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Table of Contents Page

I

Members of the Institute

Research Staff

吳茂昆
Maw-Kuen Wu
Distinguished Research Fellow, and Director
mkwu@phys.sinica.edu.tw
Low Temperature Physics, Superconductivity and Magnetism

鄭天佐
Tien-Tzou Tsong
Distinguished Research Fellow
phtsong@ccvax.sinica.edu.tw
tsongtt@phys.sinica.edu.tw
Surface Science, Surface Electron and Atom Dynamics, Atomic Resolution Microscopy, Field Emission Phenomena.

姚永德
Yeong-Der Yao
Research Fellow
phyao@gate.sinica.edu.tw
Condensed Matter Physics, Magnetism, Low Temperature Physics, Super-conductivity, Electrical Optics, Thin Films, and Nanosize Structures and Their Physical Properties.

何侗民
Tung-Min Ho
Research Fellow
ltho@gate.sinica.edu.tw
Semiconductor Physics, Impurities and Defects in Crystals, Infrared Spectroscopy.

黃榮鑑
Robert R. Hwang
Research Fellow
phhwang@ccvax.sinica.edu.tw
Vortex Dynamics, Turbulent Diffusion Process, Fluid Dynamics, Wave Mechanics.

曾忠一
Chung-Yi Tseng
Research Fellow
phnoaa@ccvax.sincia.edu.tw
Meteorological Numerical Modeling, Atmospheric Radiation and Remote Sensing.

簡來成
Lai-Chen Chien
Research Fellow
chienlc@phys.sinica.edu.tw
Computational Fluid Physics, Microgravity Fluid Dynamics, Space Material Processing.

王建萬
Chang-Wan Wang
Research Fellow
cwwang@phys.sinica.edu.tw
Experimental Nuclear Physics, Ion Beam Applications.

胡進錕
Chin-Kun Hu
Research Fellow
huck@phys.sinica.edu.tw
Statistical and Computational Physics, Nonlinear Science, Theoretical Biophysics.

謝雲生
Wan-Sun Tse
Research Fellow
Raman and Infrared Spectroscopy, Laser and Nonlinear Crystals.

李世昌
Shih-Chang Lee
Research Fellow
phsclee@ccvax.sinica.edu.tw
Particle Physics, Field Theory, Nonlinear Physics.

楊維邦
Wai-Bong Yeung
Research Fellow
phwyeung@ccvax.sinica.edu.tw
Elementary Particle Physics, Field Theory, Theory of Gravitation, Physics of Ferrofluid.

曾詣涵
Yi-Harn Tzeng
Research Fellow
phtzengyh@ccvax.sinica.edu.tw
Theoretical Nuclear Physics, Intermediate Energy Nuclear Physics, Nuclear Many-Body Problems and Nuclear Structure, Quark Models, Hypernuclear Systems.

任盛源
Shien-Uang Jen
Research Fellow
physjen@gate.sinica.edu.tw
Electron Transport properties of Ferromagnetic Materials, Magnetostriction and Application, Magnetic Domains and Domain Walls, Magnetic Anisotropy.

張志義
Chi-Yee Cheung
Research Fellow
phcheung@ccvax.sinica.edu.tw
Medium and High Energy Physics, Hadron Structure, Quantum Mechanism.

鄭海揚
Hai-Yang Cheng
Research Fellow
phcheng@ccvax.sinica.edu.tw
Particle Physics Phenomenology.

余海禮
Hoi-Lai Yu
Research Fellow
phhlyu@ccvax.sinica.edu.tw
Particle Physics, Field Theories, Perturbative QCD Calculations, Cosmology, Cognitive Science and Brain Dynamics.

李世炳
Sai-Ping Li
Research Fellow, Deputy Director
phspli@ccvax.sinica.edu.tw
Theoretical Physics, Particle and Field Theory.

陳志強
Chi-Keung Chan
Research Fellow
phckchan@ccvax.sinica.edu.tw
Nonlinear Physics, Physics of Fluid

陳洋元
Yang-Yuan Chen
Research Fellow
phcheny2@ccvax.sinica.edu.tw
Low Temperature Physics, Low Temperature Specific Heat Heavy Fermion, Nanoparticle, Thermoelectricity, Ground Freezing.

鄧炳坤
Ping-Kun Teng
Research Fellow
pkteng@sinica.edu.tw
Particle Physics, Nuclear Physics.

李定國
Ting-Kuo Lee
Research Fellow
tklee@phys.sinica.edu.tw
High Temperature Superconductivity, Nano-materials, X-ray CrystalloGraphy, Protein Structure, Protein Folding, Quantum Monte Carlo Method.

魏金明
Ching-Ming Wei
Research Fellow
cmw@phys.sinica.edu.tw
Surface Science, Kikuchi Electron Holography, *Ab initio* Total Energy Calculations.

張嘉升
Jason Chia-Seng Chang
Research Fellow
jasonc@sinica.edu.tw
Surface Physics and Chemistry, Principles of Atomic Manipulation, Quantum Effects in Low-dimensional Systems, Nanostructure Sciences and Development of SPM.

葉崇傑
Sungkit Yip
Research Fellow
yip@phys.sinica.edu.tw
Superconducting Phenomena, Quantum Fluids, Strongly Correlated Electron Systems.

李湘楠
Hsiang-Nan Li
Research Fellow
hnli@phys.sinica.edu.tw
Perturbative Quantum Chromodynamic, B physics.

梁鈞泰
Kwan-Tai Leung
Research Fellow
leungkt@phys.sinica.edu.tw
Statistical mechanics of non-equilibrium phase transitions and critical phenomena, computer simulations, self-organized criticality, fracture in disordered media.

黃英碩
Ing-Shouh Hwang
Research Fellow
ishwang@phys.sinica.edu.tw
Surface Science, Semiconductor Physics, Scanning Tunneling Microscopy, Surface Atomic and Molecular Dynamics, Mechanism of Epitaxial Growth.

林誠謙
Simon-C. Lin
Associate Research Fellow
sclin@sinica.edu.tw
Computational Physics, Statistical Mechanics, Scalable Algorithm in Simulated Annealing, Cluster Computing, Internet Strategic Planning, Digital Library/Museum.

劉　鏞
Yung Liou
Associate Research Fellow
yung@phys.sinica.edu.tw
The growth mechanism, structure, physical properties and applications of magnetic, Metal, Oxide and diamond thin films.

余岳仲
Yueh-Chung Yu
Associate Research Fellow
phycyu@ccvax.sinica.edu.tw
Accelerator based atomic physics, materials characterization.

吳建宏
Kin-Wang Ng
Research Fellow
nkw@phys.sinica.edu.tw
Particle Astrophysics and Cosmology, Early Universe, Inflationary Cosmology and Quantum Fluctuations, Dark Matter, Cosmic Microwave Background.

杜其永
Ki-Wing To
Research Fellow
ericto@gate.sinica.edu.tw
Phase transitions and critical phenomenon, physics of fluids and hydrodynamics, electrorheological fluids, porous media and granular materials, polymer physics, instrumentation.

胡宇光
Yeu-Kuang Hwu
Associate Research Fellow
phhwu@ccvax.sinica.ddu.tw
Synchrotron Radiation Application, Photoemission Spectroscopy, X-ray Surface Scattering.

侯書雲
Suen Hou
Associate Research Fellow
suen.hou@cern.ch
High energy physics, Experimental particle physics, Instrumentation.

王子敬
Henry Tsz-King Wong
Associate Research Fellow
htwong@phys.sinica.edu.tw
Neutrino Physics and Astrophysics, Astro-particle Physcis, Particle Physics Instrumentation, Cross-Strait Academic Collaboration.

王明哲
Ming-Jer Wang
Assistant Research Fellow
ming@fnal.gov
High Energy Experiment.

陳啟東
Chii-Dong Chen
Associate Research Fellow
chiidong@iis.sinica.edu.tw
High operating temperature single electron transistors, Transport properties of nano-materials, The Physics and applications of Superconducting/ Ferromagnetic nanostructures.

李尚凡
Shang-Fan Lee
Assistant Research Fellow
leesf@phys.sinica.edu.tw
Research interests include transport and magnetic properties and quantum phenomenon in metallic thin films and nano-structures.

章文箴
Wen-Chen Chang
Assistant Research Fellow
changwc@phys.sinica.edu.tw
Relativistic Heavy Ion Collisions, Quark Nuclear Physics, Vector Meson Photo-production.

蘇維彬
Wei-Bin Su
Assistant Research Fellow
weber@gate.sinica.edu.tw
Surface Science, Scanning Probe Microscopy, Low- temperature Epitaxial Growth, Quantum Phenomena in Low-dimensional System

蔣　宜
Yi Chiang
Research Assistant
yichiang@gate.sinica.edu.tw
Biophysical Experiment.

Joint Appointment Faculty

張達文
Darwin Chang
chang@phys.nthu.edu.tw
Theoretical Particle Physics.

張能復
Len Fu Chang
Environmental Engineering.

王林玉英
Yuh Ying L. Wang
Hemodynamics.

