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Relaxation Processes During Interaction of Detonation Wave and Aerosol Cloud

[Article by S. E. Khoruzhnikov, Leningrad Institute of Precision Mechanics and Optics]

[Abstract] Interaction of a detonation wave and an aerosol cloud is analyzed on the basis of the continuum-kinetic model for a pseudogas with inelastic collisions of particles and a negligible effect of the carrier phase on the dynamics of the dispersed phase. The system of K partial differential equations for space-time and velocity distribution of K kinds (size fractions) of particles, interaction of each kind and the carrier gas being approximated as a diffusion process, is solved by a numerical method simultaneously with the corresponding equations of state in a spherical aerosol particle approximation and an ideal carrier gas. This solution yields the characteristics of both thermal and dynamic relaxations. Calculations made for a detonation wave in a mixture of C_3H_2 and O_2 plus gaseous combustion products which contains MgO microparticle fractions indicate not only the validity of the continuum-kinetic model here but also the limits, in terms of particle size, within which the simpler continuum model is also applicable. The author thanks A. I. Zhmakin, Yu. P. Lundin (deceased), V. F. Mymrin, and A. A. Schmidt for assistance and for discussion of the results. Figures 4; references 11: 8 Russian, 3 Western (1 in Russian translation)

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Performance of Electron-Beam KrF-Laser at High Excitation Power and Energy Densities

[Article by A. D. Klementov, N. V. Morozov, and P. B. Sergeyev, Institute of Physics imeni P.N. Lebedev, USSR Academy of Sciences]

[Abstract] A KrF-laser with Ar-Kr-F_2 or Kr-F_2 active gas mixture occupying a volume of 450 cm^3 in a 23 cm long cell with electron-beam excitation in pulses of 70-100 ns pulses was tested, for an experimental evaluation of its performance characteristics. The laser cavity was formed by two dielectric plane mirrors 35 cm apart, their optical reflectances matched for optimum optical transmittance of the cavity. The total output energy was measured with two BKDM calorimeters built at the institute of Physics. The laser was first tested with the Ar-Kr-F_2 active gas mixture under a pressure of 1 atm, for determination of the dependence of its emission energy and efficiency on the Kr-content over the 10-100 mol.pct Kr range. Maximum efficiency of about 8.5 pct was attained with the Kr-content within the 20-40 pct range. The laser was then tested with the active gas mixture containing Ar and Kr in a 10:1 ratio with its volume reduced to 120 cm^3 only, with the pressure of the active mixture varied over the 1-3 atm range at 2-4 MW/(cm^3.atm) excitation power density and over the 4-6 atm range at 2.2 MW/(cm^3atm) excitation power density so that an excitation power density of 13 MW/cm^3 was reached under 6 atm. The laser was also tested without Ar in the active gas mixture, its performance having been found to become worse with the maximum emission energy of 3.6 J and the maximum emission efficiency of 4 pct reached with pressures of 2 atm and 1.5 atm respectively. An evaluation of the data has yielded the dependence of the optimum partial F_2-pressure on the excitation energy density, up to 1.1 J/cm^3. Figures 5; references 22: 9 Russian, 13 Western.

Giant Pulses of Radiation by Al_2O_3: Ti^{3+} Solid-State Laser

[Article by Kh.S. Bagdasarov, V.P. Danilov, A.N. Kolerov, S.S. Kalyaro, T.M. Murina, and Ye.A. Fedorov, Institute of General Physics, USSR Academy of Sciences, Moscow]

[Abstract] Short giant pulses of radiation were extracted from a tunable Al_2O_3:Ti^{3+}-laser by means of a NaF:$F2^+$-shutter, the absorption peak of this shutter material lying within the 820nm band and 60-120mm long crystals 4-8 mm in diameter being optically pumped in the experiment. The duration of a laser emission pulse was regulated over the 0.001-0.010 ms range by variation of cavity length and of the pumping electric-discharge circuit. It was regulated over a range covering up to two orders of magnitude by means of 0.8-3 mm thick NaF shutters with a 0.2-0.3 residual transmission coefficient in the cavity between the active medium and the exit mirror with a 0.85 reflection coefficient. Either regular trains or laser pulses or laser monopulses of 1-2 mJ energy and 100-200 ns duration were generated in this way. With an appropriate pumping rate giant monopulses of 80-100 ns duration were generated. In a separate experiment the duration of such giant pulses was shortened by dumping of the inverse population and thus deactivating the excited states in the shutter. This was achieved with an auxiliary cavity containing the shutter only between two mirrors featuring almost full reflectance for 870-1070 nm wavelengths. Although in this way the pulse duration was thus shortened to 50-60 ns only, emission was obtained in the two special bands 730-850 nm and 950-1050 nm corresponding to the two active media now: Al_2O_3:Ti^{3+} respectively. Figures 2; references 8: 5 Russian, 3 Western.

New Generation of Dyes for 688-860 nm Lasers

[Article by B. I. Stepanov, N. N. Bychkov, L. V. Levshin, B. A. Konstantinov, A. I. Akimov, V. Ye. Mnuskin, A. N. Tokareva, B. F. Trinchuk, A. I. Sopin, B. M. Uzhinov, and S. I. Druzhinin]

[Abstract] Eighteen new dyes for tunable near-infrared lasers with transverse excitation by a ruby laser or an N_2-laser have been developed: LKK-732, LKK-733, LKK-756, LKK-761, LKK-762, LKK-763, LKK-764, LKK-765, LKK-766, LKK-767, LKK-768, LKK-769, LKK-775, LK-780, LK-790, LK-800, LK-810, LK-840. Their tuning ranges differ and are 42-87 nm wide. Their solvent is acetonitrile and wavelength tuning is done by varying the concentration. They were tested with pumping by a ruby laser (694 nm) in pulses of 1 J energy and 20-25 ns duration, also with pumping by a "Krona-1" N_2-laser (337 nm). Their efficiency was in both cases higher than that of dyes currently used for this spectral range. They were tested for photosensitivity in acetonitrile, its measure being the photolysis time in full light of a DRSh-1000 mercury lamp, and found to be much more stable than cyanin-3966 in acetonitrile. Figures 1; tables 2; references 9: 6 Russian, 3 Western.

New Generation of Dyes for 660-860 nm Lasers With Optical Pumping

[Article by B. I. Stepanov, N. N. Bychkov, V. G. Nikiforov, L. V. Levshin, B. F. Trinchuk, A. I. Sopin, V. A. Alekseyev, A. M. Lantsov, P. V. Davidenko, B. M. Uzhinov, and S. I. Druzhinin]

[Abstract] Ten new dyes for red and near-infrared lasers with optical pumping have been developed: LK-678, LK-703, LK-740, LK-747, LK-755, LK-781, LK-790, LK-800, LK-810, LK-840. Their solvent is acetonitrile or acetonitrile with water (34:66, 28:72), ethanol or ethanol with water (40:60) being used only for the LK-678. They were tested with an INP2-4/120A flashtube as pump inside a cavity between two mirrors with 0.99 and 0.55 reflection coefficients respectively. Their efficiency is comparable with or somewhat higher than that of rhodamine 6G, 30-200 times higher than that of polymethine and oxazine dyes. Figures 1; tables 1; references 5: 2 Russian, 3 Western.

