ISRAEL PHYSICAL SOCIETY

ANNUAL MEETING

1994

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Meeting of the Israel Physical Society
May 10, 1994 – Technion

- 9:00 Coffee and Registration, Ullmann Building Cafeteria 3rd Floor
- 9:40 Opening Remarks (Amado Building, Room 233)
- 9:45 Plenary Lecture: Prof. Itamar Procaccia, Weizmann Institute
  Universality in the Small Scale Structure of Turbulence:
  Can We Reconcile Theory with Experiment?
- 10:45 Parallel Sessions (Ullmann Building 3rd floor)
  Astrophysics, Condensed Matter Physics, Physics and Biology,
  Plasma Physics, Medical Physics, Solid State Physics,
  Particle and Nuclear Physics
- 12:45 Lunch and Posters (Posters in Amado Building Atrium)
- 14:15 IPS Business Meeting (Teachers' Room, Ullmann Building)
- 14:30 Parallel Sessions (Ullmann Building 3rd Floor)
  Particle and Nuclear Physics, Condensed Matter Physics,
  Complex Fluids, Computational Physics, Solid State Physics
- 16:30 Coffee
- 17:00 Plenary Lecture: Prof. Amos Komornik, Technion
  The Strike and its Effects on Higher Education in Israel
  (Lecture in Hebrew)
  (Amado Building, Room 233)

An exhibit of scientific equipment and computers will take place in the alcove adjacent to the Ullmann Building cafeteria.

Morning Sessions

Astrophysics

Session Chair Amos Harpaz
Ullmann Building; Room 302

- 10:45 Arnon Dar; Technion
  Standard Physics Solution to the Solar Neutrino Problem

- 11:35 Yehuda Hoffman; Hebrew University
  Wiener Reconstructing the Large Scale Structure

- 12:10 Amiel Sternberg; Tel-Aviv University
  Infrared Imaging Spectroscopy of IR Luminous Galaxies

Condensed Matter Physics

Session Chair Eric Akkermans
Ullmann Building; Room 305

- 10:45 O. Agam; Technion
  The Magnetic response of Chaotic Mesoscopic Systems

- 11:15 A. Kamenev; Weizmann Institute
  Magneto-Conductance of Isolated Aharonov-Bohm Rings

- 11:45 A. Aronov; Weizmann Institute
  Electron In Static Random Magnetic Field

- 12:15 Y. Avishai; Ben Gurion university
  AC Conductivity Peak Broadening in the Quantum Hall Regime

Physics and Biology

Session Chair–Erez Braun
Ullmann Building; Room 304

- 10:45 Joel Stavans; Weizmann Institute
  Deletion Interactions between Surfactant Structures

- 11:05 David Kessler; Bar-Ilan University
  Slime Mold: Getting it Together

- 11:25 Michael Kozlov; Freie University, Berlin
  Mechanical Properties of Red Blood Cells

- 11:45 Eshel Ben-Jacob; Tel Aviv University
  Generic Modeling of Cooperative Growth Patterns of Bacterial Colonies

- 12:05 Open Discussion:
  Physics Meets Biology

High Energy Physics

Session Chair–Boris Blok
Ullmann Building; Room 306

- 10:45 Coby Sonnenschein; Tel Aviv University
  Back to QCD_2

- 11:45 Eduardo Guendelman; Ben-Gurion University
  Time Evolution (Inflation, Compactification) in the Quantum Cosmology Epoch

Plasma Physics

Session Chair Joseph Shiloh
Ullmann Building; Room 301

- 10:45 V.L. Granatstein; University of Maryland
  Gyrotron Amplifiers for Driving Electron-Positron Supercolliders

- 11:10 I. Maron; Weizmann Institute
  The Time Dependent Structure of a Cylindrically Imploding Plasma

- 11:35 J. Felsteiner; Technion
  Intense RF Power Generation in a Hollow Cathode Discharge

- 12:00 A. Gover; Tel-Aviv University
  Free Electron Radiation Generators from Microwave to X-Rays

- 12:25 A. Zigler; Hebrew University
  Ultra Short High Power Laser-Matter Interaction

Medical Physics

Session Chair Haim Taitelbaum
Ullmann Building; Room 303

- 10:45 Meir Nitzan; Jerusalem College of Technology
  Measurement of the Peripheral Circulation Resistance Variability

- 11:15 Dan Adam; Technion
  Flow Velocity Measurement by Color Doppler Ultrasound Mapping - Improvement of a Popular Clinical Tool

- 11:45 Ran Vered; Bar-Ilan University
  Optical Detection of Tumors

- 12:05 Haim Azhari; Technion
  3-D Investigation of Cardiac Mechanics Using Tagged MRI

- 12:25 Zeev Schiffer; J. Schottenstein Cellscan Center
  Fourier Analysis of Differential Light Scattering from Cell Populations as a Means for the Demonstration of Biological Activation

Solid State Physics

Session Chair Joan Adler
Ullmann Building; Room 307

- 10:45 A. Zunger; National Renewable Energy Lab, Golden, CO, USA
  Electronic Structure of Si Quantum Structures: Dots, Films, Wires

- 11.30 A. Silverman; Technion
  Computer Model for the Atomic Scale Structure of Disordered GaInP Alloys

- 11.55 O. Biham, Hebrew University
  Study of Diffusion and Island Growth in Metallic Monolayers

- 12.10 Y.M. Strelniker; Tel Aviv University
  Strong Anisotropy of Magneto-Transport Properties in Composite Systems with a Periodic Microstructure

- 12.25 I. Schuster; Technion
  NMR Imaging of 3He-4He Crystals on the Melting Curve

Afternoon Sessions

Complex Fluids

Session Chair: Dov Levine
Ullmann Building; Room 304

- 14:30 Yitzhak Rabin; Bar-Ilan University
  Recent Developments in the Theory of Polymer Networks

- 15:00 Elisha Moses; Weizmann Institute
  Instability, Topological Transitions and Surface Tension in Membranes

- 15:30 Erez Braun; Technion
  Learning and Memory in an Irreducible "Point Neuron"

- 16:00 Sam Safran; Weizmann Institute
  Membrane Mediated Interactions

Condensed Matter Physics

Session Chair Assa Auerbach
Ullmann Building; Room 305

- 14:30 Baruch Horovitz; Ben Gurion university
  Fluxon Transition in Layered Superconductors and its Role in Dimensional Crossover

- 15:00 I. Ya Korenblit; Tel Aviv University
  Magnetoconductivity and Staggered Magnetization in Oxygen Doped Cuprates

- 15:30 A. Gerber; Tel Aviv University
  Self heating Versus Quantum Creep in Bulk Type II Superconductors

- 16:00 B. Rechav; Hebrew University
  An Order-Disorder Element in An Antiferrodistortive Phase Transition

High Energy Physics

Session Chair Boris Blok
Ullmann Building; Room 306

- 14:30 Aharon Levy; Tel Aviv University
  QCD from HERA

- 15:30 Amit Giveon, Hebrew University
  Duality and Mirror Symmetry as a Gauge Symmetry and Topology Change

Computational Physics

Session Chair-Joan Adler
Ullmann Building; Graphics Classroom

- 14:30 Video and Software Demonstrations by Technion Students
  Programs for Teaching Modern Physics
  Interactive Routines for Modeling Magnets
  Additional presentations welcome!

Ullmann Building; Room 302

- 15:30 Radel Ben-Av; Bar-Ilan University
  Mean-Field z for Cluster Dynamics

Solid State Physics

Session Chair Robert Besserman
Ullmann Building; Room 307

- 14.30 E. Zeldov; Weizmann Institute
  Geometrical Barriers in High-Temperature Superconductors

- 15.00 A. Eyal; Technion
  Influence of Gallium Concentration on the Ordering Process of GaInP

- 15.15 J. Poplawski; Technion
  Photo Induced Absorption Study of Polarons in Finite Polymers

- 15.30 S. Shchemelinin; Weizmann Institute
  4π *Solid Angle Electron Spectrometer for Correlated Measurements of Energy and Angular Distribution of Electrons Simultaneously Emitted in one Event*

- 15.45 G. Reisfeld; Hebrew University
  Work Function Measurements of Metals in the Presence of Gases up to 1000 Pa

- 16.00 E.Rozenberg; Ben-Gurion University
  Magnetoresistive and Structural Properties of Annealed Fe/Cr Systems

ABSTRACTS

CONDENSED MATTER

and

SOLID STATE PHYSICS

THE MAGNETIC RESPONSE OF CHAOTIC MESOSCOPIC SYSTEMS

Oded Agam

Dept. of Physics
Technion

The magnetic response of mesoscopic systems with ballistic motion of electrons that is chaotic in the classical limit is considered. Semiclassical methods are applied in order to derive a formula for the susceptibility which is expressed in terms of a finite number of classical periodic orbits. This formula is used to study the fluctuations of the susceptibility in comparison with the fluctuations of random systems. Some of the mechanisms which lead to these fluctuations are discussed. At relatively high temperatures the formula for the susceptibility reduces to a simple expression in which only few short periodic orbits dominate the behavior. An experiment based on this result is proposed.

Onset of Vortices in Thin Superconducting Strips and Wires

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Bar Ilan University, Ramat Gan 52900, Israel

Spontaneous nucleation and the consequent penetration of vortices into thin superconducting films and wires, imposed in a magnetic field, can be considered as a nonlinear stage of primary instability of current-carrying superconducting state. Development of the instability leads to formation of a chain of vortices in strips and helicoidal vortex line in wires. The boundary of instability was obtained analytically. The nonlinear stage was investigated by simulations of the time-dependent generalized Ginzburg-Landau equation.

Pacs 74.60.Ge, 74.76.-w

Quantum Mechanical AC Conductance of the Thue Morse and Period Doubling One-Dimensional Sequences

Y.Avishai, S.I.Ben-Abraham, J.Cohen and A.Joseph

Department of Physics, Ben-Gurion University, IL-84105 Beer Sheva Israel.

We calculate the quantum-mechanical AC conductance of two automatic sequences. The Thue-Morse sequence which is defined by the substitution rule $\sigma \begin{pmatrix} 0 \to 0 & 1 \\ 1 \to 1 & 0 \end{pmatrix}$ and the Period doubling sequence defined by the substitution $\sigma \begin{pmatrix} 1 \to 1 & 0 \\ 0 \to 1 & 1 \end{pmatrix}$. The evaluation of the AC conductance in the low frequency limit ($\hbar\omega \leq 0.1E$), perform by using the formula [1]

$$G(\omega) = \frac{e^2}{h} Tr \left\{ \frac{1}{2} [\Theta(\omega = 0)\Omega(\omega)]\Theta(\omega)\Omega^{\dagger}(\omega)] \right\}.$$

The matrices $\Theta(\omega)$ and $\Omega(\omega)$ describe the effects of the scattering and the AC electric field, respectively. The sites are occupied by delta-scatterers of strength V. We study the conductance as a function of the electric field frequency ω and the length of the system L. The ratio between the one's and the zero's is taken to be of commensurate and incommensurate values.

[1] J.Cohen and Y.Avishai, *Transfer matrix formulation of the AC conductance*, Europhysics Letters (to be published)

ac Conductivity Peak Broadening in the Quantum Hall Regime

Y. Avishai and J. Cohen

Dept. of Physics
Ben Gurion University of the Negev, Beer Sheva

In this work we study the peak broadening ΔE of the real part of the longitudinal (dissipative) conductance $\sigma_{xx}(\omega)$ [1,2]. This observable is related to the pertinent critical exponents in the following way. Let E_c be the critical energy and let $\xi(E)$ be the localization length at energy E. As one approaches the critical energy the localization length diverges as $\xi(E) = |E - E_c|^{-\nu}$ where ν is the critical exponent pertaining to the localization length. At the same time, the correlation time t_{corr} which controls the dynamics of the system diverges with a corresponding exponent μ. The ratio $z = \mu/\nu$ is referred to as the dynamical exponent. A power law behavior $\Delta E = \omega^{\gamma}$ is understood as a dynamical scaling for which $\gamma = 1/\mu$. Thus, knowledge of γ and ν implies a knowledge of the dynamical exponent $z = 1/\gamma\nu$.