蕭葆羲
Bao-Shi Shiau
bsshiau@gate.sinica.edu.tw
Wind Engineering, Environmental Engineering in Ocean and Atmosphere.

Adjunct Faculty

江紀成
Ge cheng Kiang
phkiang@sinica.edu.tw
Experimental Nuclear Physics, Radiation Physics and its Application.

林爾康
Erh Kang Lin
phibmg@ccvax.sinica.edu.tw
Nuclear Reaction at Low Energy, Decay Scheme Study, Atomic Ionization, Nuclear Technology and Application.

王唯工
Wei Kung Wang
wkwang@phys.sinica.edu.tw
Hemodynamics, Foundation of Chinese Medicine, Effect of E-M Field to the Body.

郭子斯
Thomas T.S.Kuo
kuo@phys.sinica.edu.tw
Nuclear Physics

Postdoctoral Research Associates

Yeo Yie Chang (張有毅)
Yuh-Kuei Chang (張玉貴)
Chuan-Hung Chen (陳泉宏)
Yen-Chu Chen (陳彥竹)
Lu Chiang Chia (賈魯強)
Chung-I Chou (鄒忠毅)
Ming-Lee Chu (朱明禮)
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* Weng-bin Chien (簡紋濱)
Ming Yie Jan (詹明宜)
Ivo Klik (柯松仁)
Wo-Lung Lee (李沃龍)
Chin Chung Yu (余進忠)
* Chai-Yu Lin (林財鈺)
Nickyolay Izmailian (伊士麥林尼)
Ting-Hua Chang (張定華)
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Wen-Jong Ma (馬文忠)
Di Qing (卿笛)
Jie Jun Tseng (曾玠郡)
Hsin-Tza Wu (吳欣澤)
Rong-Sheng Han (韓榕生)

* 表示 已離職人員

Research Affiliate

Tse-Lin Hsu	(徐則林)

Administrative Staff

C. J. Chen	(陳鈞珍)	C. T. Sheng	(盛巧弟)
C. P. Hsieh	(謝傳平)	S. C. Tsai	(蔡素卿)

Administrative Assistants

S. J. Chen	(陳淑然)	* C.W. Lin	(林純維)
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I. T. Huang	(黃懿姿)	Tracy Liu	(劉翠霞)
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Y. J. Wang	(王一如)	Amy Liu	(劉廣平)
Yi-Ying Lai	(賴宜瑩)	An-Chun Lin	(林安純)
Yi-Chun Lin	(林怡君)	King Nan Hwang	(黃金男)
Horng-Shuen Wu	(吳宏順)	I-Ting Wu	(吳依亭)
Wen-Sheng Pan	(潘文生)	Chun-Hsi Chang	(張瓊璽)

Technical Supporting Group

C. H. Hsieh	(謝家和)	Y. H. Wang	(王裕鑫)
C. Y. Lin	(林呈應)	S. C. Wu	(吳喜成)
T. H. Su	(蘇子宣)	K.M. Chen	(陳冠銘)

Technical Assistants

M. H. Chien	(簡明宏)	M. L. Wu	(吳美玲)
C. S. Kuo	(郭忠賢)	H. L. Yeo	(楊惠玲)
* Y. H. Pai	(白裕和)		

* 表示已離職人員

II

Review of Research Projects

HYDRODYNAMICS AND ATMOSPHERIC PHYSICS

1. Atmospheric and Ocean Physics
2. Basic Research in Hydrodynamics
3. Physics of Complex Fluids

NUCLEAR PHYSICS AND ACCELERATOR-BASED PHYSICS

1. Experimental Nuclear Physics and Accelerator-Based Physics
2. Theoretical Nuclear Physics

PARTICLE PHYSICS

1. Experimental High Energy Physics
2. Particle Phenomenology
3. Particle Astrophysics and Cosmology

SOLID STATE PHYSICS AND BIOPHYSICS

1. Surface, Nano Science and Thin Films
2. Magnetism
3. Quantum Size Effects and Nanostructures
4. Crystal Growth and Optical Properties of Non-linear Crystals
5. Strongly Correlated Many-body Systems
6. Biophysics

STATISTICAL AND COMPUTATIONAL PHYSICS

1. Equilibrium Phase Transitions
2. Nonequilibrium Statistical Physics
3. Chaos and Nonlinear Dynamics
4. Macromolecules and Complex Fluids
5. Theoretical and Computational Biological Physics
6. Complex Human and Social Systems.

HYDRODYNAMICS AND ATMOSPHERIC PHYSICS

1. Atmospheric and Ocean Physics

(1) Atmospheric corrections for the resources satellite images

(2) Strong Wind Characteristics at the Coastal Area of Taiwan

(3) Application of the semi-Lagrangian method to cloud model

2. Basic Research in Hydrodynamics

(1) Maxwell-Navier-Stokes model on low gravity fluid transport phenomena

(2) Thermoelectromagnetic convection of encapsulated floating zone

(3) Effects of tidal variability and continuous stratification at estuary

(4) Liquid encapsulated floating zone

(5) Three-dimensional simulation of square jets

(6) Unsteady three-dimensional interaction and near-wall eruption

3. Physics of Complex Fluids

(1) Electromagnetic effects on material growth

(2) Surfactant driven instability in a Hele-Shaw Cell

(3) Collapse of a granular pile

(4) Nonlinear phenomena in chemical and biological systems

(5) Effect of polymer on the critical behavior of binary liquid mixture

(6) Jamming of granular flow in two- and three-dimensional hopper

1. Atmospheric and Ocean Physics

(1) Atmospheric corrections for the resources satellite images

Satellite visible images are unavoidably masked by the cloud, aerosol and water vapor existing in the atmosphere. These effects may be removed by some means, except the cloud. This is the so-called atmospheric correction. In this project we will estimate the atmospheric correction parameters for the resource satellite images by using the multi-spectral data from multiple satellites. Of all the meteorological parameters the aerosol optical thickness is believed to be the most important one for the atmospheric correction. The aerosol optical thickness may be retrieved from the VISSR visible channels data aboard the operational meteorological satellite GMS and the ocean color imager data of the ROCSAT-1. The latter is launched in December 1998. We developed new method of extracting the aerosol optical thickness and test its validity. (Chung-Yi Tseng)

(2) Strong Wind Characteristics at the Coastal Area of Taiwan

We report the in-situ measurement results of the strong wind turbulence statistics and wind velocity spectra at the Keelung coastal region of Taiwan. Strong winds induced by the Babs typhoon coming on Oct. 25-27, 1998, were measured with an ultra-sonic anemometer. The in-situ measurement data included three components of the wind velocity and temperature. The probability density functions for three components of the wind velocity fluctuations and temperature fluctuation are shown to be close to the Gaussian distributions. The turbulence intensity and integral length scales of the strong wind are calculated. The observed longitudinal wind spectrum is found to be in agreement with the Von Karman's spectrum and the wind spectrum equation of Eurocode 1. Observational results of the lateral and vertical wind spectra are approximately close to the predictions of the isotropic turbulence spectra equations. (Bao-Shi Shiau)

(3)Application of the semi-Lagrangian method to cloud model

Recently the use of semi-Lagrangian method is extended to the meso- and small-scale models. The numerical efficiency in its application to the non-hydrostatic models is limited by fast moving acoustic and gravity waves. Furthermore, there exist overshoot and undershoot of the forecast variables during the integration formula used in the semi-Lagrangian scheme. Modified schemes have been proposed to improve the performance and efficiency. In this study we apply a quasi-monotone semi-Lagrangian scheme to a three-dimensional non-hydrostatic cloud model. The ice phase is considered in the microphysical parameterization in order to investigate its effects on the precipitation structure. The results indicate that the monotone scheme can suppress efficiently the noise generated in the model and simulate correctly the time change of water substances without increasing the computation time. In addition, the new model can simulate some important features of the development of a cumulus cloud. This year we continued to use semi-Lagrangian method as advection scheme in the cloud model to study the small-scale atmospheric flow. The stability analysis was performed in the semi-Lagrangian cloud model in order to understand the character of numerical solution for different Courant numbers or forcing terms, e.g. mechanical forcing or cloud microphysics. It is well known that when the semi-implicit semi-Lagrangian method is used as advection scheme, it affords an advantage of 3 to 6 times larger time step than Eulerian methods. The numerical solution is stable, but it is not accurate enough for large Courant number. Furthermore, the orographic forcing could not be neglected in small-scale models and this mechanical forcing is more important than others in changing the atmospheric flow field. (Chung-Yi Tseng)

2. Basic Research in Hydrodynamics

(1) Maxwell-Navier-Stokes model on low gravity fluid transport phenomena

Considering the electromagnetic effects, we add Maxwell equations in CFD. The Computational Magneto-Aerodynamics is thus developed. Maxwell-Navier-stokes coupled equation has been employed to solve the equations of magneto fluid dynamics for conservation variables of mass, momentum and energy throughout the flow field. Incorporating the magneto-aerodynamics technique and using utilizing the Maxwell-Navier-Stokes equation model, we are going to integrate the conservation form governing equations in control volume and to develop a solver to simulation the magnetic effects on microgravity integrate materials processing. According the CFD technique, MUSCL is involved to solve the governing equations. In the investigation, we apply the developed model to simulate the Magnetic effects of Marangoni-Benard convection and of the horizontal Bridgman process. (Lai-Chen Chien)

(2) Thermoelectromagnetic convection of encapsulated floating zone

In a microgravity environment, the thermal convection is induced primarily by thermal-capillary stress in a liquid free surface or at liquid/liquid interface. An external applied magnetic field may reduce melt circulation. In order to control the thermalcapillary convection, the liquid encapsulated floating zone technique with electromagnetic field is developed. Electromagnetic liquid encapsulated floating zone is simulated by concentric two-fluid column system to investigate thermo-gravitational and thermo-capillary convection characteristics. The thermal and flow patterns of the two immisicible liquid system of FC-40 and 2 cst silicon oil under various gravity conditions are studied. The simulation incorporates numerical scheme based on volume of fluid transport equations with continuum mechanism. The two fluid and interface are handled by unique system of governing equations. The thermoelectromagnetic effects on the convection of encapsulated floating zone are simulated. (Lai-Chen Chien).