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Construction of XeCl-Laser Delivering 150 J Emission Energy

[Article by Yu. I. Bychkov, N. G. Ivanov, V. F. Losev, and G. A. Mesyats, Institute of High-Current Electronics, Siberian Department, USSR Academy of Sciences, Tomsk]

[Abstract] An XeCl-laser capable of delivering 150 J emission energy has been built, its main feature being bilateral transverse excitation by two counter-running electron beams. Its structure consists of a gas chamber made of stainless steel with 60 dm^3 capacity, two vacuum-tube diodes with explosive-emission cathodes, and six pulse-voltage generators. One diode is powered by three 10-stage Arkadyev-Marx generators in parallel, each stage having a 100 nF capacitance and a 200 ohm surge impedance. All stages are triggered simultaneously, their asynchronism not exceeding plus or minus 20 ns. The active medium is an Ar-Xe-HCl or Ar-Xe-CCl_4 mixture under a pressure of 4 atm for optimum performance. Each electron beam is injected into the laser cell through a 13x150 cm^2 large window, a 0.050 mm thick Ti-foil, the two windows being spaced 13 cm apart. The laser cavity is formed by a plane-parallel quartz plate and an Al-coated mirror, each placed in a window 200 mm in diameter in opposite walls of the gas chamber. With a 1400:10:1 Ar:Xe:HCl active mixture, an emission energy of 100 J and 150 J was extracted upon transverse excitation with an 80 kV electron-beam accelerating diode voltage and upon excitation between foils with a 100 kV electron-beam accelerating diode voltage respectively. With a 2000:10:1 Ar:Xe:CCl_4 active mixture, the extracted emission energy was correspondingly about 15 percent lower. Figures 2; references 5: 2 Russian, 3 Western.

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Can A Nuclear Substance Exist in a Condensed State?

[Article by D. I. Dyakonov and A. D. Merlin, Leningrad Institute of Nuclear Physics, USSR Academy of Sciences]

[Abstract] The possibility of a nuclear substance existing in the condensed state is examined from the standpoinnt of the chiral theory for a system of interacting nucleons, the chiral model being that of a "generalized" or "classical" nucleon with three Euler angles or a 2x2 matrix defining its orientation in the spin-isospin space. The kinetic energy of rotation of such a nucleon and the interaction potential of rotational states of such nucleons are calculated according to this theory, whereupon a crystal with a f.c.c. lattice is considered. Interaction of nucleons is found to be highly anisotropic and strongly dependent on their relative orientations, the interaction potential reaching the GeV level at 1-1.5 fm distances in the optimum configurations. This suggests that a nuclear substance consisting of many nucleons in close proximity can possibly exist in the form of a crystal or a Fermi fluid with short-range order. the authors thank V.Yu. Petrov and P.V. Pobylitsa for many thorough discussions. D.I. Dyakonov thanks also A.G. Aronov, B.L. Birbrair, A.A. Bykov, V.G. Zelevinskiy, D.A. Kirzhnits, and Yu.A. Simonov for interesting and helpful discussions. Figures 4; tables 2; references 11: 5 Russian, 6 Western.

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Neutrino Oscillations in Nonhomogeneous Medium

[Article by Ye. Kh. Akhmedov, Institute of Atomic Energy imeni I. V. Kurchatov]

[Abstract] Evolution of an ultrarelativistic neutrino beam and neutrino oscillations in a medium of nonuniform density are described by an approximate analytical solution to the system of two equations of kinetics in a medium whose density is an arbitrary function of the space coordinates and becomes constant after varying monotonically over a short transient period. A beam of electron neutrinos is assumed to exist at time zero, oscillations to muon neutrinos back and forth being then considered. The equations are formulated in terms of neutrino detection probabilities, with mixing length and angle in a weak-interaction system normalized to those in vacuo. A medium whose density varies periodically in time is considered as a special case, in which case parametric amplification of neutrino oscillation analogous to classical parametric resonance is found to be

possible and the necessary conditions for it are established. The author thanks S.T. Belyayev, M.B. Valuation, Yu.V. Gaponov, and V.A. Khodel for helpful discussions. References 10: 4 Russian, 6 Western (1 in Russian translation).

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Consistent Analysis of Data on Cross-Sections for (n,f)-Reaction and (n,xn)-Reactions Pertaining to Actinides

[Article by V. M. Maslov, Institute of Nuclear Power Engineering, BSSR Academy of Sciences, A. V. Ignatyuk and A. B. Pashchenko, Institute of Physics and Power Engineering, Obninsk]

[Abstract] The neutron cross-sections for (n,f)-reaction and (n,xn)-reactions are described statistically on the basis of a consistent analysis of experimental data pertaining to fission of ^{238}U nuclei and then ^{235}U nuclei at energy levels up to 20 MeV, taking into account the contributions of not only shell effects but also collective and superfluid effects to the density of levels in both neutron and fission channels in the pre-equilibrium state as well as in the equilibrium state and after strong deformation. An evaluation of the data has yielded the energy dependence of fissility and "first chance" fission above the (n,nf)-reaction threshold. Figures 8; references 24: 6 Russian, 18 Western.

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Statistical Description of Emission of Prompt Neutrons During Fission of Heavy-Atom Nuclei

[Article by A. L. Belov, Moscow Institute of Engineering Physics, and V. P. Kraynov, Higher Technical School at Moscow Automobile Manufacturing Plant imeni I.A. Likhachev]

[Abstract] Fission of heavy nuclei is analyzed from the standpoint of prompt-neutron statistics, the average number of prompt neutrons emitted in the process being estimated on the basis of their either theoretically predictable or experimentally measurable distribution. First the initial kinetic energy of fission fragments and the heat balance following rupture of the neck are calculated according to known relations which describe the initial fragment geometry and the subsequent fragment deformation as a result of charge-charge and charge-quadrupole interactions, assuming a zero dipole moment of light fragments and a minimum potential energy at the instant of neck rupture. The distance between fragments immediately after neck rupture is assumed to be of the

order of the minimum neck width and their quadrupole deformation along the axis passing through their centers, symmetry axis of the system, is assumed to be small. Statistics for determining the average number of prompt neutrons have been obtained for fission of a ^{235}U

nucleus induced by thermal neutrons and for spontaneous fission of a ^{232}Cf nucleus. Figures 4; tables 1; references 13: 5 Russian, 8 Western.

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Roughness Measurement by Nonlinear Optical Method and Surface Examination by Scanning Tunnel Microscopy

[Article by O.A. Aktsipetrov, S.I. Vasilyev, and V.I. Panov, Moscow State University imeni M.V. Lomonosov]

[Abstract] The nonlinear optical method of surface inspection, by comparison of polarization and directional characteristics of second-harmonic radiation reflected by rough and smooth surfaces, was tested for sensitivity limits on Au and Ag films of maximum attainable smoothness under a scanning tunnel microscope. Polycrystalline 60 nm thick Au-films for this purpose were deposited by the vacuum-evaporation process on a multilayer structure consisting of a chemically polished quartz substrate with a 70 nm thick Cr first coat and a 70 nm thick Pd second coat. Polycrystalline Ag films were deposited by the vacuum evaporation process, under a vacuum lower than 10^{-9} torr, on Au films cooled to 77 K and were then annealed under deep vacuum at room temperature. Surface examination was done at room temperature and under atmospheric pressure. It involved measuring the intensity of the forbidden p,s second harmonic and the intensity of the allowed p,p second harmonic, the ratio of both serving as measure of surface roughness. An evaluation of the date revealed different roughness patterns on Au-films and on annealed Ag-films, the former being smoothest. The data were compared with those on the surface of mechanically polished Ag-electrodes before and after anodic etching with a charge density of 2-3 mC/cm^2. While before etching the surface was comparable with that of annealed Ag-films, after etching it had become rougher with a granular pattern. The authors thank L.V. Keldysh for organizing the study and for helpful discussions as well as Ye.D. Mishin and V.B. Leonov for assisting in the measurements. Figures 1; tables 1; references 6: 5 Russian, 1 Western (in Russian translation).

