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JPRS L/9033

15 April 1980

USSR Report

PHYSICS AND MATHEMATICS

(FOUO 4/80)

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15 April 1980

USSR REPORT

PHYSICS AND MATHEMATICS

(FOUO 4/80)

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PHYSICS

ACOUSTICS

UDC 681.883(07)

PRINCIPLES OF HYDROACOUSTICS

Leningrad OSNOVY GIDROAKUSTIKI in Russian 1979 pp 2-3, 212-213, 215-216

[Annotation, foreword, table of contents and book advertisements from the book "Osnovy Gidroakustiki" by Izabella Aleksandrovna Rumynskaya, Izdatel'stvo Sudostroyeniye, signed to press 2 November 1978, 7,200 copies, 216 pages]

[Text] ANNOTATION

In this textbook the author explains the basic questions related to the theory of the propagation, emission and reception of acoustic waves. She gives special attention to features of the propagation of hydroacoustic signals under the conditions encountered in a marine medium. She also discusses the principles of hydrophone direction-finding and echo direction-finding.

This textbook is intended for tekhnikums graduating specialists in hydroacoustics, but it can also be used as a teaching aid for students at higher technical educational institutions who are specializing in this area.

FOREWORD

The content of this textbook is determined by the program of the course "Principles of Hydroacoustics."

The author gives an account of the basic problems in physical acoustics, discusses vibrations of mechanical systems, presents a method of electromechanical analogies that is widely used in technical acoustics at the present time, and describes the factors determining sound propagation in the sea and the operating principles of shipborne hydroacoustic equipment intended for direction-finding of noisemaking objects.

In her explication of the material, she gives particular attention to explaining the physics of the phenomena related to the processes under discussion so as to prepare the student for the study of other special courses such as "Hydroacoustic Converters and Antennas," "Hydroacoustic Stations" and "Hydroacoustic Measurements."

The author considers it a pleasant duty to express her gratitude to Candidate of Technical Sciences Yu.F. Tarasyuk and Doctor of Technical Sciences A.L. Prostakov for reviewing the manuscript and for their valuable comments.

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BOOK ADVERTISEMENTS

THE ELECTRONIC KEY TO THE OCEAN

Leningrad ELEKTRONNYY KLYUCH K OKEANU in Russian 1978 13 sheets

PROSTAKOV, A.L.

The author correlates a voluminous amount of material that reflects the present state and prospects for the development of a variety of hydroacoustic equipment used in studying and mastering the world ocean. He discusses the purpose, operating principle and organization of hydroacoustic equipment for detection, communication, telemetry, underwater "seeing" with sound and navigation, gives their generalized characteristics, and presents information on the outfitting of deep-water vessels and scientific research and oceanographic ships.

This book is intended for hydroacoustic specialists, as well as specialists in other disciplines who are working in the field of developing the world ocean, students at technical VUZ's and everyone interested in new areas in the development of modern technology.

PROCESSING HYDROACOUSTIC INFORMATION ON SHIPBORNE DIGITAL CO PUTERS

Leningrad OBRABOTKA GIDROAKUSTICHESKOY INFORMATSII NA SUDOVYKH TSVM in Russian 1979 11 sheets

ROKOTOV, S.P., and TITOV, M.S.

The authors give an account of methods for processing hydroacoustic (including telemetric) information on shipborne digital computers that are widely used to solve applied problems of modern hydroacoustics. They discuss in detail the question of organizing the input of hydroacoustic signals into digital computers. They also present the results of research into the identification of marine objects, the detection of hydroacoustic signals against a background of interference, and studies of the properties of marine reverberation.

This book is intended for scientific workers and engineers who are specialists in the field of hydroacoustics and computer technology, graduate students and students in the corresponding specialists, and everyone who is interested in the practical utilization of digital computers for processing random signals.

[112-11743]

11746
CSO: 1862

CRYSTALS AND SEMICONDUCTORS

UDC 621.315.5:542.91+592.3

GROWTH AND ALLOYING OF SEMICONDUCTING CRYSTALS AND FILMS. PART 1

Novosibirsk ROST I LEGIROVANIYE POLUPROVODNIKOVYKH KRISTALLOV I PLENOK. CHAST' 1 in Russian 1977 pp 2, 311-314

[Annotation and table of contents from the collection of works "Rost i Legirovaniye Poluprovodnikovykh Kristallov i Plenok. Chast' 1," edited by Fedor Andreyevich Kuznetsov, doctor of chemical sciences, Institute of Inorganic Chemistry, Siberian Department, USSR Academy of Sciences, Izdatel'stvo Nauka (Siberian Division), signed to press 6 April 1977, 2,800 copies, 328 pages]

[Text] ANNOTATION

This collection of works is the first of two books from materials of the Fourth All-Union Symposium on Growth and Synthesis Processes in Semiconducting Crystals and Films. The authors discuss the general rules of the growth and distribution of impurities during the crystallization of crystals and films from a gaseous phase, from a melt and from a solution in a melt. They also cover the chemical composition of impurities and new methods for investigating irregularities in crystals and films.

This book will be of interest for specialists in the field of the synthesis and growth of semiconductors, as well as those engaged in the technology of semiconducting instruments for microelectronics.

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Methods for Investigating Irregularities in Crystals and Films

[114-11746]

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CSO: 1862

CRYSTALS AND SEMICONDUCTORS

KINETICS OF GROWTH AND DISSOLUTION OF CRYSTALS

Leningrad KINETIKA ROSTA I RASTVORENIYA KRISTALLOV in Russian 1979 signed to press 25 Jan 79 pp 2, 247-248

[Annotation and table of contents from book by Yevgeniy Borisovich Treybus, Leningrad University Press, 1,700 copies]

[Text] This book represents the first attempt to create a textbook for a course in the experimental kinetics of crystal growth. In it are discussed the procedure for kinetics investigations, processes of crystallization and dissolution in different systems, different conditions for the formation, growth and dissolution of crystals with the involvement of applied problems of the theory of mass exchange, and practical applications of kinetics in geology, chemistry and physics.

Intended for student geologists, chemists and physicists, and also of interest to specialists in the field of crystal formation.

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[111-8831]

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CSO: 1862

ELECTRICITY AND MAGNETISM

COLLECTIVE ION ACCELERATION BY ELECTRON RINGS

Moscow KOLLEKTIVNOYE USKORENIYE IONOV ELEKTRONNYMI KOL'TSAMI (Collective Ion Acceleration By Electron Rings) in Russian 1979 signed to press 27 Feb 79 pp 2-4, 216

[Annotation, Foreword and Table of Contents from book by Vladislav Pavlovich Sarantsev and Elkuno Avrumovich Perel'shteyn, Atomizdat, 1,290 copies, 216 pages]

[Text] Collective acceleration of ions by electron rings is a new effective method of acceleration which was developed during the past decade. The book contains the results of theoretical and experimental investigations on the collective method of acceleration. Problems of forming the electron rings, loading them with ions and acceleration are considered. The stability of the electron-ion rings in collective accelerators is analyzed.

The book is intended for scientific workers and postgraduate students working in the field of accelerator technology and plasma physics and also for students of higher-level courses with physics specialty.

Foreword

Investigation on the problem of collective acceleration of ions by electron rings has been conducted for approximately a decade in many laboratories of the world.

Groups involved in the collective method of acceleration were formed at ITEF [Institute of Theoretical and Experimental Physics] (Moscow), IYaF [Institute of Nuclear Physics] (Tomsk), Berekley (United States), Garsching and Karlsruhe (West Germany) and other scientific centers after the first communication at the International Conference on Accelerators in 1967 (United States) on the theoretical and experimental results achieved at Dubna under the supervision of V. I. Veksler.

The advantage of the new method is its universality--collective accelerators can essentially overlap the entire energy range of interest for physics investigations. Construction of collective accelerators is economically much more advantageous than construction of traditional accelerators. Heavy-ion collective accelerators are finding the most diverse applications in industry, chemistry, biology, medicine and so on.

The intensive work of many investigators of the collective method is reflected in the large number of journal articles and in the proceedings of conferences and symposia. There are no monographs which generalize the numerous papers on the given topic. We feel that this book should partially fill the existing gap in survey papers on the collective method of acceleration by electron rings.

In working on the book, we attempted to resolve many problems. On the one hand, this book should provide an overall concept of the collective method of acceleration by electron rings and on the other hand, it should be useful to people directly involved in calculations of collective accelerators and experiments on them. Therefore, materials of a calculation-theoretical nature are included. Moreover, development of the collective method of acceleration, like investigations on storage of relativistic particles, stimulated careful study of the dynamics of heavy-current annular beams. The aspects of this problem most significant for the method are reflected here. Thus, we were forced to proceed toward obvious non-uniformity of the treatise.

We also note that the given book is far from a complete survey on the collective method of ion acceleration. We feel that established facts are reflected in it. Many problems touched on in the book still await their own solution. We hope that the book will be useful even in this aspect. In surveying the literature, we did not attempt to provide an exhaustive bibliography on the considered problem but restricted ourselves only to necessary references.

In working on the book, we had the invaluable assistance of colleagues of the Department of New Methods of Acceleration of OIYaI, specifically V. S. Aleksandrov, Yu. I. Aleksakhin, N. Yu. Kazarinov, A. A. Popov, V. A. Preyzendorf, A. P. Sumbayev, V. S. Khabarov, V. F. Shevtsov, B. G. Shchinov, G. Shchornak et al. We express heartfelt gratitude to all of them.

We are also very grateful to I. A. Zolina, N. A. Filippova and V. Yu. Shevtsova for the extensive work that they did in formulating the manuscript.

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CSO: 1862

LASERS AND MASERS

UDC 621.378.325

ON CONVERTING THE RADIATION OF A LASER HAVING AN UNSTABLE RESONATOR WITH THE HELP OF CONICAL OPTICS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 7 No 1 (91), Jan 80 manuscript received 27 Jun 79 pp 142-146

[Article by S.I. Zavgorodneva, V.I. Kuprenyuk, V.V. Sergeyev and V.Ye. Sherstobitov]

[Text] The authors discuss the possibility of reducing the angular divergence of the radiation at the outlet of a laser with an unstable resonator by converting the beam's cross-sectional shape with the help of conical optics. They present the results of experiments with a CO_2 laser that show that the use of a conical converter at the outlet of a laser with a small gain (that is, with the magnification ratio of the unstable resonator being close to unity) should result in a significant gain in the radiation's directivity.

In a number of areas of laser technology there arises the problem of converting the shape of the radiation beams' cross-section. In this article this problem is discussed using a laser with an unstable resonator as an example. As is known (see, for example, [1]), in a geometrical approximation the cross-section of a beam at the outlet of an unstable resonator with circular mirrors has the form of a ring of width $t = (M - 1)a$, where M is the resonator's magnification and 2a is the outlet mirror's diameter. From power considerations, in lasers with small amplification factors at the resonator's aperture (in CO_2 GDL's [probably gas-dynamic laser], for example), magnification M is chosen to be close to unity, so the ring's relative width t/2Ma proves to be extremely small. In this case, one of the basic shortcomings of the laser is the large angular divergence of the generated radiation, the theoretical limit of which even exceeds substantially the value

$\lambda/(2Ma)$ that is characteristic for a disk radiator with the same beam diameter (λ = wave length of the emitted radiation). This flaw can be compensated for to a considerable degree if the radiation beam, the cross-section of which has the shape of a narrow ring, is converted into a beam of the same diameter for which the relative width of the ring in cross-section exceeds the original width to a noticeable degree. Such conversion can be accomplished with the help of various optical devices with aspherical surfaces [2-4], and in particular with the help of conical reflectors.

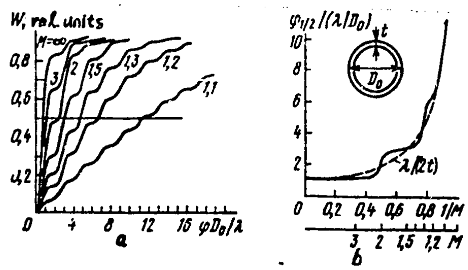

Figure 1.