(3) Effects of tidal variability and continuous stratification at estuary

Several effects in the flow field of an estuary including interaction of river current and ocean current has been studied. Other important mechanism such as density stratification and tidal variation are not touched. Hence, it is worth paying more attentions in these topics. This project is conducted using numerical simulation. The main goal is to establish a 3-D numerical model. The vertical density stratification and tidal variation will be considered. (Robert R. Hwang, Wen-Chang Yang)

(4) Liquid encapsulated floating zone

In liquid encapsulated floating zone configuration, the liquid column is concentrically surrounded by immiscible liquid encapsulant and creates a column of two concentric immiscible liquid. The shape of the volume of fluid is held between equal diameter solid disks by surface tension. The liquid bridge has been extensively investigated since the early publication of Rayleigh and Plateau more than a century. Recently, with the availability of the reduced gravity environment and the potential of containless processing, the problem has been widely studied and applied in industry applications. We have simulated the encapsulated floating zone by volume of fluid model with continuum surface formulation to take care liquid/liquid or liquid air interface. The two fluids, inner cylinder filled with FC-40 and outer 2 cSt silicon oil, are handled by unique system of governing equations and solved like single fluid problem with pressure based algorithm. The flow characteristics and the thermal properties of the liquid encapsulated floating zone in various gravity conditions are obtained. The micro-gravity effects on the crystal growth in liquid encapsulated floating zone process are simulated. (Lai-Chen Chien)

(5) Unsteady three-dimensional interaction and near-wall eruption

Direct Numerical simulations are performed to investigate the unsteady three dimensional vortex-vortex and vortex-surface interactions in the far field of a wall mounted rectangular block placed inside a channel. A sequence of stream wise rollers dominated the downstream interaction region, and they exhibit strong unsteady flow characteristic. The origin and the formation of wake vortices behind the rectangular block are investigated and they are found to be fundamentally different from what one observes behind a transverse jet. In the upstream region, an unsteady laminar necklace vortex-system formed at the upstream juncture of the rectangular block and the bottom plane of the channel. The effect of Reynolds number on the unsteady flow characteristic and on the interaction mechanism has also been investigated in a greater detail. (Amalendu Sau and Robert R. Hwang)

(6) Three-dimensional simulation of square jets

Direct numerical simulations are performed to predict the three-dimensional unsteady flow interactions in the near field of a square jet issuing normal to a cross-flow. The near field flow features investigated here include, the presence of an upstream horseshoe vortex system which resulted from interaction between the approaching upstream laminar floor shear layer and the transverse jet; the formation of a sequence of Kelvin-Helmholtz instability induced vortical rollers in the mixing layer between the jet and the cross-flow, which wrap around the front side of the jet; and the inception process of the counter rotating vortex pair (CVP) which is initiated through folding of the lateral jet shear layer. It has been observed that for a jet in cross-flow, the Kelvin-Helmholtz instability induced shear layer rollers do not form closed circumferential vortex rings. Along the downstream side of the jet the tails of such rollers are entrained upward where each tail subsequently joins a loop of the CVP. However, the inception of the CVP is observed to take place within the cross-flow induced skewed lateral jet shear layer, and such inception often occurs slightly below the jet orifice. The present simulations also demonstrate the growth and evolution of the upright wake vortices from the cross-flow floor boundary layer, where they spiral in and lift themselves away from the wall shear layer, and during upward motion they eventually get entrained into the CVP core. Such findings are found to be quite consistent with the experimental observations for a round jet, as made by Fric & Roshko (JFM 1994). It has been made clear topologically also that the unstable local surface excitations are the seeds from which upright vortices grow. The near-wall flow topology as extracted from the simulated data appeared quite consistent with the experimental predictions of Kelso, Lim & Perry (JFM

1996), for a round jet. Computations were performed for two moderate values of the Reynolds number 225 and 300, based on the jet width and the average cross-flow inlet velocity, and for two different values of the jet to cross-stream velocity ratio, 2.5 and 3.5. (Amalendu Sau and Robert R. Hwang)

3. Physics of Complex Fluids

(1) Electromagnetic effects on material growth

Solidification material processes can be controlled by heat transfer, mass transfer, convection, thermodynamic and dynamic technique. The most popular one is applying an electromagnetic field during material processes. Besides the computational fluid dynamic equations, the Maxwell equations are coupled for the crystal growth facilities. The Maxwell equations are cast into conservative form similar to those of computation fluid dynamics. The applied electromagnetic forces reduces the convection. Thus the temperature distribution is more uniform compared with that of general condition. Furthermore, the effects of Lorentz force on micro-gravity material process can improve the product quality. (Lai-Chen Chien)

(2) Surfactant driven instability in a Hele-Shaw Cell

The interfacial instability of a moving air-liquid interface moving in a Hele-Shaw cell is studied. From the classical Saffmann-Taylor result, the interface will become unstable only when the less viscous air is pushing on the more viscous liquid. However, in our experiment, we have observed that an instability will develop even when the liquid is pushing the air if the liquid used in an aqueous surfactant solution. Detailed analysis of the experiment has revealed that a wetting layer on the air side of the interface on the all of the Hele-Shaw cell is needed to produce the observed instability. Based on this observation, a phenomenological model is constructed to explain the observed experimental results. The main hypothesis of the model is that surfactants accumulated on the advancing interface will either dissolve into the bulk to form micelles or diffuse into the wetting layer on the wall. Instability of the interface will occur when the diffusing front of the surfactants in the wetting layer becomes unstable. In this aspect, the surfactant driven instability is very similar to that observed in directional solidification where the instability of the solidification front is controlled by the diffusion of impurities ahead of the front. Experiments are planned in the future to observe this diffusion front directly. (Chi-Keung Chan)

(3) Collapse of a granular pile

Usually, avalanches in granular systems are studied on granular piles by adding the granular material on the top of the piles either randomly or at a particular location to induce avalanches. However, in actual situations, another type of avalanches can also be produced in granular system by the removal of grains or collapse of structure close to the bottom of the pile. For example, in the landslide close to rivers, the collapses of nearby slopes are mainly due to the erosions of the river bed. Despite the practical importance of these avalanches, very little is known about the properties of these avalanches. An experimental investigation of the scaling properties of a collapsing rice pile induced by reducing the length of the base support of the pile is carried. It is found that two angles of repose are needed to describe the shape of the collapsing granular pile. Corresponding to these two angles of repose, the collapse of the granular pile can be characterized by local and global avalanches. Furthermore, it is found that the probability distributions of the avalanches depend on the sizes of the avalanches under consideration. (Pik-Yen Lai, Chi-Keung Chan)

(4) Nonlinear phenomena in chemical and biological systems

As it is generally observed, nonlinear phenomena is a cross-discipline study. With the new laboratory facilities which will be finished next year in place of the old library, we will be able to conduct experiments in systems of chemical and biological nature. The chemical system we have in mind is the Belousov-Zhabotinsky (BZ) reaction in which nonlinear temporal and spatial behaviors can be observed. We will be interested in the dynamic control of the pattern formation properties of such a system. As for the biological system, we will begin by carrying out preliminary studies in the aggregation behaviors of the slime mold (Dictyostelium). Similar to other pattern formation systems, interesting patterns can be created during the aggregation of the slime mold. We are interested in the non-linear dynamics of the collective behaviors of the individual ameoba in the slime mold. (Chi-Keung Chan)

(5) Effect of polymer on the critical behavior of binary liquid mixture

We studied the effects of a high molecular weight polymer (Polyacrylic Acid, PAA) on the critical behavior of a binary liquid mixture (Lutidine + Water, LW). A high precision refractometer was built to measure the temperature dependence of the refractive indexes of the two coexisting phases after the sample has phase separated. From the refractive indexes we mapped out the coexistence curve in which composition difference $\Delta c \sim (T - Tc)^{\beta}$. Here β and Tc are, respectively, the sample temperature and the critical temperature of the sample. We found $\beta = 0.40 \pm 0.01$ for the LW with 0.7 mg/cc PAA which is different from that ($\beta = 0.31 \pm 0.01$) of pure LW. (Kiwing To)