In the present work we use a numerical algorithm to evaluate and study the ac dissipative conductivity in the quantum Hall regime (at zero temperature) for finite systems (albeit large compared with the magnetic length). We then analyse our results within a two parameter scaling hypothesis. Beside the system size L and the localization length ξ there is now an additional macroscopic length $L_\omega = (\hbar N(E)\omega)^{-1/2}$ in the problem, where $N(E)$ is the density of states [10]. Therefore, $Re\,\sigma_{xx}(\omega)$ may be considered as a function of two dimensionless scaling variables, e.g $x = L/\xi$ and $y = L/L_\omega$. (The variable ξ/L_ω is inconvenient since ξ diverges at $E = E_c$ and L_ω diverges at $\omega = 0$.

Our main results could be summarized as follows: 1) In the insulating regime, $\sigma_{xx}(\omega)$ vanishes with ω according to Mott's law. 2) In the conducting regime, $\sigma_{xx}(\omega)$ increases with ω (near $\omega = 0$) but we do not know according to which law. 3) The scaling function $\sigma_{xx}(x, y)$ is computed in the quantum Hall regime. 4) The frequency exponent is found to be $\gamma = 0.31$. 5) The value of the dc conductivity at the peak is less than $e^2/2h$.

References

1) L. W. Engel, D. Shahar, C. Kurdak and D. C. Tsui, Phys. Rev. Lett. **71**, 2638 (1993)

2) D. G. Polyakov and B. I. Shklovskii, Phys. Rev. Lett. **70**, 3799 (1993); Phys. Rev. **B48**, 11167 (1993)

Low Temperature Scanning Tunneling Microscopy Studies of Granular Metal Films

E. Bar-Sadeh*, D. Porath*, M. Wolovelsky*, Y. Goldstein*, O. Millo*, Q. Zhang**, H. Deng** and B. Abeles**

**Racah Institute of Physics, The Hebrew University, Jerusalem*
***Exxon Research and Engineering, Annandale, NJ, USA*

We are using a cryogenic scanning tunneling microscope to study the electrical-transport and structural properties of very thin granular Au/Al2O3 films, having metal volume fractions close to and below the percolation threshold. The granular films typically are 15 nm thick and sputter-deposited on top of gold films. We have measured simultaneously topographic images and local tunneling current-voltage (I-V) characteristics perpendicular to the films at cryogenic temperatures. The I-V curves were found to vary qualitatively from one tip position to another over distances of the order of a few nanometers, indicating rapid spatial variations of the local transport properties. Some I-V traces show metallic behavior, whereas others exhibit pronounced structure due to single-electron charging effects of the small metal grains. Among these latter traces we observed Coulomb blockade and the Coulomb-staircase, similar to those observed for double-barrier tunnel junction systems. Many of our I-V characteristics exhibit, however, novel Coulomb-staircase structures having unusual variations in step heights and widths due to complex electron tunneling-paths. These characteristics cannot be explained assuming a double-barrier tunnel junction geometry. We have developed a triple-barrier tunnel junction model, based on the "orthodox" theory for single elctron tunneling, where electrons tunnel through two small metallic grains along their path. This model accounts very well for the experimental results.

Electron Damping at the Fermi Surface in 2D Systems

E. Batkilin

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It has been suggested by Anderson that a 2D electron system with a strong short-range repulsive interaction is not a Landau Fermi liquid (LFL) but rather a Luttinger liquid due to the peculiarities of two-electron scattering in the 2D case. Within the limitations of the model suggested by Anderson we find that at zero temperature a 2D electron gas with a short-range repulsive interaction and with an energy in a band of finite width is not a Landau Fermi liquid in the sense that there is an electron (and hole) damping at the Fermi surface.

Studies of diffusion and island growth in metallic monolayers

Ofer Biham, G. Barkema (Cornell), W. Li and G. Vidali (Syracuse), M. Breeman and D. Boerma (Groningen)

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Motivated by experimental results [1] indicating island growth in metallic monolayers deposited by molecular beam epitaxy (MBE) on metallic surfaces we have studied these phenomena theoretically and numerically [2]. We have developed a framework for microscopic numerical simulations of the growth of a Cu on Cu(001) substrate using Monte Carlo simulations at realistic temperatures and deposition rates and energy barriers obtained by the embedded atom method (EAM). Unlike previous studies of these problems, our simulations include all the relevant microscopic information and therefore they can provide detailed comparisons with experimental results. Also, unlike molecular dynamics simulations, they run fast enough to simulate time scales of minutes which are experimentally relevant. We observe that for slow deposition rates the atoms hop on the surface and nucleate into islands. Nucleation is very fast at low coverage and then quickly saturates and the island density remains approximately constant for a range of the coverage. At high coverage coalescence effects become dominant and islands merge into fewer and larger islands. We have studied the island shapes, the scaling of island density with deposition rate and related phenomena in order to provide microscopic understanding of diffusion and nucleation processes on surfaces.

1. W. Li, G. Vidali and O. Biham, Phys. Rev. B48, 8336 (93).

2. G. Barkema, O. Biham, M. Breeman, D. Boerma and G. Vidali, Surf. Sci. Lett., in press.

Two Dimensional Superconductivity and Effects of Magnetic Field in $YBa_2Cu_3O_7$

Ilya Elbert, Baruch Horovitz and Grzegorz Jung

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We report on the investigations of two dimensional (2D) superconductivity and Kosterlitz-Thouless phase transition in thin film superconducting c-axis oriented $YBa_2Cu_3O_7$ films as a function of weak magnetic field applied parallel to Cu_2O layers. We have recorded voltage-current characteristics at different temperatures and various magnetic fields, and have found that they take the form of $V \propto I^{a(T,B)}$. This $I-V$ relation indicates that even in presence of weak magnetic field our YBCO films behave as a 2D superconductor. The power law behavior of $I-V$ curves persists only below a temperature dependent critical magnetic field H^* and within a narrow range of temperatures, namely within 0.5 K below critical temperature. The experimentally determined critical field H^* scales with temperature as $H^{*0.38} \propto (T_{co} - T)$, where T_{co} is the mean field transition temperature. This behavior is consistent with the theoretical model of flux lattice melting in layered superconductors [1]. From the analysis of experimental data we were also able to obtain values of the effective thickness of 2D superconducting layers. For external fields parallel to the layers this effective thickness corresponds to the distance between flux lines in the direction perpendicular to Cu_2O layers. Magnetic field dependence of the exponent a demonstrates a discontinuous jump, which may be associated with theoretically predicted jump in the periodicity of magnetic flux structures in layered superconductors [1].

[1]. B. Horovitz, Phys.Rev.Lett. **67**, 378 (1991); Phys. Rev.**B 47**, 5947 (1993); **B 47**, 5964 (1993)

MESOSCOPIC PERSISTENT CURRENT CORRELATIONS IN THE PRESENCE OF STRONG MAGNETIC FIELDS

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The effect of a strong magnetic field on the persistent current and current-current correlations in the Laughlin geometry are discussed. Due to the violation of time reversal symmetry a single disordered sample may carry a current even in the absence of a threading flux. Once one averages over many realizations this current disappears. A theory is presented for the current-current correlations in the presence of a strong magnetic field and compared to the results of a numerical calculation. The results fit for the bulk states while discrepancies appear for edge states.

Radial Distribution X - Ray - Absorption Fine - Structure Analysis of Al - La Metallic Glass

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‡ AMT -Advanced Metal Technology Ltd., Yoqneam

Low density amorphous Al - La alloy ribbons with high Al concentrations (91 %) were produced by melt - spinning method in vacuum. Comparative analysis has been performed of the glass $Al_{0.91}La_{0.09}$ and the crystalline phase La_3Al_{11} obtained by annealing of the glass at the temperature above glassification point. Crystal and metallic glass x-ray-absorption fine-structure (XAFS) data were measured at La L_3 edge and analyzed using radial distribution function (RDF) method. The advantage of the RDF method over fitting and ratio methods is demonstrated and discussed. The reliability of the method was checked against the known crystal structure and excellent agreement with theoretical RDF was obtained. Structural characteristics of crystal and glass (coordination numbers, disorder in interatomic distances) were obtained at $T = 12$ K. The continuous random network model of glass was proposed to explain the difference between the local structures of glass and crystal.

Josephson coupling mediated by quantum diffusion

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We present results on transport properties of Pb/I/Pb junctions, where I is either an a-Ge or a-InO film. At helium temperatures, such structures sustain non-dissipative currents and exhibit systematic sub-gap I-V modulation. The data are consistent with the existence of a Josephson coupling mechanism involving multiple Andreev reflections and quantum mechanical coherent diffusion within the Anderson-insulating barrier.

Nitrogen-14 NQR Multiple-Pulse Spin-Locking

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The behavior of a nuclear spin system with the Hamiltonian including: a). the interaction of the electric quadrupole moment of nuclei with an arbitrary symmetry gradient of the crystal electric field; b). a homonuclear and heteronuclear dipole-dipole coupling; and c). the interaction with a multiple pulse radiofrequency field of an arbitrary orientation was considered.

The effective Hamiltonian is constructed by using the Floquet theory. The kinetic equations were obtained giving the possibility to find the time dependence of the magnetization of the body and the kinetic coefficients calculated in function of the multiple-pulse field parameters. The possibilities of the using the results in question for molecular structure and molecular dynamics investigations are briefly surveyed.

INVESTIGATIONS OF WRITE/ERASE FEATURES BY THE PHOTODEPOSITION TECHNIQUE

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Photodeposition[1] is now a well recognized technique by which direct material writing/erasing is feasible on various substrates in gas liquid and solid phases. New applications of this technique are being investigated in many materials science oriented domains[2] such as optoelectronics, microelectronics and metallurgy. This work will present the results obtained by direct writing/erasing optical elements in liquid phase, specifically by laser processing of colloid solutions.

1. A. Peled, Editor, "Photodeposition and Related Photoassisted Thin Film Processes", Special Issue: Thin Sol. Films 218(1-2), 1992.
2. Y. Murata, Editor, "Photoexcited Processes and Applications", Special Issue: Appl. Surf. Sci. (1991) In press.

Fluxon Transition in Layered Superconductors and its Role in Dimensional Crossover

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In a layered superconductor, fluctuations of flux loops parallel to the layers result in destruction of the Josephson coupling between layers above a critical temperature T_f. When fluctuations of point vortices in the layers are included, a 3-dimensional phase transition results at $T_c < T_f$. Study of this fluxon transition shows that variations in T_c as function of anisotropy can be much larger than those in an anisotropic XY model [1]. This can account for the large variations of T_c as function of the separation between superconducting layers in multilayer systems. Furthermore, the fluxon transition can be directly observed, corresponding to the onset of nonlinearity [2] in the c-axis current-voltage relation of $Bi_2Sr_2CaCu_2O_{8-y}$. This onset is at a higher temperature than the onset of nonlinearity in the ab plane.

[1] B. Horovitz, Phys. Rev. B**47**, 5947 (1993).
[2] Y. M. Wan, S. E. Hebboul, D. C. Harris and J. C. Garland, Phys. Rev. Lett. **71**, 157 (1993); B. Horovitz, Phys. Rev. Lett. **72**, 1569 (1994).

