BEN-GURION UNIVERSITY OF THE NEGEV

Department of Physics



# Israel Physical Society

# 1991

# Annual Meeting

## Program and Abstracts

Bulletin of the Israel Physical Society

Vol. 37, 1991

BEN-GURION UNIVERSITY OF THE NEGEV

Department of Physics



# Israel Physical Society

# 1991

# Annual Meeting

## Program and Abstracts

Bulletin of the Israel Physical Society

Vol. 37, 1991

**Israel Physical Society Annual Conference**

**Ben Gurion University of the Negev, March 27, 1991**

## Scientific Program

Wednesday, March 27

| | | |
|---|---|---|
| 08:30 - 09:45 | Registration | Sonnenfeldt Auditorium Lobby |
| 09:45 - 10:10 | Opening Session | " " " |
| Chairman : | A. Gersten | |
| Words of Welcome : | Dr. Avishay Braverman, President, Ben-Gurion University | |
| | Prof. Itzhak Tserruya, President, Israel Physical Society | |
| 10:10 - 10:50 | Plenary Session I | Sonnenfeldt Auditorium |
| Chairman: | B. Horovitz | |
| Invited Lecture: | M. Heiblum, Weizmann Institute: | |
| | Ballistic Transport of Electrons in a Two Dimensional Electron Gas | |
| 11:00 - 12:30 | Parallel Sessions I | Sonnenfeldt & Humanities Building |
| 12:30 - 14:00 | Lunch Break | Sifrotek & Room 007 in the Library Building |

| | | |
|---|---|---|
| 14:00 - 16:00 | Parallel Sessions II | Sonnenfeldt & Humanities Building |
| 16:00 - 16:30 | Coffee Break | |
| 16:15 - 16:30 | IPS Business Meeting | " " |

| | | |
|---|---|---|
| | Plenary Session II | Sonnenfeldt Auditorium |
| Chairman: | J. Bekenstein | |
| 16:30 - 16:50 | Y. Ne'eman, Minister of Science & Technology | |
| 16:50 - 17:30 | H. Sompolinsky, Hebrew University: Towards a Theory of Learning | |
| 17:30 - 18:10 | A. Bar-Nun, Tel-Aviv University: Israel's Space Research Plans | |

---

| | |
|---|---|
| 08:30 - 18:00 | Exhibition of scientific instrumentations and products by private companies (Sonnenfeldt Auditorium and Humanities Building Lobbies) |
| 12:30 - 18:00 | Poster Session - Humanities Bldg - Level 5 (corridor) and Rooms 238-240 |

**11:00 - 12:30 Parallel Sessions (Humanities Building)**

A. Particles and Fields: Room 552

Chairman: P. Singer (Technion)

Invited Lectures: Y. Sonnenschien (TAU), U. Karshon (WIS) and E. Rabinovici (HUJ).

B. Astrophysics and Space Physics: Room 529

Chairman: A. Eviatar (TAU)

Invited Lectures: N. Brosch (TAU), G. Shaviv (Technion) and M. Gedalin (BGU).

CI. Lasers and Spectroscopy: Room 502

Chairman: M. Rosenbluh (Bar-Ilan)

Invited Lectures: A. Yogev (WIS), Y. Band (BGU) and P. Julienne (NIST), R. Shuker and M. Hakham- Itzhak (BGU)

Oral Presentation : H. Yaffe and Y. Prior (WIS).

D. Environmental Physics: Room 547

Chairman: Yair Zarmi (BGU)

Invited Lectures: J. Joseph (TAU), M. Magaritz (WIS) and D. Faiman (BGU).

E. Nuclear Physics: Room 551

Chairman: A. Marinov (HUJ)

Invited Lectures: J. Lichtenstadt (TAU), M. Paul (HUJ) and S. Mordechai (BGU).

**FI.** Medical Physics I: Room 555

Chairman: S. Akselrod (TAU)

Invited Lectures: A. Lewis (HUJ) and S. Stokar (Elscint)

Oral Presentation: I. Fine (HUJ), E. Gross (Bar-Ilan) and L. Keselbrener (TAU)

**GI.** Chaos & Nonlinear Dynamics I: Room 501

Chairman: B. Meerson (HUJ)

Invited Lectures: E. Doron (WIS), I. Dana (Bar-Ilan) and E. Meron (WIS).

**HI.** Condensed Matter I: Room 554

Chairman: Z. Ovadyahu (HUJ)

Invited Lecturers: M. Pollak (HUJ and UC Riverside), A. Golub (BGU) and I. Bar-Joseph (WIS).

**14:00 - 16:00 Parallel Sessions (Humanities Building and Sonnenfeldt Auditorium)**

**I.** Particles & Fields, Astrophysics & Cosmology: Sonnenfeldt Auditorium

Chairman: S. Nussinov (TAU)

Invited Lectures: G.Bella (TAU), A. Shor (WIS), Y. Nir (WIS) and Y. Hoffman (HUJ).

**GII.** Chaos & Nonlinear Dynamics II: Room 501

Chairman: S.I. Ben-Abraham (BGU)

Invited Lectures: E. Ben-Jacob (TAU), S. Lipson (Technion), S.A. Safran (WIS) and I. Goldhirsch (TAU).

Oral Presentations.

**HII.** Condensed Matter II: Room 554

Chairman: Y. Yeshurun (Bar-Ilan)

Invited Lectures: J. Avron (Technion), A. Stern (TAU) D. Kowal (HUJ), L. Burlachkov (Bar-Ilan) and I. S. Shlimak (Bar-Ilan).

**FII.** Medical Physics II: Room 555

Chairman: A. Katzir (TAU)

Invited Lectures: Y. Horowitz (BGU), M. Lewkowicz (Bar-Ilan) and E. Meron (WIS).

Oral Presentations: S. Faerman (BGU), V. Mor-Avi (TAU) and R. Lubart (Bar-Ilan)

**CII.** Laser and Plasma Physics II: Room 502

Chairmen: A. Gover ( TAU) and R. Shuker (BGU)

Invited Lectures: I. Smilanski (NRCN), S. Eliezer (Soreq NRC), Y. Maron (WIS) and B. Meerson (HUJ)

Oral Presentation: J. Shiloh (Rafael)

**J. Poster Presentations: The area available for poster presentations is 120 x 80 cm$^2$ per contribution.**

# Foreword

The 1991 annual meeting of the Israel Physical Society will take place at the Ben-Gurion University of the Negev, in Beer-Sheva, on Wednesday March 27, 1991. The plenary sessions will be held in the Joya Claire Sonnenfeldt auditorium and the parallel sessions will be held in the Humanities Building.

The conference reflects the diversity of the physics research in Israel. The Organizing Committee acknowledges the positive response from the Israeli Physics Community, forty six speakers have agreed to deliver invited talks and many more contributed papers have been submitted. We are especially pleased to mention that among our invited speakers, four are new immigrants from the Soviet Union, to them and to the other new colleagues who joined the Israel Physical Society we extend our warm welcome.

For the first time a special session has been devoted to environmental physics which reflects the efforts done in Israel in this research field which covers a wide range of subjects e.g., global weather changes, ground water contamination, solar energy etc.

We would like to extend our warm welcome to all participants and wish them a fruitful meeting. A warm welcome is extended also to the participants of the Israeli Vacuum Society who hold their annual meeting jointly with ours.

The Organizing Committee wishes to thank Professor A. Gersten, Head of the Department of Physics, Professor N. Shavit, Dean of the Faculty of Natural Sciences and Professor D. Bahat, Rector of the University for Financial Support.

## The Organizing Committee

S. Mordechai - Chairman
D. Eichler
A. Davidson
B. Horovitz
N. Shamir

## COUNCIL

I. Tserruya (Weizmann Institute), President
G. Shaviv (Technion), Vice President
V. Halpern (Bar-Ilan University), Treasurer
A. Shor (Weizmann Institute), Secretary
S. Akselrod (Tel-Aviv University)
T. Bar-Noy (Negev Nuclear Research Center)
D. Eger (Soreq Nuclear Research Center)
D. Falik (Raphael)
S. Mordechai (Ben-Gurion University)
D. Shaltiel (Hebrew University)
R. Weil (Technion)

## CORPORATE MEMBERS

Bar-Ilan University
Ben-Gurion University
Hebrew University
Israel Atomic Energy Authority
Technion - Israel Institute of Technology
Tel-Aviv University
Weizmann Institute of Science

## ORGANIZING COMMITTEE - Ben-Gurion University

S. Mordechai, Chairman
D. Eichler
A. Davidson
B. Horovitz
N. Shamir - Representative of the Israel Vacuum Society

# Abstracts

# Plenary Lectures

## Ballistic Transport of Electrons in a Two Dimensional Electron Gas

M. Heiblum
Submicron Semiconductor Center
Dept. of Physics, Weizmann Institute of Science

Increasing electronic circuit complexity and density and thriving to higher speed of devices are driving the size of electronic devices to submicron dimensions. At these dimensions, in many cases, the active regions of devices exceed the mean free path (mfp) of charge carriers and a large fraction of the carriers traverse the structure without scattering events, namely, ballistically. Under these special conditions the electrons maintain their energy, momentum, and phase coherence, altering thus severely the classical, well known, behavior.

In this talk I'll describe transport properties of non-equilibrium, ballistic electrons in a 'two dimensional electron gas' (2DEG) system formed at the interface between GaAs and AlGaAs. Non-equilibrium electrons (or hot electrons) are usually found in practical devices at temperatures above a few °K. In our experiments the non-equilibrium electrons are injected into the 2DEG with excess energy, with respect to the equilibrium electrons (which are at the Fermi energy), than they are being allowed to interact with the 2DEG surrounding, and finally are analyzed via momentum, energy, and phase spectroscopy techniques. We find that ballistic hot electrons can refract and interfere over relatively large distances that depend strongly on the electrons' excess energy. The main scattering mechanisms determining the electrons' mfp will be highlighted. Examples of possible future applications will be shown.

# Towards a Theory of Learning

**Haim Sompolinsky**
**Hebrew University, Jerusalem**

**Abstract**

How do adaptive systems learn to perform new tasks?
Does learning lead to memorization or to understanding?
How much does learning depend on prior experiences and biases?
What is the proper strategies for generalizingrules derived from a limited set of examples?
These are some of the basic issues that challenge the research of learning, in the context of phychology, biology, computer science and machine applications.

In recent years novel learning algorithms have been developed, primarily in the framework of neutral networks. These algorithms have been applied to a broad spectrum of problems in machine information processing. They may also serve as models for some forms of learning that occur in nature. This has spurred vigorous theoretical research on the nature of learning processes.

In the talk I will review a new promising theoretical framework that is based on statistical mechanical formulation of learning of rules from examples in neutral networks. The concept of energy, entropy and temperature of training will be discussed. The predictions of this theory for both the statics and dynamics of learning will be reviewed. In particular, I will demonstrate that under certain conditions learning emerges as a discontinuous phenomenon. Increasing the number of examples induces a strong first order transition from a state of poor learning to a state of perfect 'understanding' of the underlying rule.

# Israel's Space Research Plans

Akiva Bar-Nun, Director, Israel Space Agency
Dept. of Geophysics & Planetary Sciences, Tel Aviv University.

Space research in collaboration with other countries: (Ariel, Explorer, Atmosphere Explorer, Dynamics Explorer, Spacelab, Shuttles. Voyagers, CRAF, Rosetta, Cassini-Huygens, ATMOS, Hubble Space Telescope). Rational for the development of space technology in Israel.

The Ofeq spacecrafts
The Amos communication satellite
The Israeli scientific satellite
The Ultraviolet experiment
The X-ray experiment
The $\gamma$-ray experiment
The hornets experiment

# A. Particles and Fields

# Invited Lectures

# Anyonic superconductivity

J. Sonnenschien

Department of Physics

Tel-Aviv University

## Abstract:

We derive several results pertaining to anyonic superconductivity as described by a Chern--Simons field theory.

(1) The renormalized Chern-Simons term at finite density is shown to vanish when the renormalized coefficient at zero density takes values $Ne^2/2\pi$.

This is the field theoretical requirement to have a massless pole in the current--current correlator.

We can then show that in the Chern--Simon description a system of charged anyons at zero temperature is a superconductor.

This result is shown to hold to all orders in perturbation theory by generalizing a nonrenormalization theorem of the zero density case.

(2) At finite temperature the renormalized Chern--Simons term does not vanish at the one--loop perturbative level. We compute the mass of this apparent "pseudo--Goldstone mode". We also exhibit an effect, suggestive of critical behavior, for this same system, at a nonzero $T_c$. We discuss the possible implications of these perturbative results.

(3) A low energy effective action for an anyonic superconductor is derived directly from Chern--Simons field theory. Several P an T violating effects occur.

# Physics Expectations from High-Energy Electron-Proton Collisions with the HERA Accelerator

**U. Karshon**

**Weizmann Institute of Science**

**Abstract**

The new HERA accelerator at DESY, Hamburg, to be operational in fall 1991 is a high-energy storage ring that will provide collisions between 30 GeV electrons and 820 GeV protons. The large momentum transfers possible between electron and proton make HERA a unique electron-quark collider. Electrons and quarks can be probed for sub-structure down to distances of a few $10^{-18}$ cm. One of the two HERA experiments - the ZEUS detector - will be briefly described. The following physics topics will be touched upon: Neutral and charged current processes; QCD tests; Heavy quark production; Possible production of new exotic particles; Proton structure functions and in particular the gluon content of the proton.

# On the kinematics and dynamics of string theory.

Eliezer Rabinovici

Hebrew University, Jerusalem

## Abstract

Some symmetries of the space of allowed string compactifications are discussed, as well as aspects of the stability of these compactifications.

# B. Astrophysics and Space Physics

# Invited Lectures

B-1

# TAUVEX - Israeli Ultraviolet Astronomy from Space

N. Brosch
The Wise Observatory and the School of Physics and Astronomy
Tel Aviv University

February 1991

The Israeli Space Agency adopted in fall 1990 the UV payload proposed by a group of astronomers from Tel Aviv University as the experiment with the first priority to be orbited and operated in space on board of a National Scientific Satellite. The preliminary design of the payload was produced by a joint team of TAU scientists and engineers from El-Op (Electro-Optics Industries). The UV imager payload is referred to here as TAUVEX (**Tel Aviv UV EX**plorer).

The payload comprises three co-aligned telescopes, each with a 20 cm primary mirror, imaging a field of $\sim$ 1°.7 onto photon-counting imaging detectors. The photons are stored in a temporary frame, which is emptied every few seconds. The intermediate frames are compressed heavily and stored in a large solid-state memory for subsequent telemetry to the ground station.

The spectral region of interest (1400Å to $\sim$2800Å ) is separated in three sub-regions, about 400Å wide. Each spectral region is imaged by a separate telescope. The result is three simultaneous images of the same sky field, composed of many sub-frames each of a few seconds integration time that are registered on the ground. The capability of the payload, as calculated from the preliminary study, is such that stars of UV magnitude $\sim$17 will be recorded with S/N$\simeq$10 after a looking time of 2000 seconds. The sky background itself will be recorded with S/N$\simeq$5 in the same time over 5" pixels.

The payload will operate in low Earth orbit for at least one year. During this time the experiment will perform a baseline mission of about five months, in which both Galactic poles will be observed to b=80°. The data will be used to search for QSOs, based on their colors, to find new white dwarfs, map galaxies in the UV, *etc.* In addition, the entire Virgo cluster will be mapped, as well as more than 100 galaxies of large angular size, all the Local Group galaxies, regions in the plane of the Galaxy, as well as other targets. The search for QSOs will be the most productive ever. We expect to catalog more than 10,000 new QSOs, whereas only $\sim$4000 are known today. In addition, the multi-color surface photometry of galaxies will offer an unparalleled insight into mechanisms of star formation, the state of the interstellar matter in spiral and elliptical galaxies, *etc.*

TAUVEX compares well with existing UV payloads. The field of view is about 500 times wider than that of the Wide Field Camera of the Hubble Space Telescope and the UV photometry is not compromised by similar "red leaks" of the filter and cathode combination. The time-in-orbit is extremely long, when compared to the UIT payload on the ASTRO mission, and the mode of data acquisition insures a high degree of fidelity and dynamic range. TAUVEX appears to be an ideal payload for a small satellite, as required by ISA, while providing very relevant data with a high probability of success.