(6) Jamming of granular flow in two- and three-dimensional hoppers

We studied the jamming phenomenon of granular flow in two-dimensional hoppers. We fabricated a semi-automatic setup to measure the jamming probabilities of mono-disperse metal disks (5 mm diameter, 3 mm thick) flowing in the hoppers whose opening can be varied. We found that the jamming probabilities are smaller in asymmetric hoppers than that in their respective symmetric counter part. We also investigated the jamming phenomena of granular flows through three-dimensional hoppers with rectangular opening. Stainless steel spheres were used as the particles of the granular system and the jamming probabilities J(d, b), as a function of the opening size defined by distance d and breadth b, were measured for different (d, b) combinations. We also constructed a semi-automatic experimental setup for creating flows, detecting congestion and capturing images of the configuration of jamming particles. By adjusting hopper opening sizes, we found the correlation between opening size (d, b) and the jamming probability. (Kiwing To)

NUCLEAR PHYSICS AND ACCELERATOR-BASED PHYSICS

1. Experimental Nuclear Physics and Accelerator-Based Physics

(1) Laser Electron Photon Experiment

(2) PHENIX Experiment at RHIC

(3) Monitoring both PIXE Analysis and Radioactivity Determination to River Water and Sediment Samples

(4) Stopping Power and Energy Straggling Measurements by Using a Partial Coated Si Detector

2. Theoretical Nuclear Physics

(1) A Local Density Approximation Treatment for the Pauli Exclusion Operator in Hypernuclei

(2) Two-frequency Shell Model for Hypernuclei and Meson-exchange Hyperon-Nucleon Potentials

(3) B0→D*+D*- Decay Mechanism

(4) Quantum Bit Commitment

1. Experimental Nuclear Physics and Accelerator-Based Physics

(1) Laser electron photon experiment

Since 1998 we have been collaborating with the LEPS (Laser-Electron-Photon) experiment at SPring-8, Japan. The objectives are to study the vector meson photo-production and its related physical implications. We had finished the design and construction of the time-of-flight (TOF) detector array which consisted of 40 200cm(L)*12cm(W)*4cm(T) plastic scintillation bars. We achieved the time resolution of the TOF system to be about 100ps for each scintillation bar, it is good enough to separate pions and kaons at 2 GeV/c by the mass cut.

The first physical run of the experiment were performed during the period of May, 2000 to June, 2001. In these runs, polarized laser light of wavelength 488 and 351 nm were shined on the 8 GeV electron beam of SPring-8 synchrotron to produce 1 - 2.4 GeV backscattered polarized gamma and then to induce vector meson production. A 65 mm thick CH_2 and liquid hydrogen target plus various nuclear targets were used separately in the experiments. The signal detecting system was arranged in a series of Cerenkov counter - SSD vertex detector-drift chamber - magnetic dipole spectrometer - drift chamber (*2) - TOF array. A clear signal of φ mesons via K+K- reconstruction and interesting K+ decay asymmetry with respect to the photon polarization is seen from the preliminary analysis of the collected data. We have finished up the system calibration and final analysis finished in year 2002 and will get the results published soon.

At the same time, we constructed 1200-channel Flash ADC modules: 10 bits read out and 40 MHz sampling rate this year. These modules is the main component of read-out electronics for Time-projection chamber, the major detector upgrade for LEPS experiment. The detector and electronics will be installed in the Feb, 2003 and commission runs start immediately afterwards. After the success of commission runs, we will take data for the physics subject of nuclear medium effects of vector mesons and KΛ production.

(C.W. Wang and W.C. Chang)

(2) PHENIX experiment at RHIC

We participate in the PHENIX experiment at the Relativistic Heavy Ion Collider (RHIC), Brookhaven National Laboratory. Heavy ion runs of Au+Au at 200 GeV/c in Yr 2001-2002 has proven the performance of the detector systems and the centrality dependence of charged particle multi-plicities has been measured. Three journal publications are referred to http://www.phenix.bnl.gov/phenix/WWW/run/phenix/publications.html .

Next beam run including heavy ion runs and pp runs started from the winter of Yr 2002 and will last till the spring of Yr 2003. Detailed study using energy loss method (dEdx) to improve the particle identification of low momentum e, π and K particles is going on. The strangeness production of ψ mesons in Au+Au collisions at = 200 GeV/c via K+K- and e+e- channel will be investigated as one of the signatures of Quark-Gluon Plasmas.
(W.C. Chang)

(3) Monitoring both PIXE Analysis and Radioactivity Determination to River Water and Sediment Samples

According to the research project of Shanghai Environmental Specimen Bank (SESB) and combining with Shanghai government's plan on comprehensive harness of Suzhou River, we collected water and sediment samples in the every spring season since 1998. The elemental analysis of sediment water samples was performed by PIXE technique at Taipei Institute of Physics, with 3x2 MeV NEC Tandem accelerator. The characterization and radioactive levels for water and sediment samples was measured using BH1216 low background radioactive instrument at Shanghai Institute of Nuclear Research. PIXE results showed that the elemental contents of Cl, K, Ca, Cr, Mn, Fe, Zn and Pb were gradually decreased with the rising tide. The arrival of high tide, their contents were minimum, then ones again increased up on the ebb tide. The analysis also demonstrated that the radioactivity of water samples had been decreasing year by year. It was found that a decline speed of radioactivity was a little quicker than that of radioactivity. Moreover, further aspects of environmental data evaluation and assessment were also discussed in detail.
(Y.C. Yu)

(4) Stopping Power and Energy Straggling Measurements by Using a Partial Coated Si Detector

The stopping power and energy straggling of gold film bombardment by 1.5-6.5 MeV carbon ions were measured using a partial coated Si detector. The new method developed by our group is believed to give more straightforward and reliable stopping power values. The uncertainty in this experiment is estimated to be less than 1 %. Energy dependence of stopping powers were obtained and compared to the SRIM predictions. The SRIM calculations reproduce the experimental data very well.
(Y.C. Yu)

2. Theoretical Nuclear Physics

(1) A local density approximation treatment for the pauli exclusion operator in hypernuclei

An attempt is made to simplify the complications of computing hyperon-nucleon G-matrix elements arising from the Pauli exclusion operator contained in the integral equation. We perform a two-frequency shell model folded-diagram calculation on hypernuclei using two different treatments for the Pauli exclusion operator Q_2, namely, a local density approximation where Q_2 is replaced by a nuclear-matter Pauli operator $\overline{Q}(\rho)$ with ρ being a density parameter, and an exact calculation where Q_2 is expressed in terms of shell model wave functions. With a proper choice of ρ, it is possible to reach a reasonable accuracy by using the local density approximation Pauli operator. For heavy hypernuclei, this $\overline{Q}(\rho)$ can be used to save tremendous computing time.

(Y.H. Tzeng)

(2) Two-frequency shell model for hypernuclei and meson-exchange hyperon-nucleon potentials

A two-frequency shell model is proposed for investigating the structure of hypernuclei starting with a hyperon-nucleon potential in free space. In a calculation using the folded-diagram method for ${}^{16}_{\Lambda}O$, the Λ single particle energy is found to have a saturation minimum at an oscillator frequency $\hbar\omega_\Lambda \approx 10$ MeV, for the Λ orbit, which is considerably smaller than $\hbar\omega_N = 14$ MeV for the nucleon orbit. The spin-dependence parameters derived from the Nijmegen NSC89 and NSC97f potentials are similar, but both are rather different from those obtained with the *Jülich— B* potential. The ΛNN three-body interactions induced by ΛN - ΣN transitions are important for the spin parameters, but relatively unimportant for the low-lying states of ${}^{16}_{\Lambda}O$.

