investigated ruby samples. The different sources of the optical inhomogeneity of the ruby crystals grown by the Verneuil method and their influence on the laser characteristics are analyzed. It is shown, in particular, that the beam divergence and the far-field intensity distribution for the lasers with plane-parallel mirrors as a resonator are connected to the index of refraction inhomogeneity, which is due mainly to nonuniform chromium concentration and the internal strains in the investigated ruby samples.

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25335 On the problem of self-focusing of intense light beams. V.N. Lazo-
 voy, A.M. Prokhorov, P.N. Lebedev (Physical Inst. Moscow, USSR).
 IEEE J. Quantum Electronics (USA), vol. QE-4, no. 5, p.350 (May 1968).
 (1968 international quantum electronics conference, Miami, FL, USA, 14-17
 May 1968).
 Abstract only given, substantially as follows: A digital solution of the problem
 of self-focusing of axially symmetric beams in the medium of nonlinearity
 caused by the Kerr effect is obtained.

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96493c Vibrational relaxation of carbon dioxide and nitrogen molecules in an expanding ultrasonic gas flow. ~~Konyukhin, V. K.; Matrosov, I. V.; Prokhorov, A. M.; Shalunov, D. T.; Shirokov, N. N. (Inst. im. Lebedeva, Moscow, USSR). Pis'ma Zh. Eksp. Teor. Fiz. 1969, 10(2), 84-8 (Russ).~~ The absorption of a CO₂ laser in an ultrasonic gas flow, formed by the preliminarily heated gas, expanding from a slit into the vacuum was studied. The braking temp. of the mixt. of N and CO₂ was 1000°K., the braking pressure 4.2 atm., the slit dimensions 0.5 X 100 mm.; the distance between the coordinate of the observation, where the laser beam cuts the flow, and the slit plane was 1.6 cm. The results of measurements at 4 different concns. of CO₂ in the mixt. are given. The gas flow is vibrationally strongly unbalanced and the degree of the unbalance increases with increasing N content in the mixt. The relaxation time of the CO₂ mols. in the flow is ~1/10 the gas relaxation behind the shockwave front. For the mixts. contg. a great part of N, the concn. of CO₂ mols. in the upper laser level (00¹) increases owing to the selective transfer of vibrational excitation from N to CO₂ mols.; the N mols. remain longer in an excited state in the flow. Phys. premises concerning the effect of a gas-dynamic laser on the N and CO₂ mixts. are confirmed by these expts. J. Moravec *J. Mor*

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130614e. Time characteristics of the CaF₂-Dy³⁺ pulse laser in single-mode generation. Dzhibladze, M. I.; Murina, T. M.; Prokhorov, A. M. (USSR). *Opt. Spektrosk.* 1969, 21(3), 464-9 (Russ). The title time characteristics were investigated exptl. and a selection of oscillation modes was carried out. The generation threshold was studied as a function of diaphragm diam. for several values of the reflection coeff. The laser emission consists of regularly generated packets. Each packet comprises regular generation spikes. Each spike is accompanied by transients. The regular spikes in the packet, however, are not due to transient generation processes. The mechanism of the constant generation cut-off which leads to the appearance of the spikes was discussed. V. Burjan

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CHEMICAL ABST

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7829x Self-synchronization of transverse modes of a carbon dioxide laser. Arakelyan, V. S.; Karlov, N. V.; Prokhorov, A. M. (Fiz. Inst. im. Lebedeva, Moscow, USSR). *Pis'ma Zh. Eksp. Teor. Fiz.* 1969, 10(6), 279-E2 (Russ). The synchronization of transverse modes of a CO₂ laser with nonlinear BCl₃ absorber was studied. The synchronization of the modes was accompanied by spatial pumping of the laser radiation with an intermode beat frequency. The frequency interval between the transverse and longitudinal modes were, resp., 4.25 and 8.5 MHz. Strong signals were observed at differential frequencies accompanying the synchronization. Fast scanning of the CO₂ laser beam and a sequence of short pulses of the CO₂ laser radiation during diaphragm pumping of the beam can be obtained by the synchronization of a small no. of transverse modes of the laser with the help of a BCl₃ absorber. S. P. Stoylov

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ACC NR: AP9009321

SOURCE CODE: UR/0181/69/011/002/0335/0338

AUTHOR: Vinogradov, Y. A.; Zvereva, G. A.; Irizova, N. A.;
Mandel'shtam, T. S.; Prakhov, A. Y.; Shmaonov, T. A.