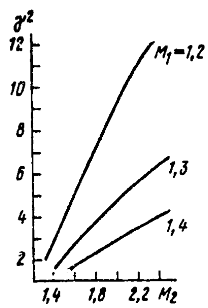

Figure 2.

Before moving on to the discussion of the features of an actual conversion arrangement, let us examine the dependence of the angular characteristics of an annular beam with an intensity that is uniformly divided with respect to its cross-section and a plane front on the ratio of the ring's outer diameter to its inner diameter. As follows from Figure 1a, where the results of the corresponding numerical calculations are presented, in the case of a disk radiator ($M = \infty$), half of all the power is concentrated in a cone with an angle at the apex of $\varphi_{\frac{1}{2}} \sim \lambda/D_0$, where D_0 is the beam's outer diameter. This angle increases as the ring is constricted, and for M = 1.2 it is $\sim 7\lambda/D_0$. As is obvious from Figure 1b, the dependence of $\varphi_{\frac{1}{2}}$ on the ring's width is described sufficiently well by the expression

$$\varphi_{1/2} \approx \lambda/(2t) = \lambda M/[D_0(M-1)]. \quad (1)$$

Thus, the maximum relative gain γ in the half-width of the radiation pattern that can be obtained as the result of conversion of the cross-section is determined by the relationship

$$\gamma \approx M_1(M_2-1)/[(M_1-1)M_2], \quad (2)$$

where M_1, M_2 = parameters of the ring before and after conversion. As follows from Figure 2, in the cases that interest us the value of γ^2 that characterizes the increase in the radiation's average density in the angle $\varphi_{\frac{1}{2}}$ can be $\geqslant 10$.

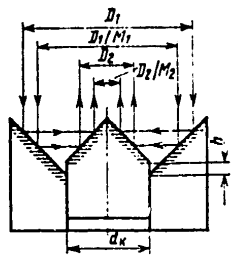

Figure 3.

Figure 3 is a diagram of one of the conical converter variants. The converter consists of two conical reflectors with a 90° angle at the apex. The inner reflector can be moved in the axial direction, which makes it possible to vary the converted beam's M_2 parameter. As is obvious from this figure, the ring's relative width actually increases during the conversion since its absolute width t is preserved and its outer diameter becomes smaller. It is not hard to see that the beam's parameters before and after conversion are related by the relationship

$$D_2/D_1=M_2(M_1-1)/[M_1(M_2-1)]. \quad (3)$$

For the sake of simplicity let us assume that the change in the amplitudinal distribution in connection with the conversion can be ignored. It then follows directly from formula (1) that such a conical converter possesses a property that is interesting from the practical point of view: it reduces the diameter of an annular beam while preserving the half-width of the radiation's angular distribution. The ring's width t actually does not change during conversion and, consequently, the value of $\varphi_1 \approx \lambda/(2t)$ also remains practically unchanged. If the converted beam is expanded by a factor of D_1/D_2 with the help of a telescope -- that is, its size is brought up to its original value -- the beam's divergence will be greatly reduced. By comparing (3) and (2) it is easy to see that in connection with this, the maximum gain in the radiation's density in the distant zone, as determined by the curves in Figure 2, is realized.

All of what has been said above applied to the case where the beam at the conical converter's outlet has a uniform distribution of intensity relative to the annular cross-section. In actuality this distribution is uneven because of variability of the areal conversion ratio at different points in the cross-section. Although in and of itself this nonuniformity [5] has an insignificant effect on the half-width of the radiated power's angular distribution (it is finite and within reasonable limits), knowledge of the distribution of the intensity is still necessary, for example, in order to prevent such undesirable phenomena as optical failure of the converter's surface, thermal deformation of the reflecting elements and others. The shape of this distribution obviously depends on the distribution of the intensity in the incident beam. From the geometrical relationships it follows that the density of the radiation in the incident and reflected beams is related in the following manner:

$$I_{ref}(r)=I_{inc}(R)R/r, \quad (4)$$

where r = transverse coordinate (reading from the converter's axis) that satisfies the condition $0 \leq r \leq d_k$; d_k = diameter of the internal cone; $R=\left[\frac{D_1}{2}\frac{(M_1M_2-1)}{M_1(M_2-1)}-r\right]$ = coordinate of the point connected by the conversion to point r.

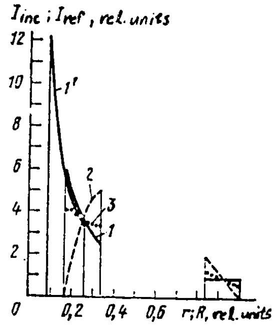

Figure 4.

From (4) it follows that when the intensity of the annular beam striking the converter is constant with respect to its cross-section, the reflected radiation is concentrated in the preaxial zone. This is quite obvious in Figure 4 (curve 1), where as an example we have presented graphs of $I_{ref}(r)$ for different intensity distributions $I_{inc}(R)$ in the incident beam; these distributions are shown on the right side of the figure by lines of the same type as the $I_{ref}(r)$ factors that correspond to them. As M_2 increases, so do the nonuniformity of the density of the radiation in the reflected beam and the density's absolute values. This is apparent from curve 1', which was plotted for the same initial distribution ($I_{inc}(R) = 1$) as curve 1, but for $M_2 = 3$ instead of 2, as in the first case.

In practice we normally encounter annular beams in which the distribution of the radiation's intensity in the radial direction is not constant across the ring's width. In particular, in lasers with unstable resonators having magnification ratios that are close to unity, the radiation density as averaged for the size of Fresnel's zone usually decreases toward the ring's periphery as the result of diffraction effects. When such radiation beams are converted, no concentration of intensity in the preaxial zone occurs, but for some laws governing the change in $I_{inc}(R)$, I_{ref} depends only slightly on r (see curve 3 in Figure 4; all three distributions of $I_{inc}(R)$ have been normalized for the same power in the incident beam).

As is obvious from the figure, the average intensity value $I_{ref}(r)$ for all the cases under discussion, which correspond to the same M_2 parameter, coincide for all practical purposes. It is not difficult to convince oneself that these average values are extremely close to the density value determined by the ratio of the areas of the rings in the incident and reflected beams:

$$\left(\frac{I_{ref}}{I_{inc}}\right)_{av} \approx \frac{S_{inc}}{S_{ref}} = \frac{(M_1+1)(M_2-1)}{(M_1-1)(M_2+1)}. \quad (5)$$

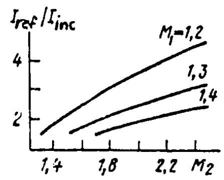

Figure 5.

The dependence of this ratio on M_2 is shown in Figure 5 for a series of values of M_1. As is obvious from this figure, in the cases that are of interest the average density of the radiation at the converter's outlet can be several times greater than the density in the incident beam and it increases as M_2 does. In each case, the final choice of the value of M_2 is based on a comparison of Figures 2 and 5, starting with the specific form of the distribution of the intensity in the incident beam, the requirements for radiation divergence at the system's outlet, and the value of the maximally allowable power density. As a rule, using a converter with $M_2 > 2.5$ is not advisable, because for large values of M_2 the radiation densities become extraordinarily large and the gain in divergence (as follows from Figure 1b) increases extremely slowly.

We conducted an experimental investigation of the practical possibility of converting an annular beam with the help of a conical converter. The investigations were performed on the basis of a continuous-action flow-through CO_2 laser. The annular beam was formed with the help of an unstable resonator with field rotation [6]. The diameter of the beam at the outlet was 26 mm. The conical converter had the following parameters: outer and inner cone diameters -- 120 and 36 mm, respectively; angle at the apex of the conical reflectros -- $90^\circ \pm 30''$. The cones' generatrix's deviation from rectilinearity was no more than 1 μm in the reflecting surface's working zone.

In order to match the beam's diameter with the diameter of the inner conical reflector, an enlarging telescope that brought the beam's outer diameter up to 80 mm was used. Directly in front of the converter we placed an annular diaphragm that cut off a beam with an outer diameter of 76 mm, and inner diameter of 64 mm ($M_1 \approx 1.2$), and a radiation intensity distribution that was close to uniform.

The shape of the thermogram of the radiation beam falling on the reflector is shown in Figure 6a. With the help of aligning movements the reflector was set so that its axis made an angle

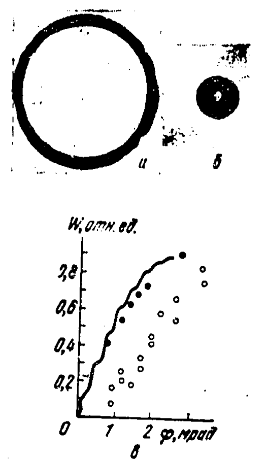

Рис. 6.

Figure 6.

of no more than 2' with the direction of the incident beam (such was the accuracy of the alignment, which was performed with the help of an He-Ne laser, the direction of which coincided with that of the CO_2 laser's radiation). Figure 6b is a thermogram of the radiation beam at the converter's outlet; its was obtained in connection with a displacement of the inner cone corresponding to M_2 = 2.25 (the exposure time for this thermogram was approximately one-third of the exposure time in the case of Figure 6a).

The angular divergence of the beams striking the reflector and reflected from it was measured calorimetrically, by the method of diaphragms. The results of the measurements are presented in Figure 6c. The distribution of the radiated power by angles in the incident beam (the black dots in Figure 6c) coincides quite well with the theoretical distribution, as determined by diffraction of a plane wave on a ring with the appropriate dimensions. The white circles designate the results of the measurement of the converted beam's divergence that were obtained in different series of experiments.

From Figure 6c it is obvious that the converted beam has an angular power distribution half-width that is about twice as large as could have been expected from the preceding discussion. The reasons for this discrepancy can be as follows. In the first place, when we made our estimates we did not take into consideration the depolarization of the radiation that, as is shown in [7], takes place in the case of the converter configuration used by us. The estimates show that the differences in the orientations of the polarization vector relative to the converted beam can actually lead to a noticeable enlargement of the angular distribution. In practice, therefore, it is more advisable to use a conical converter of the flow-through type [7] in which depolarization of the radiation does not occur. Secondly, as interferometric studies have shown, the quality of the mirror surface of the outer conical converter would not be too high (its generatrix had a relief with a depth of 0.3-0.6 μm and a period of 3-5 mm). The generatrix's unevenness also explained the comparatively low accuracy of the placement of the converter's axis relative to the incident beam's direction. It is clear that as the technology for manufacturing conical mirror surfaces is improved, these flaws can be eliminated.

Nevertheless, even with such a difference in the divergence of the incident and reflected beams, the converter that we used is utilitarian. Actually, if the size of the converted beam is brought to its original magnitude with the help of a telescope, the angular distribution's half-width will decrease by a factor of 4.4, which abundantly compensates for the twofold gain in energy that appeared during the conversion process.

In conclusion the authors wish to express their deep gratitude to I.A. Bochkovskiy for developing the technology for and manufacturing the conical reflectors, A.A. Belokon', who stimulated out interest in this work and gave us a great deal of assistance in performing it, and Yu.A. Anan'yev for his useful discussion of the results we obtained.

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[110-11746]

11746
CSO: 1862

LASERS AND MASERS

UDC 621.378.3+681.535

CONTINUOUS-WAVE LASER RADIATION POWER STABILIZERS WITH AN EXTERNAL CONTROL ELEMENT

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 7 No 1 (91), Jan 80 manuscript received 27 Jun 79 pp 147-154

[Article by S.V. Andreyev, O.N. Kompanets and Ye.L. Mikhaylov, Institute of Spectroscopy, USSR Academy of Sciences, Moscow]

[Text] The authors discuss the features of the active method for suppressing continuous-wave laser radiation power fluctuations, up to the recording system's noise level, with the help of an external control element. They describe two complementary, effective, experimentally tested plans for stabilizing the power of a CO_2 laser that suppress slow and fast fluctuations with coefficients greater than 10^2.