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Dynamics of Interaction of 2940 nm Laser Radiation With Thin Liquid Water Layer

[Article by K. L. Vodopyanov, M. Ye. Karasev, L. A. Kulevskiy, A. V. Lukashev, and G. R. Toker, Institute of General Physics, USSR Academy of Sciences, Moscow]

[Abstract] An experimental study by the methods of shadow and interference holography was made concerning action of 2940 nm laser radiation on a thin layer of water, the frequency of this radiation coinciding with the center frequency of the valence vibration band of the OH-group and water therefore having a high absorption capacity for this radiation. A 0.005 mm thick layer of water in a quartz cuvette was treated with TEM_{00}-mode radiation in pulses of 5-7 mJ energy and 100 ns half-power width, the laser spot having an area of 14 mm^2 and the radiation intensity at the water-quartz boundary being 45 MW/cm^2. Diagnostic probing was done with 530 nm second-harmonic radiation from a Nd-laser, in pulses of 10 ns duration synchronized with the pumping pulses within 10 ns and delayed behind the peak of the latter by up to 500 ns. Changes in the refractive index of water served as the indicator of changes occurring during laser action, essentially formation of a denser liquid ring along the edge of the laser caustic and of a vapor-gas bubble in the center. The refractive index of quartz was found to change insignificantly so that shadowgrams and interferograms yielded reliable information about the water. These conclusions were verified by monitoring the propagation of acoustic pulses through both media. Figures 2; references 8: 6 Russian, 2 Western.

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Scanning Tunneling Microscope With Atomic-Scale Resolution in Air

[Article by V. K. Adamchuk, A. V. Bramkov, and I. V. Lyubinetskiy, Leningrad State University imeni A. A. Zhdanov]

[Abstract] A scanning tunneling microscope with atomic-scale resolution has been built for microstructural examination of surfaces and interphase boundaries under superhigh vacuum. Its design is based on the Binning-Rohrer concept (SURFACE SCIENCE Vol 126, Nos 1-3, 1983). The piezoelectric manipulator of the needle electrode and the piezoelectric positioner of the test specimen are both mounted on a common L-form stage made of low-exansivity ($2 \cdot 10^{-8}$ K^{-1}) doped quartz. The electrode manipulator for scanning a specimen in the XY plane by moving the electrode with high precision parallel to the specimen in both X and Y directions is a symmetric cruciform bar made of PKR-6 piezoceramic. Its sensitivity is 1.38 nm/V in both X and Y direction. It can also move the electrode in the Z direction normal to the specimen surface, its sensitivity here being 0.35 nm/V. The specimen positioner for bringing the specimen to within 5-50 nm from the tip of the needle electrode is a piezoelectric motor in the form of a 1 mm thick flat tee made of PKR-8 piezoceramic with metallization on two mutually orthogonal surfaces ensuring independent response to compression in two mutually orthogonal direction. A "compression" voltage of 20-120 V applied to the motor produces discrete displacements in 20-300 steps correspondingly, at a rate

of 2-20 steps/s. The microscope is vibration-proofed by isolation mounts and thermal drift on the specimen surface is prevented by symmetry of the electrode manipulator. The performance of the microscope was tested on one (0001) face of a highly oriented pyrolitic graphite crystal with atoms 0.25 nm apart protruding 0.15 nm high, the examination being done in air. Face segments 2.5x2.7 mm^2 large were scanned within 20 s, at a tunnel current of 0.2 nA with a voltage of 10 mV and a scan frequency of 10 Hz. The authors thank G. A. Zhitomirskiy and A. Ye. Panich for supplying the piezo-ceramics. Figures 1; references 8: 3 Russian, 5 Western.

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UDC 539.32

Effect of Displacements of Speckle Structure of Image

[Article by S. Yu. Davydov and V. I. Margolin, Leningrad Institute of Electrical Engineering imeni V. I. Ulyanov (Lenin)]

[Abstract] Considering that scattering of coherent laser light by particles on a diffusely reflecting surface results in interference of scattered light waves and that the principal characteristic of any random field such as the field of a diffusely reflected light wave is its intensity averaged over all scatterers, the effect of surface deformation and attendant displacements of surface points on that intensity is evaluated analytically for the speckle structure of a diffuser image. Calculations are based on a diffuser model with additive superposition of complex intensity amplitudes at any point immediately behind it and with a given correlation radius for elementary scatterers. Both translation and rotation of the diffuser as a whole can be ignored so that only displacements of its elementary scatterers under stress and strain remain under consideration, their longwave components shown to contribute most to intensity changes in the speckle structure of its image. References 3: 2 Russian, 1 Western (in Russian translation).

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UDC 537.312.62:538.945

Superconductivity of Y-Ba-Cu-O Compounds and Their Local Contents Distribution

[Article by O. V. Kosogov, O. G. Vendik, Ye. F. Gatsura, S. F. Karmanenko, Kim Gvan De, A. B. Kozyrev, S. G. Kolesov, S. G. Konnikov, O. V. Kornyakova, A. O. Kosogov, and N. F. Leontyeva, Leningrad Institute of Electrical Engineering imeni V. I. Ulyanov (Lenin)]

[Abstract] An experimental study of $YBa_2Cu_3O_y$ compounds in solid solution was made, for the purpose of determining the temperature dependence of their electrical resistance and diamagnetic inductance decrement over the 290-4.2 K range. Specimens were produced from a stoichiometric mixture of Y_2O_3, CuO, and raw or specially predesiccated $BaCO_3$ powders by three-phase synthesis during sintering in a quartz reactor in an oxygen stream at a temperature about 950 deg C inside a platinum crucible. The sintered compact, its color black shot with green, was crushed into powder and the latter was then cold pressured into 2-3 mm thick disks 10.5 mm in diameter. These were annealed in an oxygen atmosphere at a temperature of 950 deg C. Three kinds of specimens were obtained corresponding to different modes of sintering and annealing, each with a different mode of superconducting transition. The first group was characterized by a sharp one-step transition beginning at 97 K. The second group was characterized by a milder two-step transition, the first step beginning at 100 K and extending to 96 K followed by the second step beginning at 95 K and extending to 90 K. The third group was characterized by a still milder but one-step transition beginning at 91.5 K and extending to 79 K, on the basis of inductance measurements. Microstructural examination and phase analysis by the electron-diffraction method revealed a polycrystalline polyphase constitution of all specimens. Those of the first group had the largest crystals, of the 1-2-3 phase with index y representing the oxygen content within the 6.9-7.1 range. Those of the second group, produced with raw $BaCo_3$ powder, had graded barium-free macrodomains. Those of the third group had a microcrystalline structure and varied in composition, $Y_{0.8-1.4}Ba_{2.2-1.6}Cu_3O_y$ with y within the 5-12 range. Figures 2; references 1: Western.