High Frequency Random Telegraph Voltage Noise in High-T_c Films

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B.Ya. Shapiro, V. Ashkenazy, and I.B. Khalfin

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The new vortex mechanism, possibly leading to very high frequency random telegraph voltage noise signals switching with MHz frequencies, is discussed. The mechanism assumes that vortices do not flow freely across dc current biased superconducting films but undergo subsequent processes of trapping and releasing from pinning centers. Random transitions of vortices between pinned and flow states result in the appearance of a Lorentzian component in the voltage power spectrum. It is shown that localized fluctuations of randomly distributed Abrikosov vortex density, rigidly moving across the strip contribute an oscillating component to the noise spectrum. The distance between oscillating peaks corresponds to the time of flight of vortices across the strip. Simultaneously, viscous relaxation of a pinned fraction of vortices interacts with random currents generated by telegraph voltages and thus attenuates power spectra at low frequencies. The proposed model enables us to estimate, from the analysis of spectral data, values of vortex viscosity coeeficients, size of flowing flux bundles and elastic properties of the vortex lattice.

Magneto–Conductance of Isolated Aharonov–Bohm Rings

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We study[1] the average dissipative conductance of an array of mesoscopic rings , subject to an a.c. magnetic flux. The magneto-conductance (MC) changes its sign as a function of temperature if the number of particles in each ring is kept constant i.e. flux independent (canonical statistical ensemble). The reason is that the spectral rigidity on small energy scales (of the order of the mean level spacing) increases with the magnetic field, resulting in a *negative* MC for sufficiently small temperature. By contrast on large energy scales, the spectrum becomes less rigid as the magnetic field is increased. This may be related to the weak localization picture, predicting *positive* MC at temperatures larger than a mean level spacing. Interesting enough, the MC does *not* change sign within the grand canonical statistical ensemble (constant chemical potential). This latter fact may be explained by counting the number of samples with relatively small energy gaps near the Fermi surface. If the chemical potential (rather than the particle number) is the controlled parameter, the number of such samples is reduced dramatically, compared with the canonical ensemble. As a result, the crossover between different types of spectral statistics turns out to be relatively unimportant and the MC is positive, independent on temperature. We have checked our prediction in two limiting cases: (i) in the limit of quasi–continious spectra (large T), employing diagrammatic technics and (ii) in the limit of quasi-discrete spectra (small T), using random matrix theory.

1. A. Kamenev, B. Reulet, H. Bouchiat, Y. Gefen, submitted to Phys. Rev. Lett.

PACS numbers: 05.45.+b, 72.10, 73.35.

Temperature-Frequency Dispersion of Conductivity and Dielectric Constant in High-Temperature Superconductors

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The most striking features in the temperature-frequency behaviour of HTSC's are the peak in the real part σ of complex conductivity $\tilde{\sigma} = \sigma + i\omega\epsilon\epsilon_0$ and (sharp) increase of the dielectric constant (sometimes positive and sometimes negative) observed in Y-Ba-Cu-O,Bi-Sr-Ca-Cu-O,La-Sr-Cu-O single crystals and ceramics near the transition point. Here we report the explicit expressions for $\sigma(T,\omega)$, $\epsilon(T,\omega)$ taking into account the (strong) interphase interaction of random inhomogeneities in HTSC's by means of the Effective Medium Theory. At low frequencies $(\omega/\omega_0)^2 \ll 1$, ($\omega_0 = \omega_p/\sqrt{\epsilon_n}$, $\omega_p = (ne^2/m\epsilon_0)^{1/2}$ is the plasma frequency for the total electron concentration n, ϵ_n is the dielectric constant of normal phase), position of the conductivity peak is $T = T_c$ (which is lower than the transition midpoint $(T_0 + T_c)/2$ with the transition width $T_0 - T_c$, where T_0 is the onset temperature and T_c is the temperature at which direct current resistance vanishes), its amplitude is $\propto (\omega\tau)^{-1/2}$, and its width is $\propto (\omega\tau)^{1/2}$ ($\tau^{-1} = \omega_p^2\epsilon_0/\sigma_n$ is the collision frequency of normal electrons on the Fermi surface, σ_n is the real conductivity of normal phase). Dielectric constant at temperatures $T < T_c$ and at low frequencies is $\epsilon \simeq -\epsilon_n(\omega_0/\omega)^2(1 - T/T_c)$, and at $T = T_c$ it is $\propto -(\omega\tau)^{-3/2}$. At $T_0 > T > T_c$ the usual metal-dielectric anomaly (low frequency *positive* divergence of ϵ at the percolation threshold) "challenges for survival" with the *negative* metal-superconductor divergence of ϵ, thus positive maximum in ϵ may arise with its position and height depending on $\omega_0\tau$. Frequency behaviour of $\sigma(\omega, T \neq T_c)$ and $-\epsilon(\omega, T > T_c)$ is Debye-like dispersive with the dispersion frequency $\sim (10^{-1} \cdot 10^{-2})\omega_0$. At any finite frequency there is a temperature at which $\epsilon = 0$, thus $n - s$-system can behave as a resonance $R - L - C$ contour with strong damping of free oscillations depending on $\omega_0\tau$. It is worthy to note also relative temperature stability of the huge negative dielectric constant at temperatures $T \leq T_c - 0.2T_0$.

Exact Electric Field Distributions in a Random Dipole Dielectric and the Breakdown Model for Inhomogeneous Dielectrics

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Exact expressions are derived for distribution functions of the sum potential and electric field of non-interacting rigid point dipoles randomly placed in dielectric medium. Potential distribution is of the Holtsmark type, electric field component distributions are of the Cauchy type, and the inverse electric field modulus is distributed semi-normal. One-point distribution functions for all these random fields are uniform, and they are exactly derived in the thrmodynamic limit, hence the results are applicable for media, not only for networks of finite dimensions. The knowledge of the exact one-point electric field distribution and its uniformity permits to reformulate the percolation breakdown model in a very simple manner. The breakdown field dependence on the volume fraction of metal inclusions x is $E_b \propto (x + \overline{x_c})^{-y}$ for polaryzable dipoles, and $E_b \propto (x - x_c)^y$ for dipoles with permanent or saturated moments. Like in the effective medium theories for the percolation threshold increase of conductivity and dielectric constant in dielectric-conductor mixtures, $y = 1$. Experimental data on the breakdown of paraffin with metal filler are consistent with the power-law and $y = 1$ up to the percolation threshold x_c, though correlations, fluctuations and inter-particle interactions which are essential near the threshold, were neglected in this approach.

Electrode Sheaths and Nonlinear Quasi-Neutrality Waves in Laser Gas Discharge Plasma at Radiofrequencies

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For the two-temperature plasma ($T_e \gg T_i$) of finite volume at radiofrequencies ($f \sim 10^7$Hz), approximate expressions are obtained for potential, electric field, electron and ion concentrations, space charge for the neutral - collisional Boltzmannian electrons and collisionless (or neutral - collisional) ions. Sheath behaviour, oscillatory in space and critical regimes depend upon the relation of ion and electron energies. At $Mu^2/T_e > 1$ (M, u are ion mass and ion sound velocity) the sheath width is of the order of the electron Debye length $\lambda_D(T_e)$. In the hydrodynamical approximation exact solution is obtained to the equations for the electroneutral positive column of gas discharge. At low ionization frequencies ($\omega_i/\omega \ll 1$) stationary ionization-recombination balance takes place with electron and ion concentration $n_s = 2\alpha\mu_e E_0/\pi\beta$ (α is the Townsend ionization coefficient, β is recombination coefficient, μ_e is electron mobility, and E_0 is an amplitude of external electric field). The active current - voltage characteristic of gas discharge is $j_a \propto \alpha(E_0)E_0^2$. Near the positive column, nonlinear quasi-neutrality waves are formed with a sharp jump in electron concentration ("shock" waves). Expansions near the wavefront ($x - X(t)$) lead to the harmonic time-dependence $X(t)$ of the profile edge for electrons, with the amplitude $\mu_e E_0/\omega$. Breaking of nonlinear waves can occur depending on the parameters of drift, ionization and recombination. Analytical results obtained are consistent with the numerical simulation and calculations of J. Economou and S. Park (*J. Appl. Phys.* **68**, 3904 (1990)) and of Yu.Raiser and M.Schneider (*Sov. J. Plasma Phys.* **13**, 267 (1987)).

TGS-gelatin films: Influence of moisture on their dielectric and pyroelectric properties

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TGS-gelatin films have been grown by evaporation of water from a gelatin gel containing a solution of TGS. When this material absorbs water from the atmosphere, it forms a ferroelectric TGS subsystem and a nonferroelectric but highly polarizable dipole subsystem of water absorbed in the intermolecular spaces of gelatin molecules. Moist films have pyroelectric coefficients about four times higher than dried ones. The dielectric properties also change showing the major role played by the orientational polarizability of the water molecules.

MAGNETOCONDUCTIVITY AND STAGGERED MAGNETIZATION IN OXYGEN DOPED CUPRATES

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At the early stage of the investigation of weakly doped cuprates, the parent compounds of high T_c superconductors, two intriguing effects were observed: (1) the giant hopping magnetoconductivity in La_2CuO_{4+x} (LCO)[1] and (2) the reentrant behavior of the staggered magnetization (M) in LCO and $YBa_2Cu_3O_{4+x}$ (YBCO) [2]. Our recent theoretical developments, which permit to explain these effects, will be reviewed.(1) The out-of-plane free hole mass and the long-distance asymptotics of the localized wave function in LCO are shown to be substantially affected by the subtle changes in magnetic ordering, caused by the external magnetic field. This accounts for the large hopping magnetoconductivity and the magnetic field dependence of the dielectric constant.[3] (2) The reentrant behavior of M in LCO and YBCO is explained by a model, which assumes that the localized holes reduce the sublattice magnetization more strongly than the mobile ones. A good agreement with the experiments is obtained using the measured temperature dependence of the localized hole density, which is characterized by the (measurable) hole exitation energy $E(x)$, and the difference between mobile and localized holes, described by a single x-dependent parameter. The theory also accounts for the absence of the reentrant behavior in highly doped samples.[4]

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Anisotropy and Gyrotropy of Photoinduced Light-Scattering in Chalcogenide Glass As2S3

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Several new photoinduced optical phenomena excited by sub-band-gap light were recently discovered in some bulk chalcogenide glasses [1]. These phenomena include photoinduced optical anisotropy (linear dichroism, linear birefringence), photoinduced optical gyrotropy (circular dichroism, optical activity) and photoinduced light-scattering. Correlations between all these phenomena were not studied and their mechanism is unclear so far.

In this paper, the anisotropy and the gyrotropy of photoinduced light-scattering, excited by linearly and circularly polarized He-Ne-laser light were observed in the As2S3 bulk glass and kinetics of these processes was studied. At the same time, the kinetics of photoinduced transmittance anisotropy and gyrotropy was investigated and correlation between all these processes was revealed. The angular distribution of scattered linearly-polarized and circularly-polarized light is determined and its change during the excitation process is studied. The reorientation of scattered and transmitted light was shawn to occur upon switching the polarization state of the exciting light beam between two orthogonal directions.

We conclude that the generation of scattered centers is the process which determines the whole group of photoinduced vectoral optical phenomena in the chalcogenide glasses. These centers can scatter light isotropically, anisotropically or gyrotropically depending on the polarization state of the exciting light. Possible microscopic models of scattering centers are discussed.

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Semiclassic theory of magnetotransport in superlattices

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The motion of the Bloch electron in the crossed electric and magnetic fields is studied for extremely anisotropic band that exists usually in superlattices. We elaborate the case of the strong electric field that corresponds to regime of the negative differential conductivity. The position of the current peak is founded to be shifted first by magnetic field. This shift is found to be proportional to the momentum relaxation time that is different from the picture given before for this phenomenon. With increase of the magnetic fields the peak splits. This split grow linearly with magnetic field. The electron trajectories are calculated from so-called effective Hamiltonian. The justification of this method is also discussed.