ORG: Fizicheskiy institut im. P. N. Lebedeva AN SSSR (Physics
Institute)

TITLE: Study of EPR of $\text{CaF}_2:\text{Dy}^{2+}$ at $T = 4.2^\circ\text{K}$ and in the 1.2--2.35 mm range

SOURCE: Fizika tverdogo tela, v. 11, no. 2, 1969, 335-338

TOPIC TAGS: laser optic material, laser spectroscopy, paramagnetic laser, dysprosium laser

ABSTRACT: EPR of $\text{CaF}_2:\text{Dy}^{2+}$ was investigated experimentally at $T = 4.2^\circ\text{K}$ and in the $\lambda = 1.7\text{--}2.35$ mm range (which could easily be extended lower) for transitions between the $E(2)$ and $T_1(1)$ levels of the 5I_8 term. The experimental CaF_2 crystal was 15 mm in diameter and 20 mm long and its ends were plane-parallel. The paper also defines the magnitude of the initial splitting between the $E(2)$ and $T_1(1)$ levels and the position of these and the wave functions with respect to the magnitude and direction of a constant magnetic field

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within the 0-5-koe range. The dependence of the $E(2)$ and $T_1(1)$ level energy on the magnetic field for $H_{01}C_1$, $H_{01}C_2$, and $H_{01}C_3$ are given, as are the experimental and theoretical curves for the dependence of transition wavelength on the magnitude of the magnetic field ($\vec{H}_{HF} \perp \vec{H}_0$). The value of the initial splitting was 4.867 cm^{-1} . The experiment made use of a flow-through resonatorless spectroscope with a backward-wave TWT as the microwave oscillator. The authors thank V. V. Osiko for preparing the crystals, K. V. Kiseleva for help in the x-ray analysis, and B. A. Yershov for cooperation in the computations. Orig. art. has: 3 figures. [WA-14] [YK]

SUB CODE: 20/ SUBM DATE: 02Sep68/ ORIG REF: 006/ OTH REF: 004

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Abstracting Service:

CHEMICAL ABST. 2-70

Ref. Code

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38537e X-ray luminescence of rare earth element ions in $Y_3Al_5O_{12}$ crystals. Voron'ko, Yu. K.; Denker, B. I.; Osiko, V. V.; Prokhorov, A. M.; Timoshechkin, M. I. (Fiz. Inst. im. Lebedeva, Moscow, USSR). Dokl. Akad. Nauk SSSR 1969, 188(6), 1258-60 [Phys] (Russ). Exptl. data are reported on the stationary excitation (at 300°K) of x-ray luminescence of trivalent rare earth ions (TR^{3+}) in $Y_3Al_5O_{12}$ crystals contg. up to 0.5% TR^{3+} (Nd, Sm, Eu, Gd, Dy, Tm, and Yb). An intensive x-ray luminescence was observed almost in all cases. The intensity of the x-ray luminescence is directly proportional to TR^{3+} concn. in the crystal, therefore it can be used for quant. detn. of small amts. (0.05-0.5%) of rare earth elements in $Y_3Al_5O_{12}$ crystals. The sensitivity of the x-ray luminescence detn. of rare earths depends on the nature of TR^{3+} and varies between 4×10^{-7} and $7 \times 10^{-8}\%$.

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BUZHINSKIY, I. M., DIANOV, YE. M., MAMONOV, S. K., MIKHAYLOVA, L. M., and PROKHOROV, A. M., Academician, Physics Institute imeni P. N. Lebedev of the Academy of Sciences USSR, Moscow

"Thermo-optical Characteristic of Glasses Activated by Neodymium"

Moscow, Doklady Akademii Nauk SSSR, Vol. 190, No. 3, 21 Jan 70, pp 558-561

Abstract: The problem of the thermal distortion of laser resonators associated with the development of glass lasers with a high energy density is discussed. It is noted that the active elements of neodymium-activated glass lasers have a high optical homogeneity; the change in the refractive index in a transverse cross section of the rod does not exceed $1 \cdot 10^{-7}$ for a 2.5-cm rod. However, this high homogeneity in the glass does not occur during laser operation, due to a temperature gradient developed by nonuniform pumping; this gradient, in turn, leads to a gradient in the index of refraction. A new method is presented for measuring directly the thermo-optical constant W of glasses, and values of W are given for the following neodymium-activated glasses: KGSS-3, KGSS-7, LGS-24-5, LGS-28-2, KGSS-46, LGS-36, and LGS-41. The LG-126 neon-helium laser was used as a source to measure the thermo-optical constants in the temperature interval 10-45°C at wave-