1. When taking measurements in which a laser is used as the radiation source, there frequently arises a situation where the maximum achievable sensitivity of the measurement method is determined by fluctuations in the laser radiation's power. Variability in a laser's output power can be the result of a whole series of causes (see, for example, [1]) that lead to the appearance in the radiation spectrum of quite intensive (with an amplitude of up to 20 percent) composite noise components with frequencies ranging from fractions of a cycle per second to hundreds of cycles per second, as well as weaker (with an amplitude of less than 1 percent) fast components with frequencies of up to hundreds of kilocycles per second. The limitations related to laser radiation noise manifest themselves particularly in instances where photoreceivers with a very low intrinsic noise level are used. Such a situation is frequently realized during the registration of weak modulation of the intensity of a laser's radiation that arises as the result of the

action of any investigated effect during the passage of the radiation through a medium against a background of a large, constant intensity component.

For example, when making polarization measurements using a continuous-wave CO_2 laser as the radiation source and a photoresistor based on the triple compound CdHgTe and cooled with liquid nitrogen as the receiver, the latter's dynamic range makes it possible to register a modulation depth of $\sim 10^{-6}$-10^{-7} over a wide range of modulating frequencies, even though the fluctuations in the laser radiation's output power at these frequencies can exceed the photoreceiver's intrinsic noise by 2-3 orders of magnitude. Therefore, there arises the necessity of reducing these fluctuations, either by stabilizing the laser's operating conditions (protecting its elements from mechanical, acoustical and thermal effects, obtaining single-frequency generation, active stabilization of the discharge current and the density of the excited molecules, and so on [1-5]) or -- along with passive means -- by acting directly on the output radiation's energy parameters for the purpose of maximum compensation for the possible fluctuations.

Let us examine in more detail the case that interests us: the observation of weak modulation caused by the action of the investigated effect against a background of a large, constant intensity component. For simplicity's sake, we will assume the modulation to be sinusoidal with frequency Ω, while the spectral density of the power of the laser radiation's fluctuations is constant in the band of frequencies from 0 to ω_{max}. Such as idealized approach will make it possible to achieve a better understanding of the effect of different parts of the spectrum of the laser radiation's fluctuations' power on threshold sensitivity and the accuracy of the measurement of the weak modulation's signal.

Let us write the intensity of laser radiation that has interacted with a medium in the form

$$I(t)=I_0(t)A(1+M\cos\Omega t), \tag{1}$$

where $I_0(t)$ = intensity of the incident radiation; M = depth of the weak ($M \ll 1$) modulation that has been induced with frequency Ω; A = coefficient characterizing the absorption of the medium under investigation ($A \leqslant (I_0 - M)/I_0$). In order to ascertain the dependence of the spectral density of the power of signal (1) on the frequency, let us first find the autocorrelation function for I(t) [6]:

$$\psi(\tau)=\psi_0(\tau)\psi_1(\tau), \tag{2}$$

where $\psi_0(\tau)$, $\psi_1(\tau)$ = autocorrelation functions of $I_0(t)$ and the modulating process. For a constant density W_0 of the laser radiation's fluctuations' power, according to [6] the autocorrelation functions will have the form

$$\psi_0(\tau) = \frac{1}{2\pi}\int_{-\infty}^{\infty} W_0 e^{i\omega\tau} d\omega = \frac{1}{2\pi}\int_{-\omega_{max}}^{\omega_{max}} W_0 e^{i\omega\tau} d\omega = \frac{W_0}{\pi}\frac{\sin(\omega_{max}\tau)}{\tau}; \quad (3)$$

$$\psi_1(\tau) = A^2 + \frac{A^2M^2}{2}\cos\Omega\tau. \quad (4)$$

The spectral density of the power of signal (1) is

$$W(\omega) = \int_{-\infty}^{+\infty} \psi(\tau)\, e^{-i\omega\tau} d\tau = \int_{-\infty}^{+\infty} \psi_0(\tau)\,\psi_1(\tau)\, e^{-i\omega\tau} d\tau = \frac{2W_0A^2}{\pi}\int_0^{\infty}\frac{\sin(\omega_{max}\tau)}{\tau}\cos(\omega\tau)\,d\tau + \frac{A^2M^2W_0}{2\pi}\int_0^{\infty}\frac{\sin[(\omega_{max}+\Omega)\tau]}{\tau}\cos(\omega\tau)\,d\tau + \frac{A^2M^2W_0}{2\pi}\int_0^{\infty}\frac{\sin[(\omega_{max}-\Omega)\tau]}{\tau}\cos(\omega\tau)\,d\tau. \quad (5)$$

Taking into consideration the fact that

$$\int_0^{+\infty}\frac{\sin(mx)\cos(nx)}{x}dx = \begin{cases}\pi/2 & (m>n>0);\\ 0 & (n>m>0),\end{cases} \quad (6)$$

let us discuss the spectral density of the power of signal (1) at the modulation frequency Ω at which the observations are made. It is

$$W(\Omega) = W_0A^2 + A^2M^2W_0/4 \quad (7)$$

assuming that $(\omega_{max} - \Omega) < \Omega$ and $\omega_{max} > \Omega$ (the latter condition means that the modulation frequency falls in the noise spectrum 0-ω_{max}). In the case where $(\omega_{max} - \Omega) > \Omega$, there appears a third term in expression (7) that describes the beat signal with frequency Ω between the modulation signal and the laser's noise near frequency 2Ω; in the real spectrum it can be ignored.

In order to understand the meaning of the components on the right side of expression (7), let us assume that $\omega_{max} < \Omega$ (frequency Ω does not fall into the laser's noise spectrum). From (5) and (6) it then follows that term W_0A^2 in expression (7) becomes zero. From this, it is easy to see that this term describes the signal caused by the laser's noise at frequency Ω. The second term in (7), $A^2M^2W_0/4$, which does not disappear no matter how small the value of ω_{max}, describes the signal caused by useful modulation of the radiation's intensity and the laser's low-frequency noise (during observations in a narrow band). Its meaning is obvious when a signal of the form $A \cdot \cos(\omega_1 t) \times B \cdot \cos(\omega_2 t)$ is compared with the expression $A^2B^2/4$ for medium power: it expresses the average power of the unknown modulation signal at frequency Ω that was modulated by fluctuations in the laser radiation. Thus, in cases where radiation modulation as the result of some effect is weak ($M \ll 1$, $A \sim 1$), even small (with an amplitude of $\sim$1 percent) high-frequency fluctuations in the radiation's intensity can "jam" the useful signal, while comparatively large (with an amplitude of up to 20 percent) slow fluctuations affect only the accuracy of the measurement, by leading to modulation of the useful signal's amplitude within the appropriate limits.

In a number of cases where the signal registered at frequency has been modulated with a depth of $\sim$100 percent (this occurs when the energy absorbed in the medium is measured by -- for example -- the opticoacoustic method), rapid radiation power fluctuations at frequencies close to the modulation frequency will not exert any substantial influence on the measurement sensitivity in view of their relative smallness, although slow fluctuations will, as before, determine the accuracy of the measurement of the effect being investigated.

In this article we describe two experimentally tested methods for stabilizing the power of a laser's radiation with the help of an external control element, which methods make it possible to compensate effectively for slow and rapid intensity fluctuations. Here the control elements are an electro-optical modulator and a Fabry-Perot interferometer, which are used to stabilize the power of a continuous-wave CO_2 laser's radiation.

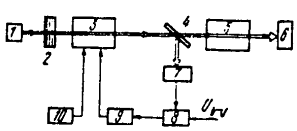

Figure 1. Diagram of power stabilizer for laser with an external control element: 1. laser; 2. attenuator; 3. control element; 4. separating plate; 5. medium interacting with the radiation; 6,7. photoreceivers; 8. comparison circuit; 9. amplification channel; 10. bias voltage source.

2. Figure 1 is a diagram of a power stabilization system (CCM) for a laser. Radiation I_0 from single-frequency pumping CO_2 laser 1, which operates in the 9.6 μm band, passes through attenuator 2, control element 3 and semitransparent separating plate 4 and strikes investigated object 5; after interacting with the later, it is registered by photoreceiver 6. Part of the radiation that has passed through the control element is reflected from the separating plate and strikes a

second photoreceiver 7. Passing through comparison circuit 8, the signal from photoreceiver 7 is converted into a difference error signal that, after amplification in amplification channel 9, passes into control element 3, thus forming a closed system for the automatic stabilization of the laser radiation's power.

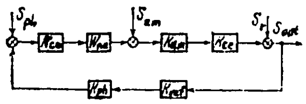

Figure 2. Block diagram of a power stabilizer with an external control element: S_{ph} = noise of photoreceiver and comparison circuit; S_{am} = amplifier noise; S_r = laser radiation noise in the absence of power stailization; S_{out} = laser radiation noise under power stabilization conditions; K_{ph} = conversion ratio of the photoreceiver; K_{ref} = reflection factor of the separating plate; K_{co} = amplification factor of the comparison circuit; K_{am} = amplification factor of the amplifier; K_{ce} = conversion ratio of the control element; W_{ne} = = transmission factor of the correction networks.

Figure 2 is a block diagram of the SSM that allows for the basic disturbances. According to this diagram, the spectral density of the power of the laser's output radiation's noise is written (using the designations for Figure 2) in the form

$$S_{out}(\omega) = S_{ph}(\omega)\left|\frac{K_{co}K_{am}K_{ce}W_{ne}}{W}\right|^2 + S_{am}(\omega)\left|\frac{F_{am}K_{ce}}{1+W}\right|^2 + S_r(\omega)\left|\frac{1}{1+W}\right|^2. \quad (8)$$

Here $W = K_{co}K_{am}K_{ce}K_{ref}K_{ph}W_{ne}$ = = total tranmission factor with respect to the feedback loop. We ignored the noise of the reference voltage, the level of which is considerably lower than that of the photoreceiver's noise. The comparison circuit's noise is allowed for in $S_{ph}(\omega)$.

In the working band of frequencies (the band of maximum noise suppression),

$$S_{out}(\omega) = S_{ph}(\omega)(K_{ph}K_{ref})^{-2} + S_{am}(\omega)(K_{co}K_{ph}K_{ref})^{-2} + S_r(\omega)K^{-2}, \quad (9)$$

where $K = K_{co}K_{ph}K_{ref}K_{ce}K_{am}$.

The first term in expression (9) defines the contribution of the photoreceiver's and the comparison circuit's intrinsic noises to the stabilization conditions. If this component is registered by photoreceiver 6 (Figure 1) with a conversion ratio that equals the conversion ratio of photoreceiver 7 in the feedback loop, and with the same intrinsic noise level, the recording device's threshold of sensitivity will be determined by the intrinsic noise of photoreceiver 6 ($S_{ph}(\omega)$) and the noise of photoreceiver 7 that has been transformed into laser radiation noise; that is,

$$N^2 = S_{ph}(\omega)(K_{ref})^{-2}K_{se}^2 + S_{ph}(\omega) = S_{ph}(\omega)\ (K_{se}^2 + K_{ref}^{2})K_{ref}^{-2}, \quad (10)$$

where K_{se} = a percentage of the radiation that has passed through the separating plate (we ignore absorption in the medium). By examining the ratio of the registered signal's power $S = I(K_{ph}K_{se})^2$ to the noise N^2, it is easy to conclude that in this case, the SSM achieves its greatest effectiveness of action for $K_{ref} = K_{se}$ (we ignore absorption in the separating plate).

The second term in expression (9), for the spectral density of the power of the fluctuations in the working area of frequencies, can usually be ignored ($S_{ph} \approx S_{am}$, $K_{co} \gg 1$). However, in the area where the correction networks act, the depth of the feedback for the amplifier's noise is reduced, so that the networks' contribution to the laser radiation's noise because of the increase in the total transmission factor of this noise increases. Consequently, in order to reduce this effect it is necessary to reduce the noise brought to the amplifier's intake.