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UDC 535.36/532+66.066.3

Inverse Problem in Laser Correlation Spectroscopy. Adaptive Method of Histograms

[Article by S. M. Burkitayev and K. V. Kotoyants, Institute of Petrochemistry]

[Abstract] Application of laser correlation spectroscopy to disperse systems is considered, the problem being to reconstruct the size distribution of particles on the basis of a given correlation function. The procedure involves an inversion of the corresponding Fredholm integral equation and thus leads to an ill-conditioned inverse problem. Modification of an already known straight method of solving this problem into an adaptive one is proposed for ensuring higher accuracy and reliability, the method of histograms being selected on account of its practical advantages. The algorithm of its adaptive variant consists of the following steps: 1) subdivision of the given range of particles sizes into equal intervals and

assignment of a histogram amplitude to each; 2) minimization of a multivariate function; 3) conversion of the size grid into a nonlinear one; 4) calculations on the nonlinear grid with return to and reiteration from step 2). The efficiency of this algorithm depends largely on the physical criteria for selection of the limits on particle size and sampling time, also of the constraints on variation of the size intervals. The algorithm was tested on a Gaussian size distribution. Figures 1; references 12: 5 Russian, 7 Western (1 in Russian translation).

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UDC 535.41

Localization of Interference Pattern in Speckle Photography of Longitudinally Displaced Objects

[Article by I. V. Markhvida, L. V. Tanin, and I. A. Utkin, Institute of Physics, BSSR Academy of Sciences, Minsk]

[Abstract] Double-exposure speckle photography is considered for measurement of longitudinal displacements, this method being conventionally used for transverse displacements on account of maximum sensitivity. Formation of interference rings on the specklogram during longitudinal motion of a diffuse object is analyzed theoretically, considering two speckle fields with a different intensity distribution along a two-dimensional vector in the speckle plane each. The problem of localizing such interferograms is solved on this basis and the planes of maximum contrast are determined accordingly. Dependence of the contrast on the aperture dimensions in the optical system is established, and the optimum aperture dimensions in an optical system of lenses are determined on this basis. The results have been confirmed experimentally. Figures 2; references 9: 2 Russian, 7 Western (2 in Russian translation).

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UDC 539.292

Vacuum Tunneling Microscopy and Spectroscopy

[Article by V. M. Svistunov, M. A. Belogolovskiy, and A. I. Dyachenko, Donetsk Institute of Engineering Physics, UkSSR Academy of Sciences]

[Abstract] Development of scanning tunneling microscopes as well as their use for elastic or inelastic spectroscopy of materials and their structure are reviewed, the first such microscope in the USSR having been built in 1985 and now operating at the Institute of Problems in Physics (USSR Academy of Sciences). Concerning further progress, particularly important is producing a vacuum barrier between the electrodes. This problem is addressed at the Institute of Radio Engineering and Electronics (USSR Academy of Sciences) and spectroscopy with such a microscope was tried on $ErRh_4B_4$ superconductor material. A breakthrough was made by the Swiss IBM, based on the exponential decay of the electron wave function in a potential barrier with a resulting strong dependence of both tunnel resistance and tunneling current on the gap width. The construction of such a microscope is outlined, it main three features including a vibration isolation and damping system in addition to a mechanism for rough movement and a mechanism for fine movement of the needle electrode toward the examined specimen. Non-needle-plate variants are considered, attainable vacuum and resolution being further increased. That first microscope built in the USSR uses a tungsten needle electrode and $BaTiO_3$ piezoceramic displacement transducers mounted on a damper, under a bell evacuated to 10^{-2}-10^{-5} mm Hg residual pressure. Such microscopes are now used extensively for examination of the atomic structure in metals and in semiconductors such as Ge, GeSi, GaAs, Si. The crucial problems are adequacy of the needle electrode, sensitivity and stability of the needle movement, the needle being also an electron injector, limits on vertical and lateral resolution, and most importantly controlling a vacuum gap of atomic dimensions, also processing of experimental data. References 50: 10 Russian, 40 Western.

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Vibration Spectra of 'Hot' Molecules in Excited Electronic State: Measurement of Picosecond Cooling Kinetics by Method of Coherent Stokes Scattering

[Article by V. F. Kamalov, N. I. Koroteyev, B. N. Toleutayev, and A. P. Shkurinov, Moscow State University imeni M. V. Lomonosov]

[Abstract] With the lifetime of the S_1-state of "hot" trans-stilbene molecules shortened upon absorption of light quanta, their picosecond cooling kinetics and vibration spectra were measured for the first time by the method of resonant coherent Stokes light scattering. Molecules of trans-stilbene in ethanol solution forming a 0.300 mm wide free jet were excited with a fourth-harmonic radiation pulse of 0.0005 mJ energy from a YAG:Nd laser (266 nm wavelength). At the same time their excited state was probed with second-harmonic radiation pulses of up to 0.010 mJ energy and 60 ps duration from this YAG:Nd laser (532 nm wavelength) as well as with radiation pulses of 0.001 mJ energy and 60 ps duration from a synchronously pumped dye laser (550-600 nm wavelength) at repetition rates of 3 kHz

each. Signals at the Stokes frequency $2f_{dye}-f_{YAG:Nd,2}$ were recorded with a 0.5 cm^{-1} resolution and signals of resonant coherent Stokes scattering were measured by photon count with strobing. The authors thank Professor S. A. Akhmanov and A. Yu. Chikishev as well as Professors R. M. Hochstrasser and A. N. Zavail in the USA for valuable discussions. Figures 2; references 10: 3 Russian, 7 Western.

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Plasma Physics

UDC 533.95

Ion-Acoustic Oscillations in Plasma of Ionic Lasers

[Article by V. I. Donin, D. A. Shapiro, D. V. Yakovin, and A. S. Yatsenko, Institute of Automation and Electrometry, Siberian Department, USSR Academy of Sciences, Novosibirsk]

[Abstract] Oscillations in the plasma of Ar and Kr lasers are analyzed, the hypothesis of their ion-acoustic nature having been validated experimentally for 5-100 MHz oscillations but not working for 250 kHz oscillations. A theory is developed for low-frequency oscillations with a wavelength of the order of the plasma nonhomogeneity scale. It is based on the hydrodynamical model of plasma discharge in a cylindrical geometry, assuming an ion temperature much lower than the electron temperature and accordingly a small statistical spread of ion velocity relative to the radial drift velocity. Partial differential equations for both zeroth and first moments of the ion distribution function lead, without the inertia term, to an ordinary differential equation of the diffusion kind for the steady-state ion concentration distribution describable by the zeroth-order Bessel function of the first kind. The dispersion law for impact ionization of atoms by electrons is then obtained in the approximation of an effective momentum transfer frequency equal to the impact ionization constant, both quantities being of the same order of magnitude. The results of analytical and then numerical solution agree with experimental data, measurements having been made with a cold plasma produced by direct-current discharge in argon and in krypton. The gas pressure in a segmental discharge tube was varied over the 0.2-0.4 torr range and the current density was varied over the 250-500 A/cm^2 range, the tube length being varied from 35 cm to 100 cm with the length of one segment varied from 0.6 cm to 2.5 cm while the diameter of the discharge channel was varied from 0.3 cm to 1.6 cm. Radiation spontaneously emitted by the plasma was measured through windows in successive tube segments. The optical instrument consisting of two "lens - diaphragm - light filter - photomultiplier" channels. Readings taken at two windows simultaneously were fed to an analyzer or to a correlator, the latter having a maximum clock frequency of 160 MHz and calculating either the autocorrelation function for a signal or the cross-correlation function for two signals. Plasma oscillations were also independently recorded on an oscillograph. The measurements have yielded the frequency spectra of the rise of plasma oscillations as profiles of the oscillation intensity along the discharge tube, also the dependence of the plasma oscillation frequency on the discharge channel diameter. The authors thank S. G. Rautian for helpful discussion of the results. Figures 6; tables 2; references 24: 14 Russian, 10 Western.