TIME OF FLIGHT ANALYSIS OF CHARGE TRANSPORT IN INSULATORS ANALYSIS OF THE NONDISPERSIVE, TRAP LIMITED CASE

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We consider the unipolar carrier transport problem through an insulating media with traps. The charge packet drifts under the influence of an external electric field applied between two electrodes. We solve the Poisson equation exactly and find the electric field distribution in the device. The displacement current on the electrodes is obtained for the case of a non-dispersive thin charge packet, with deep trapping characterized by a single time constant τ. A generalization of the induced charge "splitting theorem" in such devices is obtained for the trapping case.

Tunneling and nonresonant negative differential resistance in narrow-well interband tunneling devices

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We predict the observation of new negative-differential-resistance (NDR) in interband tunneling devices (ITD's) of well-width smaller then 100 Å. This strong NDR results from the nature of tunneling in ITD's, and is not related to resonant tunneling. It is inherent to the ITD structure and should be experimentally observed in any symmetric ITD (including polytype structures). The mechanism is given in terms of simple physical arguments. Rigorous calculations of the current-voltage characteristics of narrow-well ITD's, made in the framework of the effective mass approximation, show that the effect may be of technological interest.

Scanning Tunneling Microscopy Studies of the Effect of Annealing on Gold Films

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We have studied systematically thermal annealing effects on the surface morphology of 800 A thick gold films, using a scanning tunneling microscope (STM). The gold films were thermallly evaporated onto glass and mica substrates, and were then measured with the STM at room temperature before and after annealing. The annealing treatments were done at temperatures between 200 to 500 xC and for times from 3 to 60 hours. The topographic images were analyzed using various statistical methods and image processing techniques. We present data showing the evolution of the surface-grain size distribution and roughness amplitude of the gold films as a function of annealing temperature and duration. The typical grain size was found to increase with time for all annealing temperatures, whereas the roughness amplitude shows a more complex dependence on the annealing parameters. We are now developing a theoretical model to describe quantitatively the surface processes taking place during annealing.

WORK FUNCTION MEASUREMENTS OF METALS IN THE PRESENCE OF GASES UP TO 1000 Pa.

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The adsorption of gases on well-defined metal crystal surfaces was studied. The system consists of two main parts: A- UHV chamber for preparing and characterising the surfaces, equipped with TSD, AES, and LEED. B- The pressure chamber where the work function measurements were performed. A special telescopic device was constucted for transferring the sample from chamber to chamber. The sample consisted of an "in situ" precleaned Ru(0001) surface, covered by varios amounts of Cu. We determined the change in the work function vs. the ambient pressure (WF(p) curves), using photoelectric measurements in the near UV. The temperature range was from 300K to 500K. Hysteresis of the WF(p) curves was a common occurrence, indicating the degree of reversibility of the adsorption process. The changes in the sample, following the adsorption, were also followed by "classical" surface science methods in the UHV chamber. First results were obtained for combinations of : H_2, D_2, CO, CO_2, CH_4, and O_2.

An Order-Disorder Element in An Antiferrodistortive Phase Transition.

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The question whether structural phase transitions are of displacive or order-disorder type has been widely discussed, and the Antiferrodistortive (AFD) transitions, involving the rotations of X octahedra in ABX_3 perovskites, were generally classified as displacive. These transitions display a Brillouin zone-boundary soft mode which condences at T_c, and current theory suggests accordingly that the X atoms vibrate around center of symmetry points above T_c and displace to new equilibrium points below it. We report the first direct and quantitative evidence of large local distortions far above the AFD transition temperature, indicating a strong element of disorder in these transitions.

We have used XAFS (X-ray Absorption Fine Structure) measurements to investigate the local structure of pure $NaTaO_3$ and mixed $Na_xK_{1-x}TaO_3$ which undergo AFD transitions. XAFS is ideally suited to discover and measure local or instantaneous structural disorder, which might not be revealed in diffraction or magnetic resonance measurements. The XAFS spectrum contains information on the *local* structure around a probe atom, and is not affected by long range disorder. Furthermore, the time resolution of the measurement is of the order of 10^{-16} sec, so high frequency structural dynamics is not averaged out.

Two effects of the octahedra rotation on the XAFS spectrum were simultaneously measured, thus introducing a self-consistency check of the data analysis. The two effects were found to be in good agreement with each other. We find that in the pure crystal local rotations of the octahedra persist at least up to 50K above the highest transition temperature at 900 K. In the mixed crystals large local rotations are present even hundreds of degrees above the transition to the cubic phase. These results show that the oxygen atoms are displaced from center of symmetry points far above the transition temperature, and the octahedra are rotated disorderly above the transition so that only the *average* rotation is zero in the cubic phase. Consequently we argue that at the transition a preferred sense of the existing local rotations is established, whereas the magnitudes of the displacements of the oxygen atoms do not change significantly.

MAGNETORESISTIVE AND STRUCTURAL PROPERTIES OF ANNEALED Fe/Cr SYSTEM

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MBE grown multilayered structure of Fe/Cr is investigated. The thicknesses of components comprising the bilayers were 3.5 nm Fe and 1.0 nm Cr. The effect of structural modifications by low-temperature annealing on the magnetoresistivity (MR) was investigated. Although at the temperature range of annealing (50 - 250 C) no significant change in MR was observed, low-angle X-Ray diffraction (XRD) results indicate that the number of the peaks related to the bilayer structure decreased. At the temperatures of about 130 and 250 C respectively the numbers of XRD peaks were 6 and 5 as compared with the 8 of the unannealed sample. This might suggest structural changes. These changes are studied by TEM.

GIANT ENHANCEMENT OF SPACE CHARGE REGION EFFECT ON REFLECTIVITY OF THE INTERFACE POLARITON ACTIVE STRUCTURE INCLUDING FERROELECTRIC LAYER

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New Interface Plasmon Polariton (IPP) structure Metal-Ferroelectric layer -high doped Semiconductor (M-Fl-S) have proposed to get the big modulation levels of reflected light intensity. Light modulation takes place in the region of IPP minimum of reflectivity and is induced with the control of Space Charge Region (SCR) thickness by electrical voltage (1-10 V) applied to the structure. Greate modulation levels are conditioned by the presence of ferroelectric layer with high static constant which allows to get in semiconductor a thick SCR. The characteristic time-response of M-Fl-S structure evaluated as its RC-time is of the order of 10 s.

Elements of order-disorder in the ferroelectric phase transition in PbTiO3.

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The local structure of PbTiO3 and its temperature dependence were investigated using X-ray absorption Fine Structure (XAFS) measurements. This perovskite crystal undergoes a ferroelectric phase transition at 763K. In the past the phase transitions in perovskites have been described as displacive and $PbTiO_3$ specifically was considered a text book example of such a transition. However, many reports since have qualitatively shown that there is at least an element of order-disorder in these transitions, including evidence of disorder in $PbTiO_3$. We present quantitative measurements of the structural disorder in the paraelectric phase of this system.

XAFS provides quantitative information on the structure surrounding the probe atom up to fourth nearest neighbors. This information is independent of whether the material has or has no long range order. Therefore XAFS is ideal for measuring local structural disorder.

We have measured the XAFS of Pb L_{III}-edge and Ti K-edge in $PbTiO_3$ at various temperatures below and above T_c. The local structure was determined by fitting a parameterized theoretical XAFS spectrum to the experimental data. The theoretical spectrum was fit to the fourier transform over a limited range in R-space. The fit of Pb data included four coordination shells at low temperatures and two shells at high temperatures. The Ti data was fit only up to the first shell.

Our analysis shows that both Pb and Ti remain in off center positions above T_c. The off center displacements above T_c are about 60their values at 15K. The displacement of the Ti cube relative to the Pb Probe remains constant over the whole temperature range. Moreover, the oxygen octahedron remains tetragonal above the transition temperature. The last two results show that the local distortions are correlated over at least a few unit cells in the paraelectric phase. These results show that ordering of the local dipoles is involved in the ferroelectric transition in $PbTiO_3$ and that this transition is not purely displacive as thought before. On the other hand the decrease of the local distortions above T_c and the existence of a soft mode indicate that the transition is not pure order-disorder either.

1/f Hopping Noise in Doped Crystalline Germanium

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The low-frequency noise was measured in samples of p-Ge:Ga and n-Ge:As at liquid helium temperatures (4.2-1.3)K, where d.c. conductivity is goverened by the nearest neibour hopping mechanism of charge transport. The noise spectral density S is proportional to the square of applied voltage V and inversely proportional to the frequency f. Hence, the empirical Hooge formula for S is valid in the hopping regime as well. The temperature dependence of 1/f hopping noise is much weaker then that of the d.c. conductivity. The Hooge parameter was estimated to be about 10^{-2} that is the usual value for the inhomogeneous systems.

Strong Anisotropy of Magneto-transport Properties in Composite Systems with a Periodic Microstructure

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A new effect is predicted: strong anisotropy of the magneto-transport in composite systems with a periodic microstructure [1]. For a strong magnetic field, the values of magnetoresistance tensor components, the Hall and other Onsager coefficients (as well as the dielectric coefficient in case of low-frequency fields) exhibit a strong dependence on the direction of the applied magnetic field **H**. The angular profile of magnetoresistance is qualitatively, and sometimes even quantitatively, similar to what is experimentally observed in some metallic single crystals like copper. The latter results are usually explained by involving a Fermi-surface quantum theory [2]. However our result is for a purely classical system (composite with a periodic array of inclusions) and is not based upon quantum-mechanical concepts like Fermi-surface. Our theory has a simple geometrical interpretation: In the presence of a strong magnetic field, each obstacle of radius a produces a distortion of the current flow in the shape of a cylinder along **H** with radius a and length $a|\rho_H|/\rho$, where $|\rho_H|/\rho$ is the Hall to Ohmic resistance ratio in the surrounding medium. This cylinder of distortion interacts with other obstacles to produce a strong dependence of the magnetoresistance on the direction of **H** when the cylinder length is comparable to the distance between neighboring obstacles. This should be observable at magnetic field as low as 1 Tesla if the electron mobility in the surrounding medium is 1 m^2/Volt-sec. This effect, if verified by experiments, would not only be a new and interesting property of periodic conducting composites, but may have implications for the semiclassical theory of magnetoresistance in periodic mesoscopic systems.

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THE OPTICAL MEASUREMENT OF HNO_3 VIBRATIONS IN GRAPHITE INTERCALATION COMPOUNDS

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We report the observation of intra-molecular vibrations in α-type HNO_3 intercalated graphite, by modified Raman and infrared spectroscopic methods. These methods overcome the difficulty of optically measuring intercalant vibrations due to the high absorption coefficient of graphite in the visible and its high reflectivity in the infrared.

The Raman measurements were performed on the 'a' face of the Graphite Intercalation Compound (GIC) sample with light polarized parallel to the 'c' axis. In this arrangement, the graphite absorption is much weaker for symmetry reasons and the scattering volume is greatly increased. The experimental system was a computer controlled triple spectrometer with an optical multichannel analyzer, and the exciting light was the 514 nm line of an Argon laser.

The infrared reflectivity was measured with a FTIR spectrometer at the interface between the GIC sample and a Germanium prism. This was chosen because it is an IR transparent material with an optical dielectric constant higher than the perpendicular component of the GIC dielectric tensor. It can be shown that at a suitable angle of incidence, light can penetrate into GIC (total reflection on the sample does not occur) and the sensitivity of the reflectivity to lattice vibrations increases by almost two orders of magnitude.