The third term in expression (9) characterizes the contribution of the laser's noise. This component of the spectral density of the fluctuations' power can be reduced by the SSM to the threshold sensitivity determined above by selecting a sufficiently large value of the amplification factor K in the feedback loop. The condition for suppressing fluctuations in the laser radiation's power practically to the level of the photorecording device's threshold sensitivity has the form (see (9) and (10)

$$S_r(\omega)K_{ph}^2 K_{se}^2 / K^2 < S_{ph}(\omega)(K_{se}^2 + K_{ref}^2)/K_{ref}^2. \tag{11}$$

From this we derive the condition for selecting the amplification factor in the feedback loop for the given noise parameters of the photoreceiving device and the laser radiation:

$$K^2 > \frac{S_r(\omega)}{S_{ph}(\omega)} \frac{K_{ph}^2 K_{se}^2 K_{ref}^2}{(K_{se}^2 + K_{ref}^2)} = \frac{N_r^2(\omega)}{N_{ph}^2(\omega)} \frac{K_{ref}^2}{K_{se}^2 + K_{ref}^2} \tag{12}$$

or $K > N_r(\omega)/(\sqrt{2}N_{ph}(\omega))$ for $K_{se} = K_{ref}$, where $N_r(\omega)$ = spectral density of the noise voltage at the outlet of the recording system's photoreceiver, as caused by the noise component of the unstabilized laser radiation; $N_{ph}(\omega)$ = spectral density of the photoreceiving device's noise voltage.

3. In order to compensate for slow fluctuations in the power of the CO_2 laser's radiation, in our work we used a power stabilizer (see Figure 1), the control element of which was a low-quality Fabry-Perot interferometer with a variable base. As the element controlling the length of the interferometer we used a KP-1 piezoceramic corrector to which a movable interferometer mirror was glued. Additional bias voltage source 10

was intended for installation of an initial interferometer length corresponding to a working point chosen approximately in the middle of the slope of the interferometer's transmission curve. The choice of the slope was determined from the condition of realization of negative feedback.

The interfereometer mirrors were made of NaCl and had a dielectric spray-coating (with a reflection factor of ~80 percent, a transmission factor of ~15 percent, and a distance between the mirrors of 15 mm). In order to eliminate the possibility of radiation that had been reflected from the interferometer striking the laser, the interferometer's axis was displaced to the left relative to the laser beam's direction of propagation. The mirror holders were attached with Invar couplings and the entire design was enclosed in a thermally insulating acoustic screen, inside which a temperature slightly above room temperature was maintained.

We used the following devices for the other elements of the layout shown in Figure 1. Separating plate 4, which was set at a 45° angle, was made of germanium and was clear on one side. The radiation receivers were photoresistors based on the triple compound CdHgTe and were cooled with liquid nitrogen. Comparison circuit 8 was in the form of a differential amplifier, into one input of which reference voltage U_{rv} was fed, while the signal from photoreceiver 7 entered the other. Amplifier 9 was a U7-2 direct-current measuring amplifier, while bias voltage source 10 was a B5-32 stabilized voltage source.

The density spectrum of the power of the fluctuations in the intensity of the radiation of the CO_2 laser used in our work did not differ substantially from the typical spectra for such lasers. The spectrum's low-frequency components exceeded the noise power of the photoresistor that was used by two orders of magnitude. In the experiment, therefore, we formulated the goal of suppressing fluctuations in the laser's power in the band up to several hundred cycles per second, with a maximum suppression factor at low frequencies of at least 10^2. In view of the fact that the KP-1 piezocorrectors, which are widely used at the present time, have intensive intrinsic resonance in the 1-2 kHz area, in order to insure the stability of the power stabilization system the latter was corrected with the help of an aperiodic link with a time constant $T_1 = 10^{-2}$ s and a 2T-shaped bridge that was connected to it in series and was tuned to a frequency close to the KP-1's resonance frequency. For the estimative calculations made above, the bridge's effect can be ignored.

We obtained the following calculative and experimental data on the transmission factors of the SSM's elements: K_{ce} =

$= 4.8 \cdot 10^{-6}$ W/V for a power at the interferometer's intake of $\sim 10^{-4}$ W; $K_{ref} = 0.47$; $K_{am} = 2.2 \cdot 10^3$; $K_{co} = 10^2$; $K_{ph} = 440$ V/W (for the radiation focusing we used); the total transmission factor was K = 218. The range of the bias voltage controlling the interferometer was ±5 V.

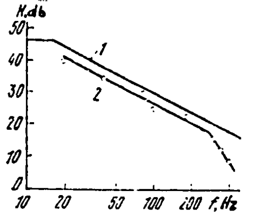

Figure 3. Theoretical (1) and experimental (2) dependences of the coefficient of suppression of fluctuations in the power of a CO_2 laser's radiations on the frequency (control element = a Fabry-Perot interferometer).

For a more accurate determination of the dependence of the SSM's effectiveness on the frequency, laser radiation power pulsations were simulated by feeding a harmonic signal in the 20-400 Hz band from an audio frequency generator into an auxiliary disk piezoelement to which the second interferometer mirror was attached. The degree of attenuation of the pulsations was recorded with the help of an S4-12 spectrum analyzer, as the ratio of the amplitudes of the spectral component of the disturbance in the recording photoreceiver's signal during open feedback to the amplitude of the disturbance's spectral component in the presence of feedback. The data that were obtained are presented in Figure 3. The increase in the steepness of the drop in the suppression characteristic (curve 2) in the area of frequencies above 270 Hz is explained by the effect of the 2T-shaped bridge. Theoretical graph 1 coincides with the experimental curve with a high degree of accuracy. A further increase in the degree of attenuation of the pulsations by increasing the transmission factor for loop K is limited by self-excitation in this plan. It should be mentioned that at the frequency of the KP-1's intrinsic resonance, a surge of noise in the radiation spectrum is seen. This can be explained by the effect of acoustical disturbances in the surrounding medium on the piezoelement, as well as by accentuation of the system's internal noise. In order to reduce this effect, the correction circuits should be placed close to the SSM's intake. Expansion of the SSM's noise suppression frequency range to several thousand cycles per second is possible if a more complicated correction method is used. A more radical method is the use of sensitive wide-band piezocorrectors, such as the PP-4 type.

As the experiment demonstrated, the Fabry-Perot interferometer with a movable mirror is a simple and quite effective device for stabilizing the power of laser radiation. Its advantages are compactness, simplicity of the production process, low control voltage, insensitivity to polarization of the radiation and a wide operating band as far as wave lengths are concerned.

4. In order to compensate for rapid fluctuations in the laser radiation's power, as the control element in the feedback circuit we used an ML-7 electro-optical modulator based on a GaAs crystal. It should be mentioned that such devices have already been described in the literature (see, for example, [7,8]), but they are not effective enough in the area of frequencies on the order of several thousand cycles per second. In this case, the goal of the work was the suppression of laser noise (to the receiver's noise level) in the area of interest to use -- 5-6 kHz.

Basically, the stabilization setup repeated the one presented in Figure 1, except for the comparison circuit in the feedback circuit. The signal from photoreceiver 7 was preliminarily amplified by a wide-band, low-noise preamplifier based on metal-ceramic tubes of the "Nuvistor" type, with a frequency band of 4 Hz to 2.5 MHz (at the 3-db level). The preamplifier noise presented at the intake, along with the receiver, was 6 $nV \cdot Hz^{-\frac{1}{2}}$ and the amplification factor was 70. From the preamplifier the signal was sent to a wide-band amplifier, the amplification factor of which was controlled within limits of $5 \cdot 10^3 - 2 \cdot 10^5$ in the 4 Hz-3 MHz band. This amplifier's maximum output voltage was 90 V (dual amplitude), which was completely satisfactory for handling (with the help of the ML-7) laser noise with an amplitude of up to 5 percent. Negative feedback was realized by selecting the appropriate polarity of the bias voltage (1.5 kV) supplied by a B5-24A high-stability direct-current source.

Prevention of SSM self-excitation was insured by correction with respect to the upper and lower frequencies. The correction was performed with the help of RC-circuits that were connected between the low-noise preamplifier and the amplifier in the amplifier. The time constants of the integrating circuits carrying out the correction for the upper frequencies were $\tau_1 = 0.9 \cdot 10^{-5}$ s and $\tau_2 = 2.3 \cdot 10^{-5}$ s. The second circuit's action was stopped before the cutoff frequency was reached in such a fashion that at the cutoff frequency, the drop in the amplitude-frequency characteristic (AChKh) of the amplification channel in the feedback circuit was 20 db per decade, which insured stable operation of the system. The differentiating circuit that carried out the correction for the lower frequencies had a time constant $\tau_3 = 3.6 \cdot 10^{-5}$ s. This circuit was connected between the preamplifier and the amplifier in order to prevent saturation of the amplifier's output stage by the signal caused by slow fluctuations in the radiation that the system did not suppress. The total effect of the correction circuits, which determine the transmission band of the amplifying channel in the feedback circuit, is shown in Figure 4.

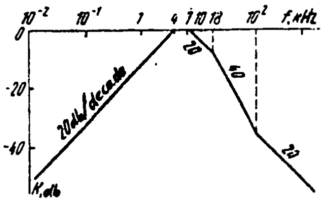

Figure 4. Amplitude-frequency characteristic of the correcting circuits (control element = ML-7 modulator).

The isolation of the amplifier and the modulator with respect to high voltage was accomplished with the help of an intermediate condenser, the capacitance of which was chosen so that it did not affect the amplifying channel's AChKh. For this purpose, a 25-MΩ resistor was connected in series with the B5-24A source so that the modulator's resistance, which is shunted by this resistor, was about 20 MΩ. In order that the total capacitance of the modulator ($\approx$20 pF) and the feed cable ($\approx$50 pF) not affect the amplifying channel's AChKh, the amplifier's output resistance was made quite small ($\sim$100 Ω).

For an exact measurement of the laser noise suppression factor at these frequencies, the noise was modeled [sic -- probably modulated] artificially by modulating the voltage in the laser's power circuit. In order to eliminate the effect on the results of slow power fluctuations, which exceed the rapid fluctuations significantly with respect to amplitude, the voltage of the signal from recording photoreceiver 6 (see Figure 1) was fed into a U2-6 amplifier, the transmission band of which was narrowed to 1 percent (for operation in the "second narrow" mode), through an upper-frequency RC-filter with a time constant of $2.2 \cdot 10^{-5}$ s.

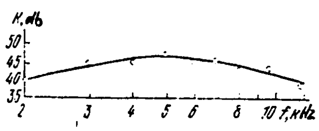

Figure 5. Dependence of suppression factor of CO_2 laser radiation power fluctuations on the frequency (control element = ML-7 modulator).

The relationship of the suppression factor of the laser radiation's power fluctuations in the frequency band from 2 to 12 kHz is shown in Figure 5. As is obvious from the graph, the frequency dependence of the noise suppression factor has a maximum in 5-6 kHz area that is $\sim$200. In connection with this, the amplification factor of the amplifiers in the feedback circuit is $2 \cdot 10^6$ (for a photoresistance conversion ratio of $\approx$1,400 V/W and the power of the radiation striking the receiving area of $\sim 10^{-4}$ W). Self-excitation of the SSM at frequencies $\sim$1 MHz prevented a further increase in the suppression factor by increasing the amplification factor in the feedback circuit. The experiment showed that in order to achieve maximum suppression of the power fluctuations it is necessary to adjust photoreceivers 6 and 7 (see Figure 1) so that radiation from approximately one part of the laser beam's cross-section strikes their receiving areas. This imposes additional limitations on the possible angular and linear displacements of the beam caused by the action of different causes that lead to disalignment of the optical system. These same causes are obviously the explanation for the lower suppression factor value in comparison with the theoretical value of ~300-400 that was determined by the correction method.