# The Asher Space Research Institute and The Agreement with The Soviet Institute for Space Research

Giora Shaviv
The Technion

The activities leading to the signing of an agreement for collaboration of the Asher Space Research Institute with the Soviet institute for Space Research will be reviewed. We will discuss the present activities in the Institute and how they can be incorporated into this agreement. The visit to Moscow of the Israeli delegation headed by Professor Tadmor, the president of the Technion and Professor Giora Shaviv, the head of the Asher Space Research Institute will be described.

# FINE STRUCTURE OF COLLISIONLESS SHOCK FRONT

M.Gedalin

*Ben-Gurion University*

Fine structure of collisionless shocks is investigated. The most important part of the shock - ramp is analyzed. It is shown that magnetosonic wave progressive steepening and overturning can result in small scale structures appearing with typical scales of the order of the electron inertial length $c/\omega_p$. These structures play an important role in particle acceleration and plasma heating and also prevent the shock from breaking. The theory reproduces typical features of the Earth bow shock: magnetic field noncoplanarity, strong potential electric field in the vicinity of the ramp, large amplitude high frequency waves upstream and ion and electron heating.

# C. Lasers, Spectroscopy and Plasma Physics

# Invited Lectures

# HIGH POWER SOLAR PUMPED SOLID STATE LASERS

A. Yogev, Weizmann Institute of Science

## Abstract

An advantageous approach to the utilization of solar energy is direct conversion of photons to chemical bond energy. Most of the organic material on earth is produced in photochemical processes via photosynthesis. Scientists are still unable to mimic these processes in a commercial way. The thermodynamic advantage in a photochemical process is based on the ability to introduce to a molecule a large amount of energy (a few e.v.) in a single process within a femto second.

Monochromatic radiation can selectively excite components in a mixture and stimulate selective reactions. Short pulses can allow high peak power with very short duration and stimulate non linear processes. Coherent light can stimulate coherent processes on a molecular level. The only source that can provide the coherence, monochromaticity and high peak power is laser light. The energy balance in chemical reactions based on laser radiation can be advantageous over thermal reactions. However, the energy yield of laser energy from electrical energy at present is very poor and the capital cost is so high that the price of laser energy on kwh basis exceeds 5 S/KWH and in short wavelength can be as high as 50 S/KWH. The cost of the photon is higher than the cost of most molecules. Electrically driven lasers can therefore be used in the chemical industry only for the production of very expensive materials. Hence, its utilization is negligible and there is a stagnation in the research of laser photochemistry other than as a tool in basic research of molecular dynamics.

Recent advanced in the technology of concentrating solar collectors provide an opportunity to obtain, by direct solar pumping, laser energy at prices that can be attractive to the chemical industry. The most advanced lasers amenable to direct solar pumping to date are solid state lasers. At present, the main objective of the research is the demonstration of high power output and high conversion efficiency from solar light to laser radiation. The efficiency of conversion is strongly dependent on the concentration of the solar radiation on the laser material.

At present we were able to demonstrate peak power of 400W and conversion efficiency of 10%. The main goal of our research is to build a multi killowat tunable laser in the UV and visible region. Another opbjective is to develop a medium power narrow line pulsed laser for space applications, mainly for atmospheric monitoring. The efficiency of direct conversion of solar energy to laser light is superior over other alternatives including diode lasers. We plan to perform in the near future a space experiment of a 100W laser.

# POPULATION TRANSFER BY STIMULATED RAMAN SCATTERING WITH TEMPORALLY SHIFTED LASER BEAMS

Y. B. BAND, Department of Chemistry, Ben-Gurion University, Beer Sheva, Israel, and P. S. JULIENNE, Molecular Spectroscopy Division, National Institute of Standards and Technology, Gaithesburg, MD USA

We compare the results of full density matrix calculations of population transfer in atoms or molecules using Raman scattering with the fundamental laser beam temporally shifted relative to the Stokes laser beam with recently reported experiments. Our calculations confirm the conclusion that almost total transfer of the population into the terminal level of the Raman transition can be achieved when the laser frequencies are tuned to resonance and the fundamental laser beam is temporally delayed relative to the Stokes shifted laser beam but still partially overlapping it, despite the decay of the intermediate level over time scales short compared to the pulse durations. We analyze these processes as a function of the frequency detuning off resonance and as funtion of the Rabi frequencies, and compare our numerical results with experimental and theoretical results. The importance of adiabatic following is discussed. For given field intensities of the two lasers, comparison of the calculations with experiment requires that an average over Rabi frequencies must be taken because the Rabi frequency is a function of magnetic sublevel of the molecular levels of the transition. A discussion of the angular momentum and magnetic sublevel considerations in determining the Rabi frequency is presented. The alignment of the terminal level as a function of time displacement of the Stokes and pump beams is predicted. Generalizations to population transfer by stimulated Raman scattering in systems with multiple intermediate levels using multiple laser beams is considered.

# *Spectroscopy of autoionization transitions by the pulsed optogalvanic technique*

R. Shuker and M. Hakham - Itzhaq

Physics department , Ben - Gurion University Beer - Sheva

Most autoionizing levels have characteristic short lifetimes on the order of psecs as demonstrated by their linewidth . We show the detection of such levels by means of optogalvanic techniques. In particular we demonstrate characteristic optogalvanic signal typical to these transitions. In these autoionization transitions, very fast and sharp voltage changes occur. This is exhibited in the optogalvanic voltage signal (OGS) . Characteristic OGS of Cu autoionization transitions as well as their line profile will be exhibited. These are Fano asymmetric lineshapes with the linewidth on the order of 10 $cm^{-1}$ signifying life time on the order of $5x10^{-13}$ sec. Spectroscopic interpretation of the relevant data signifies almost LS coupling of these levels . These features and a model relevant to the OGS related shape will be presented.

<u>References</u>

(1) R. Shuker and M. Hakham-Itzhaq, *Bull . Am . Phys . Soc. 35 , 8 sept. 1990.*

PACS : 32.80 , 82.80

# Copper Vapor: The evergreen Laser

I. Smilanski - NRCN P.O. Box 9001, Beer-Sheva

Although discovered about the same time as the $A_r^+$ laser, a generation ago, the CVL is still growing and surprising. The talk will describe the status of the CVL around the world, emerging applications, and physical puzzles still associated with it. Some of the recent achievments of the NRCN's CVL group will be reported.

# The Use of Magnetic Fields in Laser Produced Plasmas.

Shalom Eliezer
Soreq Nuclear Research Center, Yavne 70600, Israel

Large magnetic fields have been observed in laser-plasma interaction. We propose to use these large scale DC magnetic fields for the construction of a wiggler for an X-ray free electron laser (FEL). To do this, a series of close plasmas must be formed on a flat target. For example, using our Nd:glass laser with an energy of 100 joules we can produce 100 plasmas with an intensity of $10^{16}$ W/cm$^2$ (spot diameter 30 μm. Laser pulse duration 100 psec) capable of generating megagauss magnetic fields in each plasma. The advantage of this scheme is the simultaneous achievement of small wiggler wavelength (about two to three orders of magnitude smaller than the standard wigglers) and large magnetic fields (about two order of magnitude larger than the standard wigglers). This fact implies a shorter wavelength of radiation without losing gain. However the beam-plasma interaction can affect this plasma-based FEL scheme. The advantages and some problems of this scheme will be discussed.

Pacs : 42.55 Tb; 29.15.-n ;52.75 Di

# Investigations of the plasma behaviour in pulsed-power systems

Y. Maron
Department of Physics
Weizmann Institute of Science
Rehovot, Israel.

**Abstract**

The present research in our plasma laboratory concentrates on three configurations: 1) Z-pinch, 2) Plasma Opening Switch, and 3) High-power diode. Configuration 1) is an azimuthally symmetric plasma carrying axial current, 2) is an azimuthally symmetric plasma that serves to switch off a radial current flowing through the plasma, and 3) is an ion diode in which the electrons are magnetically insulated. The parameters in these experiments are: plasma density $\sim 10^{13} - 10^{18}$ cm$^{-3}$, electron temperatures ~1-50 eV, electric fields up to 1 MV/cm, magnetic fields up to 15 kG, currents up to 400 kA, and duration ~10-1000 ns.

The main emphasis is to study the time-dependent magnetic field penetration into the plasma, the particle flow, the turbulent fields, and the electron heating. Furthermore, since the plasma-electrode interaction significantly affects the device operation, the plasma properties near the surfaces are also studied.

For these investigations, diagnostic methods, based on spectroscopy of spontaneous-emission and of laser light, were developed. Spectral profiles of a few lines, in the U.V. and visible regions, are observed in a single discharge with relatively high temporal, spatial, and spectral resolutions. Theoretical treatments address magnetic field penetration and plasma flow in various geometries[1], plasma instabilities[2], and time-dependent electric fields in ionizing plasmas[3]. Observations of turbulent electric fields in the plasma[4], based on anisotropic Stark broadening, together with a proposed mechanism for the plasma instability[2], will be presented. Measurements of particle densities and velocities within 50$\mu$m from a dielectric surface, and a study of the ionization rates there[5], will be discussed.

1. A. Fruchtman and Y. Maron, Phys. Fluids (1991); A. Fruchtman, to be published.
2. A. Fruchtman, Phys. Fluids. **B1**, 422 (1989); C. Litwin et al., to be published.
3. R.E. Duvall et al., to be published.
4. E. Sarid, Ph.D. thesis.
5. L. Perelmutter, Ph.D. thesis, G. Davara, L. Troyansky, M.Sc. theses.

# DYNAMIC AUTORESONANCE AND "CHIRPED" PLASMA BEAT-WAVE ACCELERATION

**B. Meerson**

*Racah Institute of Physics, Hebrew University of Jerusalem*

Dynamic autoresonance effects can be employed to significantly increase the efficiency of the plasma beat-wave acceleration scheme.

First, a large increase in the amplitude of the accelerating plasma wave can be achieved by creating in a plasma a beat-wave pattern from two laser beams with a down-chirped beat frequency, which follows, on the average, the amplitude-dependent frequency of the strong plasma wave. Dynamic autoresonance ensures a stable phase-locking between the electromagnetic beat-wave and the plasma wave. Numerical and analytical calculations[1] which support the proposed scheme are presented. The necessary frequency chirp of one of the two laser beams can be achieved by passing the beam through a diffraction grating pair.

Second, an "unlimited" electron acceleration by the strong plasma wave can be achieved, if one finds a way to "taper" the temporal or spatial profile of the phase velocity of the wave[2]. The idea is to start with a wave, which is able to trap the accelerated particles, and then, by gradually increasing the phase velocity, to keep the particles phase-locked and continuously accelerated. This acceleration scheme does not require high injection energies and pre-bunching of the accelerated particles. The longitudinal phase stability of the acceleration process is ensured by the dynamic autoresonance. A possible way of the phase velocity "tapering" (a diverging plasma fiber and/or increasing plasma concentration) is discussed.

**References.**

1. M. Deutsch, B. Meerson and J.E. Golub. Submitted to Phys. Fluids B.
2. B. Meerson. Phys. Letters **A150**, 290 (1990).

# Contributed Papers

## Polarization and wavelength dependence of quasi-2D exciton dephasing measured by time delayed four wave mixing

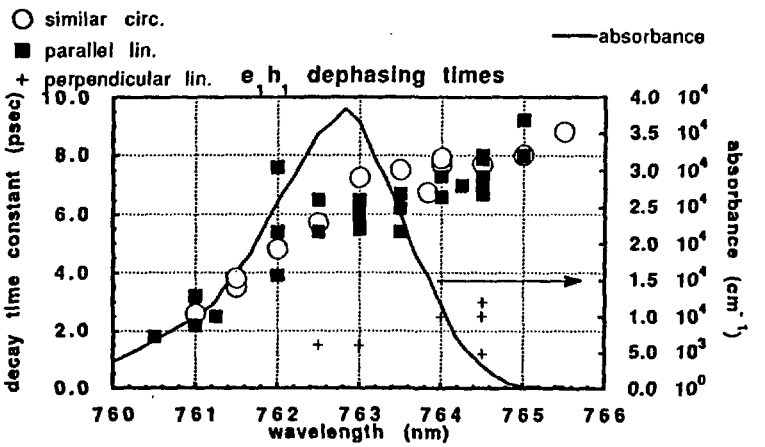
Henry H. Yaffe and Yehiam Prior
*Weizmann Institute of Science, Rehovot, 76100 Israel*

The decay rate of excitons in quasi-2D quantum wells, as measured by time delayed four wave mixing (TDFWM) has recently attracted attention[1]. We report systematic experimental results on the influence of laser polarization and wavelength on the decay of the excitons as measured by TDFWM. Two pulse TDFWM and pump-probe experiments were performed in the standard configuration. Both (4 psec) pulses were derived from the same laser, and had variable pulse delay. Different polarization combinations were used.

The (fitted exponential) decay constants vs. wavelength for two similar handed circularly polarized pulses are plotted in the figure, along with the absorbance curve of the exciton. The decay constant rises monotonically from 2.5 psec at 761 nm reaching about 9 psecs at 765.5 nm. This behavior may be explained by a decreased exciton mobility at lower exciton energies, attributed to width fluctuations at the interfaces of the QW. For opposite circular polarization of the pulses, no measurable FWM signal was observed.

Experiments with parallel linearly polarized pulses closely mimic the behavior observed when both pulses have the same circular polarization. In experiments with cross linear polarized pulses totally different behavior is observed. The decay times are nearly laser limited with decay constants between 1.5 and 3.2 psec, also shown in the figure. These decays are 2 to 3 times faster than the corresponding measurements for parallel polarized pulses. The experimental procedures, the results, and the underlying physical processes will be explained.

1) M. D. Webb, S. T. Cundiff, D. G. Steel,"Observation of time-resolved picosecond stimulated photon echoes and free polarization decay in GaAs/AlGaAs multiple quantum wells", Phys. Rev. Lett. 66(7), 18, Feb. 1991 (934)., and references therein.



# The High Altitude Electromagnetic Pulse (EMP)

J Shiloh and J Leopold
Department of Applied Physics
Rafael Labs
POB 2250 Haifa Israel

During the last decade we have studied the Electromagnetic Pulse (EMP) effect from a nuclear explosion in the atmosphere.

We have developed a theoretical model and implemented it to a computer code which enables to predict the expected EMP effect. The model consists of a very complex combination of various physical processes. The prompt $\gamma$-pulse evolving from the explosion point in the low-density high-altitude atmosphere looses energy by Compton scattering. The geomagnetic field rotates the Compton electrons which then radiate electromagnetic fields. They also produce secondary ionisation by air scattering. This entire process propagates in space with the speed of light with constant time delays between the radiating sources. Thus, an observer on the earth surface will observe a very intense electromagnetic pulse due to a giant coherent process. The effect covers very large areas and is devastating to electronic equipment; it couples to power lines and may cause disabling damage.

We have also developed a simulation laboratory which consists of a variety of EMP simulators. A simulator is a complex device which usually includes a fast rising and very high voltage power source coupled to an antenna. With the aid of these we have studied the effect of intense high-frequency electromagnetic pulses on electronic equipment and developed means to protect them from the effect. We have also developed electric and magnetic field probes to perform accurate measurements of radiated fields. We have reached a very high proficiency in this subject to the extent that our equipment is sought for in many other laboratories worldwide.

PACS no - 41.10.Hv 84.70.+p

# A PENTA PRISM POLARIZER

H. LOTEM, LASER GROUP, NRCN, P.O.BOX 9001, BEER-SHEVA
K. RABINOVITCH, ELOP-ELECTRO OPTICS INDUSTRIES, REHOVOT

Two versions of a new prism polarizer are introduced. The polarizer is shaped like a regular penta prism. Therefore, it is a constant deviation angle (90°) device. The polarizer is characterized by two internal reflections at a small incidence angle, 22.5°.

The first version of the polarizer is a prism made of a birefringent crystal. An angular polarization splitting occurs upon internal reflection due to the bireflectance (double-reflection) effect.[1] Maximum splitting corresponds to a case where the crystal optic-axis is in the plane of incidence at an angle $\alpha = 45°$ to the entrance surface. The obtained polarization splitting-angle is $\approx(n_O - n_E)/2.5$ where $n_O$ and $n_E$ are the ordinary and extraordinary refractive indices, respectively. In a polarizer made of sapphire or calcite single crystals, for example, the corresponding splitting-angle is 3 and 68 mRad, respectively, at 600 nm.