(Y.H.Tzeng)

(3) $B^0 \rightarrow D^{*+}D^{*-}$ Decay Mechanism

The Cabibbo-suppressed decay $B^0 \rightarrow D^{*+}D^{*-}$ is a promising channel for searches of CP violation in B^0 meson decays at future B-factories. In 1999, this reaction was first observed by the CLEO collaboration at the Cornell Electron Storage Ring (CESR). The measured branching ratio for this decay mode is about 6.2×10^{-4}. Now, in order to use this decay channel to study CP violation, we must first understand the reaction mechanism. Using the field theoretic approach for heavy mesons we have developed in recent years [2],we study this reaction in the heavy quark limit. The basic decay

amplitude for $B^0 \rightarrow D^{*+}D^{*-}$ is expected to be dominated by the quark level processes of b $\rightarrow cW^+, W^+ \rightarrow cd$. This reaction is rather special, in the sense that all the mesons involved are heavy. The field theoretic approach for heavy mesons we developed recently provides an ideal framework in which to study this decay. In our approach, the wave function of a heavy meson is represented by an effective meson-quark-quark vertex. Therefore the decay process corresponds to a Feynman diagram which can be calculated with standard methods.
(C,Y, Cheung)

(4) Quantum Bit Commitment

Bit commitment is an important cryptographic protocol which involves a sender and a receiver. The sender has a bit (b=0 or 1)in mind,which he wants to disclose to the receiver at a later time. The protocol is secure if (1) the sender cannot change his mind without being discovered, and (2) the receiver has no way of obtaining any information about the commitment before the sender disclose it. In this work, we propose a new quantum bit commitment scheme which is unconditionally secure. The key observation we make is that, by random permutation of particles, two appropriately prepared quantum mixtures with distinguishable density matrices can be rendered indistinguishable to another observer. Consequently, in our new scheme, the sender can encode the committed bit in a quantum mixture with commitment dependent density matrix (so that the sender cannot cheat), and randomizes the order of the particles to conceal the information from the receiver. Our result shows that quantum bit commitment can be unconditionally secure.
(C.Y. Cheung)

PARTICLE PHYSICS

1. Experimental High Energy Physics

(1) ATLAS experiment
(2) The Fermilab CDF Collaboration
(3) Neutrino and Astroparticle Physics Group
(4) AMS experiment

2. Particle Phenomenology

(1) Study of charmless and charmful baryonic *B* decays
(2) Nonresonant three-body decays of *D* and *B* mesons
(3) Weak annihilation and the effective parameters a_1 and a_2 in nonleptonic *D* decays
(4) Hadronic $D \rightarrow SP$ decays
(5) PQCD study of exclusive *B* decays - k_T factorization theorem
(6) Threshold resummation
(7) Three-body nonleptonic *B* decays
(8) Symmetry breaking effects in heavy mesons
(9) Out of equilibrium and RHIC physics
(10) Direct photons: a nonequilibrium signal of the expanding quark-gluon plasma at RHIC energies
(11) Photon production from nonequilibrium disoriented chiral condensates in a spherical expansion
(12) Field theory
(13) Nonperturbative bound on high multiplicity cross sections in ϕ^4 theory in three dimensions from lattice simulation
(14) *p*-brane production in fat brane or universal extra dimension scenario
(15) Quantum bit commitment

3. Particle Astrophysics and Cosmology

(1) Primordial magnetic fields from dark energy
(2) Constraining evolution of quintessence with CMB and SNIa data
(3) Time-dependent correlation of primordial cosmic perturbations in the inflationary cosmology
(4) Observational strategies of CMB temperature and polarization interferometry experiments
(5) SPOrt: an experiment aimed at measuring the large scale cosmic microwave background polarization

1. Experimental High Energy Physics

(1) ATLAS Experiment

The European Laboratory of Particle Physics (CERN) is building the World's largest hadron collider, the Large Hadron Collider (LHC), which is expected to commission in 2006 and will allow us to explore the new frontier of physics at the TeV energy scale.

Two general purpose detectors, namely ATLAS and CMS, are being constructed for LHC experiments. The high energy physics group of the Institute joined ATLAS Collaboration in September 1999. The Memorandum of Understanding (MoU) between CERN and the National Science Council (NSC) was signed in April 2001.

The first task of the Taiwan team in ATLAS was to develop an optopackage of the size of 5.5mm x 5.5mm x 1.6mm to house two VCSEL's (Vertical Cavity Surface Emitting Laser) and one PIN diode. The optopackage is the key component in the optolink of the Semi-Conductor Tracker (SCT) to readout the 6 million channel silicon microstrip subdetector of the ATLAS. Oxford University had been collaborating with GEC-Marconi to develop such a package without much success and the optical link of SCT was becoming a critical item when Taiwan joined ATLAS.

One of the main difficulty of building such an optopackage is the constraint of 1.6mm on its height. Ming Lee Chu overcame the difficulty by developing a method of polishing the fiber end to 45° and directly coupled to the VCSEL by total refection. By October 2000, the optopackage (Fig. 1) designed by Ming Lee was selected by ATLAS to be used in the SCT optolink. Moreover, Mike Tyndel, the leader of the UK group and the SCT project, asked Taiwan to take the responsibility of developing a way of assembly of the 800 opto-harnesses (Fig. 2), the essential part of the SCT optolink.

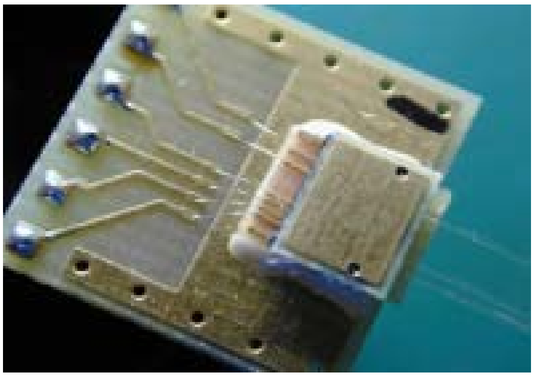

Fig. 1 optopackage for SCT

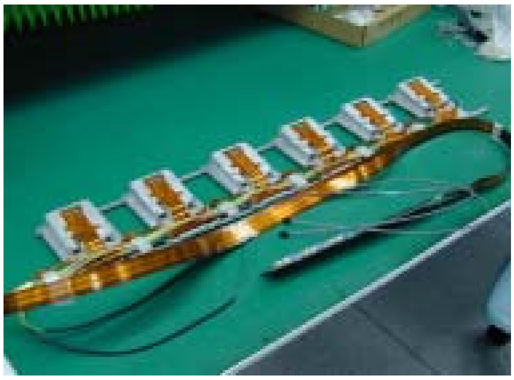

Fig. 2 optoharness for SCT

The production readiness review (PRR) of the barrel harness was held at Academia Sinica and Radiantech Inc. Taiwan in November 2001 and the production procedures for the harnesses were approved. There were several design changes since then to accommodate the needs of mechanical design、thermal design and integration as well as some unexpected problems that surfaced. In particular, it was found in summer 2002 that the light leakage from the optopackage and the radiation tolerant fiber resulted in non-negligible noise at the sensor module of SCT. The leakage from fiber can be reduced to acceptable level by using black furcation tubing instead of colored ones. It is not so easy to make the optopackage light-tight since the requirement was not forseen and not built into the design. Fortunately Ming Lee came up with a solution without modifying the basic design of the optopackage.

6 pre-series harnesses were made at Radiantech and delivered to the Rutherford Appleton Laboratory (RAL) in June 2002. Besides the light leakage of optopackage mentioned above, 19 problems were identified. Most of them are related to connectivity, namely cold soldering, bad connection at connecters and current leakage at high voltage. All these problems are understood and can be solved in future production. Most of the solutions, including light-tightness of the optopackge, were implemented in the last 2 pre-series harnesses that were shipped to RAL in December 2002. There were a few incidences of broken DORIC, the receiver ASIC of PIN provided by RAL. This can be solved by screening the chips before die-bonding. We are in the process of investigating the causes of the breakdown.

The other major responsibility for Taiwan team in SCT is to provide the 12-channel VCSEL and PIN array modules (Fig. 3, 4) for use in the readout driver (ROD) of both SCT and PIXEL. The VCSEL arrays are used to send trigger, timing and control (TTC) signals to the on-detector PIN's.

Fig. 3 VCSEL array module for readout driver of SCT and PIXEL

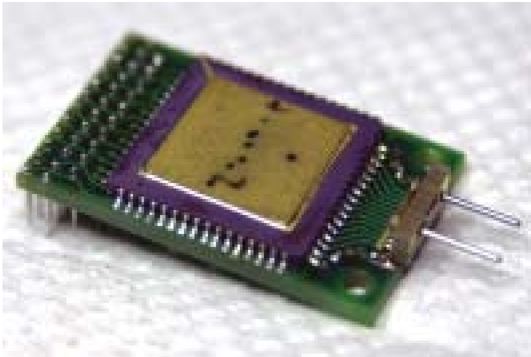

Fig. 4 PIN array Module

The responsivity of PIN decreases as the radiation doses increases and could become as low as 1/3 of its original value. Moreover, the on-detector PIN is susceptible to single event errors. Thus a high threshold for on-detector PIN is desired and that implies we need high-power off-detector arrays with a spec of greater than 1mW per channel. These are not available commercially at affordable price. Our team provides the only viable solution for ATLAS.

For the PIXEL detector of ATLAS, Taiwan team is also responsible for providing the optopackage for data readout and TTC signals reception. Ming Lee had invented an inexpensive way of producing opto arrays (Fig.5) and had argued for the advantage of using such arrays on detector to replace an optopackage housing 8 individual VCSEL's or PIN's. This is finally accepted by the PIXEL community. The final design review (FDR) for the PIXEL optical link will be held in February 2003.