It should be mentioned that it is not difficult to expand the range of use of this power stabilizer, with a suppression factor of $K \approx 200$, to several tens of thousands of cycles per second. In the low-frequency area, where the practical realization of the device entails considerable technical difficulties because of the high control voltages and the large required amplification factors of the direct-current amplifier, it is more feasible to accomplish the suppression of the low-frequency components of the CO_2 laser's power fluctuations with the help of a control element based on a Fabry-Perot interferometer with a movable mirror.

5. We should add here that in a number of cases -- particularly when making delicate polarization measurements -- it is sometimes necessary that the power stabilization system that is used not disrupt the experiment's axial symmetry because of a change in the laser beam's polarization. In such cases, the use in the SSM of a separating plate that shunts part of the radiation in order to obtain a feedback signal becomes undesirable, since it requires the introduction into the optical plan of additional compensating elements. In our opinion, one of the ways of overcoming this difficulty can be the use of an opticoacoustic detector, the working substance of which is the radiation-absorbing medium, as the photoreceiver in the feedback loop.

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LASERS AND MASERS

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LASER RADIATION ABSORPTION IN A CRATER IN A METALLIC TARGET

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 7 No 1 (91), Jan 80 manuscript received 14 May 79 pp 183-186

[Article by A.Ya. Vorob'yev and V.M. Kuz'michev, Khar'kov State University]

[Text] The authors have experimentally investigated the integral (average for a pulse) absorptive capacity in a crate in metal targets irradiated by giant pulses from a ruby laser. The metals investigated were Cu, Al, Mg, Cd and Sn. Spasmodic behavior of the absorptive capacity, caused by optical breakdown on the target's surface, was observed. Under developed vaporization conditions the absorption in the crater is of the steady-state type and its value -- 70 percent -- is practically the same for all the materials. This research is valid for the case where light absorption in the crater, as in a geometrical cavity, can be ignored. The authors also present the results of measurements of the heat transfer coefficient.

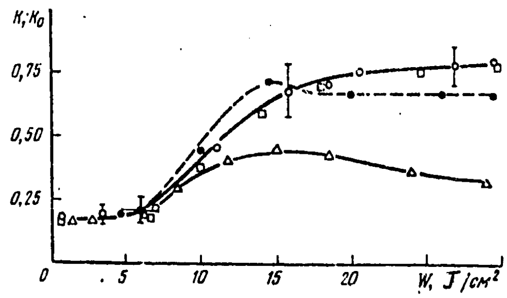
When light fluxes on the order of 10^7-$5\cdot10^8$ W/cm^2 act on metals, the geometrical area in which light absorption takes place is no longer limited to a single skin layer, but includes some of the space adjacent to the target's surface that is occupied by a plasma absorbing layer [1,2]. For this reason, the investigation of the absorption processes taking place in direct proximity to the surface of metal targets is a matter of particular interest. In our work we studied the crater area of a target; more precisely, we measured the average (over a pulse) absorptive capacity K of this area (the ratio of the laser radiation energy absorbed in the crater to the energy of the radiation pulse) as a function of the incident radiation energy's density W.

The measurement method was as follows. On the side of the metal test pieces being studied that was exposed to the incident radiation, a transparent quartz plate that changed the geometry of the scattering of the vapors was superimposed. In order not to cause any substantial retardation of the vapors' scattering in the irradiation zone, the quartz plate-target contact must not be solid. Since the vapor pressure during vaporization is high (normally more than 10 bars), in such a system the vapors do not expand toward the laser beam, but along the boundary of the quartz plate-metal contact and, after condensing outside the irradiation zone, settle in a ring around the crater, thereby returning to the target the thermal energy that they contain. Under these conditions, light absorption is limited by the processes taking place in the crater area. The amount of energy absorbed by the target in the crater can be determined by the calorimetric method if the target's thermal capacity is known and the increase in its average temperature is measured, as is done in measurements of the heat transfer coefficient [3 5], with the difference that in this case the value of the measured energy will equal the sum of the heat transfer energy in the crater and the vapors' thermal energy.

There arise two questions concerning the adequacy of the measurement of K with the help of such a technique: how does the quartz's transparency change at the point of contact with the target irradiation zone and is there a substantial change in the nature of the vaporization process in the presence of the transparent barrier on the target? It is known [6] that thin ($\sim 10^{-3}$ cm) layers of quartz that are heated to a temper ture of $\sim$4,200°K have an optical thickness of $\sim$0.1 in the visible part of the spectrum. The thickness of the quartz layer that was heated during the time the giant laser pulse was in use was $\sim 10^{-5}$ cm. Thus, light absorption in the quartz on the boundary with the target can be ignored. This is also confirmed by a visual investigation of the contact zone in the gap.

In order to be certain that there was no significant change in the nature of the vaporization, we measured the geometrical dimensions of craters for the cases of vaporization both with and without the plate. These measurements agreed with each other quite well. Besides this, along with K we measured the heat transfer coefficient K_0 (this relationship is measured if the quartz plate is removed). As is obvious from the figure on the next page, the K and K_0 relationships "emanate" smoothly from each other without revealing any anomalous deviations.

In the experiments we used a ruby laser with modulation of the quality factor (the pulse's half-height duration was $\sim$45 ns, the energy in the pulse was $\sim$1 J, and the nonuniformity of the



Absorptive capacity K of the crater area of a copper target (solid lines) and the part K_0 of the laser radiation's energy that remains in the target in the absence of a quartz plate in front of it (dotted line), as functions of the density W of the incident radiation's energy: o = air; □ = xenon; ● = vacuum; Δ = air.

illumination's intensity across the beam's cross-section was no greater than ±20 percent). The experiments were performed in a vacuum ($p = 3 \cdot 10^{-2}$ mm Hg) and in atmospheres of different gasses (air, xenon) at normal pressure. Cu, Al, Mg, Cd and Sn were investigated. In addition to measuring K and K_0, we recorded the plasma that formed with the onset of violet radiation. The experimental results for copper are shown in the figure. The experimental points plotted in the graphs are the result of the averaging of a series of measurements. Analogous behavior was seen for the other metals that were studied. Typical of them is the fact that as the radiation energy's density increase, at first microcraters appeared in the target's irradiation zone (for copper, at $W' \approx 4.2$ J/cm²), after which there came a moment ($W'' \approx 6.1$ J/cm²) when K_0 and K began to increase abruptly and, in connection with this, noticeable violet radiation appeared. It is a curious fact that the ratio W'/W'' is not the same for all the materials. For Cd and Mg it is less than for Cu and Al.

In the area of the discontinuity, the irradiation zone has a quite pronounced damage focus that is, however, smaller than the irradiated spot. As a rule, the vaporization product loss here is small, particularly for materials with a high W'/W'' value. Beginning with a certain value W''', absorption in the crater acquires a steady-state character and the heat transfer coefficient begins to decrease. In connection with this, vaporization occurs over the entire irradiated spot. In this area of incident radiation energy densities, there is a significant loss of mass of the breakdown materials (as a result of which W''' can be defined as the beginning of the developed vaporization regime), which carry part of the absorbed energy away with them and cause K_0 to decrease.

The appearance of noticeable violet radiation simultaneously with the beginning of the sharp increase in K and K_0 indicates that the cause of this discontinuity is optical breakdown. In addition to this, since K and K_0 coincide at the moment of breakdown, while light absorption in the case of measurements of K is limited by the area of the microcraters (for example, for Cu their depth as measured is $\sim 1\ \mu m$), the breakdown is of a surface nature and is engendered before the onset of the developed vaporization regime at "hot" points in the irradiated zone; that is, at points where the highest local surface temperature is reached under the influence of such factors as nonuniformity of the surface's structure and nonuniformity of target illumination.

Our evaluation of the surface temperature at the moment of appearance of the discontinuity in K and K_0 gives the value $\sim 2,300^oK$ for copper. In [2] this moment corresponds to a temperature of $3,100^oK$. Such a discrepancy is understandable if we keep in mind the fact that the appearance of breakdown depends on the state of the target's surface [7], the focusing conditions [5] and the degree of uniformity of light distribution in the beam.

In view of the breakdown nature of the initiation of the discontinuity in absorptive capacity, an investigation of the role of the pressure and type of the surrounding gaseous medium is a matter of interest. The conditions of this experiment make it possible to conduct such an investigation in the presence on the target's surface of a gaseous layer of a thickness of the order of the irregularities in the surface (approximately 0.5 μm). The experimental relationships that were obtained for K (see the figure on the preceding page) for vapor scattering into a vacuum and into a medium with counterpressure demonstrate the coincidence (within the limits of experimental error) of the K curves in the area of the discontinuity and reveal a discrepancy when W W"'. This indicates that the basic role in the K discontinuity is played by breakdown of the target disintegration products, while the surrounding medium has an effect only in the developed vaporization regime. As is obvious from the figure, in both air and xenon K is somewhat higher than in a vacuum and it has some tendency toward a further increase as the counterpressure increases. Such behavior can be explained by the higher density of the vapors in the case of scattering into a medium with counterpressure and the lower value of their adiabatic cooling [8]. The type of surrounding gaseous medium does not have any effect on K.

Материал (1)	Cu	Al	Mg	Cd	Sn
K, %	68	84	70	69	73

Key: 1. Material

For all the metals that were investigated, the steady-state values of K in a vacuum are presented in the above table.

It is obvious that the value of K does not depend on the target material, for all practical purposes. It should be mentioned that in all of the investigated cases, absorption in the geometrical cavity was negligibly small, since the ratio of the crater's diameter to its depth was very large.

From the results that have been presented it follows that the general rules for the behavior of absorptive capacity in a crater area are similar to those observed in experiments where the geometrical area of the laser radiation's effect was not limited to a single crater and included the space in front of the target that was occupied by vapor [1,2,7]. Considering the high value of the crater area's absorptive capacity, it is possible to draw the conclusion that during the initial stage of developed vaporization, laser radiation absorption takes place primarily in the crater. In this respect, it is an interesting fact that increasing the thickness of the area of the laser radiation's effect by repeated irradiation of a crater in a copper target caused an increase in the steady-state value of K of approximately 15 percent, whereas irradiation by three or more pulses did not have any effect. The depth of the craters in the metal targets that were studied was $\sim$5-10 μm.

The authors wish to express their sincere gratitude to M.N. Libenson for his constant attention and useful advice.

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NUCLEAR PHYSICS

NUCLEAR PHYSICS LECTURES PUBLISHED

Leningrad FIZIKA VYSOKIKH ENERGIY (Materialy XIV Zimney Shkoly LIYaF) (High Energy Physics (Materials of the 14th Winter School of the Leningrad Nuclear Physics Institute) in Russian 1979 signed to press 26 Feb 79 pp 2, 194)

[Annotation and table of contents from collected volume of lectures, edited by V. Ye. Bunakov et al, LIYaF, 500 copies, 195 pages]

[Text] This volume contains materials presented for the attention of persons enrolled at the 14th Winter School of the Leningrad Nuclear Physics Institute. They discuss certain questions connected with the manifestation of quantum chromodynamics, excitation of gluons, and the property of partons and quarks. This volume also contains papers on parity nonconservation in atomic systems and on problems of μ-catalysis of synthesis reaction as a source of energy, which will be of definite interest.

These lectures are written by highly-qualified specialists and are intended for the prepared reader, specializing primarily in the area of high-energy physics.

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NUCLEAR PHYSICS

UDC 621.039(091.2)(023)

PROBLEMS IN ATOMIC SCIENCE AND TECHNOLOGY

Moscow PROBLEMY ATOMNOY NAUKI I TEKHNIKI in Russian 1979 pp 2, 452-454

[Annotation and table of contents from the book "Problemy Atomnoy Nauki i Tekhniki" by Andranik Melkonovich Petros'yants, chairman, USSR State Committee for the Utilization of Atomic Energy and corresponding member, Armenian SSR Academy of Sciences, Izdatel'stvo Atomizdat, signed to press 7 May 1979, 6,300 copies, 454 pages]

[Text] ANNOTATION

This book, which was written by the chairman of the USSR State Committee for the Utilization of Atomic Energy, tells about the USSR as an atomic power in the world that uses atomic energy for peaceful purposes.