Both methods allowed us to observe vibrational frequencies of the HNO_3 molecule intercalated into graphite. Measurements performed at temperatures much lower than the melting temperature (248 K) at which the intercalant crystalizes in a bidimensional lattice, consistently show a four-fold splitting of these frequencies. We interpret this splitting as a Davydov (correlation field) splitting due to the coupling of vibrations of four non-equivalent intercalant molecules in each unit cell of the 2D crystal. While various X-ray structural studies suggest unit cells containing a much larger number of molecules when taking into account the comensurability of the intercalant with the graphite lattice, our interpretation is consistent with a structure that takes into account only the interactions between intercalant molecules.

Viscosities of Some Molten Alkali Halides and their Binary Mixtures in the Reduced Units of Temperature

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Precision determinations of the viscosities of RbCl, RbI, KI, NaI and their binary mixtures RbCl-RbI(0.58) and KI-NaI(0.58) using the oscillating cylinder method are reported. The experimental values are described well by the Arrhenius type equation.

Our viscosity data together with the other available in the literature data form a family of curves when plotted against a conventionally reduced temperature. The viscosity data for the CsCl show that in the molten state it has the same coordination number as in solid. Glassification temperatures T_g of the salts were found. It has been shown that T_g is an important parameter in transport phenomena.

PERSISTENT CURRENT IN A TWO BAND DISORDERED INTERACTING 1D RING

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Using numerical exact diagonalization and analytical variational calculations we examine the effect of an electronic two band structure on the persistent current of an interacting disordered 1D ring.

Several new features in comparison to a single band model are encountered. A transition in the magnitude of the current for a critical ratio of the hopping elements in the two bands due to a transfer of electrons from one band to the other. For the case of overlaping bands a very sharp Mott Transition is observed. The reason for this is that delocalized electrons prefer to reside in the upper band (gaining the hopping term), but as the e-e interactions grow larger a Wigner lattice is created localizing the electrons. Localized electrons will naturally reside in the lower energy band (lower on site energy). When disorder is considered a large increase in the rms value of the persistent current for certain values of interaction and disorder is observed.

ABSTRACTS

HIGH ENERGY PHYSICS

Measurements of anthropogenic radioisotopes in environmental samples

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Concentrations of ^{129}I, ^{41}Ca radionuclides of anthropogenic origin are studied in environmental samples. Measurements of a concentration profile in a Greenland firn core spanning the years 1935 to 1989 have been performed by accelerator mass spectrometry (AMS). Two sets of data points measured for ^{129}I show discrepancy and prevent definitive conclusions. One of the sets indicates no large increase of ^{129}I concentrations in contrast with precipitations at lower latitudes. The results indicate the possibility of a different behaviour in the atmospheric transport for ^{129}I, ^{41}Ca in comparison with ^{36}Cl and ^{90}Sr. ^{129}I was also measured in a sample of soil near Chernobyl's nuclear facilities and its concentration is compared to those of other long-lived radionuclides. The feasibility of ^{90}Sr detection by AMS was investigated. The estimated sensitivity limit for this radionuclide determined by the ^{90}Zr background is of 2×10^{-12}.

Quark Solitons from effective action of QCD

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We derive an effective low energy action for QCD in 4 dimensions. The low energy dynamics is described by chiral fields transforming non-trivially under both color and flavor. We use the method of anomaly integration from the QCD action. The solitons of the theory have the quantum numbers of quarks. They are expected to be the constituent quarks of hadrons. In two dimensions our result is exact, namely the bosonic gauged action of WZW.

Subtleties in QCD theory in Two Dimensions

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It is shown that in a formulation of Yang-Mills theory in two dimensions in terms of $A = if^{-1}\partial f$, $\bar{A} = i\bar{f}\bar{\partial}\bar{f}^{-1}$ with $f(z,\bar{z})$, $\bar{f}(z,\bar{z}) \in [SU(N_C)]^c$ the complexification of $SU(N_C)$, reveals certain subtleties. "Physical" massive color singlet states seem to exist. When coupled to N_F quarks the coupling constant is renormalized in such a way that it vanishes for the pure Yang-Mills case. This renders the above states massless and unphysical. In the abelian case, on the other hand, the known results of the Schwinger model are reproduced with no need of such a renormalization. The massless QCD_2 theory is analyzed in similar terms and peculiar massive states appear, with a mass of $e_c\sqrt{\frac{N_F}{2\pi}}$.

Topological Landau-Ginzburg Formulation and Integrable Structure of 2d String Theory

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We construct a topological Landau-Ginzburg formulation of the two-dimensional string at the self-dual radius. The model is an analytic continuation of the A_{k+1} minimal model to $k = -3$. We compute the superpotential and calculate tachyon correlators in the Landau-Ginzburg framework. The results are in complete agreement with matrix model calculations. We identify the momentum one tachyon as the puncture operator, non-negative momentum tachyons as primary fields, and negative momentum ones as descendants. The model thus has an infinite number of primary fields, and the topological metric vanishes on the small phase space when restricted to these. We find a parity invariant multi-contact algebra with irreducible contact terms of arbitrarily large number of fields. The formulation of this Landau-Ginzburg description in terms of period integrals coincides with the genus zero $W_{1+\infty}$ identities of two-dimensional string theory. We study the underlying Toda lattice integrable hierarchy in the Lax formulation and find that the Landau-Ginzburg superpotential coincides with a derivative of the Baker-Akhiezer wave function in the dispersionless limit. This establishes a connection between the topological and integrable structures. Guided by this connection we derive relations formally analogous to the string equation.

Phase-Space Propagators for Barrier-Penetration

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The phase-space propagator for Wigner's functions incident on a general, localized, one dimensional, potential barrier is found to have a universal simple form. Any initial Wigner's function, with a well defined momentum, gives asymptotically two final parts; a reflected one and a transmitted one. Both parts will be delayed by the barrier compared to a free motion. Both will be spread in phase-space and oscillate in a similar functional form. The numerical parameters of these functions depend on the specific barrier considered. They are calculated for two examples: a Dirac δ function potential barrier and a Poschl-Teller type barrier. The subject of time delay due to tunneling is treated within this approach.

Quantum Gravity from a Dynamical-Space Regular-Time Lattice Model

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It is proposed that gravity may be induced in the low energy limit of a model of matter fields defined on a special kind of a dynamical random lattice. Time is discretized into regular intervals, whereas the discretization of space is random and dynamical. A family of triangulations is associated to every distribution of the spacetime points using the flat metric. There is only a scalar action which, in turn, depends *only* on diffeomorphism invariant properties of the triangulations.

We provide evidence that the ground state, as probed by low energy measurements, is Poincaré invariant. We show that the zero momentum scalar excitation has a finite energy in the limit of vanishing lattice spacing, and argue that it should be the end point of a continuous spectrum. We show that a gravitation field arises naturally in the classical continuum limit of the matter action, where the components of the curved metric tensor are defined as quasi-local averages of certain microscopic properties of spacetime.

A mechanism is proposed for recovering general coordinate invariance in the continuum limit. Provided this mechanism works, the low energy theory should reduce to General Relativity, where the Planck scale is identified with the mass of the most massive ordinary particle. It will be indicated how to investigate the validity of key features in a simplified version of the model.

ABSTRACTS

ASTROPHYSICS

SOLAR OSCILLATIONS AND SUNSPOT FORMATION

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As was previosly shown [1,2], small-scale magnetohydrodynamic (MHD) turbulence results in modification of the Ampere law, by significantly reducing the elasticity of the magnetic field lines. As a result, the 'effective' magnetic pressure is reduced and may even reverse its sign. We show here that this modification can be related to a variety of phenomena observed in the Sun and in particular the following four are investigated: the 11-year variations of the solar radius, the torsional oscillations and the meridional flows, the solar short time oscillations and the large-scale magnetic flux ropes formation in convective zones of the Sun (as well as in stars and spiral galaxies).

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TAUVEX- an Israeli Space Telescope On Board an International Multispectral Observatory

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The Tel Aviv UltraViolet EXplorer (TAUVEX) will image the sky simultaneously with three parallel space telescopes, as well as performing high rate photometry of several sources in the field of view. The observations will be simultaneous with data from other bore-sighted high-energy imagers [SODART (Denemark, USA, Finland); Jet-X (UK); MART (Italy); MOXE (USA); EUVITA (Switzerland, Russia)] and other experiments on board the Russian - international SRG satellite. Moreover, TAUVEX is the single experiment of SRG that provides precise ($< 3''$) real time attitude information to SRG for star tracking purposes. The large and eccentric SRG orbit (200,000x500 km) enables long duration exposures that will show objects as faint as $M_{uv} \sim 21$ or fainter. The flexible flight software enables the use of several observational configurations with different filters and fast-photometry windows.

The expected scientific returns consists of numerous UV objects, $\sim$ **30,000** quasars, 300,000 galaxies and millions of stars, which will significantly improve the study of their properties. So far, only a small fraction of them, the very bright ones, have been detected. We also intend to measure UV background radiation to study the properties of the interstellar dust and the extragalactic background, and to image extended objects, such as supernova remnants and HII regions. We will also focus on temporal phenomena in cataclysmic variables, white dwarfs, neutron stars and black holes. Hopefully we will detect old and very faint neutron stars in the close vicinity of the sun. The unique UV, X-ray and gamma ray observations, obtained for the first time simultaneously, will provide an extremely important database for comprehensive astronomical research.

Detailed preparation of the observations consists of a new method for predicting the UV brightness of stars and producting synthetic UV maps and preliminary optical observations on some selected targets. This will enable identification of the imaged objects with their optical counterparts, determination of their UV colors in the six TAUVEX bandpasses, and selection of variable, nonthermal, extremely hot, very faint or other peculiar objects.

TAUVEX has already passed successfully the main development milestones and the electronic integration tests with SRG. The Engineering model has been delivered to the Russian Academy of Sciences' Space Research Institute and the Flight model will be delivered this fall. The launch of SRG is scheduled for December 1995 for an active in-orbit lifetime of three years or longer.

ABSTRACTS

MEDICAL PHYSICS

Flow Velocity Measurement by Color Doppler Ultrasound Mapping - Improvement of a Popular Clinical Tool

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Doppler ultrasound (US) is widely used as a non-invasive clinical tool for studying blood flow velocity in the cardiovascular system. Color mapping is a mode in which the cross-sectional structural image of an artery, vein or heart, is superimposed with color coded 2D profile of flow velocities within the structure. Since the US beam is at angle (ϕ) with the direction of flow, the measured velocity value must be corrected by the factor of $1/\cos(\phi)$. We have developed a measurement protocol and correction procedure which facilitates the measurement of the orienation and location of the ultrasound probe, calculation of the orientation and location of the imaged artery (or vein or heart), and the calculation of the angle between the two orientations. A 3D position/orientation measurement system is used in conjunction with a cardiac echo ultrasound imaging system. The measurements and the correction procedure have been evaluated by using a phantom, which allows comparison to calibrated flows and angles.

Three Dimensional Investigation of Cardiac Mechanics Using Tagged MRI

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Cardiac diseases are the major cause of mortality in developed countries today. Hence, accurate mapping of myocardial damage is essential for right prognosis and treatment of such diseases. As the heart is an organ that functions by a cyclic alteration of its geometry any major myocardial malfunction has a geometrical manifestation. Thus, by studying the geometrical deformations associated with the heart's function, regions of damaged myocardium can be located within its walls.