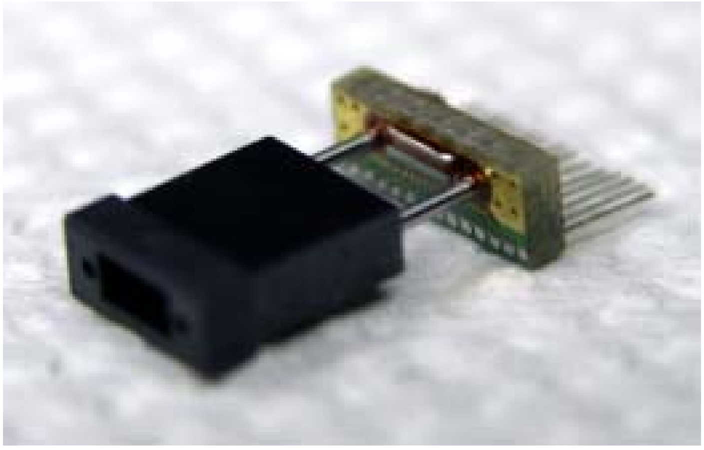

Fig. 5 opto array for PIXEL on-detector optolink

The Taiwan team is also responsible for providing the high speed (1.6GHz) transmitter and receiver modules for the optical link of the Liquid Argon Calorimeter (LAr). In September 2002, it was found that the receiver module we designed is susceptible to electromagnetic interference (EMI). This is solved by adding a shielding box and designing a better receiver board.

CERN had decided to implement the idea of Grid Computing for the LHC project. The LHC Computing Grid Project (LCG) which is to build a prototype computing grid to test the LHC computing models was initiated in late 2001 and will continue to 2005. The required resources for LCG are mainly provided by CERN member states but non-member states like Taiwan are also allowed to contribute to manpower and hardware. Dr. Di Qing formally joined LCG project and worked on LCG full time since September 2002. The director of the Computing Center of Academia Sinica (ASCC), Simon C.C. Lin, is now a member of the Grid Deployment Board (GDB) representing Taiwan. LCG is expected to test the first version of Grid firmware in the first half of 2003. Dr. Zhongliang Ren has been participating in ATLAS mock data challenge (DC). ATLAS data challenge will start to utilize and stress-test the LCG grid in March 2003. ASCC is in the process of being recognized as a Certification Center. We had installed and tested the EU-Data Grid (EDG) firmware v.1.4.0. and will try to have a combined test with EU-Grid in early 2003.

Grid computing is expected to be the "next big thing" of information technology and application. It may very well change the way we use computing resources whether it is for commercial、industrial or research purpose. As in the case of World-Wide-Web, the need of high energy physics research is once again leading and guiding the revolution. ASCC and the Institute is working hard to keep Taiwan abreast of the ensuing change.

(2) **The Fermilab CDF Collaboration:**

For the next decade, Fermilab Tevatron Collider remains the highest energy frontier of particle physics. With the completion of Main Injector (which will enhance the luminosity) and with the upgrade of the collider detectors (CDF and D0), Tevatron Run II provides the potential for discovery of new phenomena and opportunities for the precision measurements in hadron collider physics.

In a press release on March 1, 2001, Fermilab Driector Michael Witherell announced the start of Collider Run II at Tevatron, the highest energy particle accelerator now operating in the world. "I am delighted that we are starting Run II on time," Witherell said. "Now we can look forward to the excitement of seeing new physics results. We can't predict what Nature has in store for us. All we can guarantee is the opportunity for discovery."

The Run IIa operation is slowly improving for stable performance. The Tevatron luminosity is a major concern for improvement. During the second week of October, Tevatron achieved an all-time record of $6.7pb^{-1}$ in a single week. The prospect for the Run IIa integrated luminosity is $3fb^{-1}$ and a peak instantaneous luminosity of 2×10^{32} $cm^{-2}S^{-1}$.

Year 2002 was a busy year for our group as usual. Two new members joined us in this year. Rong-Shyang Lu joined in mid October as a postdoctoral fellow. Roman Lysak (Slovak), who did his master thesis with Jaroslav Antos, joined us as a full time assistant in November. Unfortunately Miroslav Siket has to return to Slovakia at the end of the year due to the expiration of the US visa.

The major activities of our group members in CDF can be categorized into three areas. In the following, we briefly summarize the progress made in year 2002

1. DOIM/SVXII Project

The Run II CDF detector upgrade addressed the issues related to shorter beam crossing time with a completely rebuilt DAQ and trigger system. The vertex detector has a larger silicon detector to improve tracking efficiency and enhance b-tagging at larger rapidity. The silicon detector is a combined system of L00, SVXII and ISL detectors providing up to 8 layer measurements. Academia Sinica is responsible for the optical readout system for the silicon detector. A total of 700 pairs of Dense Optical Interface Module (DOIM) have been successfully produced in summer, 2000.

In October 2000, a commissioning run of the CDF Detector was carried out. A "Barrel 4" Silicon detector was also installed to the performance of the silicon and the link. Twenty-eight pairs of DOIM were used for the optical readout. On Oct. 14, the first silicon hit was observed. It marks the milestone of the high energy physics experiment as it is the first time the silicon data were readout via optical link. The CDF Detector was rolling into the Collision Hall in January 2001 immediately after the insertion of the silicon detector into the CDF Detector.

Various problems have been encountered since then and most of the efforts of the silicon team are given to solve the problems in order for the smooth operation of the silicon detector. Much progress has been made in commissioning the silicon detector. Major problem is the unstable of the power supply. Many cooling problem was fixed during the scheduled six weeks maintenance shutdown in October 2001. However, two sections of the cooling pipe in ISL were still clogged and one with insufficient cooling. Several ladders were irrecoverably damaged during operation (e.g. beam incident of March 30,2002).

A total 570 DOIM module pairs were implemented in the readout system of the Silicon tracker. The DOIM optical link had gone through a major checkup for bit error problems too. The total channels giving errors were reduced to about a dozen channels. The examination includes a check up of all fiber channels before entering the FTM boards. RX modules for those having bit error were all replaced. Lately we gather clue pointing to freaky circuits and pin contacts for transmitting ECL signals, mostly on the receiver board. The efforts were rewarded for more stable optical link performance, and we aim for limiting the cause to those get damaged upstream inside the detector, of about 2% of the total modules.

Currently a stable running condition of the silicon detector has been achieved. The DOIM performance is expected to remain stable and the radiation damage is expected to be lower than the silicon detector or other portcard components.

The silicon detector is 90% currently operational and 80% fully functional. Summary on the DOIM performance is reported in a CDF note in preparation and a presentation at the Vertex 2002 Conference.

2. Production Farm Activities

Production farm has been working steadily for the past couple of years without problems. However, a lot of changes were required in the past year, mostly due to the changes in the design and organization of the Farm with respect to the other components of CDF, primarily Data Handling part.

We have implemented transition from the single I/O machine with DIM (Disk Inventory Manager) managed space towards Enstore system and its direct approach to the tape drives. The Enstore system allows data to be read-in in parallel via eight PC's thus removed the I/O bottleneck from the stage-in step. We have optimized access to the tapes drives to serve CDF Production Farm. Also, the overall throughput requirement has changed for the Farm due to the increased demand on the re-processing. Rapid development of the software at CDF led to the need of re-processing of data several times. That led to new requirement on the overall throughput of the Farm.

Therefore we have changed the design of the Farm to accommodate that requirement and we have departed from the model of the single I/O machine towards distributed farm model - i.e. all of the I/O tasks have been redirected to the Farm. That required change in several subcomponents of the software as well as the network configuration. That has been done. Preparations have been also done with respect to future changes - dCache, SAM, and other Grid oriented approaches. We have done further steps to increase the overall performance of the Farm by using worker node disk sharing mechanism developed at Fermilab together with us - so called dFarm (disk farm).

We have also organized good run selection mechanism and validation framework to accommodate easier validation within the CDF in order to determine physics quality data.

In order to tune the detector and optimize the trigger, special test run were taken from time to time. For those special validation runs we have devised a mechanism within the Production Farm framework to allow fast turnaround. This proves the timely information of the detector system.

Super Express Stream has being run by our group as well for day-to-day validation purposes. Data are processed in the fastest way by using the L3 trigger constants only without waiting for the normal calibration constants.

Production Farm has allowed us to take steps in presentation of the physics for the public. We have devised a web page where we show Live Events from the CDF experiment on the web. The page can be found at

http://fnpcc.fnal.gov/event_display.php

or at

http://www.fnal.gov/pub/now/live_events/

3. Physics Analysis

The CDF Run IIa operation has accumulated more than 100 pb^{-1} data. The preliminary physics results are reported in conferences showing compatible performance to the Run I results and improvement with new detector features. With the new data that CDF is getting at the present moment, we have opportunity to look for the new physics as well as understand better Standard Model. Many activities have been done with respect to that -

3.1 Studies of the Pythia generator level of $t\bar{t}$ sample in order to determine top mass and to determine the most precise and efficient mechanism to extract that information. Full kinematics approach has been adopted where one tries to determine any missing piece of information by calculating the most probable value. The agreement has been achieved up to a good precision.

3.2 The same has been done with the current MC sample with the simulation of the CDF detector included. Even though the MC simulation at CDF is not yet at the end of its development, adequate results have been achieved.