The reader will find much of interest about the results of the efforts of the scientists, engineers, technicians and workers who are creating the material and technical base of communism. It shows the transformation of atomic science and technology into a gigantic branch of the national economy and a direct productive force for the Soviet society.

This fourth edition of the book (previous editions were published in 1970, 1972 and 1976) has been reworked and supplemented with additional materials that reflect the successes of atomic science and technology in the Ninth and Tenth Five-Year Plans.

This book is intended for a broad circle of readers who are interested in the state and prospects for the development of this comparatively young branch, as well as for lecturers and propagandists, for whom it is an encyclopedic publication.

It can be used as a teaching aid by teachers, graduate students and students in higher educational institutions oriented toward engineering and physics, as well as instructors in departments for improving the qualifications of teaching staffs.

The second edition of this book has been translated and published in the GDR, Czechoslovakia, Romania and the United States; the third, in Poland, Hungary and France; this, the fourth edition, is being translated and published in England and Japan.

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OPTICS AND SPECTROSCOPY

HIGH-RESOLUTION PHOTOMATERIALS FOR HOLOGRAPHY AND PROCESSES OF TREATING THEM

Moscow VYSOKORAZRESHAYUSHCHIYE FOTOMATERIALY DLYA GOLOGRAFII I PROTSESSY IKH OBRABOTKI (High-Resolution Photomaterials for Holography and Processes of Treating Them) in Russian 1979 signed to press 22 Aug 79 pp 2-3, 135-136

[Annotation, Foreword and Table of Contents from book by Nikolay Ivanovich Kirillov, Izdatel'stvo Nauka, 2,550 copies, 136 pages]

[Text] The essence and application of holography and the main methods of holographing are considered briefly in the monograph. The characteristics of high-resolution photomaterials for holography, their properties and the necessary and essential variety are given. The different processes of treating holographic photomaterials and of producing various types of holograms on them are considered. Different methods of testing and analysis of the properties of photomaterials for holography are presented.

The book is intended for specialists involved in the application of holography in imaging technology and for various scientific and technical purposes and also those involved in development of manufacture and treatment of holographic materials.

Foreword

Holography, which is a new, progressive, rapidly developing field in modern science and technology, begins to change from the sphere of laboratory investigations to the stage of practical application in imaging technology and for various scientific and technical purposes, which is impossible without the presence of the necessary recording media. The main means are especially fine-grain high-resolution silver halogenide photomaterials characterized by adequate light sensitivity with high quality of the holographic image produced on them.

It has now become necessary to systematize and summarize the data dispersed among different sources and of little access for use on the properties and processes treating various silver halogenide holographic photomaterials.

Selection and systemization of the required data were related to specific difficulties caused by the fact that estimates of the properties and processes of treating various photomaterials were carried out by different methods in most papers.

General data on holography and its applications are outlined briefly in Chapter 1. The characteristics, properties and varieties of holographic photomaterials and processes of treating them are considered in the next two chapters. The last chapter contains a general description of various methods of testing and investigating the properties of holographic photomaterials and of monitoring the process of treating them. The referenced literature includes both monographs and survey papers as well as original investigations and developments in the considered field.

Unfortunately, it was not possible to include a number of interesting investigations and developments published recently in the paper. We would hope that this can be supplemented to one or another extent by the reader himself.

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OPTICS AND SPECTROSCOPY

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ABSORPTION COEFFICIENTS OF MIRROR SURFACES OF INTERMETALLIC COMPOUNDS AT WAVE LENGTH $\lambda = 10.6\ \mu m$

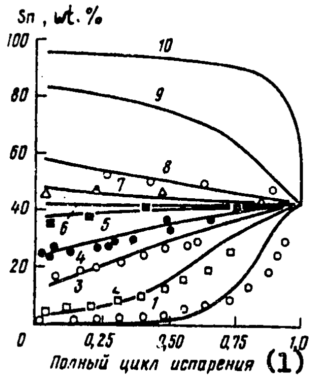
Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 7 No 1 (91), Jan 80 manuscript received 3 Aug 79 pp 214-216

[Article by V.V. Apollonov, A.I. Barchukov, A.L. Yegorov, L.T. Kir'yanova, L.M. Ostrovskaya, V.N. Rodin, V.Yu. Khomich and M.I. Tsypin, Physics Institute imeni P.N. Lebedev, USSR Academy of Sciences, Moscow]

[Text] The authors present the results of experimental investigations of the dependence of absorption coefficients on the chemical and phase composition of vacuum condensates of copper-tin alloys with a tin concentration range of 17-60 wt. %, as well as the γ-phases of copper-aluminum and copper-gallium systems in massive and thin-film states. The minimum absorption coefficient (2.1 percent) was obtained for the intermetallide Cu_3Sn with a 38-40 wt. % tin concentration.

1. In [1] it was shown that coatings of intermetallic compounds of the electron type make it possible to obtain mirror surfaces of power optics elements that are of high optical quality. A low laser radiation scattering coefficient, great hardness and resistance to oxidation that increase mirror service life significantly, strength of adhesion to the base, and ease of production -- these are the basic advantages of intermetallide coatings that insure their widespread practical use.

In recent times, interest in intermetallic compounds and the technology of their application by spraying has increased considerably in connection with the creation of cooled laser mirrors based on structures with open porosity [2]. Up until now, however, the intermetallides that have been used have one substantial flaw -- high absorption coefficient values -- that makes it impossible to use them to create mirrors without the application of highly reflective coatings.



Change in the tin concentration in the vapor phase (solid curves -- numerical calculations made with a computer [5]) and in the condensate (experimental points) during the vaporization of copper-tin alloys with the following tin concentrations: 10 (1,o); 20 (2,□); 30 (3,Δ); 35 (4,●); 40 (5,■); 42.6 (6); 45 (7,▲); 50 (8,o); 70 (9); 90 (10) percent; T_{pro} = 1,400°C.
Key: 1. Complete vaporization cycle

The optical properties of the intermetallic phases have not been studied, for all practical purposes, and in particular there are no experimental data on absorption coefficients, the theoretical calculation of which with sufficient accuracy is not possible at the present time. In our opinion, a study of the optical properties of intermetallic compounds in order to select the compounds and compositions having minimal absorption coefficients without any deterioration of the other characteristics is a matter of great interest, since it will make it possible to abandon the application of highly reflective coatings during the production of a large group of laser mirrors.

In this article we present the results of experimental investigations of the dependence of absorption coefficients on the chemical and phase compositions of vacuum condensate of copper-tin alloys in the range of tin concentrations of 17-60 wt. %, as well as the γ-phases of copper-aluminum and copper-gallium systems in the massive (50-100 μm) and thin-film (0.2-0.5 μm) states.

The coatings we investigated were obtained by the method of vaporization and condensation in a vacuum. The composition of the condensates was studied with the help of a "Cameca" micro-X-ray spectrum analyzer, in both the plane of a cross-sectional cut and the reflection plane.

The quality of the test pieces' optical surface was determined by measuring the scattering coefficient by the screen method at a wave length of λ = 0.63 μm and by electron-microscope studies utilizing the method of stereoscopic surveying of angular replicas.

Table 1. Absorption Coefficients of Mirror Surfaces of Intermetallic Compounds (λ = 10.6 μm)

Chemical Composition of the Surface [Sn], wt. %	Phase Composition of the Surface	Absorption Coefficient, %
0	Cu	1.0
17-19	$\alpha + Cu_{31}Sn_8$	5.7
20	$\alpha + Cu_{31}Sn_8$	6.3
22	$\alpha + Cu_{31}Sn_8$	5.8
28	$\alpha + Cu_{31}Sn_8$	5.3
28-30	$Cu_{31}Sn_8 + \alpha$	5.1
30-32	$Cu_{31}Sn_8 + \alpha$	3.6
32.5	$Cu_{31}Sn_8$	2.8
35	$Cu_{31}Sn_8 + Cu_3Sn$	3.9
36-38	$Cu_3Sn + Cu_{31}Sn_8$	3.6
38-40	Cu_3Sn	2.1
41	$Cu_3Sn + Cu_6Sn_5$	2.7
43	$Cu_3Sn + Cu_6Sn_5$	2.9
44	$Cu_3Sn + Cu_6Sn_5$	2.5
45	$Cu_6Sn_5 + Cu_3Sn$	2.7
50	$Cu_6Sn_5 + Cu_3Sn$	4.0
61	Cu_6Sn_5	3.5

The absorption coefficients of the intermetallides' mirror surfaces were measured at the wave length λ = 10.6 μm [3,4]. The high optical quality of the polished intermetallic surfaces and the corresponding insignificant losses due to scattering made it possible to use the method of multiple reflections, with an accuracy of $\sim$5 percent, in addition to the calorimetric method.

2. The results of the identification of the condensates' chemical compositions and the distribution of components with respect to thickness are shown in the figure on the preceding page, where the stages of the increase in condensate thickness are expressed in fractions of the complete vaporization cycle. From the figure it is obvious that in the 15-45 percent interval of tin concentration, as its content in the vaporized melt increases the coating's chemical uniformity does also and approaches practically complete correspondence to the composition of the original mixture.

These data were used in our work so that we could purposely vary the composition during the application of intermetallic coatings. In Table 1 we see the absorption coefficients of massive condensates; the data have been averaged from the results of measurements for test pieces from different series. An extensive set of compounds was obtained by sequential abrasion of layers of the condensate parallel to the plane of the substrate and exposure of the zones with a monotonically decreasing tin content, as well as by varying the composition of the vaporized alloy.

The microstructures of the investigated mirror surfaces are represented by mixtures of an α-solid solution of tin in copper in a maximum concentration with a eutectoid (α + δ) containing 27 percent tin, a eutectoid with an intermetallic δ phase ($Cu_{31}Sn_8$), intermetallic δ and ε phases (Cu_3Sn), and intermetallic ε + η phases (Cu_6Sn_5), as well as pure δ, ε and η phases [6,7].

On the basis of the results presented in Table 1, it is possible to conclude that the absorption coefficient essentially depends on the surface's phase composition, but is not a monotonic function of the tin concentration.

The worst absorption indicators (>5 percent) are seen for compounds with a relatively low tin content that are represented by α-solid solutions with a face-centered cubic structure and two-phase mixtures (α + $Cu_{31}Sn_8$). As the percentage of δ-phase in a two-phase mixture increases, the absorption coefficient decreases and reaches a minimum (<3 percent) for intermetallic δ- and ε-phase surfaces and alloys with a predominance of ε-phase; an increase in the percentage of η-phase in a two-phase mixture leads to a noticeable increase in absorption.

The minimum absorption coefficient, which was 2.1 percent for $\lambda = 10.6$ μm, was obtained in our work for the intermetallic compound Cu_3Sn with a tin concentration of 38-40 wt. %.

Table 2 gives the microhardness values for pure metals [8,9] and intermetallides, as arranged in the order of increasing absorption coefficients [3]. From this table it follows that as far as the absorption coefficient's value is concerned, intermetallic phases are comparable with such metals that are widely used in the production of power optics elements as molybdenum, tungsten, nickel, beryllium and aluminum. In connection with this, their microhardness is considerably higher and, consequently, the quality of the polishing is better and the laser radiation scattering coefficients are lower. Therefore, the total losses to absorption and scattering of the mirror surfaces of intermetallic compounds are, in a number of cases, even lower than for highly reflective metals, to say nothing of the other advantages of such coatings.

3. A material's capability for being worked with diamond powders, which is basically determined by its hardness, has an effect on the absorption coefficient's value, which to a high degree depends on defects in the polished mirror surface in the form of residual diamond powder grains [3].