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BUZHINSKIY, I. M., et al, Doklady Akademii Nauk SSSR, Vol. 190, No. 3, 21 Jan 70, pp 558-561

lengths 0.63 and 1.15 μ . The minimum thermal distortion at this temperature was exhibited by glasses with a thermo-optical constant in the limits $(-10 - +10) \cdot 10^{-7} / ^\circ\text{C}$. Measurements showed that glasses MGSS-3 and LGS-41 satisfy conditions for minimum thermal distortion.

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GORBEIKO, B. Z., DROZHDEH, YU. A., KAYTMAZOV, S. D., MEDVEDEV, A. A.,
PROKHOROV, A. M., Academician, and TOLMACHOV, A. M., Physics Institute imeni
P. N. Lebedev, Academy of Sciences USSR, Moscow.

"Investigation of Optical Breakdown in Air Caused by Ultrashort Pulses Using High-Speed Photography With an Image Converter"

Moscow, Doklady Akademii Nauk SSSR, Vol. 187, No. 4, 1 Aug 69, pp 772-774

Abstract: The dynamics of spark development over the entire interval between laser pulses was examined in studying the breakdown in air caused by a series of ultrashort laser pulses, using high-speed photography of the plasmoids and the radiation pulses scattered by them. The distance between the points of breakdown was used to determine the average velocity of the propagation of the spherical shock wave in the plasma; analysis of the photography was also used to show that the maximum velocity may be considerably different from the aver-

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age velocity. Photographs were taken every 10-15 nsec. Photographs are shown of the development of a spark over an interval of 100 nsec. The velocity of the plasma as measured from the photographs has a sharp maximum reaching $4 \cdot 10^7$ cm/sec over a time interval of 2 nsec, while the average velocity of the plasma was equal to $10 \cdot 10^6$ cm/sec. Since the time of flight of the hot plasma with a velocity $4 \cdot 10^7$ cm/sec occurred after cessation of the laser pulse, the temperature was evaluated from the formula

$$T = 1.25 \cdot 10^{-2} V^2, \text{ } ^\circ\text{K},$$

giving an ion temperature $T = 6 \cdot 10^6 \text{ } ^\circ\text{K}$. It is noted that the formula of a spark by ultra-high light pulses is a complex physical process which will be discussed in further detail in a subsequent article.

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BATANOV, V. A., BUNKIN, F. V., BROKHOROV, A. M., Academician, and FELOROV, V. B.,
Physics Institute imeni P. N. Lebedev of the Academy of Sciences USSR, Moscow

"Gas Dynamic Molecular Laser With Optical Pumping"

Moscow, Doklady Akademii Nauk SSSR, Vol. 191, No. 6, 1970, pp 1267-1269

Abstract: Molecular gas lasers with incoherent optical pumping are claimed to have a relatively broad spectral band for the absorption of pumping light in a relatively narrow width of the working transition line. An infrared molecular laser is proposed with optical pumping to the molecules' rotation-vibration band in the electron ground state by incoherent radiation from a "fixed" shock-wave which arises during the stationary flow of the working gas mixture from a nozzle in an underexpanded state into a gas atmosphere. The composition of this gas may either coincide or not coincide with the composition of the working mixture. The working mixture in this discussion is assumed to be $\text{CO}_2 + \text{N}_2 + \text{He}$, in which the helium plays the same role as in CO_2 lasers with an electric discharge. It is noted that the nitrogen is not necessary to obtain inversion but it is desirable since it increases the effective lifetime of the upper laser level 00^0_1 (sic) and broadens the effective rotation-vibration band of the pumping absorption.

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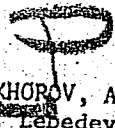
BATANOV, V. A., et al., Doklady Akademii Nauk SSSR, Vol 191, No 6, 1970,
pp 1267-1269

This version of the laser is intended to overcome technical difficulties encountered in IR molecular lasers with optical pumping in the traditional tube version, which were the restricted choice of optical materials in the IR range for laser tube with CO₂ gas and for pumping tubes, and also eliminate the requirement of maintaining a fairly high temperature of the working mixture ($\sim 200^{\circ}\text{K}$). Specific parameters are proposed for this laser to produce a power of approximately 500 w at one meter.