A second version of the penta prism polarizer is made of an homogeneous material. Polarization is obtained in the reflection mode, utilizing dielectric multilayer thin film coatings. The applied thin film stack has a periodic structure of a type: $n_{SUB}|(HL)^m|n_o$ or $n_{SUB}|(LH)^m|n_o$, where $n_{SUB}$ and $n_o$ are the refraction indices of the entrance and exit media, respectively. (HL) is a one period consists of two layers having high and low indices of refraction, respectively, and m is the number of the applied periods. At a non normal incidence, this type of thin film system usually behaves as a polarization filter. The reflectance, $R_S$, of the s-state radiation increases with the number of the applied periods, m, hence $R_S$ could be very close to 100 %. However, the transmittance $T_P$ of the p-state has losses especially due to production errors and tolerances. Therefore, a thin film polarizer has an high extinction ratio in the transmission mode and a low extinction ratio in the reflection mode. In our case, for two cascade reflections and for a proper choice of glass and coating materials, a thin film polarizer with an high extinction ratio such as $10^4$ in the reflection mode is achieved.

The two versions of the introduced penta prism polarizer have high transmission in the designed spectral region as well as high optical damage threshold. The crystal version, which is expensive and harder to manufacture, is useful when both polarization components are equally needed.

(1) Haim Lotem and Uri Laor, Appl. Opt. 25,1971 (1986).

# ESTIMATING ATMOSPHERIC INFRARED TRANSMITTANCE FROM RADIOMETRY OVER MULTIPLE PATH LENGTHS

I. Levin
Electro-Optics Department, RAFAEL, Haifa, Israel
D. Clement
Optronical Systems Analysis Division, FfO, Tuebingen, Germany

A parameter which necessarily should be measured in any vision and other sensing experiment in the atmosphere is the spectrally relevant transmittance. Experience shows, however, that in many cases and for many reasons, transmittance measurements are simply ignored. Instead, transmittance is calculated from data derived from general meteorological observations. The presentation proposes a method by which transmittance estimates can be obtained from relatively simple radiometric measurements over multiple path lengths, thus avoiding the often complex operation of research type transmissometers.

The underlying theory is presented together with a consideration of the errors to be expected. An experimental example demonstrates both, the usefulness of the method, and its limitations.

Before applying the method, a more detailing investigation of its range of validity may be necessary, both at theoretical and experimental level.

It is interesting to note that the method could then be used to derive transmittance estimates over slant air-to-ground paths which otherwise is thechnically not possible right now.

PACS no: 42.68.Db

# Time dependent gain saturation in a small bore copper vapor laser amplifier

Mordechai Lando and Shimon Gabay
Nuclear Research Center Negev, P.O. Box 9001, Beer-Sheva, Israel

In the past,[1] the following law has been employed in curve fitting of pulse amplification in copper vapor laser amplifier:

$$\ln\left(\frac{I_{out}}{I_{in}}\right) = g_o L - \frac{I_{out} - I_{in}}{I_{sat}}$$

Values of $g_o L$ (small signal gain multiplied by the active length) and $I_{sat}$ (the saturation intensity) have been reported for the optimal synchronization time between the probe signal and the electrical drive pulse to the amplifier circuit. However, for the design of either MOPA (master oscillator power amplifier) chain or an injection scheme, it is essential to measure these quantities as function of the aforementioned delay time. For this sake, the amplified power have been measured while changing the delay time for various input power values. The measurement was conducted for the green laser line in a 1.5 meter long, 28 mm diameter copper vapor laser head operated at 5.5 kHz. Typical values for the optimal time delay are 1.55 watt and 9.3, for $I_{sat}$ and $g_o L$, respectively. The corresponding values for 25 nsec after the optimal delay time are 1.1 watt and 7.5, respectively.

Let alone the excellent agreement achieved, a full justification for the use of the above law is not given in the literature. As a partial justification, a demonstartion of the non-storing characteristics of the lasing medium is reported here. To this aim, two independent probe signals were amplified in series in a single copper vapor amplifier. The demonstrated non-storing property is compatible with the manifested dominance of lasing levels kinetics by the electrical discharge.[2]

References

1. R.S. Hargrove, R. Grove and T. Kan, IEEE J. QE-15, 1228,1979.
2. J. Tenenbaum, I. Smilanski, S. Lavi, L.A. Levin and G. Erez, Opt. Commun. 36,391,1981.

PACS no: 42.60Da, 42.55Hq

Mordechai Lando, Lasers Department, NRCN, P.O. Box 9001, Beer-Sheva 84190. Tel. 057-567701

# ELECTRON DENSITY AND GAS TEMPERATURE MEASUREMENT IN COPPER-VAPOR LASER

P. Blau, I. Smilanski and S. Gabay
Lasers Department, Nuclear Research Center-Negev, P.O.Box 9001,
Beer-Sheva, Israel

S.Rosenwaks
Department of Physics, Ben-Gurion University of the Negev,
Beer-Sheva, Israel

A simultaneous measurement of gas temperature and electron density in the plasma of a Copper-Vapor Laser (CVL) will be presented. These parameters are measured utilizing Doppler and Stark broadening of the first four Balmer lines of the hydrogen atoms emission. The dependence of the broadening on gas temperature and electron density for hydrogen is well established. The experimental set-up allows radial and temporal resolution of these parameters.

The line profile analysis involves evaluation of all line broadening mechanisms including: natural, pressure (Van-der-Waals and resonance), instrumental, self-absorption and fine-structure splitting. Iterative algorithm was employed to deconvolve the different lineshapes.

Average temperature of 4300°K and average electron density of $1.3 \cdot 10^{13} cm^{-3}$ were measured along the laser axis. The implications of the measurements to the correct modeling of the CVL will be discussed.

PACS no: 42.55Hq, 52.70Kz

CII-10

# FORMATION OF CHARGED PARTICLES FROM THE DETONATION OF LEAD AZIDE

**T. Ben-Porat, I. Bar, G.Erez, D. Heflinger and S. Rosenwaks**
**Department of Physics, Ben-Gurion University of the Negev**
**Beer-Sheva 84105, Israel**

The formation and temporal behavior of charged particles ensuing from the detonation of lead azide is studied. A ionization probe tailored for measurements in the hostile environment produced following the detonation is described. It is shown that the charged particles form the leading edge of the expanding products cloud resulting from the detonation. The average ion density in the leading edge is around $10^{12}$ $cm^{-3}$, its velocity ~ $4*10^5$ cm/sec and the temperature is 2500 - 3000 K.

PACS no: 42.55.Ks, 52.25.Lp, 52.50.Lp

# STRETCHING ELECTROSTRICTION TO THE LIMIT

Steven Jackel, Shmuel Sternklar,Pinchas Shalev and Yakov Glick

Dept. of Atmospheric Optics
Soreq Nuciear Research Center

We present devices for laser beam processing based upon Stimulated Brillouin Scatter (SBS). These devices benefit from various of SBS, such as phase conjugation, amplification,spectral filtering,and thresholding. The issue of intrinsic noise in SBS is treated theoretically and experimentally with an eye towards the development of 'noise' and 'noiseless' systems.

CII-12

# HYDRODYNAMICS OF THE DETONATION PRODUCTS OF LEAD AZIDE

**Y. Tzuk, I. Bar, T. Ben-Porat and S. Rosenwaks**
**Department of Physics, Ben Gurion University of the Negev**
**Beer-Sheva 84105, Israel**

The spatial and temporal behavior of the detonation products of lead azide (LA) expanding into vacuum is studied by high-speed framing photography, transmission of a HeNe beam through the products and chemiluminescence of (mainly) Pb atoms. The photography reveals a bell-shaped plume expanding during the first 18 μsec after initiation. A time-dependent attenuation of the HeNe beam is observed following the detonation. The attenuation starts 4 - 15 μsec after initiation depending on the height of the probe laser relative to the LA sample. The chemiluminescence consists of two components: the first, ~ 1.5 μsec after initiation, is obtained from the heated surface of the LA sample, while the second originates mainly from the expanding cloud of products. The cloud contains gaseous products and solid particles which propagate in the same direction with maximum velocity of $4.5 \pm 0.1$ km/sec and $3.8 \pm 0.2$ km/sec, respectively. A self-similar hydrodynamic model accompanied by calculations based on Beer-Lambert's law and Mie's theory reproduces very well the attenuation of the HeNe beam and suggests that lead particles with diameters of 0.05 - 0.15 μm are involved in the attenuation. Also, there is a very good agreement between the prediction of the self-similar hydrodynamic model and the shape of the second component of chemiluminescence.

PACS no: 42.20.Gg, 42.55.Ks, 51.70.+f

# Amplified Spontaneous Emission from Three Dimensional Lasing Medium

O. Zahavi, Z. Zinamon

Dept. of Phys., Weizmann Institute, Rehovot

and G. Hazak

Nuclear Research Center, Negev

Properties of radiation, emitted by three-dimensional lasing medium, were investigated in details, using ray-tracing method for solving the time dependent Maxwell-Bloch equations. More specifically, we consider single-pass lasing media as they appear in interstellar space and in very short wavelength laboratory lasers (e.g. X-ray lasers). The ray-tracing method, although limited by the Geometrical Optics approximation, was found to be effective and appropriate for many realistic cases. This is due to the fact that it gives a simple and bright physical picture, and also due to its efficiency as far as numerical calculations are involved. Time dependent as well as steady state analytical calculations of the radiation intensity and coherency, were carried out . In addition, a numerical code was built in order to treat most general and realistic samples. Non-homogeneity of the refractive index of the sample has shown to increase the medium spatial degree of coherence and also to affect substantially its far-field intensity pattern. These phenomena can be easily explained in the view of ray optics and can be quantified by simple analytical considerations. Time dependent calculations of coherence and intensity exhibit fast evolution of the system into steady state, in the linear regime.

CII-14

# MODE-SELECTIVE BOND FISSION: COMPARISON BETWEEN THE PHOTODISSOCIATION OF HOD (0,0,1) and HOD (1,0,0)

**Y. Cohen, I. Bar, D. David, T. Arusi-Parpar and S. Rosenwaks**
**Department of Physics, Ben-Gurion University of the Negev, Beer-Sheva 84105, Israel**
**and**
**James J. Valentini**
**Department of Chemistry, Columbia University, New York, NY 10027**

The 193 nm photodissociation of individual rotational levels of HOD molecules excited with *one* quantum of O-H or O-D stretching vibrational energy is described. Stimulated Raman excitation and coherent anti-Stokes Raman scattering are used to prepare and detect, respectively, the (0,0,1) (O-H stretch) or (1,0,0) (O-D stretch) vibrationally excited HOD. The OD and OH fragments are detected by laser induced fluorescence. In the photodissociation of HOD (0,0,1) the yield of both fragments is enhanced but the yield of OD is increased 2.5 ± 0.5 times more than that of OH. In the photodissociation of HOD (1,0,0), no enhancement of the yield of the fragments is obtained. Our results show that even the very lowest possible level of vibrational excitation can be "leveraged" to effect selective bond breaking. Also, these results demonstrate that bond cleavage does not necessarily occur on the weakened bond, and they agree with theoretical calculations indicating that the release of OD and OH fragments depends on the Franck-Condon overlap of the vibrational wavefunction with the repulsive surface of the upper state.

PACS no: 33.80Gj, 42.65.Cq

CII-15

# $O_2(^1\Delta)$ GENERATION IN A BUBBLE COLUMN REACTOR FOR CHEMICAL IODINE LASERS: EXPERIMENT AND MODELING

**A. Elior, O. Aharon*, M. Herskowitz*, E. Lebiush and S. Rosenwaks**
**Department of Physics**
***Department of Chemical Engineering**
**Ben-Gurion University of the Negev, Beer-Sheva 84105, Israel**

$O_2(^1\Delta)$ was generated in a bubble column reactor by the reaction between chlorine diluted in inert gas and a basic hydrogen peroxide solution. It was fed to an oxygen-iodine laser system designed to operate under supersonic conditions. The $O_2(^1\Delta)$ yield was measured as a function of the time elapsed from the onset of bubbling, type of diluent, molar flow rate of chlorine and diluent and the residence time of $O_2(^1\Delta)$ in the gas phase. A model which accounts for realistic physical and chemical processes in this system is presented. The model is divided into two stages which together describe the processes that occur between the reactor inlet and the measuring point of the $O_2(^1\Delta)$ (before the supersonic nozzle). The first stage describes processes occurring in the solution. It employs the film model for a fast reaction regime to describe the chlorine absorption, in contrast to film models where the instantaneous reaction regime is assumed and to models assuming instantaneous absorption at the sparger outlet. The second stage describes the processes occurring in the gas phase above the solution. A good agreement between the model predictions and $O_2(^1\Delta)$ yield data from this and other studies is obtained.

PACS no: 42.55.Ks, 47.70.Fw

# Submicron Holographic gratings recording by the Photodeposition Process of a-Se colloids

A. Peled*, V. Weiss, D. Rosenblatt and A.A. Friesem
Weizmann Institute of Science (WIS),
Electronics Department, Rehovot 76100, Israel.

Photodeposition (PD) of Thin Films is an emerging new method with photographical recording characteristics. In this study, we have aimed at holographic methods to investigate coherent light patterning of photodeposition processes from colloids in liquid phase solutions. The coherent interference pattern from Argon laser spectral lines was projected onto plastic substrates/colloid interfaces. The photo-deposited film thickness was controlled by exposure time and secondary system controlling parameters such as photon energy ($\lambda < 600$ nm for a-Se colloids), photon flux density, coloid concentration and temperature. In comparison to Silver Halide or DCG (Dichromated Gelatin) holographic recording systems, the PD holographic pattern is obtained directly in one single step, without emulsion coating and subsequent developing and fixing processes. Very thin grating holograms of 100-1000(Å) were so produced with 2000 pairlines/mm resolution. Diffraction efficiencies of the gratings were 2.5% for $\lambda = 623$(nm) and about 1% for $\lambda = 514$(nm).

# Investigation of Chemisorption Processes by Laser Resonance Ionization[1]

M.H. Mintz and P. Shuker

Nuclear Research Center - Negev,
P . O. Box 9001, Beer-Sheva 84190, Israel

Direct detection of changes in atom vaporization from surfaces can be used to study variety of surface processes, which involve both single and multiphase systems. But this method was not experimentally feasible, due to the low vapor pressure of metals at room temperature ($\approx 10^{-17}$ Torr).

We used the single atom detection capability of resonant multiphoton ionization technique [1], to measure vaporization of metal atoms at room temperature. The method is demonstrated for the case of room temperature chemisorption of oxygen on polycrystalline magnesium.

Gas chemisorption on solid metallic surfaces can progress via different topochemical mechanisms [2]. Two such extreme processes are "the clustering (or island growth) mode and the disordered homogeneous chemisorption modes".

A sputtered clean magnesium sample in ultra high vacuum was exposed to various doses of pure dry oxygen. Relative changes in vapor density were monitored as a function of oxygen exposure. The gas phase density of Mg atoms was measured by photoionizing the Mg atoms in the vicinity of the metal surface, with pulsed dye laser tuned to 285.2 nm [3]. The ions were extracted by electric field into a time of flight mass spectrometer, and detected by a microchannel plate. The ion intensity, which is proportional to the vapor pressure, was measured as a function of oxygen exposure.

The dependence of the vapor pressure on the surface coverage was deduced by taking the dependence of the surface coverage on oxygen exposure from [4]. The behavior of the curve suggest a dominant initial random chemisorption process which at certain coverage is changing into an island growth process.

## References:

[1] V.S. Letokhov, Photoionization of atoms and molecules (1986) ch.1.
[2] E. Bauer, Z. Kristallogr, 110 (1958), 372.
[3] D.J. Bradley, C.H. Dugan, P. Ewart and A.F. Purdie, *Phys. Rev.* **A13**, (1976), 1416.
[4] J.A. Schultz, M.H. Mintz, T.R. Schuler and J.W. Rabalmis, *Surf. Sci.*, 146 (1984), 438.