We have developed a method which utilizes tagged MRI and by which 24 myocardial cuboids can be non-invasively marked and reconstructed in 3D at end diastole (ED) and at ends systole (ES) in each heart. We start by selecting two sets of imaging planes which are perpendicular to each other and which are located perpendicular to and aligned with the left ventricular long axis. Applying a selective RF pulses to the first set of planes and imaging along the second set, we obtain a set of radially tagged four short axis images. Then by switching the order, we apply selective RF pulses to the second set of planes and image along the first set of planes. As a result a set of four long axis images with four parallel tags are obtained. Utilizing the fact that the obtained tag lines correspond to the intersection lines between the imaged and RF tagged planes and by applying a special computer algorithm, 24 myocardial cuboids can be reconstructed at ED and ES. We have applied this method to 7 normal and 9 ischemic canine hearts and investigated their regional myocardial function. Correlating our measurements with PM studies we were able to show that with this method ischemic regions on the myocardium can be mapped non-invasively in 3D.

The Measurement of the Peripheral Circulation Resistance Variability

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The heart beat rate for a normal subject is not constant but changes in a regular manner in defined frequencies, due to the respiration (0.35 - 0.45 Hz) and the activity of the autonomic nervous system (0.02 - 0.09 and 0.09 - 0.15 Hz). The influence of the respiration and the autonomic nerves on the heart rate variability (HRV) is via their influence on the venous return to the right atrium: the inspiration increases the intra abdominal pressure and the sympathetic and parasympathetic nerves change the resistance to flow of the microcirculation vessels. The evaluation of the peripheral circulation resistance variability (CRV) by the measurement of HRV is indirect and subject to various errors, and other parameters of the blood circulation system were tried for the measurement of the peripheral CRV. The arterial blood pressure is greatly influenced by the peripheral CRV, but the measurement of its spontaneous variability is not simple, since non-invasive measurement of the arterial blood pressure requires compression of the arteries by means of turniquette. Other parameters of the peripheral circulation whose variability was investigated are skin blood flow by laser Doppler flowmetry, arterial diameter by ultrasound waves and skin temperature.

Plethysmography is the measurement of the blood volume increase in the tissue during systole. Photoplethysmography (PPG) is the measurement of the systolic blood volume increase in the tissue by measuring its absorption of light. A LED and light detector are attached to the skin so that the light emitted from the LED can reach the detector only through the tissue. During systole the blood volume in the tissue increases and its light absorption is higher, so that the detector output oscillates with the heart beat period. The amplitude of the PPG signal depends on the heart stroke volume and on the compliance and resistance of the blood vessels.

In a recent study the PPG signal was measured for 800 heart beats and the variability of its amplitude and the heart beat period was examined by power spectrum analysis. Both spectra showed oscillations in similar frequencies, but their power was different. In general, the amplitude variability showed lower oscillation in the respiration frequency and higher oscillation in the low frequencies than HRV.

The PPG variability seems to be a convenient potential tool for direct examination of the role of autonomic nervous system in the hemodynamic characters of the peripheral circulation.

Fourier analysis of differential light scattering from cell populations as a mean for demonstration of biological activation

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A new method for cell activation demonstration has been tested on a variety of cell types. Populations of cells suspended in PBS (phosphate buffered saline) water solutions, were illuminated by laser light, thus producing scattering patterns that were analyzed FFT mathematical processor. As a reaction to incubation with certain stimulants these cells slightly changed their size and shape, thus modifying their light scattering pattern. This method appears to be more sensitive to size changes than most other existing methods. One significant property of this analysis is that a dry specimen of cells attached to a microscope slid can be analyzed as well. Our system produced results for latex beads populations which according to control and calibration (including SEM) tests appear to be accurate to order of 0.2 micron.

This method can be applied as a mean for early detection of a few types of cancer, thus it is of substantial diagnostic significance.

OPTICAL DETECTION OF TUMORS

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A new mathematical model has been recently suggested to describe photon migration in turbid biological tissues, and its validity to the visible and near-IR light has been proved by a number of experiments. In this model, light propagation in the tissue is described as diffusion subject to absorption, which can be formulated in terms of a random-walk on a cubic lattice, with an absorption factor $\exp(-\mu)$ per step on the lattice, according to Beer's Law.

This method has been used to study the detectability of tumors in optically turbid tissues. The tumors have different absorptive properties than the surrounding tissue. In this work we focus on time-resolved transillumination measurements, and study measures of the detectability of finite-sized tumors in slab-like tissues.

We consider a slab of tissue of finite thickness with absorptivity μ_1. An inclusion of linear size with absorptivity μ_2 ($\mu_2 > \mu_1$) is assumed to be located in the center of the slab. Light is injected into one face and detected at the opposite face, where the source, the center of the inclusion and the detector are collinear. We calculate the transmitted intensity *with* and *without* the inclusion at a given time, and take their ratio, $R(t)$, as the measure of detectability.

We found that the detectability depends only on the *difference* between the absorption coefficients of the inclusio n and the bulk ($\Delta\mu = \mu_2 - \mu_1$). This means that a single parameter suffices to describe the absorption. The behavior of $R(t)$ has been found to exhibit three regions in time: At the earliest times the detectability improves with time ($R(t)$ decreases), since most of the photon trajectories must pass through the inclusion. At later times, the diffusive nature of photon trajectories implies that there is a significant contribution to the transmitted light from photons that did not cross the inclusion, thus the detectability becomes worse. At very long times photons have high probability of passing through the inclusion, thus more information about the latter is obtained at the detector and the detectability asymptotically improves. For given $\Delta\mu$ and tumor size one can use our results to determine the optimal time for best detection.

Our conclusion is that time-resolved transillumination experiments can be used for detecting hidden tumors in biological tissues. The resolution limits of this method depend on the sensitivity of the instrumentation.

ABSTRACTS

NON LINEAR PHYSICS

Quasi Arnold Diffusion of Periodically Kicked Charges in a Magnetic Field

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The classical chaotic diffusion of charged particles, subjected to a uniform magnetic field (in the z-direction) and to a periodically kicking potential varying only in the x-direction, is rigorously studied using the characteristic-function formalism. The problem exhibits a constant of the motion, the component p_y of the canonical momentum (in the Landau gauge). At a fixed value of p_y, the diffusion takes place on a stochastic web. The symmetry of the web (crystalline or quasicrystalline) is determined only by the ratio between the kicking period and the cyclotron period, but its actual form varies with p_y. Because of this fact, the ensemble average defining the diffusion coefficient D must be taken also over p_y (i. e., over a set of stochastic webs), despite the fact that p_y is a constant of the motion. Such a diffusion process, averaged over p_y, is then termed "quasi Arnold". Exact closed expressions are found for the correlation functions and the coefficient D characterizing this quasi Arnold diffusion in the crystalline case. For large values of the kicking parameter, the accurate evaluation of D using these expressions is much faster than numerical simulations. However, the characteristic-function formalism cannot account for the anomalous diffusion ("flight") near accelerator modes.

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SEMICLASSICAL DYNAMICS OF A BOUND SYSTEM IN A HIGH-FREQUENCY FIELD

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The dynamics of a particle in a one-dimensional triangular potential well, driven by a monochromatic electric field, is studied. A classical high-frequency expansion together with semiclassical uniform methods leads to an explicit form of the Floquét operator in the unperturbed basis. The general features of this matrix provide a simple explanation for the appearance of quasiresonances, and allow the analytic investigation of the quasi-energy eigenstates. These are found to be asymptotically extended, with a finite region of exponential decay. The crossover point between the two behaviours depends on the parameters of the driving field. The specific system studied here is suggested as a prototype model for a class of driven one-dimensional bound systems, whose main characteristic is an increasing density of states as a funcion of energy.

Quantum Suppression of Chaos on Stochastic Webs

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Quantum suppression of chaos on stochastic webs is shown to take place for the kicked harmonic oscillator in the form of exactly *periodic* recurrences. This phenomenon occurs, in general, only if three conditions are satisfied: 1. The kicking potential is *odd*. 2. The web is *crystalline* with *square* or *hexagonal* symmetry. 3. A dimensionless $\hbar$ assumes *integer* values. In the classical case, and for small kicking parameters, the classical chaotic diffusion on crystalline webs for odd potentials is much slower than for even potentials. The phenomenon appears to be the only known case of exact quantum suppression of chaos on stochastic webs. While the system is exactly related to a symmetric kicked Harper (KH) model, the phenomenon does not occur in this model (it occurs in non-symmetric models as ordinary quasiperiodic recurrences). However, one can interpret the phenomenon as an "anti-resonance" effect between a KH model and its inverse. The phenomenon persists for long times under small perturbations of the potential and/or $\hbar$, and it is associated with a topological Chern integer = 1.

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NONLINEAR WAVES AND PATTERN FORMATION IN MULTI-PHASE FLOWS

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Pattern formation in initially homogeneous one-dimensional multi-phase flows is studied. It is shown that generally these flows are unstable. The mechanism of the instabilities is associated with inertial effects. Such instabilities are probably important in various engineering applications and natural phenomena. In small-amplitude finite approximation the evolution of patterns is governed by the Korteweg-deVries-Burgers equation. Pattern formation occurs when the coefficient multiplying the Burgers term becomes negative. It is the explosive-type instability.

Theory of Random Advection in Two Dimensions

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Steady statistics of a passive scalar advected by a random two-dimensional flow of an incompressible fluid is described at the scales less than the correlation length of a flow and larger than the diffusion scale. By using Lagrangian path integral the problem can be reduced to a classical problem of studying the product of many random matrices with a unit determinant. The main value of interest is the Lyapunov exponent that determines the rate of line stretching. We found the change of variables which allows one to map the matrix problem into a scalar one and enables us to prove a central limit theorem for the statistics of the Lyapunov exponent for any finite correlation time of a velocity field. The mean rate of stretching can be analytically calculated for the opposite limits of a fast and slow strain. A simple interpolation formula (valid for any relation between the turnover and correlation times of the velocity field) is suggested and checked by numerical simulations. We thus can evaluate the rate of cloud stretching by a quite arbitrary atmospheric turbulence.

The set of simultaneous correlation functions of the scalar is found. Whatever be the statistics of the velocity field, the statistics of passive scalar in the inertial interval of scales is shown to approach Gaussianity as one increases the Peclet number (the ratio of the external scale to the diffusion one).

Berry's phase in the Floquet Representation

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The topological phase for a systems whose Hamiltonians depend periodicaly on time and evolution have a cycle adiabatic character was introduced by Berry [1] . Most futher generalization of this phase have been confined to such system with time-dependent Hamiltonian and have a prefix non - : non-Abelian [2], non-adiabatic [3], and non-cyclic [4].

In the present report the Floquet theory is applied to the system whose Hamiltonian is periodic in time and the evolution is described by differential equation with time dependent coefficients. By means of the Floquet theory the investigation of the Berry's phase for such system is transformed into the study of the time independent eigenvalue equation. An expression is obtained describing the Berry's phase in terms of the Floquet state [5].

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NONLINEAR DYNAMO IN 'ABC' FLOW: THE HALL EFFECT

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Nonlinear evolution of the magnetic field generated by a prescribed deterministic flow of a conducting fluid in form of the ABC flow is studied numerically. The nonlinearity is caused by the Hall effect. After the linear regime, the Hall's term in the induction equation becomes important, leading to saturation of the magnetic field. The oscillations of the magnetic field which characterize the linear regime fade away into a steady state regime.

The structure of the magnetic field can be viewed as a sum of two components: a field of the integral scale and a small-scale field. The large-scale field contains most of the energy of the system, whereas the energy of the small-scale field is very small.

These results demonstrate significant difference between the actions of two types of nonlinearity in terms of the magnetic field: the Ampere force and the Hall effect.

DISTRIBUTION FUNCTION of the INTENSITY of optical WAVES in random SYSTEMS

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The distribution function for the intensity of coherent radiation propagating in a random medium is calculated diagrammatically. For large values of intensity the distribution function differs drastically from the simple exponential, corresponding to Rayleigh statistics, and the asymptotical behavior is a stretched exponential.