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Films of YBa$_2$Cu$_3$O$_{7-d}$ High-Temperature Superconductor Produced by Magnetron Sputtering

[Article by Yu. V. Gulyayev, I. M. Kotelyanskiy, V. V. Kravchenko, V.A. Luzanov, and A. T. Sobolev, Institute of Radio Engineering and Electronics, USSR Academy of Sciences, Moscow]

[Abstract] Films of YBa$_2$Cu$_3$O$_{7-d}$ with a superconducting transition temperature above 77.4 K, on BaF$_2$ single-crystal substrates with a low dielectric constant of approximately 7 and a (111) orientation, were produced by magnetron sputtering with subsequent chemical and mechanical polishing. As target material was used YBa$_2$Cu$_3$O$_{7-d}$ ceramic which had been produced from a mixture of Y$_2$O$_3$, BaCO$_3$, CuO powders by compaction and subsequent annealing at 1000 deg C. Sputtering at a rate of 800-1000 nm/h was done with a 13.56 MHz magnetron at a power of 100-150 W. The films, 800-1000 nm thick with a mirror surface and an electrical resistivity higher than 10^8 ohm· cm, were not superconducting. Annealing then at 900-930 deg C reduced their electrical resistivity to 10^{-2} ohm· cm over the 300-110 K temperature range and produced a superconducting transition upon further cooling with the resistance dropping to zero at 80 K. Microstructural examination in a DRON-3 x-ray diffractometer with a CoK$_{alpha1}$-radiation source revealed a preferential grain orientation along the "C" axis normal to the substrate surface and existence of grains up to 0.003 mm in size. The authors thank Ye. P. Salkovskiy for making the target and M. Ye. Gershenzon for measuring the temperature dependence of the electrical resistance. Figures 2; references 2: Western.

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Anomalies Resulting From Interaction of Millimetric-Wave Electromagnetic Radiation and Thin Y-Ba-Cu-O Films

[Article by V. N. Gubankov, Yu. Ya. Divin, S. G. Zybtsev, P. M. Shadrin, and R. N. Sheftal, Institute of Radio Engineering and Electronics, USSR Academy of Sciences, Moscow]

[Abstract] An experimental study of thin YBa$_2$Cu$_3$O$_{7-d}$ films was made, for the purpose of determining the effect of millimetric-wave electromagnetic radiation on their electrical characteristics. Films of 200 nm thickness were deposited on slices of MgO single crystals by laser evaporation of YBa$_2$Cu$_3$O$_{7-d}$ ceramic under a vacuum of 2· 10^{-6} mm Hg. They were subsequently annealed at 1000 deg C in an oxygen atmosphere for 10 min and then cooled to 500 deg C within 60 min. The temperature range of their superconducting transition varied from 10 K to 20 K with 67-63 K in the middle and with zero resistance reached at 50 K. The films were exposed to electromagnetic radiation of 70 GHz frequency. This affected the temperature dependence of their electrical resistance appreciably, but only its tail segment of the superconducting transition range. Zero resistance was approached at successively lower temperatures, as the radiation power was increased in steps up to 8· 10^{-4} W. The voltage drop across a film at a fixed current did also change, under weak radiation sharply peaking at 59 K and thus at a temperature approximately 10 K lower than that corresponding to the maximum slope of the resistance-temperature curve and also ceasing to be proportional to that slope over the superconducting transition range. This inconsistency with the bolometric effect of radiation-film interaction and with heating of electrons in a film in the resistive state was compounded by deviation of the current-voltage characteristic at low temperatures from the classical square-law relation, the second derivative of voltage with respect to current becoming almost independent of the current above the critical one. These anomalies can be explained by a granular film structure and a percolative mode of conduction in a system of weak links. Figures 2; references 6: 2 Russian, 4 Western.

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Producing Y-Ba-Cu-O Superconductor Films

[Article by Ye. I. Givargizov, I. S. Lyubutin, A. I. Pankrashov, M. K. Gubkin, Ye. M. Smirnovskaya, L. N. Obolenskaya, and A. A. Volobuyev, Institute of Crystallography, USSR Academy of Sciences, Moscow]

[Abstract] Films of the Y-Ba-Cu-O high-temperature superconductor material were produced experimentally by two nonconventional methods, first by pulverization with pyrolysis and then by zone recrystallization. They were deposited on various single-crystal substrates (BaF$_2$, MgO, alpha-Al$_2$O$_3$) and ceramic substrates (MgO, Al$_2$O$_3$). In the first method aqueous solution of Y, Ba, Cu nitrates was sprayed through a nozzle onto a hot substrate. Annealing them in an oxygen atmosphere at a temperature within the 850-950 deg C range for a period of time ranging from 10 min to 2 h produced the 1-2-3 superconductor phase with a polycrystalline structure. Phase analysis was done in a DRON-2 x-ray diffractometer and using the ASTM film. Electrical resistance was measured over the 300-4.2 K temperature range by the current-voltage method with a current of 0.3 mA. The mode of superconducting transition was found to depend strongly on the substrate material, the transition

range being narrowest for films on MgO substrate. In the second method films were deposited on MgO and Al_2O_3 substrates by cooling powder of synthesized Y-Ba-Cu-O compound from a suspension in acetone. These films had a very wide transition range on an MgO substrate and no superconducting transition on an Al_2O_3 substrate. Annealing as before narrowed the transition range on an MgO substrate but did not produce a superconducting transition on an Al_2O_3 substrate. Figures 2; references 7: 1 Russian, 6 Western (1 in Russian translation).

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Optical Properties of $YBa_2Cu_3O_{7-d}$ Superconductor Single Crystals

[Article by M. P. Petrov, A. I. Grachev, M. V. Krasinkova, A. A. Nechitaylov, V. V. Prokofyev, V. V. Poborchiy, S. I. Shagin, and N. F. Kartenko, Institute of Engineering Physics imeni A. F. Ioffe, USSR Academy of Sciences, Leningrad]

[Abstract] An optical study of $YBa_2Cu_3O_{7-d}$ superconductor single crystals was made for a determination of their reflection and Raman scattering spectra. Specimens were produced by the method of spontaneous crystallization at a temperature of 1000 deg C in an oxygen atmosphere, from powder with a slight excess of CuO in the otherwise superconductor-yielding mixture. Wafers of micron thickness and of a usually irregular shape after pulling from the ingot were black with a mirror surface and had a surface area up to but not exceeding 0.5x0.5 mm ^{2}. Superconductivity was monitored at 77 K on the basis of the Meissner effect. Phase analysis of pulverized single crystals by the x-ray diffraction method indicated that they were of the rhombic phase. Polarization and spectral characteristics of the reflection coefficient in isotropic and anisotropic regions of the surface were measured with an IBAS (Opton Co) optical microanalyzer. Raman spectra were measured in anisotropic regions at frequencies within the range of Cu-O valence fluctuations. Variances from crystal to crystal, except a consistent location of spectral lines within three ranges (420-430 cm^{-1}, 480-500 cm^{-1}, 580-600 cm^{-1}), and the larger number of bands than allowed by the nominal crystal symmetry indicate deviations caused either by oxygen deficiency or by noncontrollable microinclusions, possibly by existence of several rhombic phases. Figures 3; tables 1; references 11: 1 Russian, 10 Western.