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Lasers & Masers

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KOROBKIN, V. V., BROKHOROV, A. M., SEROV, R. V. and SHCHELEV, M. YA., Physics
Institute imeni P. N. Lebedey, Academy of Sciences USSR

"Filaments Which Are Self-Focusing by Movement of Focal Points"

Moscow, Pis'ma v Zhurnal Eksperimental'noy i Teoreticheskoy Fizika, Vol. 11,
No. 3, 5 Feb 70, pp 153-157

Abstract: The question of whether filament self-focusing is the result of movement of individual focal points or whether it exists in a steady state is investigated. To clarify the problem of which theory is valid, the authors investigated the kinetics of self-focusing in liquids, using an electron-optical image converter. The radiation of a single-mode laser (one angular and one axial mode) was passed through a cell of length 10 cm containing nitrobenzene or carbon bisulfide. The radiation at the input to the cell had a plane phase front with an approximately normal transverse distribution. The diameter of the input beam was 0.25 mm and the power was up to 1.5 Mw for a pulse length of 15 nsec. A light filter was placed in front of the image converter which transmitted only laser radiation. A typical photograph shows that at the output of the vessel the diameter of the self-focusing spot is approximately 5 μ , corresponding to the resolution of the recording system. The self-focusing spot exists <0.5 nsec and then disappears; then a subsequent spot appears after

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KOROBKIN, V. V., et al, Pis'ma v Zhurnal eksperimental'noy i teoreticheskoy fizika, Vol. 11, No. 3, 5 Feb 70, pp 153-157

1-2 nsec at the same place. Sometimes another self-focusing spot appears at a distance of $\sim 50 \mu$, but this is observed very rarely. Under the conditions of this experiment the maximum value of $N = E/E_{cr} = 7$, where E is the input field strength and $E_{cr} = 1/\sqrt{n_2} (ka)^2$ (k is the wave number, a is the radius of the input beam, and n_2 is the nonlinear index of refraction). The steady-state theory predicts the existence of only seven focal points for $N = 7$, which is fairly close to the experimental data obtained in this paper. The velocity of the focal points is also in agreement with this theory. The authors feel that the experimental results support the validity of the steady-state theory of self-focusing.

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LUGOVOY, V. N., PROKHOROV, A. M. and STREL'TSOV, V. N., Physics Institute imeni P. N. Lebedev of the Academy of Sciences USSR

"On the Possibility of Generating Subpicosecond Pulses Under Forced Combination Radiation"

Moscow, Pis'ma v Zhurnal Eksperimental'noy i Teoreticheskoy Fiziki, Vol. 10, No. 2, 5 Dec 69, pp 564-567

Abstract: The phenomenon of forced combination radiation in a gas filling an optical resonator formed by slightly transparent mirrors is discussed. It is assumed that the resonator is excited by an external longitudinal monochromatic beam of a given intensity. It is further assumed that the resonator mirror has good reflection not only at the frequency of the incident beam but at the first, second, etc. Stokes frequencies. The stationary modes of light oscillations in a similar resonator filled with a liquid or solid active in a combination spectrum were discussed in two earlier papers by the authors. A feature of these modes is that the different Stokes components of the forced combination radiation interact only through two-photon transitions. Parametric interaction of these components is absent due to the fairly large dispersion in the refractive index for liquids and

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LUGOVOY, V. N., et al, Pis'ma v Zhurnal Eksperimental'noy i Teoreticheskoy Fiziki, Vol. 10, No. 2, 5 Dec 69, pp 564-567

solids. The dispersion of the refractive index of gases is fairly small, however. There will therefore be a strong parametric interaction between different Stokes components under forced combination radiation in a gas under these conditions. It is shown that in this case the phases of the light oscillations at different Stokes frequencies will be related to one another in a certain way, so that the total output radiation from the resonator will be a sequence of ultrashort pulses with a time interval between pulses of $T = 2\pi/\omega_0$, where ω_0 is the frequency difference between neighboring Stokes components. The length of a single pulse τ will be of the order T/N , where N is the total number of Stokes components generated. Since typical values for ω_0 are $100-1000 \text{ cm}^{-1}$, pulse lengths $\tau \leq 3 \cdot 10^{-14} - 3 \cdot 10^{-15}$ sec are achievable for $N \geq 10$.