Intrinsic optical bistability and resonances in nonlinear composites

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Optical materials with bistable behavior have attracted much attention recently due to their potential uses as components of optical devices. Optical bistability can be achieved in composite materials made of a nonlinear dielectric and a metal the dielectric constant of which has a negative real part and a small imaginary part. We propose a general framework that enables us to investigate the bistable behavior of such two-component composites. It is based on a relation between the electric field in the nonlinear component and the external applied electric field. The bistable behavior is strongly connected to the existence of sharp resonances in this relation in which the local field is greatly enhanced above its mean value. These resonances also appear in the dielectric function of linear composites with the same microgeometry. In their vicinity bistability can be achieved even when the nonlinear behavior is weak. This relation between the fields is exact in composites in which the field in the nonlinear component is constant and thus allows exact treatment of some microgeometries. In periodic composites the existence of many sharp resonances should allow great flexibility in the conditions for the occurrence of bistability. Such microgeometries can be treated using approximations for the average value of the electric field in the nonlinear component.

The conditions for bistable behavior in a few three component composites are also investigated. It is found that the threshold field intensity required for bistable behavior in them is much lower than in two component composites and can be as low as $1W/cm^2$.

Geometrical Aspects of Thick Holograms' Efficiency

(to be presented as a poster)

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In this paper the geometrical aspect of phase hologram efficiency is analysed. The problem arises when optical element with complex phase function is recorded with light of wavelength which is different from the readout one, and becomes extremely crucial in planar optics, drawing growing attention in present day research in the field of optoelectronics.

Confining eikonal equations of recording waves onto the two-dimensional hologram surface, we show that the geometrical problem is fully described by a nonlinear partial differential equation of the first order (arbitrary boundary conditions can be imposed). The immediate consequence of this formulation is that for any holographic grating function and any pair of recording and readout wavelengths it is theoretically possible to achieve nearly 100 % efficiency with diffraction limited imaging.

We developed a method (based on Taylor series expansions and resembling solution of ordinary differential equations) for solving nonlinear partial differential equations by iterative analytic calculations of Taylor coefficients. The design method is illustrated with the computing of the recording waves for a substrate-mode holographic lens, used for compact optical interconnections. The method seems extremely powerful in solving problems, where the whole interesting region is within convergence radius of the Taylor series around a single point. Problems of geometrical optics of nonhomogeneous media, including electron and ion optics, may be treated by the method. Other possible field of applications can be semiclassical treatment of quantum problems.

ABSTRACTS

PLASMA PHYSICS

SPECTROSCOPIC INVESTIGATIONS OF THE ELECTRON DENSITY AND KINETIC ENERGY IN A PLASMA OPENING SWITCH

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The electron density and bounds on the electron kinetic energy are studied during the various phases of a coaxial Plasma-Opening-Switch operation. A gaseous plasma source placed inside the inner positively-charged POS electrode injects the plasma radially outward into the interelectrode region. Our laser seeding technique allow for measurements with high temporal and spectral resolutions in r, z, and θ. Using the absolute level populations for various ions seeded in various locations in the plasma and detailed collisional-radiative calculations we obtain a lower bound on the electron kinetic energy. The average electron kinetic energy was shown to increase to at least a few tens of eV within $\simeq$ 20 ns after the application of the 180 ns current pulse. Using this lower bound on the electron energy, the electron density was determined from ionization times of various species seeded in the plasma. The electron density was shown to be consistent with the density measured by Stark broadening of Ha and Hb prior to the application of the high current pulse. It is shown that the determination of the electron density from hydrogen line profiles during the pulse, neglecting the effects of collective fields on the line broadening results in a large error. The effect of charge-exchange processes with hydrogen on the excited-level populations is investigated.

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Intense RF Power Generation in a Hollow-Cathode Discharge

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High-intensity periodic variations of the potential fall across the cathode sheath have been observed in a low-pressure magnetic-field-free hollow-cathode discharge. These potential variations cause modulation of the discharge current, reaching a depth of almost 100%. Typical frequencies are tens of MHz, slightly lower than the ion plasma frequency near the cathode sheath boundary and associated with the ion transit time through the sheath. The measured pressure dependence of the current threshold for the oscillations indicates that the mechanism of the instability is collisionless. The AC part of the discharge current produced a significant RF power in an external resistive load. Typical results first obtained without optimization, for frequencies of 20 – 30 MHz and load resistances of several tens of Ohms, are: Power of about 5 kW and efficiency of about 30%.

CURRENT CONDUCTION BY A PLASMA BETWEEN ELECTRODES

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Two issues in current conduction by a plasma between electrodes are addressed: transient effects during the rise time of the current, and current neutralization in the bulk of the plasma. For the first issue an analytical method is developed and shown to recover some of the features recently demonstrated in PIC simulations. [1] The potential and the electron flow are shown to be oscillatory at the initial phase of current rise, before ions start to move. The possibility of electron trapping in the potential hill is discussed. For the second issue an equilibrium is constructed that describes a plasma of dimensions larger than the electron skin depth. A beam of charged particles moves ballistically into the plasma and the plasma electrons generate a return current that neutralizes the beam current. When the plasma electrons reach the plasma boundary they bend into a skin layer and conduct the current along the plasma boundary. The relation between the steady state of an unmagnetized plasma and the penetration of the magnetic field due to the Hall field is discussed.

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FAST DECAY OF PLASMA RETURN CURRENTS INDUCED BY A CHARGED PARTICLE BEAM DUE TO WHISTLER WAVES

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A charged particle beam in a magnetized plasma is considered and the evolution of the return current induced by the beam, is studied. If the beam current is perpendicular to the background magnetic field, the return current is shown to depart from the beam along the background magnetic field with a fast whistler velocity rather than a diffusion or an Alfven velocity which are much slower for plasmas of interest. In a plasma bounded by two conductors the return current oscillates with the whistler period. Analytical expressions for the evolution of the magnetic field and of the plasma return current are derived for a beam with a finite width and with various rise time dependences. When the whistler time is shorted than the rise time of the beam current, the plasma return current does not grow beyond the whistler time. Thus, we conclude that when the beam current has perpendicular component to the background magnetic field the beam remains neutralized only for whistler time scale. This may be the reason for the difficulties in obtaining beam focusing in some experiments.

Free Electron Radiation Generators from Microwave to X Rays

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Free electron lasers (FEL) expand the range of microwave tubes to the mm waves up to optical frequencies. They are based essentially on stimulated undulator synchrotron radiation, which is emitted from high energy electrons traversing through the periodic magnetic field of an undulator. The emitted radiation is accumulated in an optical resonator and arrives to saturation and to high coherence similar to conventional lasers.

The emission wavelength of the FEL is determined by the double Doppler shift formula, and is proportional to the undulator period and to the e-beam energy squared. Based on state of the art undulators (of periods 1-10 cm) FELs demonstrated lasing in numerous experiments ranging through the entire spectrum of mm-waves to U.V.

Considering the proportionality relation between the emission wavelength and the undulator period, it was suggested once and again to use intense laser beams as the undulators for the e-beam. Attaining this way undulator periods 4-5 orders of magnitude shorter, operation in the X-ray regime may become possible. Unfortunately, available laser intensities give little hope for attaining laser threshold conditions in the X-ray regime. However, substantial spontaneous synchrotron radiation emission (or "Doppler Shifted Compton Scattering") can be attained with recent state of the art high intensity lasers. This can give rise to development of an interesting source of radiation (laser synchrotron source - LSS) with special characteristics not available and competitive to conventional synchrotron sources.

Following a review of the state of the art of these research subjects, the status of the Israeli tandem - FEL project will be presented. In this project an electrostatic tandem accelerator was converted into a high current electron accelerator (0.5 Amp, 3 MeV), which can operate with a very long pulse ($100\ \mu s - 1 msec$) and eventually quasi continuously. The present goal of the project is to operate this accelerator as the driver of a 3 mm waveglength FEM. The status of the present project and possible future developments of the facility for scientific users will be discussed. These include options of a FIR FEL source and an X-ray LSS in the 30-40 Å region.

Gyrotron Amplifiers for Driving Electron-Positron Supercolliders

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A major international thrust in providing accelerators for high energy physics research is the development of linear colliders with center-of-mass energy $\approx 1TeV$. To keep the cost and length of such a collider within reasonable bounds, one needs to develop more capable microwave amplifiers in the frequency range 10-30 GHz and with output pulse energy $\gtrsim$ 100 joules (e.g. 100 MW for $1\mu sec$). Criteria for comparing the performance of competing amplifier configurations will be presented. Specific results for a leading amplifier concept will be reviewed in detail; i.e., the gyroklystron amplifier with frequency doubling in the output cavity. Such an amplifier has already been operated with $31MW, 1\mu sec$ output pulses at 19.7 GHz. Modifications in the gyroklystron conceptual design that will allow for output power $\gtrsim 100MW$ will be described.

[1]Visiting Professor at Dept. of Electrical Engineering - Physical Electronics, Tel-Aviv University during Spring Semester - 1994.

Cellular automata applications to plasma physics

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Cellular automata (CA) are increasingly being used to model nonlinear N-body processes in physics. Recent applications are in fluid dynamics [1], radiation transport [2], driven diffusive systems [3], traffic flow [4-5], and other fields. CA models can treat boundary conditions in a straightforward fashion, and are readily adaptable to massively-parallel supercomputers. Of current interest is the applicability of CA to plasma physics simulations. A proof-of-principle object-oriented code in C++ has been written to simulate the motion of a charged-particle beam. Particular interest is on a pure CA model, i.e., introducing an electric field locally instead of globally. This differs from the study of Montgomerey and Doolen who introduced a nonlocal electric field into a CA MHD model [6], and that due to Chen and Matthaeus [7] who did not. Both of these studies were based on incompressible MHD.

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ENERGETIC ION DYNAMICS DURING A 100-NS-LONG POS OPERATION

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A flow of fast ions in the vaccuum section between the plasma and the load in a coaxial Plasma Opening Switch (POS) experiment was observed. Our POS, of positive polarity is powered by an LC-water-line generator (4.1 kJ, 300 kV, 1Ω), giving an upstream current with a peak amplitude of 135 ±10 kA and a quarter period of 90 ns. The ion current density and the ion velocities were studied as a function of time using Collimated Faraday Cups (CFC) insulated by transverse magnetic fields. Two arrays of four Faraday cups were placed in the axial and radial directions at different distances from the preformed-plasma region. In the radial observations an ion spike 2-3 ns long was observed almost simultaneously in the CFC for all axial locations. Following the ion spike, longer duration ion current traces were measured, first at the generator side of the plasma and later at the load side of the plasma. In the axial direction, the appearance of fast ions moving towards the load was found to be correlated with the beginning of the downstream current. The fast-ion velocity in the axial direction, determined from time-of-flight measurements, was $2 \pm 1 \times 10^8$ cm/s and the duration of the fast-ion pulse was 30 ± 10 ns. These ions are found to be accompanied by co-moving electrons. The comparison of these data with the specrosocpic local meausurements of the ion velocities is presented. Possible explanation of the current switching to the inductive load are discussed.

The main ion current trances were measured first at the generator side of the plasma and later at the load side of the plasma. In the axial direction, the appearance of fast ions bunch with pulse duration of 30±10 ns propagating in the axial direction was found to be correlated with the beginning of the downstream current. These ions are found to be accompanied by co-moving electrons. The comparison of these data with the spectroscopic local measurements of the ion velocities is presented. Possible explanations of the current switching to the inductive load are discussed.