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Two Classical Superconductivity Experiments

[Article by Ye. Z. Meylikhov]

[Abstract] In memory of Isaak Konstantinovich Kikoin (1908-84), two of his experiments are discussed which rank among the classical ones in modern (20th century) physics and pertain to superconductivity. The first one, performed in 1916, dealt with the Einstein-deHaas effect. The second one, performed in 1933, dealt with the Meissner effect. Both involved reversal of the magnetic field and measurement of gyromagnetism, the major difficulty being the very weak magnetization of superconductor metals and the need to exclude extraneous effects so as to ensure high accuracy. The apparatus for the second experiment included a suspension system for the spherical Pb specimen, an automatic field-switching device, a magnetizing solenoid, and a set of Helmholtz coils for compensation of the geomagnetic field. Determination of the Lande factor has revealed that electrons are the magnetization carriers and magnetization of superconductors is due to electron currents in closed paths rather than to electron spin. The results of Kikoin's experiments were interpreted by Meissner in 1948. Interestingly, attempts to produce the reverse gyromagnetic effect with superconductors by rotating them at high speed and thus generating a magnetic field have so far been unsuccessful. References 13: 4 Russian, 9 Western (1 in Russian translation).

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Decrease of Rate of Transverse Relaxation of Cu Nuclei in $YBa_2Cu_3O_{7-y}$ at Temperatures Below Critical

[Article by O. H. Bakharev, R. Sh. Zhdanov, A. V. Yegorov, M. V. Yeremin, V. V. Naletov, M. S. Tagirov, and M. A. Teplov, Kazan State University imeni V. I. Ulyanov-Lenin]

[Abstract] An experimental study of the $YBa_2Cu_3O_{6.9}$ ceramic involving nuclear-quadrupole-resonance measurements on its ^{63}Cu nuclei by the pulse method has revealed that only Cu2 atoms are subject to superconducting transition. Specimens for these measurements were produced from Y_2O_3, BaO, CuO powders, synthesized at a temperature of 950 deg C in air for 60 h. Measurements were made over the 10-200 K temperature range in an NQR relaxometer. Within that temperature range the NQR frequencies of ^{63}Cu in Cu1 and Cu2 positions varied over the 22.0-22.1 MHz range and over the 31.6-31.3 MHz range respectively. Nonuniform broadening of NQR-lines was estimated from the frequency dependence of the amplitude of NQR spin echo,

no temperature dependence of this broadening having been detected and the large nonuniform width being evidently attributable to variance of the electric field gradient on Cu nuclei owing to defectiveness of the crystal structure. The uniform width of lines was estimated from the attenuation of an echo signal upon an increase of the interval between sounding radio-frequency pulses. The uniformly broadened NQR-lines in both Cu1 and Cu2 positions were found to have contours intermediate between Gaussian and Lorentzian one. Upon transition into the normal state, the uniform width of the Cu1 NQR-line remained the same and that of the Cu2 NQR-line almost doubled. The narrowing of the Cu2 NQR-line upon reverse transition into the superconducting state is interpreted in terms of Cu^{2+}-Cu^{3+} pairs forming as a result of antiferromagnetic superexchange interaction, fluctuations of the hyperfine magnetic field on Cu nuclei caused by fast movements of Cu^{3+} holes adding to the width of the Cu2 NQR-line. The authors thank A. S. Borovik-Romanov for interest, N. V. Zavaritskiy and S. V. Petrov for assisting in the preparation of specimens. Figures 3; references 8: 2 Russian, 6 Western (1 in Russian translation).

Localized Superconductivity in Twinned Metal Crystals

[Article by I. N. Khlyustikov, Institute of Microelectronics and Extra-Pure Materials, USSR Academy of Sciences, and A. I. Buzdin, Moscow State University imeni M. V. Lomonosov]

[Abstract] A general description of a twin crystal according to the simplest model of a two-dimensional lattice with a rectangular unit cell, representing two single crystals joined together by the operation of point symmetry, is followed by a review of the results of experimental and theoretical studies on superconducting transition and superconductivity characteristics of the twinning plane in Sn (type-I superconductor) and Nb (type-II superconductor) twin crystals. Twin crystals of five other metals (Al, In, Re, Tl, Pb) were also studied, a SQUID magnetometer with a sensitivity of the order of 10^{-9} G• cm^2 being extensively used for magnetic field and moment measurements at low temperatures. First is considered a solitary twinning plane in crystals of type-I and type-II superconductors, its superconducting transition characteristics and superconductivity parameters having been evaluated semiempirically on the basis of measurements. Next its superconductivity is described theoretically, using an appropriate modification of the Ginzburg-Landau functional and the phase diagram in the H,T coordinate plane for both types of superconductor. The magnetic properties of the material are taken into account as well as the orientation of the magnetic field relative to the twinning plane, from normal to parallel and including the shielding effect in the latter

case. Critical magnetic fields are calculated for a twinning plane in each superconductor crystals of each type. Superconductivity of a twinning plane in "absence" of the proximity effect, which largely determines the temperature range of superconducting transition, is evaluated on the basis of experimental data and described theoretically on the basis of the linearized equation for the Ginzburg-Landau order parameter. In the final part of the review are considered new high-temperature superconductor materials, relevant data being presented on twinning and superconductivity of their single crystals. The authors thank M. S. Khaykin for assistance, for reading the draft copy of this review, and for many helpful discussions. They also thank A. A. Abrikosov, L. N. Bulayevskiy, and V. S. Edelman for discussing the various problems and for valuable suggestions. Figures 17; tables 2; references 93: 55 Russian, 38 Western (3 in Russian translation).

Theory of Josephson Medium in High-Temperature Superconductors: Vortices and Critical Magnetic Fields

[Article by E. B. Sonin, Institute of Engineering Physics imeni A. F. Ioffe, USSR Academy of Sciences]

[Abstract] The vortex structure of a Josephson medium and its characteristics in a very weak lower critical magnetic field are analyzed on the basis of the granular model of a superconductor consisting of weakly linked grains, the equation for its average mean energy being applicable as long as the penetration depth exceeds the grain diameter so that the vortices are large and their structure then depends on their scale. When the penetration depth approximately equal to the Josephson depth is much smaller than the grain diameter, then either the array of Josephson junctions has no influence on the properties of a superconductor with Abrikosov vortices and London penetration depth or the size of vortices in the lower critical magnetic field is the same as in a monolithic single Josephson junction depending on whether the Josephson depth is respectively much smaller or much larger than the London depth. The lower critical magnetic field is evaluated on the basis of its being approximately equal to the product of Josephson binding energy and grain diameter divided by a magnetic flux quantum and multiplied by the logarithm of the ratio of penetration depth to grain diameter. When the magnetic field becomes approximately equal to a magnetic flux quantum divided by the grain diameter squared, the grain diameter being much smaller than the London penetration depth and vortices beginning to penetrate the grains, then this magnetic field must be the upper critical one in the theory of an averaged Josephson

medium where the grain diameter is equal to the coherence length and the distance between vortices is smaller. It represents the upper limit not for superconductivity, however, but rather for validity of that theory. The author thanks K. B. Yefetov, A. I. Larkin, and Yu. N. Ovchinnikov for helpful discussions. Figures 1; references 5: 2 Russian, 3 Western.