[1]The work was done in the National Institute of Standards and Technology, Gaithersburg, MD 20899, USA.

# AMA: Autoresonance Microwave Accelerator

**R.Shpitalnik, C.Cohen, F. Dothan, L. Friedland**

A novel autoresonance acceleration scheme consisting of a circularly polarized traveling electromagnetic wave and a tapered magnetostatic axial guide field is presented. Phase trapping and the possibility for continuous acceleration are explained. Numerical results using the exact field equations are also presented. The proof-of-princple experiment employs a pulsed, 50kW peak power transmitter. The spatially tapered magnetostatic field keeps the gyrating electrons along the full length of the device. Experimental results, showing acceleration to energies of 200keV after 1.5 m from initally 10keV are presented.

# Emission and Absorption of the 213.9 nm Band of Zn-Rare Gas Excimers

**Y. Tamir and R. Shuker**

**Physics Department, Ben-Gurion University of the Negev**

**84 105 Beer Sheva, Israel**

Emission and absorption excimer bands of the 213.9 nm Zn transition in Zn-Ar system are displayed and compared.[1] These spectra are also compared with the spectra of other Zn-rare gas systems, and with the absorption spectra of other metal $II_B$-rare gas systems. Features typical to other metal $II_B$-rare gas excimers become resolved, as the rare gas density increases. These features are: a red shift of the intensity maximum, asymmetric wings, diffused maxima on the red wing and undulations on the blue wing. Detailed study of these features indicates that two criteria are important in the determination of the dissociation energy of these excimers, namely, the rare gas polarizability and the metal atom size. Based on the present work we give estimates of the binding energy of the eximer states of Zn-Ar and features of similar pairs.

In the absorption measurements, a novel design of hot windows device is used[2] to make possible accurate determination of the absorption length of saturated metal vapors inside a long cylindrical absoption cell functioning in the heat-pipe regime.

[1] Y. Tamir and R. Shuker, (submitted to Phys. Rev. A1, 1991).

[2] Y. Tamir and R. Shuker, (submitted to Rev. Scien. Instr., 1991).

PACS : 32.30.Jc

# Laser Induced Photoemission: Simulation and Experiment.

B. Sappir and R. Shuker
Physics Department, Ben-Gurion University
and
G. Hazak and A. Levine
NRCN

A one dimensional code for induced photoelectric current induced by a pulsed laser irradiating an emitting photocathode is presented. The simulation shows saturation of the resulting current that obeys Child's law for steady state. We find that for laser pulses short relative to the electron transit time the photoelectric pulse is spread by space charge interactions , irrespective of the initial pulse shape. We present an analytic description of the phtoelectric pulse propagation between the electrodes. For pulses long compared to the electron transit time the photocurrent follows the laser profile. The profile of induced photocurrent from metallic Mg(probably MgO) surface irradiated by 20ns (FWHM) XeCl excimer laser (308nm) pulses is presented.

# D. Environmental Physics

# Invited Lectures

D-2

# New Methodology for Tracing the Motion of Water and Contaminants from the Earth Surface to Ground Water

**M. Magaritz**

**Weizman Institute of Science**

(No abstract)

D-3

# Solar Energy for Electric Power Production in Israel?

by

David Faiman

Ben Gurion University of the Negev,
Center for Energy and Environmental Physics, Sede Boqer 84993,
and Department of Physics, Beer Sheva 84105.

## Abstract

A brief review is presented of the three methods that have thus far proved to be technologically feasible for solar electric power generation on the multi-megawatt scale: Direct photovoltaic conversion; Salt-gradient pond-driven, low-temperature turbines; and Mirror-concentrated, medium-temperature, steam-generating systems. Attention is drawn to attainable efficiencies and achieved costs. Estimated projections are given based on Israeli electricity usage patterns and solar availability.

# Contributed Papers

# TWO DIMENSIONAL AXISYMMETRIC SOLIDIFICATION AROUND A COOLANT-CARRYING TUBE: ANALYTICAL AND NUMERICAL SOLUTIONS

Ch. Charach[1], Y. Keizman[2] and M. Sokolov[2]

[1]CEEP, J. Blaustein Institute for Desert Research, Ben Gurion University of the Negev, Sede-Boqer Campus, 84990, Israel and department of Physics, Ben Gurion University of the Negev, Beer-Sheva, 84120, Israel.

[2] Department of Fluid Mechanics and Heat Transfer, Faculty of Engineering, Tel-Aviv University, Ramat Aviv, 69978, Israel.

## ABSTRACT

The two-dimensional, conduction-controlled axisymmetric solidification of a medium, surrounding a cylindrical coolant-carrying tube is considered in the regime of small Stanton numbers. In this range of Stanton numbers which is typical of most of the practical applications, the axial variation of the temperature field is very weak. This fact is then used in order to develop approximate analytical solutions of the problem. In addition to that numerical algorithms which are designed for such problems can be significantly simplified by superpositioning axisymmetric section in an axial tandem. Thus the computation efforts as compared with the existing fully two-dimensional schemes are substantially reduced. The results of such a simplified approach are in excellent agreement with the published fully two-dimensional solutions.

PACS: 44. 10 + i, 05.70 Fh.

# Entropy Production in Tube and Shell Heat Exchanger With a Phase Change Material

Ch. Charach and A. Zemel

Center for Energy and Environmental Physics
J. Blaustein Institute for Desert Research
Ben Gurion University of the Negev
Sede-Boqer Campus, 84990 Israel

We address the problem of entropy generation in latent heat storage based upon a tube and shell heat exchanger with a phase change material. Assuming the melting process to be conduction-dominated and the flow of the heat-transfer fluid to be fully developed and turbulent, we study various sources of irreversibility during the storage process. The analysis accounts for the two-dimensional nature of the melting process and its coupling to the forced convection in the coolant. Upper and lower bounds for the thermal effectiveness and the entropy generation number are developed. The optimal selection of the melting temperature and the dependence of the entropy generation number upon the size of the system and upon the Biot number are discussed.

PACS 44.10 + i., 05.70.Fh.

# RENORMALIZATION IN CLASSICAL HARMONIC OSCILLATIONS WITH SMALL NONLINEAR PERTURBATIONS

Peter B. Kahn
Physics Department
State University of New York
Stony Brook, N.Y. 11794

and

Yair Zarmi*
Center for Energy and Environmental Physics
Jacob Blaustein Institute for Desert Research
Ben-Gurion University of the Negev
Sede Boqer Campus, 84993, Israel

**ABSTRACT**

The freedom of choice of the zeroth order approximation in the perturbative expansion of solutions to oscillatory problems with small nonlinearities is exploited within the framework of the method of normal forms. A priori, the normal form may contain an infinite number of resonant terms. It is shown that in a large class of problems of interest, the normal form can be simplified so that the number of such terms is small, or to have other desired properties. In conservative systems this approach leads to frequency renormalization. In systems with small dissipative nonlinearities, that exhibit limit cycles, the zeroth order term in the perturbative expansion of the solution can be chosen so that the radius of the asymptotic circle approximation to the limit cycle is unaffected by higher orders in the expansion.

**Key words**: Nonlinear Oscillations; Normal forms; Limit cycles.

PACS: 03.40-t; 02.90+p



* Also, Physics Department, Ben-Gurion University of the Negev, Beer Sheva, Israel

# E. Nuclear Physics

# Invited Lectures

E-1

# Search for Pentaquarks in High Energy $\pi$ Nucleus Interactions

J. Lichtenstadt†
School of Physics and Astronomy
The Raymond and Beverly Sackler Faculty of Exact Sciences
Tel Aviv University

Exotic hadrons, consisting of more than 3 valence quarks have never been observed but their existence is still an open question. The $H$ dibaryon[1] consisting of 6 quarks ($uuddss$) and the pentaquark[2,3] ($P$), an anticharmed strange baryon ($uud\bar{c}s$) are among the most interesting candidates for such exotics. We shall present the planned experimental search of the $P$ utilizing high energy $\pi$ nucleus collisions. The main experimental considerations will be discussed as well as the significance of the proposed measurement.

1. R. Jaffe, Phys. Rev. Lett. **38**, 195 (1977)
2. H. J. Lipkin, Phys. Lett. **B 195**, (1987) 484.
3. C. Ginoux, B. Silvestre-Brac and J. M. Richard, Phys. Lett. **B 193**, (1987) 323.

† Supported in part by the U.S.-Israel Binational Science Foundation, Jerusalem.

E-2

# ULTRA-SENSITIVE MASS SPECTROMETRY WITH ACCELERATORS

Michael Paul
Racah Institute of Physics, Hebrew University, Jerusalem

Heavy-ion accelerators provide mass-spectrometry instruments of unrivaled sensitivity and analytical power for the detection and identification of rare nuclides and particles. While this new technique has revolutionized the $^{14}C$ dating methodology, it has also expanded the range of measurable radioisotopes in nature to very long half-lives and allows presently the study of processes on geological time scales. An experimental system of accelerator mass spectrometry has been developed at the 14UD Pelletron Accelerator Laboratory and is applied to measurements of several medium and heavy nuclides : $^{36}Cl$ ($T_{1/2}$=3 x $10^5$ yrs), $^{41}Ca$ ($T_{1/2}$=1 x $10^5$ yrs), $^{59}Ni$ ($T_{1/2}$=7.6 x $10^4$ yrs) and $^{129}I$ ($T_{1/2}$=1.6 x $10^7$ yrs). $^{36}Cl$, produced in the atmosphere by cosmic-ray interaction, is introduced in the hydrological systems and acts as a natural tracer. $^{41}Ca$ produced mainly by capture of cosmic-ray secondary neutrons on $^{40}Ca$ in the earth crust, may behave as a clock for calcium-bearing materials like bones on a time scale compatible with the human evolution. $^{129}I$, a long-lived and volatile fission product, is naturally produced in uranium ores; it has also been introduced in the environment by the nuclear technology and with the analytical power of AMS, can be utilized as a global monitor. Elegant and sophisticated experimental methods have been developed to reach the level of sensitivity and background discrimination needed for these measurements, characterized by isotopic ratios in the range of $10^{-10}$ to $10^{-16}$. Very recently, the combined use of lasers and Accelerator Mass Spectrometry has been explored and shows interesting prospects for a further improvement of the selectivity. It opens also a new avenue in the study of the photon-ion interaction in cases where an unambiguous identification of rare ions is required.

E-3

# Two-Step Giant Dipole Excitations in Nuclei*


## S. Mordechai

*Ben-Gurion University of the Negev, Beer-Sheva 84105, Israel*


## Abstract


The double isovector giant dipole state has been observed in the $(\pi^-, \pi^+)$ $\Delta T_z = +2$ and $(\pi^+, \pi^-)$ $\Delta T_z = -2$ double charge exchange reactions (DCX). The resonances observed in the $(\pi^-, \pi^+)$ reaction are closely related via Coulomb energy and isospin symmetry to the resonances measured in the inverse $(\pi^+, \pi^-)$ reaction on the same nuclei. The new observations provide strong support for the identification of the double giant dipole state in nuclei (i.e., states arising from a charge-exchange dipole operator acting twice on the ground-state wave function). The differences between the self-conjugate and non-self-conjugate cases will be discussed. The data indicate that the newly observed resonances are general collective features of all nuclei for the double-dipole and for nuclei with at least one neutron excess for the giant dipole built on the isobaric analog state.

In this talk, results from recent DCX experiments performed at LAMPF and the selectivity of the reaction in exciting double-isovector resonances will be discussed.



PACS number(s): 25.80. Fm, 24.30. Cz, 24.30. Eb

*Supported in part by the U.S.-Israel Binational Science Foundation.

# Contributed Papers

# MeV Ion Confinement in Tokamaks

R.E. Duvall
Department of Physics
Weizmann Institute of Science
Rehovot, 76100, Israel

## Abstract

The confinement of MeV ions created by D-D and D-T fusion reactions in tokamaks is considered. The confinement of these fusion products is essential in any tokamak intended to reach ignition, as the thermalization of such ions will be the only heating source of the plasma. Measurements on TFTR (Tokamak Fusion Test Reactor) show a correlation of the losses of such ions with strong magnetohydrodynamic (MHD) activity[1]. Losses during such activity can be an order of magnitude higher than that in an MHD quiescent plasma. A model is presented which gives an explanation for these losses, and which is consistent with existing experimental data. Its implications for the design of future ignition devices is also considered.

1. Zwebin et al., Phys. Fluids **B2**, 1411 (1990).

# F. Medical Physics

FI-1

## Pioneering Cold Laser Microsurgery

**Prof. Aharon Lewis, Applied Physics Department, Givat Ram,and Laser Center, Hadassah University Hospital, Hebrew University**

**Abstract:** We have developed a methodology for producing spots of ArF excimer laser light that can be varied in dimension from submicron diameters to tens and hundreds of microns. Presently, due to the lack of techniques for guiding the 193nm radiation, this laser is used exclusively in ophthalmology for topical applications such as corneal sculpturing. Our approach, which is to confine and guide the excimer laser with variable diameter syringe needles, resolves this problem in a unique way and with impressive results. Specifically, we show that with this syringe guided excimer laser it is possible to accurately remove retinal tissue without any detectable damage to surrounding cells. Applications of this new technology in retinal surgery will be discussed.

It will be shown that all the same methodology can be used to produce well-defined alterations in cells without detectable heating and/or other structural damage in the surroundings. To demonstrate the method holes were drilled in the zona pellucida of mouse oocytes. The diameter of the drilled holes was determined by the dimension of the tapered tube (which in the case of zona drilling was finely drawn glass micropipette) and the depth of penetration per pulse was defined by the emitted energy density.

Scanning electron microscopy of the drilled holes showed uniform, round, well-circumscribed holes with sharp edges. Oocytes that had their zona pellucida drilled with this new method were fertilized in-vitro and developed to the blastocyte stage at a rate which was similar to that of a control group. These results demonstrate the non-invasiveness of this cold laser microsurgical procedure. In addition to the extension of our results for clinical in-vitro fertilization purposes, such as enhancement of fertilization and embryo biopsy, there are wide ranging possible uses of our method in fundamental and applied investigations that require submicron accuracy in cellular alteration.

# Recent Advances in Magnetic Resonance Angiography

Dr. Saul Stokar
Elscint Ltd. P.O. Box 550 Haifa, Israel

Due to its ability to visualize soft tissue, Magnetic Resonance Imaging (MRI) has become an increasingly important tool in diagnostic radiology. Recently, techniques have been developed which allow for visualization of blood vessels. Such techniques, known as Magnetic Resonance Angiography (MRA), offer the promise of non-invasive angiography.

We begin by reviewing the basic physics of 2-D NMR imaging, using the k-plane formalism. Two different techniques for angiography are outlined - phase contrast angiography and inflow techniques - and their relative advantages and disadvantages are compared. We then discuss reconstruction techniques as well as methods for distinguishing between venous and arterial flow. Finally, we discuss the utility of MRA as compared with x-ray angiography as well as a prognosis on the future lines of development in MRA.

# LiF Thermoluminescent Methodology for Optimum Precision in Radiotherapy Dosimetry

Y.S. Horowitz

Physics Department, Ben Gurion University of the Negev

Ionizing radiation dosimetry via thermoluminescence (TLD) has been one of the standard tools of clinical radiation dosimetry for the last two decades. It has established itself as a very reliable and practical radiation dosimetry technique (1). TLD is applied to check dose and dose distributions in vivo and in phantom studies to verify and/or optimize treatments. Thermoluminescence dosimetry using LiF:Mg,Ti (LiF-TLD) is claimed to be capable of 2% precision (1 SD), however, in practise, many groups report a lower precision of perhaps 5% and even higher (2). The precision attainable with LiF-TLD is a crucial matter (3) since small underdosage of the radiation delivered to a tumour volume may dramatically decrease the tumour control probability. On the other hand, small overdosage in the surrounding normal tissue may cause severe damage. Margins with respect to the dose as well as to the geometry are often small. Naturally the achieved precision is also correlated with the experience and/or expertise of the dosimetrists but there are still apparently objective, not fully understood reasons, which limit the ultimate precision of LiF-TLD.