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Acc. Nr: AP0038024

Ref. Code: UR 0056

PRIMARY SOURCE: Zhurnal Eksperimental'noy i Teoreticheskoy
Fiziki, 1970, Vol 58, Nr 1, pp 31-36

SURFACE DESTRUCTION OF RUBY CRYSTALS
BY LASER RADIATION

Yu. K. Danilyuk, A. A. Manenkov, A. ~~V. Ya. Khaimov-Mal'kov~~
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Processes of surface destruction of ruby crystals under the action of radiation from a ruby laser are investigated experimentally. The dependence of the threshold destruction power on duration of laser pulses ranging from $3 \cdot 10^{-7}$ to $4 \cdot 10^{-4}$ sec and the effect of structure-optical properties of the surfaces on destruction threshold are studied. A theory of thermal destruction on absorbing surface defects is developed. An expression is obtained for the dependence of the destruction power on duration of the light pulses. Good agreement is found between the experimental data and the theory of thermal destruction proposed.

REEL/FRAME
19731065

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C48

ACC NR: AP9009067

SOURCE CODE: UR/0568/69/010 (0317/0433/0235)

AUTHOR: Zolotov, Ye. M.; Prokhorov, A. M.; Shipulo, G. P
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ORG: none

TITLE: The mechanism of optical generation of $\text{CaF}_2:\text{Dy}^{2+}$

SOURCE: Zhurnal prikladnoy spektroskopii, v. 10, no. 2, 1969, 233-235

TOPIC TACS: laser optics, crystal laser, laser spectroscopy, laser R and D, luminescent crystal, calcium fluoride, crystal, calcium fluoride luminescence, crystal luminescence, calcium fluoride light emission

ABSTRACT: The role of the 5/6 term in the mechanism of optical generation of the $\text{CaF}_2:\text{Dy}^{2+}$ crystal was investigated to verify conclusions arrived at by Kiss (Phys. Rev., v. 137, 1965, A1749) and Pressley and Wittke (IEEE J. Quant. Electr., QE-3, 1967, 116). The authors investigated the same region (4500—11000 cm^{-1}) of the spectrum on a cylindrical specimen (Dy concentration ~0.1 mol %) 10 cm long excited by a ruby laser. A 300- μsec probe pulse train with 20-nsec intervals was fed into the specimen immediately after the end of the ruby emission cycle. Appropriate spectra of the

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ACC NR: AP9009067

train were separated by a monochromator and compared in terms of amplitudes to the spectrum of a similar train fed into an unexcited specimen. The absorption coefficient of the excited specimen was determined from the comparison data, and the spectrum was plotted point by point at 100—150-cm⁻¹ intervals. The lifetime at the 5000 cm⁻¹ region was found to amount to 15—20 msec. Special experiments with pumping of the specimen by unfocused and focused (by a system of cylindrical lenses) laser beams were conducted to identify the term to which the absorption level at 5000 cm⁻¹ applies. Some theoretical considerations show that if the absorption level at 5000 cm⁻¹ pertained to the 5/6 term, essentially the same absorption level should be observed for both pumping methods. However, the experiments showed a 3—5-fold lowering of the absorption level in the case of unfocused pumping. This observation leads to the conclusion that the spectral characteristic in the 5000-cm⁻¹ region is linked with absorption from the 5/7 term, i.e., the 5/6 term does not play the role assigned to it by the above-mentioned Western authors. In conclusion, the authors refer to the phenomenon of multiple spikes in CaF₂:Dy²⁺ emission from the 5/6 term reported earlier (Zolotov et al., Zh. eksperim. i teor. fiz., v. 49, 1965,

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ACC NR: AP9009067

720) and indicate that subsequent experiments have shown that the spikes stem from different modes with differing loss levels and, consequently, different time delays. Orig. art. has: 1 figure and 4 formulas. [WA-14] [FP]

SUB CODE: 20/ SUBM DATE: 02Aug68/ ORIG REF: 002/ OTH REF: 002

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UDC: None

BATANOV, V. A., BUNKIN, F. V., PROKHOROV, A. M., and FEDOROV, V. B.