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Temperature Dependence of Electrical Resistance of Y-Ba-Cu-O Superconductor Films

[Article by F. V. Garin, A. V. Kochemasov, M. D. Strikovskiy, A. S. Melnikov, and S. V. Sharov, Institute of Applied Physics, USSR Academy of Sciences]

[Abstract] An experimental study of thin $YBa_2Cu_3O_7$ films was made, the purpose being to determine the temperature dependence of their electrical resistivity including correction for fluctuations and the slope of its descent to zero within the superconducting transition range. Film specimens were deposited on substrates by treatment with laser pulses in an oxygen atmosphere as chemically active medium. Measurements were made on 100 nm thick strips 0.100 mm wide and 1 mm long in a nitrogen cryostat by the current-voltage method, at a current density of 10 A/cm^2 and with a TPK-19.1 resistance thermometer recording their temperature. An evaluation of the data in accordance with the Aslamazov-Larkin theory has yielded a three-dimensional correction to the electrical conductivity largely dependent on the thickness of the superconducting layer, the inverse-power temperature dependence of this correction becoming weaker with increasing layer thickness but stronger and eventually two-dimensional in the vicinity of the critical temperature. The authors thank V. M. Genkin for helpful discussions. Figures 2; references 3: 2 Russian, 1 Western.

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High-Temperature Superconductivity in Bi-Sr-Ca-Cu-O System

[Article by N. V. Anshukova, A. I. Golovashkin, O. M. Ivanenko, K. V. Krayskaya, and K. V. Mitsen, Institute of Physics imeni P. N. Lebedev, USSR Academy of Sciences]

[Abstract] An experimental study of $Bi(Sr_{1-x}Ca_x)_2Cu_3O_y$ compounds with x ranging from 0.1 to 0.9 was made for a determination of their superconductor properties, superconducting transition of $BiSr_2Cu_3O_x$ having been found to occur at very low temperatures of 7-15 K and superconducting transition of $BiCa_2Cu_3O_y$ having been found not to occur at all. Specimens were produced from Bi_2O_3, SrO, CaO, CuO powders by the method of three-phase reaction and synthesis in an oxygen stream at a temperature of 820-870 deg C for several hours with subsequent cooling in an oxygen atmosphere at a rate of 100 deg/h. Their electrical resistivity at 300 K temperature was 4-100 mohm• cm depending on the relative Cu content and its ratio to that at 100 K temperature ranged from 1.5 to 2.2, the maximum ratio corresponding to $BiSr_{1.6}Ca_{0.4}Cu_3O_y$. The principal transition was found to occur at 80-60 K, depending on the Ca content x, the width of the transition temperature range being 4-10 K. Magnetic susceptibility measurements revealed 20-25 pct of a Meissner phase. Electrical resistance measurements revealed a 1-2 pct second jump above 100 K, indicating a small amount of a phase with a high superconducting transition temperature. The existence of such a phase with a superconducting transition temperature approaching 120 K has been confirmed by electron-paramagnetic-resonance spectra. The authors thank A. I. Tsapin for EPR analysis. Figures 2; references 1: Western.

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Theory of Raman Light Scattering in $YBa_2Cu_3O_{7-d}$

[Article by E. I. Rashba and Ye. Ya. Sherman, Institute of Theoretical Physics imeni L. D. Landau, USSR Academy of Sciences]

[Abstract] A theory of Raman light scattering in orthorhombic and tetragonal $YBa_2Cu_3O_{7-d}$ with D^1_{2h} and D^1_{4h} symmetry respectively is developed on the basis of qualitative analysis, quantitative numerical analysis being too unwieldy on account of the many electron bands in the intermediate states. The characteristics of Raman spectra such as polarization which derive from the lattice anisotropy but do not follow from the group-theoretical constraints are examined, considering the lattice structure and the vibrations of O-ions most strongly interacting with charge carriers. Inasmuch as oxygen is found in weakly dimpled but still almost plane $Cu(2)-02-03$ layers and in $Cu(1)-(01)_2-04$ chains with plane-square coordination in the bc-plane, only the A_g-phonon in zz-polarization is considered on account of its being the dominant one. Semiquantitative analysis of Cu-O chains and Cu-O planes in the strong-ling approximation indicates that the bridging oxygen 01 contributes largely to 1-phonon Raman scattering. Phonons in the "breathing" mode in the theory of electron-phonon interaction are, meanwhile, involved in 2-phonon Raman scattering dominant in La_2CuO_4. The authors

thank V. D. Kulakovskiy and V. B. Timofeyev for thorough discussion of available experimental data. Figures 2; references 14: 3 Russian, 11 Western.

Spin-Lattice Relaxation of ^{63}Cu IN $YBa_2Cu_3O_{7-y}$

[Article by S. V. Verkhovskiy, Yu. I. Zhdanov, B. A. Aleksashin, K. N. Mikhalev, V. V. Serikov, A. M. Bogdanovich, V. L. Kozhevnikov, and S. M. Cheshnitskiy, Institute of Metal Physics, Ural Department, USSR Academy of Sciences]

[Abstract] An experimental study of $YBa_2Cu_3O_{7-y}$ has revealed a temperature dependence of the spin-lattice relaxation time for ^{63}Cu nuclei, the critical superconducting transition temperature of this compound being 87 K and measurements of the magnetic susceptibility having been made over the 25-300 K temperature range. The oxygen content was determined on the basis of neutron diffraction and thermogravimetric analyses, nuclear-quadrupole-resonance spectra having been recorded by the spin-echo method in an ISSh-3-12 spectrometer. In the normal state the amplitude of quadrupole spin echo was found to be exponentially temperature-dependent, spin-lattice relaxation of Cu nuclei being evidently determined by the fluctuating component of their magnetic hyperfine interaction with surrounding electrons. In the superconducting state the amplitude of quadrupole spin echo was found to be nonexponentially temperature-dependent, probably owing to the nonuniform distribution of the energy gap over a specimen from zero at the surface to a large maximum deep inside. Variation of the oxygen content has revealed a weakening of the pair formation mechanism with increasing oxygen deficiency. Figures 3; references 4: 1 Russian, 3 Western.

Superconducting Magnetic Electron Storage Based on 'Troll' Synchrotron: 1. Calculation of Magnetic Field Distribution

[Article by N. S. Shestavin, A. Ya. Laptiyenko, N. G. Usov, and V. I. Zonzov, Donetsk Institute of Engineering Physics, UkSSR Academy of Sciences]

[Abstract] The design of a superconducting magnetic electron storage for generation of vacuum-ultraviolet synchrotron radiation in the "Troll" facility with cyclotron preacceleration, the magnetic field distribution in this synchrotron is calculated with sixth-order precision. Several design variants are considered with three different radii of storage orbits for optimization of the form factor, conical superconducting coils being preferable, each including corrective coils and ferromagnetic inserts so as to ensure the conditions necessary for electron storage. The authors thank V. I. Kurochkin and V. S. Panasyuk for assistance and steady interest. Figures 5; tables 1; references 20: all Russian.