In this paper, we review some of the standard procedures routinely applied to LiF:Mg,Ti, especially the influence of reproducibility of the annealing procedures (time and temperature) on the dosimetric precision. New data suggesting different (from the standard) optimal annealing procedures will be presented (4). Dosimetric advantages using computerized glow curve deconvolution will be discussed (5). Special problems introduced by the supralinear behaviour of LiF:Mg,Ti in the clinical dose range and potential solutions will be reviewed. General factors affecting both long term and short term reproducibility will also be discussed.

1) C. Pla and E.B. Podgorsak, "A computerized TLD system", *Med. Phys.* **10**, 462-466 (1983).

2) H.I. Amois, M.S. Weinhous and L.E. Reinstein, "The variability of clinical thermoluminescent dosimetry systems: A multi-institutional study", *Med. Phys.*, **14**, 291-295 (1987).

3) ICRU, 1976, Determination of absorbed dose in a patient irradiated by a single beam of X or Gamma rays, Report 23, (Washington D.C.: ICRU Publications).

4) Y.S. Horowitz, "The annealing characteristics of LiF:Mg,Ti" Invited Paper, *Radiat. Prot. Dos.*, **30**, 219-230 (1990).

5) Y.S. Horowitz, M. Moscovitch and M. Wilt, "Computerized glow curve deconvolution applied to ultra low dose LiF thermoluminescence dosimetry", *Nucl. Instrum. Meths.*, **A244**, 556-564 (1986).

# How Accurate is Linear Theory for Cardiac Mechanics?

Meir Lewkowicz,[1] Richard Chadwick[2]

1. Department of Physics, Bar-Ilan University, Ramat-Gan, Israel
2. Theoretical Biomechanics Group, NIH, Bethesda, MD 20892, USA

Analytical studies of cardiac mechanics have progressed using several approaches: thick-walled shell theories, membrane theories, and three- dimensional elasticity theory applied to simple geometric configurations of the left ventricle. In the latter category both linear and finite deformation theory have been recently used. The finite deformation method has the advantage of being 'exact', but the disadvantage of being very difficult to use when conditions of regional nonuniformities prevail as during regional ischemia or right ventricular pressure or volume overload. On the other hand, linear theory has recently been applied to these types of problems, but the accuracy of the method has never been sufficiently evaluated.

Here we consider a test problem for which the exact solution using finite deformations can be obtained, and compare the solution with that found from the linearized theory. In doing so, we also develop a method of successive approximation whereby the linear theory can be systematically corrected to approach the exact solution by solving a hierarchy of linear problems. We show that the full nonlinear theory is not necessary and that at most a one term correction to linear theory provides sufficient accuracy. The method can be also applied to problems involving regional nonuniformities.

PACS no: 87.10, 46.20

# Vortex Dynamics in Excitable Media and the Onset of Fibrillation

*Ehud Meron*

Department of Chemical Physics
Weizmann Institute of Science
Rehovot 76100, Israel

## Abstract

Ventricular fibrillation normally develops from tachyarrhythmia. A possible cause of the latter is the appearance of vortex-like structures of action potentials in the myocardium. Fibrillation then amounts to a multi-vortex state. In homogeneous and isotropic excitable media these vortices take the forms of rotating spiral waves. A survey of recent results concerning the formation of spiral waves, factors that affect their dynamics, and non-steady forms of rotations, will be given. Preliminary considerations of the transition from a single to a multi-spiral state will conclude the presentation.

# Contributed Papers

FI-3

# THE NON-INVASIVE OXIMETRY OF THE SKIN

I. Fine and A. Weinreb

Department of Physics, Hebrew University of Jerusalem
Jerusalem 91904, Israel

Non invasive oximeters for arterial blood monitoring are now widely used in clinical practice in order to estimate the adequacy of respiration. On the other hand, so far, no method exists for the noninvasive measurement of the absolute oxygen saturation in mixed venous blood in the skin. Such measurements supply information about the relationship between the oxygen transport and the oxygen demand of the tissues. The main goal of our research is the development of an algorithm for the determination of blood oxygen satuation of the skin from light reflection measurements on the skin.
Oximetric devices employ spectrophotometric methods which are based on the different light absorption properties of oxygenated hemoglobin and reduced hemoglobin. Generally, the Lambert-Beer law is employed for the transmission oximetry algorithms. However, the absorption properties of whole blood are greatly modified by the strong scattering of the light, which is the main reason for the breakdown of Lambert-Beer's law. Our theoretical and experimental investigation was therefore undertaken in an attempt to improve the existing algorithm of oxygen saturation calculations. In our model a combination of two analytical approaches was used in the description of light propagation in blood, that of multiple scattering theory and that of diffusion theory. This theory, combined with an appropriate original technique of illumination and light detection, form the basis of a clinical method for the determination of mixed venous blood oxygen saturation.

FI-4

## SPECTROSCOPIC STUDIES OF 9,10-DIMETHYLANTHRACENE AND BACTERIORHODOPSIN PHOTOSENSITIZATION BY PORPHYRINS IN LIPOSOMES

Eitan Gross, Benjamin Ehrenberg and Fred M. Johnson
Department of Physics, Bar Ilan University, Ramat Gan 52900, Israel

We used the fluorescent membrane probe 9,10-dimethyl anthracene (DMA) as a target in the photosensitization reaction taking place in liposomal membranes and mediated by singlet oxygen. We present a method to determine the quantum yield of singlet oxygen generation ($\Phi_\Delta$). We compare the photosensitization kinetics and $\Phi_\Delta$ of the classical HPD, PF-II and $Zn^{2+}$-phthalocyanine tetrahydroxyl (ZnPC), to that of the newly introduced sensitizers $Zn^{2+}$- and $Mg^{2+}$-tetrabenzoporphyrin (ZnTBP and MgTBP). The reaction photosensitized by ZnTBP was found to be the fastest with a time constant of 7.5 minutes, followed by PF-II (8.3), MgTBP (8.4), HPD (12.1) and ZnPC (41.2). HPD was found to have the largest value of $\Phi_\Delta$ (0.215), followed by PF-II (0.191), ZnTBP (0.025), MgTBP (0.019) and ZnPC (0.005). The partition coefficients of the sensitizers to lecithin liposomes are also reported. The application of porphyrins' photosensitization mechanisms in membranes to a structural study of of the membrane-bound protein bacteriorhodopsin will be discussed.

PACS No. 87.60

FI-5

# IMPROVEMENT OF RESOLUTION OF CAT IMAGES BY APPLICATION OF DATA-DEPENDENT FILTERS.

L. Keselbrener, Y. Shimoni and S. Akselrod.
Medical Physics, School of Physics, Tel Aviv University.

Nowadays, Computerized Axial Tomography CAT scanners use strong Linear Low Pass filters applied on the 1-D X-ray projections, before the reconstruction of the 2-D image of the absorption coefficients of the slice. These filters reduce statistical noise in the reconstructed images, however they also deteriorate their resolution. Our purpose in this study is to apply a very weak Low Pass filter on the projections, to perform the reconstruction, and only then to apply a 2-D Data-Dependent (Nonlinear) filter on the image. We investigated various kinds of Nonlinear filters with a wide range of possible combinations of parameters, and evaluated the effects of these filters on the spatial resolution and on the noise reduction. We compared some well-defined criteria of their achievement on phantom images to the criteria achieved with the built-in CAT Linear filters in two different scanning modes, the normal resolution one and the Ultra High Resolution mode. We found that the Nonlinear filters reduce noise to the same amount as the Linear filters, but they clearly improve the spatial resolution and the edge conservation. Our results enabled us to choose some combinations of parameters which create the optimal Nonlinear filters. In addition, we evaluated the achievement of the "best" Nonlinear filter on phantom images scanned with a lower dose of X-ray radiation than usually used. We can conclude from our study that applying this filter instead of the Linear CAT filters may permit to reduce the scanning dose to about half its current value. We also applied the above obtained most suitable Nonlinear filter on actual medical images, (e.g., cervical spine ...). We found that the images obtained after several iterations of our Nonlinear filter present a clearly better quality than all the images reconstructed with the built-in CAT filters. We thus conclude from this study that the Nonlinear filters improve the quality of CAT images, thus providing the physician with a better diagnostic tool. In addition, they might permit to reduce the scanning dose required to obtain an adequate CAT image.

**FII-4**

DESIGN OF A HIGH ENERGY MEDICAL CASSETE FOR RADIOTHERAPY IMAGING

S.Faermann and Y.Krutman, Soroka Medical Center, Dep. of Oncology and Faculty of Health Sciences, Ben-Gurion University of the Negev, Beer-Sheba

Portal radiographs, defined as the patient image produced through the irradiation of a film-screen combination in the treatment machine, are an essential tool for accurate routine radiotherapy treatment of cancer patients.
For high -energy photon beams, the main interaction process is by Compton scattering, thereby limiting the quality of the obtained image (insensitivity to the atomic number of the irradiated tissues), as compared to conventional medical radiography performed at low photon energies (for which the main interaction process is the photo-electric effect).
One of the main factors which contributes to the image degradation for high photon energies,are the Compton scattered electrons from the patient, which contributes to a high blurring and a low contrast in the film.
In order to significantly reduce the influence of the scattered electrons from the patient,a new cassette was designed, having a front copper screen with 2gr/sq.cm thickness , coupled with a fast film( X-OMAT- TL KODAK) and a rear Cu screen .4 gr/sq.cm thick.
A comparison between the designed cassette and a commercial one (RMI-ALDRICH Model 435- 4 gr/sq.cm front and rear Cu screens), for our 10 MeV x-ray beam (Clinac 12/10 linear accelerator- Varian) is presented, using 2 types of fast films.

FII-5

# REGIONAL MYOCARDIAL BLOOD FLOW: QUANTITATIVE ASSESSMENT BY COMPUTER ANALYSIS OF CONTRAST-ENHANCED ECHOCARDIOGRAPHIC IMAGES

Victor Mor-Avi, Daniel David, Yves Bitton and Solange Akselrod

Medical Physics Dept., School of Physics, Tel Aviv University,
and Dept. of Cardiology, Meir Hospital, Kfar Saba, ISRAEL

Tissue blood flow constitutes probably the most accurate means of assessing blood supply to the individual myocardial cell. To date, there is no reliable method for the quantitative assessment of myocardial tissue blood flow, either invasive or non-invasive. We utilized recent technical developments in the ultrasonic imaging of the heart to provide a method for quantitative evaluation of the regional myocardial perfusion. Microscopic air bubbles introduced into the coronary circulation, were previously shown to produce transient echocardiographic enhancement of the myocardial tissue. We have devised a theoretical approach based on indicator dilution principles linking the tissue blood flow with the time dependence of changes in regional ultrasonic intensity produced by the microbubbles. A computer model based on theoretical considerations was constructed in order to achieve optimization of the steps of the analysis. Several preliminary animal experiments were carried out in order to find optimal experimental setup for verification of the method in vivo. The experiments involved computer analysis of the echocardiographic images obtained following direct left atrial injection of the ultrasonic contrast material under different flow conditions, such as ischemia and reactive hyperemia. Both the computer study and the animal experiments have shown promising results. In view of the recently reported feasibility of myocardial enhancement by peripheral intravenous injection, our approach promises to provide a basis for the convenient non-invasive quantitative measurement of myocardial tissue blood flow.

**FII-6**

# A posible explanation of laser-induced stimulation and damage of cell cultures.

[1]R. Lubart, [2]H. Friedmann, [1]I. Laulicht and [3]S. Rochkind

1) Dept of Physics, Bar-Ilan University.
2) Department of Chemistry, Bar-Ilan University.
3) Neurosurgery Dept., Ichilov Medical Center, Tel Aviv.

Low power lasers have been used for more than a decade in clinical practice causing biostimulation. The therapeutic effects of these lasers were attributed to enhanced cell proliferation. In the present work a general mechanism is proposed, capable of accounting for both the stimulating action of certain lasers on cell cultures, at low laser doses, and the damaging action at larger doses. It is assumed that singlet oxygen ($^1O_2$) is photoproduced by the endogeneous porphyrins or by the cytochromes in the cell. Singlet oxygen at minute concentrations may promote cell mitosis. At high amounts it destroys the cells.

# G. Chaos and Nonlinear Dynamics

# Invited Lectures

# Chaotic Scattering and Conductance Fluctuations

Eyal Doron and Uzy Smilansky

Department of Nuclear Physics, Weizmann Institute of Science

## Abstract

We discuss the phenomenon of chaotic scattering and its application in the study of transmission of electrons in mesoscopic devices as well as the transmission of microwaves through junctions. We show that the fact that the ray optics (classical dynamics) is chaotic, implies fluctuations in the observed transmission coefficients, whose statistics is determined by the theory of random matrices. We also show how the classical distribution functions which reflect the chaotic nature of the classical dynamics, determine the dependence of the correlations observed in the fluctuating transmission coefficients on external parameters. The time domain properties of chaotic scattering systems are also examined, and are shown to depend on the chaotic nature of the classical dynamics, together with a wave mechanical enhancement in time reversal invariant systems. In particular, the quantum mechanical time delay is shown to be enhanced relative to the classical staying time, in systems which display time reversal symmetry. These results are then compared to results of an experiment performed on scattering of microwaves from a metallic cavity.

# ORGANIZATION AND CHARACTERIZATION OF HAMILTONIAN CHAOS

Itzhack Dana
Department of Physics, Bar-Ilan University, Ramat-Gan 52900, Israel

Understanding chaos in Hamiltonian systems is of major interest in a variety of physical applications. While regular motion in these systems has been investigated extensively, much less is known about the precise nature of chaotic motion. In particular, a systematic organization and characterization of Hamiltonian chaotic orbits does not seem to exist.

A key observation is that in generic Hamiltonian systems regular and chaotic motions coexist on all scales of phase space, leading to the "stickiness" of chaotic orbits near regular ones, and to the related slow decay of correlations. It is thus natural to approach the problem of chaos organization on the basis of regular-motion components. We identify these basic components with the resonances, which are phase-space regions associated with hyperbolic ordered periodic orbits. It is now well established for a large class of area-preserving maps (including the standard map) that, in the absence of KAM tori, resonances give a complete partition of phase space. A typical chaotic orbit is then a sequence of segments, each lying in some resonance, and resembling an ordered rotation. The type of a chaotic orbit specifies the sequence of resonances visited and the number of rotations performed in a resonance. All the chaotic orbits of given type generally form a strange set. A chaotic region may thus be viewed as a collection of such basic strange sets, analogous to strange attractors in dissipative systems. Using the hierarchy of unstable periodic orbits, we provide topological and metric characterizations of the strange sets.[1]

Global diffusion may be characterized by an infinity of diffusion coefficients, associated with ensembles of chaotic orbits that are trapped in extended sets of resonances (each such ensemble exhibits several types). These coefficients provide a much more detailed picture of the effect of regular motion on diffusion than a single, ordinary coefficient D.

1. I. Dana, Physical Review Letters 64, 2339 (1990)

PACS numbers: 05.45.+b

# Non-Variational Effects in Non-Equilibrium Systems

*Ehud Meron*

Department of Chemical Physics
Weizmann Institute of Science
Rehovot 76100, Israel

## Abstract

Extended non-equilibrium systems exhibit a variety of phenomena that have similar counterparts in equilibrium systems. Bifurcation phenomena versus phase transitions, defect dynamics in periodic spatial patterns versus that in crystals and defect mediated turbulence versus two-dimensional melting, are a few examples. The analogy, however, do not go too far. An important distinctive feature is the non-variational nature of the equations which govern non-equilibrium systems. The absence of a free energy to minimize leads to rich spatio-temporal behaviors and calls for new analytical tools. Two phenomena will be discussed in this presentation; front propagation and vortex interactions. In equilibrium systems, both phenomena manifest ultimate evolutions toward uniform states whose free energies are minimal. A "droplet" of a stable phase will grow into a metastable phase until a uniform state of the stable phase is established. Similarly, vortices with opposite windings numbers will attract and annihilate to form a uniform, vortex-free state. In non-equilibrium systems, on the other hand, droplets with *fixed sizes* can exist and *bound* vortex pairs may form. The appearance of these self-sustained spatio-temporal structures will be illustrated with examples of excitable and oscillatory systems.