"Light Self-Focusing in a Plasma and the Ultrasonic Ionization Wave in a Laser Beam"

Moscow, Pis'ma v Zhurnal Eksperimental'noy i Teoreticheskoy Fiziki, vol 16, No 7, 1972, pp 378-382

Abstract: This letter describes a new type of behavior of a plasma flare in which the flare almost fully absorbs a laser beam passed through it. In the experiment in which this phenomenon occurs, a bismuth target is vaporized by a laser beam into a helium atmosphere with a pressure of 2.5 to 5 atm. The laser beam has a wavelength of 1.06μ and an intensity of 10^7 W/cm^2 , emitted in a pulse of 1 ms duration. Photographs of the flare show the drift of the plasma cloud from the target and along the lens caustic, and they demonstrate the breakaway and drift of the flare from the target at the beginning of the process. The authors assert that they were the first, in 1969, to report this breakaway and thus to indicate the possibility of obtaining a strongly absorbent plasma by vaporizing a solid target. The photographs also indicate the

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BATANOV, V. A., et al., Pis'ma Zhurnal Eksperimental'noy i Teoreticheskoy Fiziki, vol 16, No 7, 1972, pp 378-382

development of the self-focusing effect, caused by the aforementioned lens, and the plasma bunching produced by the focusing. The front of the ultrasonic ionization wave is at the back of the plasma cloud, with the length of the cloud increasing as a result of the ionization wave-front motion in the direction of the laser beam. The authors are connected with the P. N. Lebedev Institute of Physics.

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DAVIDOV, A. A., KULEVSKIY, L. A., PROKHOROV, A. M., SAVEL'YEV, A. D., and SMIRNOV, V. V., Physics Institute imeni P. N. Lebedev, Academy of Sciences USSR

"Parametric Oscillation of a CdSe Crystal With Pumping From a $\text{CaF}_2:\text{Dy}^{2+}$ Laser"

Moscow, Pis'ma v Zhurnal Eksperimental'noy i Teoreticheskoy Fiziki, Vol 15, No 12, 20 Jun 72, pp 725-727

Abstract: The authors report obtaining parametric oscillation for the first time of a CdSe semiconductor crystal. The parametric radiation wavelengths were 3.37 and 7.86 microns. The pumping source used was a Q-switched $\text{CaF}_2:\text{Dy}^{2+}$ crystal laser with a laser wavelength of 2.36 microns and a repetition rate of 1 Hz. The resonator of the parametric oscillator was formed by two plane-parallel dielectric mirrors applied to fluorite substrates. The authors thank YU. N. POLIVANOV for useful discussions.

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UDC: 621.396.677.73

PROKHOROV, A. T.

"Some Problems of Calculating a Generalized Family of 'Hyperexponential' Horns"

Izv. Leningr. elektrotekhn. in-ta (News of Leningrad Electrical Engineering Institute), 1972, vyp. 102, pp 144-150 (from RZh-Radiotekhnika, No 12, Dec 72, abstract No 12B55 [résumé])

Translation: A wave equation is derived for a family of hyperexponential horns which accounts for the phase mismatch of oscillations in cross sections perpendicular to the axis. The solution of the equation is given and the impedance in the throat of the horn is determined for an exponential horn. It is shown that accounting for the phase mismatch of oscillations has no effect on the cutoff frequency. Formulas are presented for the polar patterns of a family of horns. The computations showed a lower frequency dependence of the directional characteristics of hyperexponential horns as compared with exponential horns. a formula is derived for the second harmonic which arises in hyperexponential horns when a wave of finite amplitude develops in them. Bibliography of 5 titles.

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PROKHOROV, A. V.

"Sums of Random Vectors"

Teoriya Veroyatnostey i Ee Primeneniya [Theory of Probabilities and its Applications], 1973, Vol 18, No 1, pp 193-195 (Translated from Referativnyy Zhurnal Kibernetika, No 6, 1973, Abstract No. 6V23, by the author).

Translation: This work suggests one version of a multidimensional analogue of the Kolmogorov-Bernshteyn inequality. Suppose X_1, \dots, X_n are identically distributed, independent random vectors in R^m , for which $EX_i = 0$, $|X_i| < L$, $Y_n = \sum_j X_j / \sqrt{n}$. It is assumed that the Eiganvalues of the covariation matrix for X_i are $\lambda_1 = \dots = \lambda_m = \lambda$. Under these conditions, it is proven that where $\rho^2/2 \geq m$ and $a = Lr/\lambda\sqrt{n} \leq 1$,

$$P\{|Y_n| \geq \rho\sqrt{\lambda}\} < C_{\alpha} Q(\rho, m) \exp\left\{-\frac{\rho^2}{2}(1-\eta(a))\right\}$$

where $Q = (\rho^2/2)^{(m-1)/2} / \Gamma(m/2)$ and $\eta(a) \rightarrow 0$ as $a \rightarrow \infty$.

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