Detection of Short-Range-Order Domains in Vortex Structure in Type-2 Superconductor

[Article by L. Ya. Vinnikov and I. V. Grigoryeva, Institute of Solid-State Physics, USSR Academy of Sciences]

[Abstract] An experimental study of a type-2 superconductor, Nb plus 5 percent Mo, involving decoration with Fe powder has yielded the first evidence of short-range-order domains in the vortex lattice of this material with a highly nonuniform dislocation structure. Decorating powder was sprayed over the surface of a bulky single crystal while the latter was being cooled down to 4.2 K and the external magnetic field was increased from zero to the upper critical field, then slowly decreased back to zero, with the magnetic flux frozen-in and its distribution determined by pinning on defects. Structural examination revealed blocks and close-packed vortex trails, with evidence of plastic deformation. Numerical estimates based on the theory of collective pinning as well as analysis of the magnetic field distribution aided by measurement of local induction gradients confirm that the blocks within the vortex lattice represent correlation regions in transverse planes and thus existence of short-range-order domains within that structure, their size determining the magnitude of the upper critical magnetic field intensity. Figures 2; references 7: 2 Russian, 5 Western (1 in Russian translation).

Hall Effect in $YBa_2Cu_3O_{7-x}$ Single Crystals in Plane Perpendicular To c-Axis

[Article by I. G. Gorlova, S. G. Zybtsev, and Yu. I. Latyshev, Institute of Radio Engineering and Electronics, USSR Academy of Sciences]

[Abstract] An experimental study of $YBa_2Cu_3O_{7-x}$ single crystals involving measurement of the Hall e.m.f. and the electrical resistivity in a plane perpendicular to the

c-axis across Cu-0 layers with the external magnetic field parallel to the c-axis has revealed a temperature-dependent positive Hall e.m.f., this e.m.f. in a plane parallel to the c-axis in an external magnetic field parallel to the b-axis known to be negative and independent of the temperature. Specimens of such crystals had been synthesized at the Institute of Crystallography (USSR Academy of Sciences), in the form of 0.8 mm long and 0.2 mm wide plane-parallel plates 0.010-0.040 mm thick in the c-direction. Measurements were made in a magnetic field of up to 8 kOe intensity parallel to the c-axis in the ab-plane, with the current varied over the 0.3-60 mA range. At any temperature from 400 K to 90 K the Hall e.m.f. was found to be linearly dependent on both the magnetic field intensity and the measuring current. From 400 K to 280 K the Hall e.m.f. was found not to change with the temperature while the parallel electrical resistivity decreased linearly, a typical metallic behavior. From 280 K to a less than 0.5 K wide superconducting transition range about 93 K the Hall e.m.f. was found to increase almost linearly while the parallel electrical resistivity continued decreasing linearly at the same rate. Within the superconducting transition range both the Hall e.m.f., having peaked, and the parallel electrical resistivity dropped sharply, the latter to zero. The decrease of charge carrier concentration as the temperature was dropped from 280 K to 93 K could have been caused by Peierls instability or by antiferromagnetism. What causes the Hall e.m.f. in planes parallel and perpendicular to the c-axis to have opposite signs is not yet understood. The authors thank S. M. Stishov, O. K. Melnikov, and I. N. Makarenko for supplying the specimens and discussing the results, also R. N. Sheftal and V. N. Gubankov for valuable comments. Figures 2; references 9: 3 Russian, 6 Western.

Direct Viewing of Abrikosov Vortices in Single Crystal of YBa$_2$Cu$_3$O$_x$ High-Temperature Superconductor

[Article by L. Ya. Vinnikov, L. A. Gurevich, G. A. Yemelchenko, and Yu. A. Osipyan, Institute of Solid-State Physics, USSR Academy of Sciences]

[Abstract] A magnetic vortex structure on the surface of YBa$_2$Cu$_3$O$_x$ single crystals grown from the melt could be viewed directly under a high-resolution scanning electron microscope, despite the high values of the Ginzburg-Landau parameter characteristic of high-temperature type-2 superconducting materials as well as low-temperature ones. The specimens of such crystals were 0.7 mm long and 0.5 mm wide, their thickness being tens of microns and their wider faces lying in (001) planes. An external magnetic field of 20 Oe intensity was applied perpendicularly to the wider faces at a temperature above superconducting transition, whereupon the crystals were cooled in that field down to 4.2 K for decoration with Fe powder. The negatives of surface microreliefs reveal an anisotropy of vortex lines obviously associated with the locations of twins always existing in orthorhombic YBz$_2$Cu$_3$O$_x$ and a distance between vortices much larger than the distance between twin boundaries. This evidence supports the macroscopic model of volumetric superconductivity and contradicts that of plane superconductivity along twin boundaries. The authors thank I. F. Shchegolev for helpful discussions and L. G. Isayev for assistance. Figures 2; references 6: 3 Russia, 3 Western.

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Possibility of Voltage Multiplication in Josephson Structures

[Article by V. K. Semenov, Moscow State University imeni M. V. Lomonsov]

[Abstract] The possibility of using a homogeneous Josephson structure with synchronization of all individual junctions as a multiplier of a constant or slowly varying voltage is examined on the basis of the interferometer model. Such a structure is accordingly regarded as a cascade of identical multijunction interferometers with inductive coupling between them connected in series for direct current. Adjacent junctions within each interferometer are connected through inductances and the neighboring outermost junctions of adjacent interferometers are connected through RC-circuits. The process of conduction pulse triggering in successive junctions upon application of a constant voltage to the first one is tracked in accordance with the Josephson relation, whereupon the conditions necessary for voltage multiplication are established. These conditions specify that the internal inductances distribute the supply current among junctions proportionally to the corresponding critical currents, that at the pulse repetition rate the asymptotic resistance of the input junction of the first interferometer be much larger than the impedance of the RC-circuits and much smaller than the impedance of the couplings for direct current, and that plasma oscillations in the structure decay fast. The feasibility is demonstrated by numerical simulation of a shunted tunnel junction. The author thanks K. K. Likharev for support and useful comments. Figures 2; references 5: 3 Russian, 2 Western.

Electron-Paramagnetic Resonance of Free Charge Carriers in RE-Ba-Cu-O Oxide Superconductor Materials

[Article by Yu. I. Vesnin, V. Ye. Istomin, and E. G. Kostsov, Institute of Automation and Electrometry, Siberian Department, USSR Academy of Sciences, Novosibirsk]

[Abstract] An experimental study of electron-paramagnetic resonance in YBa$_2$Cu$_3$O$_y$ and EuBa$_2$Cu$_3$O$_y$ ceramics was made, particularly of the part of its spectrum

associated with free charge carriers, paramagnetic resonance on Cu^{2+} ions known to take place in superconducting materials of this class. Specimens of both materials were produced by sintering respective oxide mixtures: some specimens with superconducting transition according to the temperature dependence of resistance and with the Meissner effect, others with identical chemical composition and crystal structure according to X-ray analysis but not superconducting. For measurement of the EPR spectra a RE-1301 radiospectrometer was used with a 9300 MHz klystron frequency and a 975 kHz modulation frequency. These measurements revealed an identical Dyson absorption line characteristic of conduction electrons in the EPR spectra of both superconducting compounds at a temperature of 77 K in a weak magnetic field of 0.006-0.05 T intensity, but no such a line in the EPR spectra of both materials not superconducting above 77 K, this line shrinking with rising temperature and vanishing slightly below the critical superconducting transition temperature. The electron concentration in these materials could be determined from estimates of the number of charge carriers contributing to resonant absorption, assuming a 10^{-7} m deep skin layer. Specimens with larger amplitude of the Dyson line emitted weaker signals of paramagnetic resonance on Cu^{2+} ions. Figures 2; references 7: 2 Russian, 5 Western.

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