Table 2. Absorption Coefficients ($\lambda = 10.6\ \mu m$) and Hardness of Metals and Intermetallic Phases

Investigated Material	Absorption Coefficient, %	Microhardness, kg/mm^2
Copper	0.97	76
Silver	1.06	25
Magnesium	1.46	31-48
Aluminum	1.77	19
Tungsten	2.02	340
Cu_3Sn	2.1	560
Beryllium	2.56	26
Molybdenum	2.67	160-200
$Cu_{31}Sn_8$	2.83	537
Nickel	3.2	180
Cu_9Ga_4	3.3	640
Cu_6Sn_5	3.5	365
Cu_9Al_4	4.5	480
Vanadium	5.57	182
Tantalum	8.58	106-230

For the experimental determination of the dependence of absorption coefficients on surface defects in intermetallic coatings, we applied films that were 200-500 nm thick to substrates of known high optical quality. In this case we avoided the possible mechanical damages to the reflecting surface that are related to its being polished.

The results of the measurements confirm the good polishability of the investigated intermetallides. The change in absorption coefficients for all the test pieces did not exceed several tenths of a percent; for example, for Cu_3Sn the different was 0.1 percent.

The results of our experimental investigations of the dependence of the absorption coefficients of optically polished mirror surfaces of condensates and thin films of intermetallic compounds on the chemical and phase composition, as presented in this article, are of considerable interest from the point of view of both their applicability in the manufacturing of coatings for power optics elements and for gaining an understanding of the relationships between the composition, structure and optical properties of intermetallic phases of the electron type.

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SUPERCONDUCTIVITY

LOW-TEMPERATURE PHYSICS RESEARCH

Moscow ISSLEDOVANIYA PO FIZIKE NIZKIKH TEMPERATUR in Russian 1979 signed to press 1 Nov 79 pp 2, 3-4, 210-212

[Annotation, foreword, table of contents from a book by B. T. Geylikman, Atomizdat, 3200 copies, 216 pages]

[Text] Annotation

Various problems originating in investigations of the properties of substances at low temperatures are considered. Phenomena of heat conductivity of superconducting and normal metals, sound absorption in superconductors and the theory of kinetic phenomena in HeII are described. Electron-phonon interaction in metals and properties of superconductors with strong bonds are investigated on the basis of the adiabatic theory. The problem of finding new superfluid and superconducting systems is discussed and the properties of quanta crystals are considered.

For physicists interested in low temperature physics problems.

Foreword

This monograph combines the work of B. T. Geylikman and his students, and is dedicated to describing the properties of condensed bodies at low temperatures. This edition of the book was planned a long time ago; however, it sees the light of day only after the death of Boris Tov'yevich Geylikman and, therefore, the book is in the nature of a memorial.

The scientific interests of B. T. Geylikman, one of the greatest Soviet theoretical physicists, were very broad. His work on nuclear theory, physics of fission, theory of strong interactions, the general problems of statistical physics, the theory of metals and superconductivity are widely known. A highly educated man who was thoroughly familiar with literature and art, B. T. Geylikman brought to his research on theoretical physics a distinctive original cast of mind that made it possible to recognize his work. This also applies to many of the works of his students.

As a rule, in his investigations, B. T. Geylikman used the usual methods of theoretical physics; however, his ideas were always fresh and original. They involved various areas of physics and, therefore, were not always developed properly and sometimes, regrettably, were not properly appreciated. B. T. Geylikman was distinguished by the high demands he made on himself. Many of his papers did not see the light of day because he did not consider them brought to the degree of completion that would satisfy his criteria.

B. T. Geylikman's research was involved basically with low temperature physics. He devoted his main efforts to this and he dedicated his best work to it. The unusual interrelationship of various phenomena observed at temperatures near absolute zero fascinated him and gave him food for his creative fantasy. His work facilitated the development of many directions of low temperature physics. They are collected in this monograph.

This book considers a wide range of problems. Most of them are related to the description of the physics of the superconducting state. One would like to stress especially the full description of heat conductivity processes, the development of the theory of superconductors with strong bonds and the theoretical investigation of the new nonphonon superconductivity mechanism. This monograph considers in detail general theoretical problems (the variation principle in the theory of kinetic phenomena, the electron-phonon interaction on the basis of the adiabatic theory etc.), and discusses in detail experimental data (for example, data on heat conductivity, on measuring the critical temperature etc). This combination is undoubtedly one of the strong sides of the monograph.

I am glad to offer this book to the attention of the readers and hope that it will bring pleasure and benefit to all who are interested in one of the most important directions of modern physics.

Corresponding member USSR Academy of Sciences

V. M. Galitskiy

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MONOGRAPH DESCRIBES SUPERION CONDUCTORS

Moscow SUPERIONNYYE PROVODNIKI (Superion Conductors) in Russian No 2, 1980 signed to press 22 Jan 80 pp 2, 3, 64

[Annotation, foreword and table of contents from pamphlet by Yu. Ya. Gurevich, doctor of chemical sciences, candidate of physical-mathematical sciences, Znaniye Seriya Fizika, 40,060 copies, 64 pages]

[Text] Annotation

This pamphlet is dedicated to the description of a new and unusual class of substances which differ sharply in their properties from the other solids known at this time. They may exist in unusual, mixed hybrid states, possessing surprisingly high ion conductivity. At present, superion conductors have attracted the attention of scientists--physicists and chemists, as well as engineers, technologists and inventors. This pamphlet describes what the unusual properties of the superion conductors are related to, how they are being investigated and how they can be used in practice.

The pamphlet is intended for a wide circle of readers.

Introduction

Studying properties of solids is very important for many broad areas of modern science -- physics and chemistry of solids, crystal-chemistry and materials technology. One of the basic reasons for such interest is the importance of the applied practical results following from purely scientific investigations. Transistor radio receivers and TV sets, the most complicated supersensitive apparatus, new methods for obtaining and converting energy, unusual materials of extreme hardness, heat resistance, elasticity and electrical conductivity -- the advent and development of all this are related closely to the achievements of the fundamental sciences about solids. The scientific successes of the last decades have left their imprint on literally all facets of the life of modern man starting with his daily life, work and rest, and ending with achievements in space.

But time does not stand still and poses new problems for investigators. The solution of modern problems in power, medicine,environmental protection and the assimilation of the space near the earth require the creation of apparatus and materials that possess new and previously unforeseen properties.

Superion conductors -- they are an unusual class of substances which differ sharply in their properties from all solids known at present. These substances are sometimes called the materials of the future, but even now they are attracting the attention of scientists-- physicists and chemists, as well as engineers, technologists and inventors. What are superionic conductors, how are they being investigated and how can they be used in practice -- all this is described in the pamphlet that you are holding in your hand.

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SUPERCONDUCTIVITY

BIBLIOGRAPHY ON VACUUM PHYSICS, BASIC AND APPLIED SUPERCONDUCTIVITY

Khar'kov BIBLIOGRAFICHESKIY UKAZATEL' RABOT PO VAKUUMU I SVERKHPROVODIMOSTI (1971-1977) (Bibliography of Vacuum and Superconductivity Studies (1971-1977)) in Russian 1979 signed to press 1 Feb 79 pp 2, 3, 23, 33

[Annotation, introduction, and table of contents from bibliography compiled by R. K. Miroshnichenko et al, Khar'kovskiy Fiziko-Tekhnicheskiy Institut (KhFTI), 1,000 copies, 33 pages]

[Text] This bibliography includes papers published in 1971-1977 in the volume "Voprosy atomnoy nauki i tekhniki" [Problems of Atomic Science and Technology] (VANT) and dealing with the problems of vacuum physics and technology (183 papers), basic and applied superconductivity (94 papers). These papers were published in the series "Low-Temperature Adsorption and Cryogenic Vacuum" (1971-1973), "High-Vacuum Physics and Technology" (1973-1977), "Basic and Applied Superconductivity" (1972-1977), as well as in separate issues of a number of other series.

This bibliography consists of two parts, each of which is divided into sections and contains an index by authors and a chronological index.

This bibliography will be of use to a broad group of specialists working in the area of vacuum science and technology, basic and applied superconductivity.

Part I. Vacuum Physics and Technology

Introduction

Papers dealing with problems of vacuum physics, vacuum equipment and technology were published in the series "Low-Temperature Adsorption and Cryogenic Vacuum" (issues 1-4, 1971-1973) and "High-Vacuum Physics and Technology" (issues 1-8, 1973-1977) of the collection "Voprosy atomnoy nauki i tekhniki." Since 1978 they have been published in separate issues of the series "General and Nuclear Physics" of this collection.

Thus in a period of 8 years there have been three changes in the name of the series in which these materials have been published. This naturally complicates reference by specialists who need to utilize them. A total of approximately 200 papers were published in the above-listed series during these years, papers the data in which are extensively utilized by scientists and engineers conducting research and development in the area of vacuum science and technology. Utilization of these materials should be considerably facilitated by this bibliographic index, which covers all items published in 1971-1977 in the two series of the collection "Voprosy atomnoy nauki i tekhniki": "Low-Temperature Adsorption and Cryogenic Vacuum" and "High-Vacuum Physics and Technology."

The material in this bibliography is organized into the following sections:

1. General problems of vacuum physics and technology (historical surveys, reviews, biographic).

2. Processes in a vacuum (heat and mass transfer, measurements, degassing of components of vacuum devices).

3. Physics of a cryogenic vacuum (cryogenic condensing vacuum, sorption of gases by layers of condensed vapors and metallic layers, cryovacuum adsorption of gases and vapors by microporous adsorbents, processes of desorption, regeneration of adsorbents, adsorbents, their structure and properties).

4. Cryogenic means of producing and maintaining a vacuum (forevacuum cryopumps, cryocondensing, cryosorption, and cryocondensing pumps and equipment).

5. Cryosupport (coolant liquids, producing them and controlling their temperature, refrigerators).

6. Noncryogenic means of producing a vacuum (diffusion steam-jet pumps and their working fluids, electrical discharge and magnetic discharge sorption pumps, electric arc pumps).

7. Vacuum system components and assemblies.

8. Employment of a vacuum in industrial devices and physical instruments (vacuum technology and properties of materials obtained with its employment; employment of a vacuum and adsorption (desorption) in physical instruments).

The material is arranged in alphabetical order within each section.

This bibliography contains an author index and chronological index.

Part II. Basic and Applied Superconductivity

Introduction

Papers dealing with investigation of the nature of the phenomenon of superconductivity and its applications were for the most part published in 1973-1977 in five issues of the scientific-technical collection "Voprosy atomnoy nauki i tekhniki," in the series: "Basic and Applied Superconductivity," published by the Khar'kov Physics-Technical Institute of the Ukrainian SSR Academy of Sciences. In addition, separate issues of the following series: "High-Energy Physics" (Issue 1 (1), 1972); "Plasma Physics and the Problem of Controlled Thermonuclear Synthesis" (Issue 1 (1), 1973); "Automation of the Physics Experiment and Computer Softwear" (Issue 1 (2), 1973); "High-Energy Physics and Physics of the Atomic Nucleus" (Issue 4 (6), 2 (11), 3 (12), 2 (14), 1973-1975); "Linear Accelerators" (Issue 1 (1), 1 (2), 1975-1976) of that same Sbornik contained 17 articles on utilization of superconductivity in various devices. On the whole, during these years approximately 100 articles were published, by 132 authors from organizations in Moscow (Atomic Energy Institute imeni I. V. Kurchatov), Kiev (Institute of Physics of Metals and Institute of Colloid Chemistry and Water Chemistry of the Ukrainian SSR Academy of Sciences), Khar'kov (Khar'kov Physics-Technical Institute and Physics-Technical Institute of Low Temperatures of the Ukrainian SSR Academy of Sciences), Donetsk (Donetsk Physics-Technical Institute and Special Design Office of the Donetsk Physics-Technical Institute of the Ukrainian SSR Academy of Sciences), and Chernogolovka (Institute of Solid-State Physics of the USSR Academy of Sciences). The total volume of these scientific papers comprised the equivalent of more than 40 publisher's sheets.