3.3 For the comparison we have applied the same mechanism to the Run I data and the outcome was in agreement with the previous published results.

3.4 The search for the new $t\bar{t}$ events in the dilepton channel has been done for the Run II data. At the moment we have positively identified about 2 $t\bar{t}$ dilepton candidates in about $30pb^{-1}$ of the good physics quality data.

3.5 All of the above have been presented at the regular meeting of the top dilepton group in CDF and we have established a good name.

3.6 The prospect is to produce the $t\bar{t}$ cross section and top mass for the early winter conferences in 2003.

(3) Neutrino and Astroparticle Physics Group

Group Members at the Academic Sinica (2001-2002):

Chang Chung-Yun[1], Chang Wen-chen, Chen Chin-ping, Hsu Hui-Chin, Iong Chan-Hin[2], Jon Guo-Ching, Lai Wen-Ping[3], Lee Feng-Shiuh, Lee Shih-Chang, Li Hau-Bin, Li Jin[4], Lin Feng-Kai[5], Lin Shin-Ted[6], Liu Da-Zhi[7], Nie Jing[3], Qiu Jin-Fa[3],

[1] Visitor from University of Maryland, USA

[2] M.Sc. student from National Chiao Tung University

[3] Visitor from Chung Kuo Institute of Technology, Taipei

[4] Visitor from Institute of High Energy Physics,Beijing

Venktesh Singh, Su Da-Shun, Teng Ping-Kun, Wang Xin-Wen[3], Wong Tsz-king[8], Wu Shih-Chiang, Xin Biao[9], Yue Qian[3]

Abstract

The research program and infrastructures of the "TEXONO" Collaboration continues to enhance and consolidate around the theme of adopting scintillating crystal and solid state detectors for low-energy low-background neutrino experiments. The construction of the "Kuo-Sheng Neutrino Laboratory" at the Nuclear Power Station II has been completed. The first physics data taking period from June 2001 till April 2002 was successfully completed. The magnetic moment results are among the best in the world, while various analysis are being pursued. The second data period with improved shieldings and detector configurations are being prepared. Various R&D efforts are pursued. This report summarizes our status, achievements and plans.

1. Research Program and Status

A Collaboration has been built up since 1996 to initiate and pursue an experimental program in neutrino and astro-particle physics in Taiwan. At present, the "TEXONO"[10] Collaboration comprises more than 50 scientists with diversified expertise from Taiwan (Academia Sinica, Chung Kuo Institute of Technology, Institute of Nuclear Energy Research, National Taiwan University, and the Kuo-Sheng Nuclear Power Station), Mainland China (Institute of High Energy Physics, China Institute of Atomic Energy, Tsing Hua University) and the United States (University of Maryland).

Since mid-1997, the research program of the Collaboration has been around the theme of exploring the physics potentials and experimental realization of scintillating crystal and solid state detectors in low-energy low-background experiments (Ref. [2]).

The "flagship" efforts have been the design, construction and execution of a "pilot experiment" near the reactor core of the the Kuo-Sheng Nuclear Power Station. Using reactor neutrinos as probe, the physics program is to study various neutrino interactions at keV-MeV energy range (Refs. [3, 4]). Various R&D efforts are also

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[5] M.Sc. student from National Tsing Hua University

[6] Ph.D. student from National Taiwan University

[7] Visitor from Tsing Hua University, Beijing

[8] Principal Investigator

[9] Visitor from the China Institute of Atomic Energy, Beijing

[10] Taiwan EXperiment On Reactor NeutrinO.

pursued, profiting from the infrastructures and connections built up along the way.

By November 2002, the construction of the "Kuo-Sheng" (KS) Neutrino Laboratory has been completed (and several distinguished guests have already visited our site). It is equipped with a versatile electronics, data acquisition and control systems (Ref. [5]), as well as a general-purpose shielding infra-structures with cosmic-ray active veto. Extensive background measurements have been done on-site. Data taking of the first Reactor ON/OFF cycle from June 2001 till April 2002 focuses on the search of neutrino magnetic moments with a top-of-the-line Ultra Low Background High-Purity Germanium Detector (HPGe) as well as 46 kg of CsI(Tl) crystal scintillators. We have achieved world-level sensitivities in this important neutrino parameter. The KS limits on neutrino magnetic moment $\mu_\nu < 1.3(1.0) \times 10^{-10} \mu_B$ at 90(68)% confidence level and radiative decay lifetime $m_\nu^3 \tau_\nu > 2.8(4.8) \times 10^{18}\ eV^3 s$ are among the best in the world. We have achieved much lower threshold compared to previous efforts, and the background level at this energy is comparable to those from underground Dark Matter searches. A paper on these first results has been submitted for publication [13, 14]. The unique low energy data allows us to pursue several other analysis, including: (a) calculation and analysis of electron neutrino from reactors, (b) inclusive search of anomalous neutrino interactions with visible energy larger than eV, and (c) looking for possible neutrino-induced nuclear transitions.

Meanwhile, improved shielding configurations for the HPGe system, and a total of 186 kg of CsI(Tl) crystals were installed at the KS site for the 2nd data taking period from January till July 2003. Besides improving on the neutrino magnetic moment sensitivities, the goals are to perform a measurement of the $\bar{\nu}_e$ - e cross-section at the MeV range, and to study various standard and anomalous neutrino interactions.

On the R&D fronts:

(i) The feasibility studies for Dark Matter searches have completed, which includes a neutron calibration measurement done at CIAE (Ref. [10]), where we produced the best data for CsI(Tl), and performed a first direct verification of the optical model calculations. A Korean group (KIMS) will perform a full-scale experiment in Korea with CsI(Tl). Beijing Tsing Hua University, a TEXONO collaborating institute, participated on behalf of the group by sending a Ph.D. student.

(ii) An upgraded FADC (Flash Analog Digital Convertor) module has been successfully commissioned for the SPring-8/LEPS experiment (where AS Nuclear Physics group participates). It makes major improvement over the present system by having 32 channels per module, 40 MHz sampling rate and 10-bit resolution, and is equipped with on-board processing capabilites via the FPGA techniques. A 1000-channel system is being produced in Taiwan for LEPS. Plans are drawn to integrate that to the TEXONO-KS system.

(iii) A pilot "demonstration" measurement with AMS on ^{129}I and ^{40}K was successfully performed at CIAE in 2000, with a complete measurement on ^{40}K in 2002.

(iv) A paper was published on our previous work on GSO (Ref. [6]) while other crystals like Yb-loaded scintillating crystals as well as lutetium orthosilicate (LSO) are being explored.

(v) We also initiate the study of aa "Ultra Low Energy" HPGe which may get down to 300 eV threshold. If this would be successful, we will consider doing the first measurement of neutrino coherent scattering on the nucleus.

2 Publications

The complete list of published work and technical reports of the Collaboration as well as selected photos and transparencies can be retrieved from our Web-site: http://hepmail.phys.sinica.edu.tw/~texono/ or are available upon request from HTW. The articles based on the various research efforts of the Collaboration published in SCI-journals *since 2000* include:

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3 Outlook

The TEXONO Collaboration and its extensive connections and infra-structures has been built up in the past few years. The focus is on the frontiers of low-energy low-background experiments for neutrino and astro-particle physics. The first goals of performing the first particle physics experiment in Taiwan *and* building up the first Taiwan-China big research collaboration are successfully achieved. The Kuo-Sheng Neutrino Laboratory has been commissioned. Our first results include a world-level sensitivity for neutrino magnetic moment searches, and one of the lowest background level for a surface experiment. Complementary to the flagship program, various R&D projects are pursued, and possible future directions are being explored.

The protocols for large-scale scientific collaboration between Taiwan and Mainland China are being explored and established along the way. Many joint articles have already been published. Much international interest, recognition and respect have been generated by these efforts. Our research program and results have been presented in four international meetings (including important events like WIN02, Neutrino02, PaNic02) in 2002.

Based on the foundations built up in the last five years, we will continue to strive to achieve higher grounds.

(4) AMS Experiment

AMS-02 is an international collaborated project led by Professor S.C.C. Ting to build the first precision magnetic spectrometer (Fig.1) to be placed on the International Space Station (ISS) for three years (2005~2008) to search for anti-matter and dark matter in the Universe. Observation of a single anti-carbon will imply the existence of anti-stars. AMS-01, which is a simplified version of AMS based on a permanent magnet, was on board the shuttle Discovery for a 10 day test flight from June 2~12, 1998. Analyzing the data collected led to several unexpected discoveries[2~5]. The major results are summarized in the Physics Report [6]. An anomalous cosmic ray event, which is a candidate for strangelet [7], a new form of matter, was identified recently (Fig. 2).