## Surface Kinetics and Morphology Transitions in Non-Equilibrium Growth

Reviews of Theoretical Work by

E. Ben-Jacob, School of Physics and Astronomy, Tel-Aviv University, 69978 Tel-Aviv

and of Experimental Work by

S. G. Lipson, Physics Dept, Technion, 32000 Haifa.

These two talks describe theoretical and experimental studies of the nature of morphological transitions in diffusion-controlled systems, of which crystal growth and electro-chemical deposition are examples. We suggest that the nature of the transitions between different growth morphologies, such as faceted, tip-splitting and dendritic, should be classified by the behaviour of the selected interface velocity as a function of the driving force. We further advance the hypothesis that the fastest-growing mode determines the stable morphology observed in experiments. To study the specific role of surface kinetics in the determination of a morphology, we have recently developed a new method that allows us to include specific microscopic processes at the interface in a simulation of the crystal growth form. In particular, this approach allows us to see the development of kinetic roughening.

We shall describe experiments carried out on $NH_4Cl$ crystals grown from supersaturated solution, using an optical interferometric method with digital image processing. This allows us to investigate the concentration field in the fluid phase. The resulting field measurements indicate a non-linear relationship between the growth velocity and driving force, and suggest the importance of surface roughening in determining the growth morphology. We have also discovered novel periodic growth structures with long-range ordering, and which grow without developing instabilities. These compete with dendritic morphologies when the growth is geometrically constrained. Our latest effort is to apply the optical technique to a study of the morphologies developed during electrochemical deposition of metals, a more complicated system in which several different fields are involved.

References

1. E. Ben-Jacob, P. Garik, D. Grier and T. Mueller. Phys. Rev. **A38**, 1370 (1988),
2. Eli Raz, S. G. Lipson and E. Polturak, Phys. Rev. A40. 1088 (1989),
3. Eli Raz, S. G. Lipson and E. Ben-Jacob, Jour. Cryst. Growth (in the press).

GII-2

# Pattern Formation and Wetting

S. A. SAFRAN

*Department of Polymer Research*
*Weizmann Institute, Rehovot, Israel, 76100*

**ABSTRACT:** The dynamics of wetting of solid surfaces by fluid drops are important in the formation of coatings and are a challenging problem in both surface physics and hydrodynamics. While the spontaneous wetting of a droplet on a smooth substrate proceeds in a uniform manner (*e.g.*, a hemispherical droplet spreads with a circular perimeter), recent experiments have indicated that when the spreading is *driven* by external forces such as gravity, centrifugal force, or surface tension gradients, the spreading occurs through a fingering pattern. These patterns can be understood theoretically if one considers both the effects of the driving force as well as the subtleties of the interfacial profile near the substrate. The relations between the finger width (instability wavelength) and the driving force are predicted in agreement with experiment.

# Spectral Degeneracy and Hydrodynamic Stability

I. Goldhirsch

Dept. of Fluid Mechanics and Heat Transfer, Faculty of Engineering

Tel-Aviv University, Ramat-Aviv, Tel-Aviv 69978.

It is well known in solid state physics (or in quantum mechanics, in general) that when two energy levels cross, an appropriate perturbation of the pertinent Hamiltonian (i.e. one that couples the levels) will give rise to a spectral gap.

The Hamiltonian operator (or matrix) relevant to quantum mechanics is always hermitian. In the realm of Hydrodynamic stability, one is interested in perturbing operators (or matrices) that are not necessarily hermitian. In that case, besides the possibility that a perturbation gives rise to a spectral gap, it may change a zeroth order real spectrum into a complex one, implying instability. We have shown that this mechanism is responsible for all known instabilities of two dimensional Stokes (water) waves and we have predicted an infinite number of new ones. We have shown that, in fact, all instabilities of water waves are created by this mechanism. In another application of the same idea we have shown that the instability of elliptical vortices (which are bvelieved to be an important source of excitations of small scales in the preturbulent state) proceeds through a similiar mechanism. Other hydrodynamic instabilities can also be traced to the above mentioned mechanism.

# Contributed Papers

GII-4

# CHAOTIC DYNAMICS OF ENVELOPE SOLITONS

Igor Aranson

Formerly: Institute of Applied Physics USSR, Academy of Sciences, Gorky.

The long time chaotic behavior of envelope solitons in the framework of perturbed Nonlinear Schrodinger Equation (NSE) is investigated analytically and numerically. The estimation of the soliton lifetime and radiation level is derived by means of the inverse scattering transform. It is shown that the soliton is a "statistical attractor" and the high frequency field is concentrated in a circle.

GII-5

# Convective vs, Absolute Instability in Couette-Taylor Flow with an Axial Flow

Avraham Tsameret and Victor Steinberg

Department of Nuclear Physics

Weizmann Institute of Science

Rehovot 76100, Israel

**Abstract**

Couette-Taylor flow between cylinders with a superimposed axial flow is studied experimentally. The axial flow suppresses the basic stationary instability and gives rise to various periodic patterns : at low through-flow velocity ($Re < 4$) travelling waves in the form of propagating Taylor vortices (TV) are observed. At higher Re the flow becomes spiral-like - Stationary Spirals appear first and Moving Spirals take over as Re is further increased.

The absolute instability line for the TV, below which any pattern is swept away from the system and above which TV with constant amplitude are observed, is measured. Above $Re > 1$ this line is crossed by a new line, suggested to originate from the Stationary Spirals, above which TV with modulated amplitude are observed. The modulation results from competition between the TV and the Stationary Spirals, which leads to the motion of the interface between these patterns. The surprising coexistence of steady Ekman and propagating Taylor vortices close to the inlet and outlet boundaries was discovered. The wavenumber selection mechanism for the TV, similar to existing in front propagating case is also identified.

# Dynamics of Source between 1D Counter Propagating Waves in Binary Mixtures Convection

Eran Kaplan and Victor Steinberg

Department of Nuclear Physics

Weizmann Institute of Science

Rehovot 76100, Israel

## Abstract

Dynamics of source between Counter Propagating Waves (CPW) and the interaction between the large scale flow and the underlying (small scale) roll structure is studied experimentally. Such interaction should appear in the GL equations as an exponentially small periodic term, which should give rise to locking and pinning phenomena.

We used, as an experimental system, one dimensional convection in binary mixtures. For this system, a state of CPW is observed when the temperature difference is increased slightly above criticality ($\epsilon \equiv \frac{\Delta T - \Delta T_c}{\Delta T} \sim 10^{-3}$). We apply small lateral heat flux $q_l$, such that $\frac{q_l}{q_c} \approx .001$, thus causing the source on the interface between right and left travelling waves to move towards the heat source.

As $q_l$ is increased from zero, a locking region, in which the source is stationary is observed. This region becomes smaller as $\epsilon$ becomes higher. Above this threshold, we observe pinning as the source moves in jumps of $\frac{\lambda}{2}$, corresponding to a $2\pi$ slippage in phase. This effect disappears for higher values of $q_l$, where the movement is continuous.

GII-7

# A RIGID ROTATOR UNDER SLOWLY-VARYING KICKS: DYNAMICAL AUTORESONANCE AND TIME VARYING CHAOS

Baruch Meerson and Shalom Yariv
Racah Institute of Physics, Hebrew University of Jerusalem, Jerusalem 91904

We investigate numerically and analytically the dynamics of a rigid rotator under the action of "kicks" with slowly varying strength and period. We derive a discrete map for this model and use the map to study three effects. The first of them is the dynamic autoresonance, which can lead to a significant regular accelaration or decelaration of the rotator. We find conditions for which the effect occurs, including the condition for an unlimited accelaration. The second effect is the transition to global chaos that arrises due to the increase of the stochasticity parameter with time. We find that this transition occurs through bifurcation of the main island (the bifurcation parameter being simply time) and the development of a complicated separatrix structure. Also, slowly evolving global chaos is studied numerically, and a time dependent analog of the "quasi-linear" diffusion equation is shown to describe quite accurately the numerical simulations.

# PSEUDORANDOMNESS AND LOCALISATION

Naama Hurvitz and Shmuel Fishman

Department of Physics, Technion-IIT, 32000, Haifa, Israel.

## ABSTRACT

The degree of pseudorandomness of several sequences and its relation to Anderson localisation is investigated. It is rated with the help of the $\chi^2$ test and the spectral test, which are extensively used in computer science. The relation between this rating and localisation for tight-binding models with hopping to nearest neighbours and to next nearest neighbours in one dimension is investigated. The results are relevant for localisation in the systems that are studied in "Quantum Chaos" where the potentials are pseudorandom but not truly random.

# H. Condensed Matter

# Invited Lectures

# Localized Interacting Particles in Disordered Systems - a New Algorithm, and Application to the Coulomb Problem.

M. Mochena* and M. Pollak**

*Dept. of Physics, Univ. of California, Riverside

**Racah Inst. of Physics, Hebrew University, Jerusalem

To calculate properties of such a system, one should know the density of states of the system, and the transition rates between them. The most difficult problem in a computer simulation then is the enormous number of states even in a moderate size system. In the presence of interactions and disorder, there is no way to obtain the spectrum short of calculating the energies of all states. The present algorithm deals with this difficulty by first constructing very small systems where all system energies can be computed. These are then used to gradually build up a larger system, keeping at every step only the lowest lying states. At the end, all (or almost all) states are obtained in a certain energy interval, including the ground state. This allows to evaluate physical properties at low temperatures (T). Quantum effects can also be evaluated, even though they are entirely neglected initially.

We applied the algorithm to Coulomb interactions in a three dimensional system, and obtained the low T specific heat, dielectric relaxation, and the life time of the Coulomb gap, and compared these to similar properties in non-interacting systems. The results will be discussed in the context of current contoversies about the coulomb problem in disordered media.

## Charge fluctuations in small tunnel junctions

**Anatoly A. Golub**

**Department of Physics, Ben-Gurion University**

In very small tunnel junctions with the capacitance C in the range $C \leq 10^{-15}F$ the presence of discrete charge transport leads to the effect of single-electron tunneling oscillations. dc transport properties are influenced by Coulomb blockade. In Josephson junctions of similar sizes the energy and voltage can oscillate under a weak external current I with the Bloch frequency I/2e.

We study the quantum fluctuations of charges in small normal tunnel junctions. The dependence of these fluctuations and the junction energy levels on tunneling resistance (single electron tunneling rate) is obtained. The shunting resistance is assumed to be very large. We provide a detailed analysis of the physical states. The choice of physical states is sufficient for two different mechanisms of charge transport: a continuous flow of charges or a discrete transport.

The numerical calculations of the partition function for different values of resistance parameter ($\alpha_T$) is done It follows that the difference between discrete and continuous charge states is shifted with increasing $\alpha_T$ to lower temperature. To give more insight to the problem we derived analytical caluculation representing the partitition function by periodic Gaussian approximation (Villain model) and get a simple expression for energy levels and charge fluctuations. These expressions connect regions of low and large tunnel resistance. Due to the neglect of shunt contribution in the action the energy levels remain discrete.

## Inelastic scattering in resonant tunneling

**Israel Bar-Joseph**

*Department of Physics, Weizmann Institute of Science, Rehovot 76100, Israel*

The effect of inelastic scattering on the resonant tunneling process in the double barrier diode is investigated experimentally and modeled theoretically. Using optical spectroscopic techniques we measure the charge accumulation in the quantum well region between the barriers and study its temperature dependence. The measured electrons distribution demonstrates clearly the occurrence of inelastic scattering, yet the total accumulated charge is shown to be temperature independent. To model the resonant tunneling process in presence of inelastic scattering we use a novel time dependent approach. We show that in general the total current and accumulated charge are not conserved when inelastic scattering is introduced. However, the special case of the double barrier diode is such that the changes are very small.

# PERSISTENT CURRENTS AND THE SCATTERING MATRIX[†]

Eric Akkermans*, Assa Auerbach, Joseph E. Avron and Boris Shapiro

Department of Physics

Technion, Haifa, 32000, Israel

We consider the persistent currents in extended systems, and in particular, in systems that admit good scattering theory. For such systems the contribution to the persistent currents from the states associated with the continuous spectrum is related to the scattering matrix. The central result is a formula which gives the differential contribution to the persistent currents from the states near energy $E$ as:

$$(2\pi i)^{-1}\partial_\phi(\ln \det\ S(E,\phi))dE$$

where $S(E,\phi)$ is the (on-shell) scattering matrix. We apply this result to the calculation of the persistent currents in few examples: A mesoscopic loop connected to one infinitely long lead, and the plane pierced by a flux line. In the last example spin plays a remarkable role. Persistent currents give information on the on-shell scattering which is complementary to that which follows from the conductance via the Landauer formula.

[†] Work supported in part by the BSF, the Israel Academy of Science and the Fund for Promotion of Research at the Technion

* Lady Davis Fellow

# The effect of spin interactions on the quantum correction to the conductivity

**Ady Stern and Ora Entin-Wohlman**

**Tel Aviv University**

The electric conductivity of samples in the diffusive regime is known to be affected by constructive quantum interference of time reversed electron paths. This interference yields the weak localization negative correction to the conductivity.

In this work we investigate how this interference effect is modified by the interaction of the electron with its spin. Specifically, we focus on the combination of two types of spin interactions - a Zeeman interaction of the spin with an external uniform magnetic field and a spin-orbit interaction. We find that , when both interactions are present, the interference pattern of time reversed paths oscillates as a function of the external field. These oscillations are related to the Larmor precession. The quantum correction to the conductivity is found to reflect these oscillations. In particular, the conductivity of a thin ring is predicted to show damped oscillations when the external field is varied.

To summarize, our work investigates the special role the electron's spin plays in electronic interference effects, a role that reflects general principles of dephasing of interference, as well as unique properties of the spin.

# Effects of Zeeman Splitting on Weak Antilocalization

D. Kowal, M. Ben-Chorin and Z. Ovadyahu

Racah Institute of Physics, Hebrew University

Within the single particle picture the most significant quantum mechanical correction to electron transport in the diffusive regime is due to interference between time-reversed paths. Application of a magnetic field affects this interference through the Aharonov-Bohm effect, causing magnetoresistance (MR). This MR is a flux effect which, for a thin enough film, should be anisotropic, since the areas presented by the time-reversed paths change when viewed from different directions. However, the MR of Au-doped indium-oxide metallic thin films exhibit an isotropic component. This is interpreted as evidence for an additional source of MR due to the interplay between the Zeeman effect and spin-orbit (SO) scattering. This effect was proposed nearly a decade ago and has recently been expanded upon by A. Stern et al. When SO scattering is present the Zeeman splitting caused by an external field will break the symmetry of the time-reversed paths if their spin states are not identical everywhere. This mechanism, which yields positive MR, is not flux driven and is therefore isotropic. The experiments and the proposed MR mechanism will be discussed in the talk.

# Bean-Livingston barriers and first field for flux penetration in high $T_c$ monocrystals.

L.Burlachkov (1), M.Konczykowski (2), Y.Yeshurun (1) and F.Holtzberg (3)
(1) Dept.of Physics, Bar Ilan University, 52900 Ramat-Gan, Israel
(2) Laboratoire des Solides Irradies. CEREM, Ecole Polytechnique, 91128, France
(3) IBM T.J.Watson Research Center, NY 10598 USA

We present the first evidence for the importance of Bean-Livingston (BL) barriers for the field penetration into high-Tc monocrystals. The first field $H_p$ for flux penetration and magnetization curves M(H) were measured near the transition temperature $T_c$ of untwinned Y-Ba-Cu-O monocrystalby using a miniaturized Hall probe. There are three evidences for the efficiency of BL barrier:
1) The descending branches of the magnetization loops M(H) were found to coincide with the axis M=0.
2) The slope of $H_p(T)$ dependence exhibits a clear change in the very vicinity of $T_c$, being the largest at $T_c$
3) After introducing additional surface damage by irradiating of the sample, both the field Hp and the width of the M(H) loops reduce significantly, showing almost reversible properties of the sample.
The BL barrier is shown to be especially important in high-$T_c$ superconductors, and could be responsible for the controversy of the $H_{c1}$ values reported previously in the literature.