Since 1978 papers on superconductivity and its applications have been published in separate issues of the Sbornik "Voprosy atommoy nauki i tekhniki." Series: "General and Nuclear Physics."

In connection with a change in the name of the Series, enlargement of readership and substantial reader interest in superconductivity, it would seem beneficial to publish this systematized bibliography, which will facilitate finding and utilizing published materials.

Materials are systematized according to the following major sections:

1. Nature of phenomenon of superconductivity (16 papers).

2. Properties of superconductors with high parameters (22 papers).

3. Devices employing superconductors (56 papers).

The material is arranged in alphabetical order within each section (according to the last names of the first authors of the papers).

This publication contains an index by author and a chronological index.

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THEORETICAL PHYSICS

INVESTIGATIONS IN SUPERSONIC AERODYNAMICS

Novosibirsk ISSLEDOVANIYA PO GIPERZVUKOVOY AERODINAMIKE in Russian 1978 signed to press 22 Dec 78 p 2, 185

[Annotation and table of contents of symposium of scientific papers, 400 copies, 185 pages (Novosibirsk)]

[Text] The symposium contains new results on urgent problems of supersonic aerodynamics. Using the method of asymptotic expansions, solutions to problems are given for streamlining thin blunt bodies, thin conical bodies with a break in the generatrix, and a system of common differential equations was obtained to determine the pressure in the "vacuum" region.

Using the gas-dynamic design, new classes of supersonic aircraft configurations were plotted including aircraft with air intakes of the convergent type. The results of experimental investigations are described of V-and delta-shaped wings at supersonic speeds for "uneconomical" streamlining modes.

Minimum resistance V-shaped bodies with curvilinear cross sections and longitudinal contours were obtained, and experimental investigations of aerodynamic characteristics of optimal configurations were described

Efficiency characteristics of Kreyser's flight were obtained by calculation on the basis of a model of a supersonic aircraft with a ram air jet engine using hydrogen fuel.

The symposium is intended for specialists in the area of aerodynamics of aircraft.

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THEORETICAL PHYSICS

UDC 621.373.826

OSCILLATORY RELAXATION OF MOLECULES AND GAS-DYNAMIC LASERS

Moscow KOLEBATEL'NAYA RELAKSATSIYA MOLEKUL I GAZODINAMICHESKIYE LAZERY in Russian 1979 signed to press 3 Jul 79 pp 2-4, 190

[Annotation, foreword and table of contents from book edited by Academician N. G. Basov, Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences, Izdatel'stvo Nauka, 1,400 copies, 191 pages]

[Text] This collection of works is devoted to the results of theoretical and experimental research on two interrelated problems: the oscillatory relaxation of molecules in both gasses and gas-dynamic lasers, at the base of which lies the phenomenon of the oscillatory-nonequilibrium flow of gasses.

The theory of the phase method of measuring the rate constant of the oscillatory relaxation of CO_2 molecules is explained, and a broad spectrum of experimental results obtained by this method is presented. The results apply to both collisions of molecules with each other in a volume of gas and their interaction with the surface of a solid.

The different authors discuss the principles of the construction of powerful, continuous-action, gas-dynamic lasers. A model of the working medium in a section of the gas's flow through the optical resonator is given. The results of experiments with optical resonators operating as part of a gas-dynamic laser are presented. There is also a discussion of questions relating to the optimization of gas-dynamic lasers and lasers with working mediums of different compositions.

Foreword

This collection of works is devoted to theoretical and experimental research in a new area of quantum electronics and the physics of powerful gas lasers: the field of gas-dynamic lasers. This area had its inception in a hypothesis advanced by V.K. Konyukhov and A.M. Prokhorov [1,2], although the prerequisites of a physical nature were contained in many more works. Among them we should include: 1) the principle of the thermal excitation of quantum mechanics systems for the generation of electromagnetic radiation, as introduced and developed by H.E.D. Scovil and E.O. Schulz-DuBois [3,4]; 2) the phenomenon of lagging thermal capacity in gas dynamics, which was first predicted and experimentally detected by A. Kantrowitz [5] and which was further developed in works on the oscillatory-nonequilibrium flow of molecular gasses; 3) the phenomenon of resonance transmission of oscillatory excitation during the collision of molecules in a gaseous phase, which was first observed by A.N. Terenin and G.G. Neuymin in a mixture of carbon dioxide and nitrogen in a glow discharge [6] and was later used in order to create a gas-discharge CO_2 laser [7,8].

The specific stage of development that gas-dynamic lasers have gone through in the last 10 years found its expression in the monographic literature [9-12] and survey articles [13,14].

The first article is devoted to a broad-scale investigation of the oscillatory relaxation of a CO_2 molecule located on the (00^01) level. Initially the phase method, which was used in all the experiments, was proposed as the method for measuring the relaxation rate constants [15], without knowledge of which it is impossible to formulate a quantitative theory of gas-dynamic lasers. Its development as the most accurate method now known made it possible to carry out physical research on a broader scale and, in particular, to publish the first results of experiments on the oscillatory relaxation of a CO_2 molecule on the surface of an ion crystal, which results are of undoubted interest for surface physics.

In the second article the author explains the fundamental physical concepts on which powerful gas-dynamic lasers are based. It contains a description of the first experimental work (performed in our country) that led to the realization of the idea of the gas-dynamic laser. This work was done in the 1966-1972 period, so that formulation of the problems and goals that was natural to that time has been retained.

The third article is devoted to the optical resonators of gas-dynamic lasers. Until the appearance of lasers with a fast-acting active medium, the problem of optical resonators -- which are capable of operating with large volumes of moving and optically heterogeneous gas -- did not exist. In this articles the author presents for the first time a description of and the results of experiments with resonators with additional feedback, which recommend themselves quite well for use under conditions where the amplifying gaseous medium is flowing at a supersonic velocity.

The fourth, fifth and sixth articles are concerned with the development of the physics of gas-dynamic lasers in recent years and, in particular, gas-dynamic lasers based on other emitting molecules. Although the gaseous mixture of carbon dioxide, nitrogen and water vapor is still unsurpassed as far as energy characteristics and simplicity of production are concerned, the search for other gaseous mixtures is both timely and advisable.

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THEORETICAL PHYSICS

DIRECT NUMERICAL MODELING OF GAS FLOW

Moscow PRYAMOYE CHISLENNOYE MODELIROVANIYE TECHENIY GAZA (Chislennyy Eksperiment V Gazovoy Dinamike) (Direct Numerical Modeling of Gas Flows (Numerical Experiment in Gas Dynamics)) in Russian 1978 signed to press 11 Jan 78 pp 3-5, 172

[Foreword and table of contents from book by Corresponding Member USSR Academy of Sciences O. M. Belotserkovskiy chief editor, Vychislitel'nyy tsentr Akademii nauk SSSR, 1,040 copies, 172 pages]

[Text] Foreword

This volume contains papers dealing with development of new models and methods of numerical solution of problems of modern gas dynamics. The demonstrated approaches make it possible to investigate a broad class of complex gas flows -- calculation of "supercritical" transonic flows, local supersonic zones, flow separation regions, solution of Navier-Stokes equations, MHD-equations, modeling of flows of rarefied gas, etc.

On the whole this volume is thematic. The majority of the papers reflect the authors' endeavor to achieve a unity of ideology of construction of numerical algorithms for the most diversified areas of gas dynamics, from numerical modeling of Euler equations to MHD-equations and the Boltzmann equation.

The article by O. M. Belotserkovskiy presents the general ideas and ideology of the elaborated methods on the basis of the principles of splitting and conservativeness. Numerical models for Euler, Navier-Stokes and Boltzmann equations are sequentially examined. Results of methods calculations are presented, as well as investigations of concrete problems with complex internal structure.

A characteristic feature of the examined schemes is the fact that they are based on fairly clear and simple physical models. Thanks to this, numerical realization of corresponding algorithms can be viewed as unique computer modeling of a corresponding physical experiment. We feel that such an approach to computer schemes is the most fruitful when studying complex problems of computer physics and mechanics.

The numerical experiment procedures examined here are based on a number of fundamental principles. These include, first of all, the "physical nature" of the computation process, linked essentially with modeling of the laws of conservation written down for terminal elements -- Euler network cells. In addition, the principle of splitting the general modeled phenomenon into more elementary physical processes in small time step Δt is effectively utilized here for constructing a computer algorithm.

Both these ideas are implemented most clearly in the method of "large particles" (Yu. M. Davydov's article) and in the method of direct statistical modeling of a rarefied gas (the Ye. S. Sedova and V. Ye. Yanitskiy article), although there exists a fundamental difference between these two papers both in regard to area of application and in the sense of realization of computer algorithms.

The idea of effectiveness of construction of "physical" computer diagrams is also reflected in the article by A. V. Babakov and L. I. Severinov, which examines conservative approaches for hydrodynamic equations of a compressed viscous gas, which realize direct numerical modeling of integral laws of conservation written down for each cell of a fixed Euler network.

Application of the splitting scheme to Navier-Stokes equations for an incompressible viscous fluid is demonstrated in the paper by V. A. Gushchin and V. V. Shchennikov. A splitting scheme of a second order of accuracy is set up here for Navier-Stokes equations written in "velocity-pressure" variables and makes it possible to perform calculations on a single algorithm for two-dimensional, axisymmetric and three-dimensional gas flows. The expediency of selection of such an arrangement was revealed in particular in the fact that the traditionally complex problem of statement of boundary conditions for a vortex on the solid surface of a body is not applicable here. The value for a boundary vortex in this approach can be computed directly from the velocity field. This made it possible to improve accuracy and effectiveness of solving problems for equations of a viscous incompressible gas.

The paper by V. A. Lyul'ka examines and solves with classic computer methods the practical-importance problem of the flow of a viscous fluid containing particles of another phase. The importance of examination of this problem is obvious if only because almost all processes of transport in a living organism involve the movement of suspensions or emulsions. And finally, the paper by I. G. Zagnibeda and V. A. Lyul'ka is devoted to a new statement of the problem of self-consistent motion of a solid and viscous fluid contained in it under the effect of external forces and moments. The authors propose utilization of a dynamic description of the behavior of a solid and a viscous fluid as a single mechanical system as the basis for mathematical formulation of this problem. In this way one can write the requisite equations, plan an approach to computer modeling of this phenomenon and obtain an energy integral for the entire system.

The paper by V. V. Aristov and F. G. Cheremisin proposes utilization of the basic principles of splitting by physical factors to solve one of the most complex problems of numerical methods in the dynamics of a rarefied gas -- construction of a conservative difference arrangement of the Boltzmann equation. Numerical experiments confirm that here as well application of the above-stated principles of "physical nature" and splitting of the computation process prove to be an effective means of problem solving.

In conclusion we should note that the contents of this volume reflect to a substantial degree the principal directions of research being performed at the computer physics laboratory of the USSR Academy of Sciences Computer Center.

O. M. Belotserkovskiy

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MATHEMATICS

PUBLICATIONS

NEW VOLUME OF PAPERS IN MATHEMATICAL PHYSICS

Kiev MATEMATICHESKAYA FIZIKA (Mathematical Physics), in Russian Issue 26 1979 pp 2, 125

[Annotation and table of contents from volume of scholarly papers, Yu. A. Mitropol'skiy, chief editor, Izdatel'stvo Naukova Dumka, 125 pages]

[Text] This volume contains research papers on theory of periodic and conditional-periodic solutions, stability of motion, and mechanics of gyroscopic compasses. Evaluations of solutions to Neumann problems are established, methods of approximate solution of operator equations are elaborated, and mathematical problems of mechanics of a continuous medium are investigated. Classes of uniqueness of Cauchy problems for systems with singular coefficients are investigated.

This volume is intended for scientific workers, higher educational institution graduate students and upper-division students specializing in mathematics and mechanics.

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