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INVESTIGATIONS OF ELECTRODE PLASMAS IN A PLASMA OPENING SWITCH

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Spectroscopic techniques with high a spatial resolution are used to determine the electron density and velocity distributions of ions and neutral particles of the plasmas formed over the electrode surfaces during the operation of a 100-ns Plasma Opening Switch (POS). The POS current is delivered by an LC-water-line generator (4.1 kJ, 300 kV, 1Ω) giving a peak current of 135±10 kA with a quarter period of 90 ns. The temporal and spatial dependence of the plasma formation are determined from the line emission of selectively deposited materials on the electrode surface. Plasmas were found to be formed at both electrodes within 50 ns after the beginning of the upstream current. The electron density of these plasmas was observed from Stark broadening of hydrogen lines. The velocity distributions of ions and neutral particles were determined from emission-line Doppler broadenings and shifts. The electron temperature was obtained from absolute level-population densities and collisional-radiative calculations. These plasmas flow into the POS interelectrode gap at a velocity 1 - 3×10^{6} cm/s. Their densities are seen to rise to $\simeq 10^{16}$ cm^{-3} in $\simeq 2\mu$s within few millimeters from the electrodes. These electrode plasmas contain singly and doubly charged ions and neutral particles originating from the metal surface and surface adsorbents. The mechanism responsible for the plasma formation is discussed and effects on the operation of long-time switches are considered.

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CYCLOTRON MODES OF A PURE ION PLASMA

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NON-NEUTRAL PLASMAS, CONSISTING OF ONLY IONS OR ELECTRONS (BUT NOT BOTH) ARE CHARACTERIZED BY LONG CONFINEMENT TIMES AND ENABLE SIMPLE AND ACCURATE BASIC PLASMA EXPERIMENTS. IN THIS POSTER WORK ON THE CYCLOTRON MODES OF A NON-NEUTRAL MG ION PLASMA WILL BE PRESENTED. SEVERAL MODES WITH DIFFERENT ANGULAR DEPENDENCE WERE OBSERVED. THEIR SHIFTS AWAY FROM THE CYCLOTRON FREQUENCY DEPEND ON THE PLASMA SIZE AND COMPOSITION, AND THUS TURN INTO AN IMPORTANT DIAGNOSTIC TOOL. SURPRISING IMPROVEMENT OF THE PLASMA CONFINEMENT TIME DUE ITS HEATING WILL ALSO BE DISCUSSED.

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A 4π SOLID ANGLE ELECTRON SPECTROMETER FOR CORRELATED MEASUREMENT OF ENERGY AND ANGULAR DISTRIBUTIONS OF ELECTRONS SIMULTANEOUSLY EMITTED IN ONE EVENT

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Experiments providing simultaneous measurement of *all kinematical parameters*, which belong to *a number of electrons coming from the same event*, are of interest for the study of multi-electron processes mechanisms, which have been the subject of permanent investigation (see, for example, reviews[1]). For example, some information on the multi-electron ionization mechanism is obtained from $e, 3e$ and $e, (3-1)e$ experiments[2]. Presently, the list of multi-electron correlated measurements probable applications can be extended by adding the study of the interaction between high-intensity laser radiation and atoms, molecules or clusters.

A new type of electron spectrometer for the application fields mentioned above is suggested. The device is based on a 3-dimensional time and position sensitive imaging detectors and has no movable parts. This device is a result of further development of the spectrometer we suggested previously[3] for analysis of electrons ejected from fast moving (belonging to an accelerator beam) particles. The new device is suitable for experiments with a stationary gas or low-energy beam target which are ionized by fast particles or short pulses of radiation. The collecting solid angle is 4π minus a "dead" region which averages between 10 and 30 % depending on the energy working domain.

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SPECTROSCOPIC MEASUREMENTS OF THE TIME DEPENDENT MAGNETIC FIELD IN A PLASMA OPENING SWITCH

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Recently developed plasma seeding techniques are utilized in our nanosecond POS experiment to perform measurements of the magnetic field that are local in r, z, and θ. The seeding is made by laser evaporation of material initially deposited on the anode into our preformed plasma whose density is $\simeq 10^{14}$ cm^{-3}. The size of the region observed in our experiment is $\simeq$1 cm, $\simeq$1 cm, and 0.05 cm, in the axial, azimuthal, and radial directions, respectively. Since the line spectral profiles are dominated by both the ion Doppler broadening and Zeeman splitting, we observe *in a single discharge* both the π component ($\Delta M = 0$) and the σ component ($\Delta M = \pm 1$) of the transition to obtain the Doppler broadening and the Zeeman splitting, respectively. The time-dependent magnetic field in the plasma is thus determined. Various examinations (observations of line-intensities of various species and of Stark broadened line profiles) were made to verify that the seeding does not affect the parameters of the preformed plasma. The magnetic field in the axial and radial plasma center was found to start rising within $\simeq$40 ns after the beginning of the upstream current. This result is compared to measurements of the ion motion observed at various regions of plasma. i

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OBSERVATIONS OF ION VELOCITY DISTRIBUTIONS AND ELECTRIC FIELDS IN A PLASMA OPENING SWITCH

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Spectroscopic diagnostic methods are used to investigate the ion velocity distributions and electric fields in a coaxial nanosecond Plasma Opening Switch (POS) experiment. Recently developed laser evaporation techniques are used to locally seed the plasma with various species in order to obtain measurements resolved in the axial, radial, and azimuthal directions. A gaseous source injects the plasma from inside the inner positively-charged POS electrode. Doppler line shifts and broadenings yield the velocity distributions of various ions and neutral particles. The ion directed velocities are found to scale with the ion charge-to-mass ratio. The ion motion starts over the entire plasma within 40 ns from the beginning of the upstream current, indicating relatively fast magnetic field penetration. The velocities are found to be low over most of the plasma and higher at the load-side edge of the plasma, implying a higher current density there. The local ion velocities are used to infer time dependent magnetic field distributions in the plasma. The current through the plasma, calculated from the magnetic field gradients, appears to be smaller than the difference between the generator and load currents, implying current flow in the vacuum between the plasma and the load. Profiles of hydrogen lines observed for various polarizations show the presence of collective electric fields in the plasma during the high current pulse. Electric fields with peak amplitude of $\approx$8 kV/cm were observed over the entire POS anode-cathode gap from 20 to 100 ns after the generator current pulse beginning.

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ABSTRACTS

STATISTICAL MECHANICS AND COMPLEX FLUIDS

On the scaling description of the elastic phenomena in gels.

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We discuss the scaling approaches to the elastic and osmotic properties of gels and present the new results, concerning the uniaxial deformation of swollen gels. The main finding is that the swollen gel can demonstrate negative Poisson ratio in nonlinear regime of deformation in good solvent conditions. The physical reason for this result is that the stretched gel can minimize its free energy by swelling in the direction perpendicular to that of the stretching.

Dynamical scaling from measurements with definite length scale

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We present a new measure of the Dynamical Critical behavior: the "Multi-scale Dynamical Exponent" z^{MDE}. A correspondence between space scales and the eigenmodes of the autocorrelation matrix (introduced by Ben-Av and Bhanot) is defined by $\Lambda = \frac{1}{k}$. The dynamical evolution on each spatial scale Λ is characterized by the autocorrelation time τ_Λ. Assuming dynamical universality we argue, and verify numerically that z^{MDE} has the same value as the usually defined z. We measure z^{MDE} in the two-dimensional (2D) Ising model with the Metropolis and respectively Wolff dynamics. We find z^{MDE} from the fit $\tau_\Lambda \propto \Lambda^{z^{MDE}}$. We find $z^{MDE}_{met} = 2.0 \pm 0.2$ and respectively $z^{MDE}_{wolff} = 0.3 \pm 0.25$. We note that in our approach z^{MDE} can be measured using a single temperature($\beta = \beta_c$) and a single lattice size, L. In addition, in the Metropolis case we present a new method - Local After Global (LAG) - which helps to overcome critical slowing down in the dynamical measurements themselves.

Phase transition in finite-length liquid crystalline polymers.

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The isotropic-nematic phase transition in liquid crystalline polymers of arbitrary length is discussed. The description in terms of Gupta-Edwards theory allows one to follow the critical temperature and concentration behavior for the whole range of molecular weights: from rod-like short molecule liquid crystals up to infinitely long polymers. The critical temperature of the transition is shown to be a decreasing function of the chain length. The reason for this is that the ends of the chains are more free then their internal parts. Thus the transition into nematic phase is associated with the greater loss of entropy for finite-length polymers then for infinitely long ones.

Yuri Golfand 1922 - 1994

On February 16, Professor Yuri Golfand, the discoverer of super-symmetry, passed away in Jerusalem, Israel, from complications of a brain stroke.

Yuri Abramovich Golfand was born in Kharkiv, Ukraine in January of 1922. Like many famous Soviet scientists of his generation, he went to study at the Leningrad University. In 1944, he graduated from the Department of Mathematics. An outstanding student, he continued his studies there and his doctorate was completed within a year and a half. The subject of the research was some problems in group theory. In the end of the 1940' Golfand worked in a research institute for electrical engineering. In 1950 he joined the group of I.E. Tamm at the Theoretical Department of the Lebedev Physical Institute (FIAN) in Moscow, and he was a member of the institute for 40 years, with a long break. He became Doctor of Science in 1955. In the fifties and sixties, Dr. Golfand did much important work in quantum field theory, in particular, on applications of the functional methods. In 1956, he published a famous work on a method of renormalization, based upon the assumption that the four-dimensional momentum space has a constant non-zero curvature. This was a fascinating attempt to introduce an elementary length into relativistic field theory.

In 1970 Golfand proposed a brilliant idea: extend the Poincaré group by introducing bispinor generators. The known generators were the momentum vector and the angular momentum tensor; but bispinors also were present among the fundamental matter fields: this was his motivation in looking for the extension. Golfand's student Evgeniy Likhtman helped him in performing the calculations, providing a proof that the commutation and anti-commutation relations satisfy the (generalized) Jacobi identities, and their short paper was submitted for publication to JETP Letters. A more detailed paper was published a year later in the Tamm Memorial Volume. Golfand believed then that his theory would be applied to weak interactions, so the chiral super-Poincare algebra was proposed, violating space parity. The auxiliary field and super-space methods were discovered later, and to construct the Lagrangian having the desired symmetry, Golfand and Likhtman employed a recursive procedure.

The importance of that work, one of the most significant in Soviet physics, was only understood a few years later. Meanwhile, Golfand was fired from FIAN in 1973. His dissenter attitude to Soviet communism was revealed, and he applied for an exit visa to Israel. Golfand became active in the Jewish movement for human rights. In particular, he edited a "samizdat" periodical *Jews in the U.S.S.R.* and took part in the seminar of "refusenik" scientists. He was not alien also to Russian dissidents and visited Professor Orlov in his Yakutian exile.

Golfand was unemployed for 7 years, until 1980, when he was accepted back to FIAN under a strong pressure from the world scientific community, the American Physical Society in particular. Soviet authorities tried to persuade him to withdraw his application for repatriation to Israel, but Prof. Golfand insisted upon his right to leave Russia.

It was only in 1990 that his family was granted a permit to leave. In October of 1990, they arrived in Jerusalem. After a few months of getting used to the new life and studying Hebrew, Golfand was accepted as a research fellow at the Department of Physics of the Technion (Israel Institute of Technology) in Haifa. Because of his age, he could not get a regular professorship, but his work was supported by a special program of the Israeli Government. For almost 3 years, Golfand continued an active work on functional methods in quantum field theory. His last paper "Photon Part of Quantum Action Functional in QED" has been accepted for publication in *Modern Physics Letters* posthumously.

Yuri Golfand was an extremely modest and kind person, always ready to help and to share his vast knowledge. Colleagues and friends will remember forever his smile and his quiet and sympathizing eyes.