HII-5

## ULTRA HIGH CONDUCTIVITY AT ROOM TEMPERATURE IN FILMS OF POLYMERS

I.S. Shlimak

Department of Physics, Bar-Ilan University, Ramat-Gan 52900, Israel

The creation of channels with high conductivity at room temperature has been observed in thin films of oxidized polypropilene[1,2]. This fact can be considered as a "puzzle" because polypropilene belongs to the "saturated" class of polymers in which there are no conditions for the electron transport. Moreover, the estimation of the electrical conductivity in these channels exceeds $10^{11}$ Sm/cm at 300 K and is limited only by the instrumental capability[3]. This value of conductivity is more than 5 orders of magnitude above the conductivity of the best metals, and cannot be explained without taking into account the possible superconductivity. Some experimental data supporting this idea is presented.

References

1. N.S. Enikolopyan et al, JETP Lett. 49, 371 (1989)
2. V.M. Arkhangorodskii et al, Sov. Phys. Dokl. 34, 252 (1989)
3. V.M. Arkhangorodskii et al, JETP Lett., 51, 67 (1990)

# Contributed Papers

# Absorption Quantum Beats of Magneto-excitons in GaAs Heterostructures

**S. Bar-Ad and I. Bar-Joseph**

*Department of Physics, Weizmann Institute of Science, Rehovot 76100, Israel*

We report the observation of a transient oscillatory behavior of the magneto-exciton absorption in GaAs heterostructures. Our experiments were conducted at liquid helium temperature in a split coil 5 Tesla magnet, using a standard pump-probe configuration with a time resolution of $\approx$ 1ps, on two GaAs/AlGaAs samples: a MQW sample and a short period superlattice. A slow decay of the signal measured at B=0, consistent with the finite lifetime of the exciton, is strongly modified as a magnetic field normal to the layers is applied: very deep oscillations have been observed, which are being damped with the same decay time as in the B=0 case. The oscillations for the case of *parallel* pump and probe polarizations are in anti-phase to the *orthogonal* polarizations case. We verified that the oscillation period (8 ps at 4T) is inversely proportional to B for magnetic fields from 1T up to 5T. These experimental results change dramatically when circular polarizations are used. Whenever the pump or the probe is circularly polarized the oscillations disappear. In the particular case of counter-rotating circular polarizations only a weak signal is observed.

We interpret the experimental results as a coherent beating arising from the spin splitting of the different $m_j$ levels involved in the exciton formation. The allowed transitions correspond to circularly polarized light. A linearly polarized pump excites the two transitions coherently, and the polarizability of the medium seen by a linearly polarized probe is a linear combination of these eigenstates. The resulting change of absorption exhibits an interference term oscillating at the difference frequency, which is linearly proportional to B. A circularly polarized pump or probe, on the other hand, interacts with one eigenstate only, and the beating disappears. The weak signal in the counter-rotating circular polarization case indicates that there is no spin flip in the excitonic state. This explains the long duration of the observed coherent oscillations (a few tens of picoseconds), which is limited only by the exciton ionization process.

# MEASUREMENT OF BIREFRINGENCE IN ZnCdTe

E. Fredj and R. Weil
Physics Department and Solid State Institute, Technion, Haifa, Israel.

Birefringence was observed for the first time in $Zn_{0.1}Cd_{0.9}Te$:In and in $Zn_{0.04}Cd_{0.96}Te$, between 20-130°C and 20-98°C, respectively. The optical anisotropic phase was found in the ferroelectric phase of the samples[1,2]. This phase has never been shown to occur in either CdTe or in ZnTe. The coefficient of birefringence was measured with the upper face of the crystal was oriented in the <1,1,1> direction when the laser beam was transmitted through the face in the <2,1,1> direction at a wavelength of 10.63 μm. The polarizer and the analyzer were perpendicular to each other at ±45° from the <1,1,1> direction. The range of transition found is close to the results of other experimental methods (thermodynamic, optic and electric). The transition was observed at 115-140°C and 90-120°C for 10% and 4% Zn, respectively. The coefficient of birefringence was found to be $10\times10^{-5}\pm2\times10^{-5}$ for 10% Zn and $3\times10^{-5}\pm0.5\times10^{-5}$. This result is in the same range as the coefficient of birefringence known in other ferroelectric crystals.

This reserach was supported in part by Grant No. 89-00324 from the US-Israel Binational Science Foundation (BSF), Jerusalem, Israel. The support of the Ralph Levitz Foundation is gratefully acknowledged, by E.F.

1. Weil, R., Nkum, R., Muranevich, E. and Benguigui, L. Ferroelectricity in Zinc Cadmium Telluride, Phys. Rev. Lett., 62, 2744-2746 (1989).

2. Marbeuf, A., Mondoloni, C., Triboulet, R. and Rioux, J., Structural distortions from ferroelectric origin in $Zn_{1-x}Cd_xTe$ semiconductor alloys, Solid State Communications 75, 275-277 (1990).

PACS: 78.20.Fm, 78.20.Nv, 77.80.Bh

**III-8**

# HEAT CAPACITY OF ZnCdTe IN THE FERROELECTRIC AND PARAELECTRIC PHASES

E. Fredj and R. Weil
Department of Physics and Solid State Institute, Technion, Haifa, Israel.

Specific heat at a constant pressure was measured for the first time in $Zn_xCd_{1-x}Te$:In ($x$=0.1), as a function of temperature, between 30-150°C. The material was observed to undergo a transition between 100°-130°C. A second order phase transition was found, from dielectric measurements, in ZnCdTe[1], apparently pointing at an order-disorder transition. The shape of the heat capacity curve as a function of temperature was not distinct enough to fully ascertain this assertion. Heat capacity was measured by a calorimetric method. Near the transition temperature, the heat showed a distinct peak. The range of transtion found is close to the results of other experimental methods for ZnCdTe used to measure the transition temperature (optic, thermodynamic and electric). The specific heat below the transition temperature was found to be 0.137 J/gr/°K + 5%, and above the transition temperature, it was 0.132 J/gr/°K + 5%. The peak value for heat capacity was 0.165 J/gr/°K + 5%. A thermodynamic model, the theory of second order transitions, partially explains the results, although there is no full correlation between the results and the model.

This reserach was supported in part by Grant No. 89-00324 from the US-Israel Binational Science Foundation (BSF), Jerusalem, Israel. The support of the Ralph Levitz Foundation is gratefully acknowledged, by E.F.

1. Weil, R., Nkum, R., Muranevich, E. and Benguigui, L. Ferroelectricity in Zinc Cadmium Telluride, Phys. Rev. Lett., 62, 2744-2746 (1989).

PACS: 65.40.-f, 77.80.Bh

# MOLECULAR DYNAMICS STUDY OF FLUORINE DIFFUSION IN AMORPHOUS SILICON

A. Silverman, J. Adler and R. Weil

Department of Physics, Technion-IIT, Haifa 32000, Israel.

The influence of fluorine in amorphous silicon (a-Si:F) films is of scientific and technological interest[1]. Consequently, we decided to study the diffusion parameters for this material. Molecular dynamics are used to simulate the process of the formation of amorphous silicon samples[2] and the study of the diffusion qualities of fluorine and silicon atom in the amorphous silicon. The molecular dynamics are generated using the silicon-silicon and silicon-fluorine interatomic potentials[3,4]. We observed for the first time large transient coordinate fluctuations of single silicon and fluorine atoms. The parameters of these fluctuations are in agreement with kinetic theories based on the existence of short-lived large energy fluctuations. We also found localization of fluorine atoms in some silicon neighborhoods, and characterized the structures of such sites.

The research was supported in part by the Kernforschungsanlage Julich Germany, the Israel Academy of Science, the U.S. - Israel Binational Science Foundation, the Technion VPR Fund, the Japan Technion Society Fund and the Ralph Levitz Fellowship.

1. A. A. Langford, A. H. Mahan, M. L. Fleet and J. Bender, (1990), Phys. Rev. B41, 8359.

2. A. Silverman, J. Adler and R. Weil, (1990), Thin Solid Films, 193/194, 571.

3. F. H. Stillinger and T. A. Weber, (1985), Phys. Rev. B31, 5262.

4. F. H. Stillinger and T. A. Weber, (1990), J. Chem. Phys, 92, 6229.

HII-10

# NOVEL KINETIC MANY-BODY APPROACH TO SURFACE RATE PROCESSES IN SEMICONDUCTORS AND APPLICATIONS TO HYDROGEN DESORPTION FROM a-Si:H

Yu.L. Khait*), R. Weil*), R. Beserman*), W. Beyer**), H. Wagner**).
*)Solid State Institute, Technion, Haifa, Israel. **)Institut für Schichtand Ionentechnik, Forschungzentrum, Jülich, GmbH, D-5170, Jülich 1, F.R.Germany

A novel kinetic many-body approach to surface rate processes in semiconductors and its application to hydrogen desorption from a-Si:H[1,2] are discussed. This approach is based on the kinetic theory of thermally activated rate processes[1]. The theory has been successfully applied to a-Si[3], a-Si:H[2] and other materials[1,4]. The transient kinetics of many-body picosecond atomic and electronic phenomena occurring in the nanometer vicinity of the desorbed particle is considered. These phenomena are synchronized with the desorption event of duration $\tau_1 = 10^{-13}-10^{-12}$s.

The approach applied to hydrogen desorption from a-Si:H explains for the first time[2]: (i) The observed large variations in the Arrhenius prefactor $K_0$ (about 14 orders of magnitude) and the activation energy $\Delta E$ (a factor of 7) caused by dopant variations; (ii) The linear dependence between $\ln K_0$ and $\Delta E$ associated with the kinetic compensation effect (CEF). The coefficients in the CEF equation and other kinetic parameters are calculated in good agreement with experimental data.

1. Yu.L. Khait, Phys.Reports 99, 237 (1983).
2. Yu.L. Khait, R. Weil, R. Beserman, W. Beyer and H. Wagner, Phys. Rev.B 42, 9000 (1990).
3. Yu.L. Khait, R. Brener and R. Beserman, Phys.Rev.B 38, 6701 (1988); Yu.L. Khait and R. Beserman, Phys.Rev.B 33, 2983 (1986).
4. Yu.L. Khait, J. Salzman R. Beserman, Appl.Phys.Lett.53, 2135 (1988); ibid 55, 1170 (1989).

PACS no: 05.20.Dd; 61.42.+h; 68.85.Da

# NUCLEAR RESONANCE PHOTON SCATTERING STUDY OF NITRIC OXIDE ADSORPTION ON ACTIVATED CARBON FIBER

R. Moreh[1,2] and D. Levant[1]
[1] Physics Dept., Ben-Gurion University of the Negev, Beer-Sheva
[2] Physics Dept., Nuclear Research Center - Negve, Beer-Sheva

The nuclear resonance photon scatering (NRPS) technique was used to study the dimerization of Nitric Oxide (NO) molecules and the zero-point energy of the binding potential between NO and activated carbon fiber (ACF). This was done by measuring the NRPS cross section $\sigma_s$ from $^{15}N$ in the form of NO adsorbed on ACF as a function of temperature in the range 15 K to 300 K. The value of $\sigma_s$ was found to be much higher than that from a pure NO sample. The increase in $\sigma_s$ amounted to about 14% at 297 K and 45% at 10 K, and is explained by the effect of the strong binding NO-ACF potential and in terms of the dimerization of adsorbed NO on ACF. The magnitude and the behaviour of $\sigma_s$ may probably be used as an indicator of the occurrence of chemical adsorption. The average zero-point energy of the binding potentials are deduced using a simple model.

This technique monitors the Doppler broadening of the 6324 keV level of $^{15}N$ arising from the instantaneous velocity of the N-atom. Contributions to this velocity come in part from thermal motion but primarily from the zero-point kinetic energies of the potential binding the $(NO)_2$ molecule to the ACF and of the internal vibrational motion of the dimer. This method relies on the fact that the 6324 keV nuclear level of $^{15}N$ is photoexcited by a chance overlap with one of the $\gamma$-lines of the $Cr(n,\gamma)$ reaction. It turns out that in this nuclear resonance process, $\sigma_s$ is proportional to the Doppler broadening and hence can be viewed as a measure of the potential binding the NO molecule to the ACF.

# The Temperature Dependence of the Magnetization and Paramagnetic Linewidth in Thin Yttrium-Iron-Garnet Films.

I. Laulicht and J. T. Suss
Department of Physics, Bar-Ilan University
Ramat-Gan 52100, Israel.

J. Barak
Department of Solid State Physics
Soreq Nuclear Research Center, Yavne 70600, Israel

The ferromagnetic resonance (FMR) and paramagnetic resonance (PMR) spectra of a thin yttrium-iron-garnet (YIG) film were studied from room temperature to 120K above $T_C$ ($T_C$=553K). Magnetization values extracted from the FMR spectra are in good agreement with the published magnetization data for YIG spheres, obtained by a vibrating sample magnetometer. At temperatures higher than 413K the normalized cubic anisotropy $K_1/M$ is found to be practically temperature independent, in contrast with recent studies on YIG spheres which conclude that $K_1/M \to 0$ when approaching $T_C$. In the paramagnetic phase we observe an anisotropy in the resonance fields due to the sample shape and the induced magnetization. The linewidths $\Delta H$, have also been measured and the product $[\Delta H - \Delta H(T_C)] \times T$ is found to be practically linearly dependent on $T-T_C$ in a wide range of temperatures. $\Delta H(T_C)$ is the linewidth at $T_C$. This result is in good agreement with recent experimental studies of paramagnetic linewidths in YIG spheres and in fair agreement with Huber's zero field theory[1] of paramagnetic linewidths near $T_C$ of non Heisenberg ferromagnets, where the "critical speeding up" effect is absent.

1. D.L. Huber and M.S. Seehra, J. Phys. Chem. Solids 36, 723 (1975).

PACS no.: 76.50

# Extremely Narrow Non-Linear FMR Absorption Lines in the Region of the Main Resonance Fields in YIG Films.

I. Laulicht and A.M. Frishman*
Department of Physics, Bar-Ilan University
Ramat-Gan 52100, Israel.

Fascinating non-linear ferromagnetic resonance (FMR) effects are observed in thin yttrium-iron-garnet (YIG) films at room temperature. When the microwave power is increased above a threshold power of 5mW, extremely narrow peaks appear in the region of the magnetostatic lines. The apparent linewidth of these lines is about 3mOe, which is two orders of magnitude narrower than that of a typical low power FMR line in YIG. We presume that these narrow peaks are due to a second order instability which excites magnons non-linearly. At threshold, the dissipation loss of a magnon going unstable is just compensated by non-linear energy transfer from the uniform precession mode, thus leading to an extremely long effective life time i.e. to an extremely narrow line. Theoretical expressions for the linewidth were calculated taking into account the above considerations and will be compared with the experimental results. The effects of various experimental parameters (dc and ac magnetic field homogeniety and stability, temperature stability, modulation frequency and microwave power) on the experimental linewidth will be discussed. The nature of the absorption lines will be compared with the very narrow subsidiary absorption lines observed by Jantz and Schneider[1] in YIG spheres at much lower fields.

*Present address: Department of Chemical Physics, Weizmann Institute of Science, Rehovot, Israel.

1. W. Jantz and J. Schneider, Phys. Stat. Sol. (a) 31, 595 (1975).

PACS no.: 76.50

# ROOM TEMPERATURE Control and Patterning of 90 K Superconductivity in Thin Films of $YBa_2Cu_3O_{7-x}$ via Oxygen Electromigration

Yosef Scolnik and David Cahen
The Weizmann Institute of Science, Rehovot 76100 Israel

Among the superconducting cuprates, $YBa_2Cu_3O_{7-x}$ (1237) is the one most readily amenable to controlled, solid state chemical modifications, due to the relative ease of its (de)oxygenation at moderate to high temperatures.
Earlier we reported that bulk polycrystalline 1237 can be reduced electrochemically also at room temperature, yielding normal and/or lower temperature superconducting phases (1). We showed that this is possible because of a remarkably high effective chemical diffusion coefficient of oxygen at room temperature in bulk pellets, as well as in thin films (2). We have now been able to achieve both reduction (via wet electrochemistry) and re-oxidation (via solid state electrochemistry) at room temperature in thin films, via extraction or insertion of oxygen. Working with thin films leads to increased homogeneity of affected areas, and thus to improved control over superconducting properties. This is so not only because of control over $n(E_F)$, but also due to changes in the quality of the intergranular contact, via control of their oxygen content. Together with our experimental results we will discuss the implications of this methodology for future superconducting technologies.

**REFERENCES**

1. M. Schwartz et al., Mater. Lett., 7, 411 (1989).
M. Schwartz et al., J. Mater. Chem., in press.
2. Y. Scolnik et al., submitted to Physica C.

HII-15

# LONG-RANGE ANGULAR CORRELATIONS OF WAVES IN A TUBE GEOMETRY

D. Eliyahu, R. Berkovits[+] and M. Kaveh

Department of Physics, Bar-Ilan University, Ramat-Gan 52900, Israel

[+]Department of Physics, University of California
Los Angeles, CA 90024, U.S.A.

We show the existence of unique angular correlations for transmitted and reflected waves for a random medium in the shape of a long tube. The brightness of the speckle spot extends much above its normal angular size $\Delta\theta = \lambda/W$ (where W is the width of the tube), and falls off only as a power law with oscillatory strength. We show a gradual disappearance of the memory effect as the length of the tube exceeds its width. We have also performed numerical simulations which confirm our analytical expressions for the correlation functions $C_1$ and $C_2$ and are able to determine the constant background correlation $C_3$.

HII-16

# VECTOR STATISTICS OF MULTIPLY-SCATTERED WAVES IN RANDOM SYSTEMS

S.M. Cohen, D. Eliyahu, I. Freund and M. Kaveh
Department of Physics, Bar-Ilan University, Ramat-Gan 52900, Israel

New statistical distribution functions are derived for the polarization of optical waves transmitted through a random medium. Excellent agreement is obtained with experiment. Our most significant result is the distribution function for the ellipticity $\epsilon$, the ratio between the major and minor axes of the elliptically polarized scattered light. This has a maximum at $\epsilon = 0$ and vanishes for $\epsilon = 1$, indicating that linear polarization is the most probable state and that circular polarization has vanishing probability. The averaged ellipticity is found to be $\langle\epsilon\rangle = 1-\ell n2 = 0.307$.

HII-17

# NON-RAYLEIGH STATISTICS OF WAVES IN RANDOM SYSTEMS

N. Shnerb and M. Kaveh
Department of Physics, Bar-Ilan University, Ramat-Gan, Israel

We show that when the effective disorder of a system increases, non-Rayleigh statistics characterize the intensity fluctuations of a propagating wave in a random medium. We find a single scaling parameter that describes the intensity distribution function, which depends on the conductance and transmission coefficient of the system. Our analytical results are in agreement with the results of numerical simulations, which indicates that the statistics of transmitted and reflected waves in restricted geometries is very different.

# DISPERSIVE TRANSPORT AND NON-EXPONENTIAL RELAXATION PROCESSES IN SYSTEMS WITH AGE-DEPENDENT TRANSITION RATES

V. Halpern

Department of Physics, Bar-Ilan University, Ramat-Gan 52900, Israel

Arguments are presented to demonstrate the plausibility of age-dependent transition rates (ADTR) in systems showing dispersive transport and/or relaxation processes that do not decay as a simple exponential function of the time. An analysis is presented of multiple trapping transport processes with age-dependent release rates from the traps, and it is shown that such systems behave in many cases like those having a distribution of traps with fixed transition rates. In particular, they show anomalous dispersion for the transient photocurrent, but do not lead to frequency-dependent equilibrium transport coefficients. For a system of dipoles with ADTR, on the other hand, use of the correct initial conditions leads to a non-Debye form for the frequency-dependence of the dielectric constant. The reason for this different behaviour of the two types of system is discussed.

PACS No: 66.30D, 72.20, 72.80N

# PHASE DIAGRAM OF THE DILUTE ISING SPIN GLASS IN GENERAL DIMENSION

Shye Shapira[‡], Lior Klein[*],
Joan Adler[‡,*], Amnon Aharony[*], and A. B. Harris[†]

‡ Department of Physics, Technion
*School of Physics and Astronomy, Tel Aviv University
†Department of Physics, University of Pennsylvania

We have obtained complete phase diagrams for the dilute Ising spin glass in general dimension. The phase diagrams have been deduced from analysis of new two variable high-temperature-low-concentration series[1] for the Edwards-Anderson spin-glass susceptibility. We chose a model with nearest neighbour interactions which randomly assume the values $+J$, $0$, $-J$ with probabilities $p/2$, $1-p$, $p/2$, respectively and obtained 15th-order series as a function of temperature for arbitrary dilution and dimension, and 14th-order series as a function of dilution for selected temperature choices. The generation was made possible by the implementation of the Harris NFE (no-free-end diagrams) scheme which considerably reduces the amount of diagrams counted. This project complements our earlier studies of the zero-temperature dilute Ising spin glass[2] and the $p = 1$ Ising spin glass[3].

Padé analyses of the different series in various dimensions were made in order to ascertain critical temperatures and dilution thresholds. Excellent agreement was observed in general between results obtained in the temperature direction and the results in Refs 1 and 2. Crossover exponents were also measured. The results support the idea that spin-glass critical exponents are observed at all points in this system.

1. J. Adler, Y. Meir, A. Aharony, A. B. Harris, and L. Klein "Low concentration series in general dimension" for a volume in honour of C. Domb: (1990) J. Stat. Phys. 58, 511-38.

2. L. Klein, J. Adler, A. Aharony, A. B. Harris, and Y. Meir, "The dilute spin glass at zero temperature in general dimension", (1989), Phys. Rev. B. 40, 4824-32.

3. L. Klein, J. Adler, A. Aharony, A.B. Harris, and Y. Meir, "Series expansions for the Ising spin glass in general dimension", (1991), Phys. Rev. B, in proof.

# NEUTRON DIFFRACTION STUDIES OF THE MAGNETIC ORDERING IN SEVERAL $UM_2X_2$ COMPOUNDS AND $U(M,M')_2X_2$ SOLID SOLUTIONS (M,M' = Co,Ni,Cu; X = Ge,Si)

Moshe KUZNIETZ, Haim PINTO, Hanania ETTEDGUI, and Mordechai MELAMUD
Nuclear Research Centre - Negev, P O Box 9001, 84 190 Beer-Sheva

We have studied the magnetic ordering in polycrystalline samples of several $UM_2X_2$ compounds and $U(M,M')_2X_2$ solid solutions (M,M'=Co,Ni,Cu; X = Si,Ge) by neutron diffraction down to 10 K and AC-susceptibility down to 80 K, following x-ray diffraction at 295 K. As in the $RM_2X_2$ compounds (R = Gd to Tm) studied previously [1], the crystallographic structure of most compounds is tetragonal, of the $ThCr_2Si_2$-type, with space group I4/mmm, and two formula units per unit cell. $UCoNiGe_2$ is an exception, and has lower crystal symmetry.

Magnetic results of $UCo_2Ge_2$ [2], $U(Co_{1-x}Cu_x)_2Ge_2$ [3], and $UNiCuGe_2$ [4] have already been published. $UCoNiGe_2$ does not order magnetically [4]. Magnetic data for the $U(Co_{1-x}Cu_x)_2Ge_2$ and $U(Ni_{1-z}Cu_z)_2Ge_2$ systems are:

| System | x/z | $T_C$ (±5) (K) | $T_N$ (±5) (K) | Order below $T_C/T_N$ | $T_o$ (±5) (K) | Order below $T_o$ | Uranium moment(10 K) ($\mu_B$) |
|---|---|---|---|---|---|---|---|
| $UCo_2Ge_2$ | 0 | | 175 | AF-I | | | 1.5±0.2 |
| | 0.25 | | 130 | AF-I | | | 1.9±0.1 |
| $U(Co_{1-x}Cu_x)_2Ge_2$ | 0.50 | | 100 | AF-I | | | 2.0±0.2 |
| | 0.75 | 102 | | Ferro | | | 1.5±1.0 |
| $UCu_2Ge_2$ | 1 | 107 | | Ferro | | | 1.9±0.4 |
| $UNi_2Ge_2$ | 0 | | 80 | AF-I | | | 1.9±0.5 |
| | 0.25 | | 135 | AF-I | | | 2.0±0.4 |
| $U(Ni_{1-z}Cu_z)_2Ge_2$ | 0.50 | | 140 | AF-I | | | 2.2±0.1 |
| | 0.75 | 133 | | Ferro | 117 | AF-I | 2.2±0.2 |
| $UCu_2Ge_2$ | 1 | 107 | | Ferro | | | 1.9±0.4 |

The tentative magnetic phase diagrams proposed for the $U(Co_{1-x}Cu_x)_2Ge_2$ and $U(Ni_{1-z}Cu_z)_2Ge_2$ solid solutions are compared and discussed.

Recent AC-susceptibility studies show magnetic ordering with two transitions (above 80 K) in both $UCoCuSi_2$ (at 157 K and 112 K) and $UNiCuSi_2$ (at 162 K and 122 K) and only one in $UCoNiSi_2$ (at 115 K). These results are discussed in relation to the $UM_2Si_2$ compounds.

1. H.Pinto, M.Melamud, M.Kuznietz, H.Shaked, Phys.Rev.B 31, 508 (1985)
2. M.Kuznietz, H.Pinto, H.Ettedgui, M.Melamud, Phys.Rev.B40,7328(1989)
3. M.Kuznietz, H.Pinto, M.Melamud, J.Magn.Magn.Mater. 83, 321 (1990).
4. M.Kuznietz, H.Pinto, M.Melamud, J.Appl.Phys. 67, 4808 (1990).

PACS nos. 75.25.+z, 75.30.Kz

# I. Particles and Fields,

# Astrophysics & Cosmology

# Invited Lectures

# Recent Results from LEP

G. Bella

Tel-Aviv University

**Abstract**

The LEP e+e- storage ring at CERN, Geneva, has been in operation since summer 1989 with a c.m. energy around the ZO mass. With a luminosity of 8 pb-1 for each of the four LEP experiments, the total number of ZO's seen so far exceeds 150000 per experiment. This enables a thorough investigation of the ZO parameters resulting a precise determination of the number of light neutrino species. All the results agree with the Standard Model predictions including higher order loop corrections from which, some limits on the top-quark mass can be deduced. Searches for the Higgs boson and other new particles have yielded so far negative results and lower limits on their masses are obtained.

## Quark-Gluon Plasma Formation in High Energy Nuclear Collisions

Asher Shor
*Department of Physics, The Weizmann Institute of Science*
*Rehovot 76100, Israel*

### Abstract

Collisions of heavy nuclei at high energy provides an opportunity to study the properties of nuclear matter at large energy densities and temperatures. At large energy densities, a transition from hadronic matter to a quark-gluon plasma ( QGP ) is expected to take place. The QGP would consist of deconfined quarks and gluons in a perturbative environment over an extended region ( where $R_T \gg \frac{1}{\Lambda_{QCD}} \sim 1fm.$). Recent experimental results from heavy ions at CERN-SPS indicate that energy densities have been achieved which are in the range required for QGP formation as suggested by lattice QCD calculations.

Several signals and probes of quark-gluon plasma have been proposed. $J/\psi$ suppression can be a measure of the deconfining nature of the plasma, strangeness enhancement measures the approach to chemical equilibrium, while dilepton production can serve as a direct probe of the hot interior providing a temperature profile of the plasma, etc. Several of these signals have recently been detected in high energy heavy-ion collisions at CERN. These results are generating theoretical investigations to what extent purely hadronic effects can also yield these signals at the levels presently observed.

We describe the CERES* spectrometer designed to measure $e^+e^-$ production in p-nucleus and nucleus-nucleus collisions at CERN-SPS. This detector is hadron blind, employing the novel technique of double Ring Imaging Cherenkov (RICH) counters to measure the electrons. In addition to measuring the direct dilepton signal, the CERES detector will look at the strangeness signal in the form of $\phi/\omega$ ratios, study the approach to chiral restoration by 'melting' of the $\rho_o$-meson, and measure the pion dispersion in hot hadronic matter by means of the pion 'cusp' at $m_{e^+e^-} \sim 2 \times m_\pi$. Preliminary results on Cerenkov rings measured by the CERES spectrometer will be presented.

* work performed with A. Breskin, R. Chechik, R. Folman, Z. Fraenkel, V. Steiner, G. Telzur and I. Tserruya in collaboration with Heidelberg University.

# A 17 keV Neutrino ?

Yossi Nir

Weizmann Institute of Science

Abstract:

Recently, it has been claimed that there is experimental evidence for a neutrino with a mass of 17 keV. While waiting for further experimental checks, theorists test their particle and cosmological models in view of this possibility. Only very peculiar particle models can explain the required properties of such a particle, while several basic ideas in cosmology and astrophysics need to be significantly modified if it exists.

# The Large Scale Structure of the Universe

Yehuda Hoffman

Racah Institute of Physics

Hebrew University

Jerusalem, Israel

## Abstract

Recent observations of the galaxy distribution and motion on scales of a few $10h^{-1}Mpc$ are reviewed. The present status of the inflationary paradigm and the question of the cosmological constant are examined from the point of view of observational cosmology. The existence and nature of the so-called 'Great Attractor' is reviewed in light of the observed velocity and density fields. Various tests are applied to the data and are compared with theoretical models. In particular, the bulk velocity and cosmic Mach number are considered. The present velocity data seems to be consistent with the cold dark matter model with very mild biasing. However, the galaxy distribution on scales of about $100h^{-1}Mpc$ shows an excess of power compared with that model.

# Contributed Papers

I-5

# GRAVITATIONAL ENERGY OF A SPHERICAL SOURCE

Noah Nissani, Center for Theoretical Physics, Ben Gurion University of the Negev, Beer Sheva 84105, Israel.
The late Elhanan Leibowitz, Department of Physics and Department of Mathematics, Ben Gurion University of the Negev, Beer Sheva 84105, Israel.

An exact expression for the general relativistic gravitational energy of a spherically symmetric source is derived from a tensorial representation of the gravitational energy-momentum density. The global conservation of the total energy-momentum tensor is accomplished in the non-rotating coordinates, in which the covariant divergencelessness of the energy-momentum tensor reads as ordinary divergencelessness. For a source with a radius far larger than its Schwarzschild radius, the relativistic gravitational energy reduces to the Newtonian value. In the case of an ordinary star, like the sun, it coincides with the Newtonian value up to six digits.

RELATED PAPERS

1. Nissani, N. and Leibowitz, E., Physics Letters A, 126, 447 (1988).
2. Nissani, N. and Leibowitz, E. Proc. of the Fifth M. Grossmann Meeting, Vol. 1, 415, World Scientific, Singapore, (1989).
3. Nissani, N. and Leibowitz, E., International Journal of Theoretical Physics, Vol. 28, No. 2, 235 (1989).
4. Carmeli, M., Leibowitz, E. and Nissani, N. Gravitation: SL(2,C) Gauge Theory and Conservation Laws, World Scientific, Singapore, p. 77. (1990).
5. Nissani, N. and Leibowitz, E., International Journal of Theoretical Physics, (to appear) (1991).

PACS no: 04.20.Cx

# Author Index

# החברה הישראלית לפיסיקה

## הועד

י.צרויה (מכון ויצמן למדע), נשיא
ג.שביב (טכניון) סגן נשיא
ח.חלפרין (אוניברסיטת בר-אילן), גזבר
א.שור (מכון ויצמן למדע), מזכיר
ד.אגר (המרכז למחקר גרעיני, נחל שורק)
ס.אקסלרוד (אוניברסיטת תל-אביב)
ט.בר-נוי (הקריה למחקר גרעיני, דימונה)
ר.וייל (הטכניון)
ד.פאליק (רפא"ל)
ש.מרדכי (אוניברסיטת בן-גוריון)
ז.שאלתיאל (האוניברסיטה העברית)

## גופים חברים

אוניברסיטת בר-אילן
אוניברסיטת בן-גוריון
האוניברסיטה העברית
הועדה לאנרגיה אטומית
הטכניון - מכון טכנולוגי לישראל
אוניברסיטת תל-אביב
מכון ויצמן למדע

## הועדה המארגנת - אוניברסיטת בן-גוריון

ש.מרדכי, יו"ר
ד.אייכלר
א.דוידסון
ב.הורוביץ
נ.שמיר, נציג האגודה הישראלית לואקום

אוניברסיטת בן - גוריון בנגב
המחלקה לפיסיקה



# החברה הישראלית לפיסיקה

# תשנ"א

# הכנס השנתי

# תכנית ותקצירים

1991