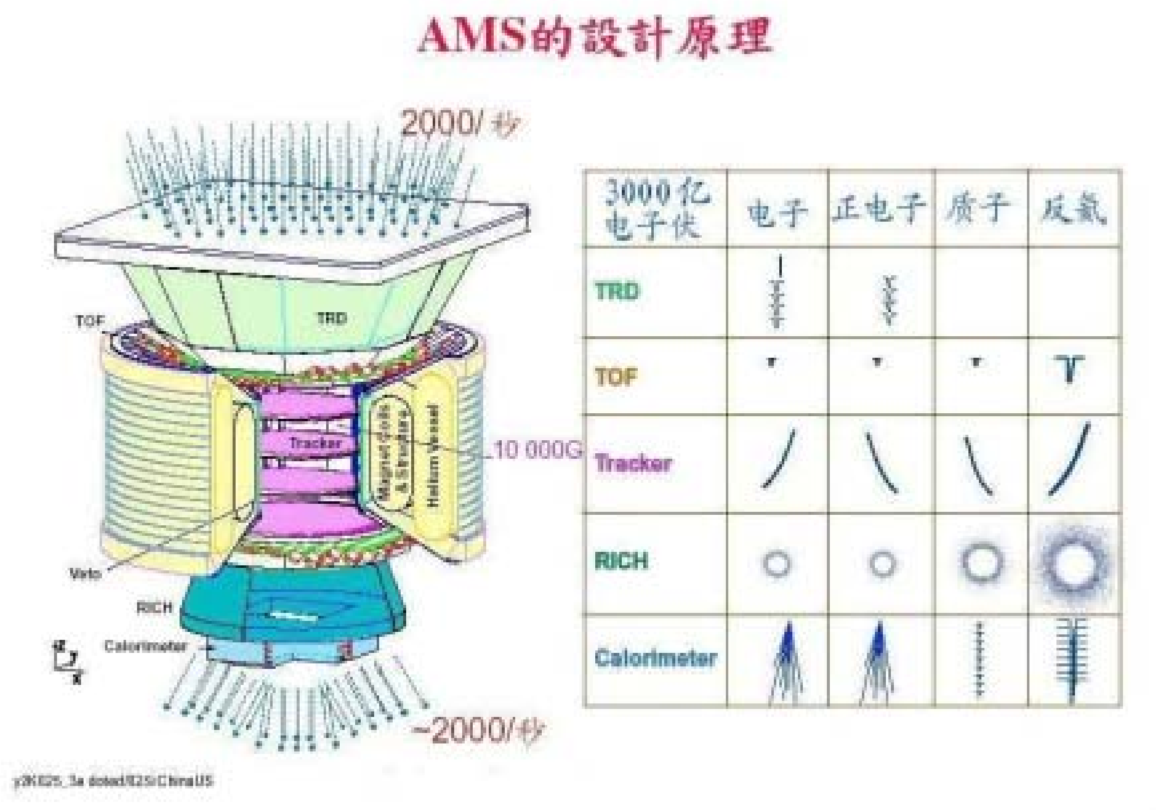


Fig. 1 AMS-02 a precision magnetic spectrometer

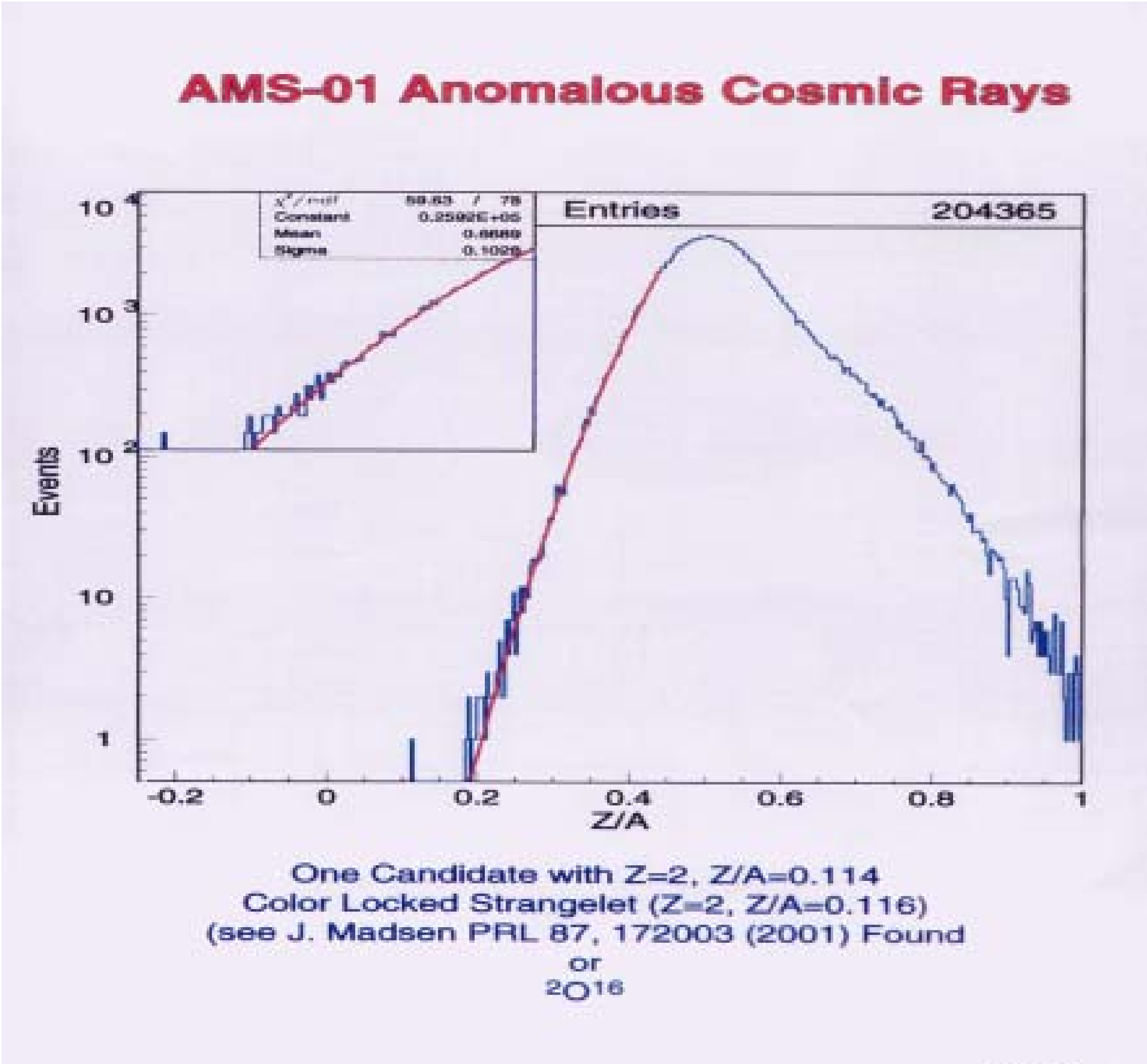
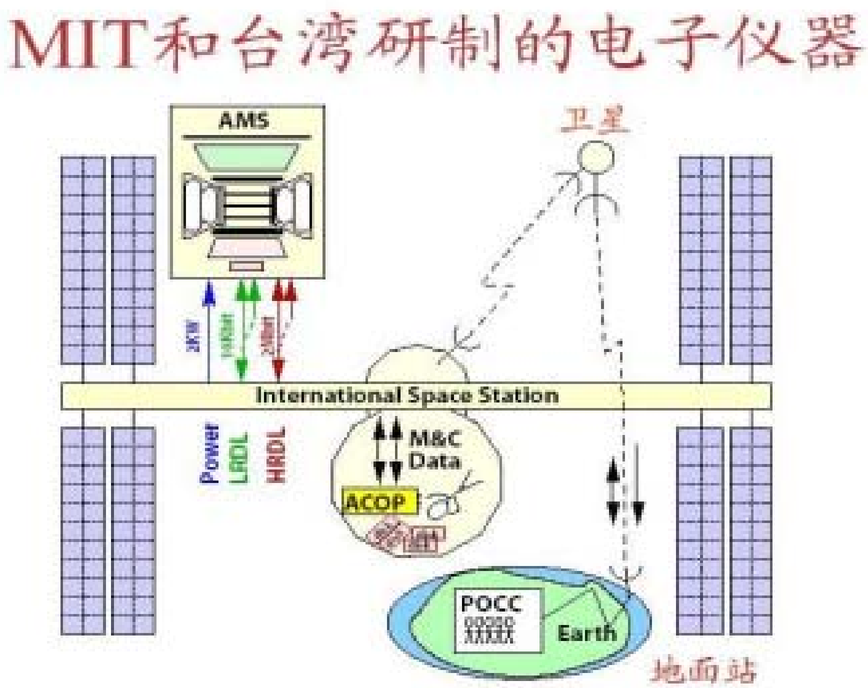


Fig. 2 An candidate event for strangelet

The electronics system for AMS-02 is illustrated in Fig. 3. More details can be found in Ref. 8. Prototyping of the electronics system had been finished. Qualification modules had been produced and flight qualification completed in December 2002 (Fig. 4,5,6). All flight modules and crates will be produced and delivered to ETH by the summer of 2004. A team of physicists and engineers from Taiwan will station at ETH starting 2004 for the AMS-02 integration tests. They will collaborate with the MIT team to develop the system software. Beam tests at CERN are essential for understanding and calibrating the performance of AMS-02.



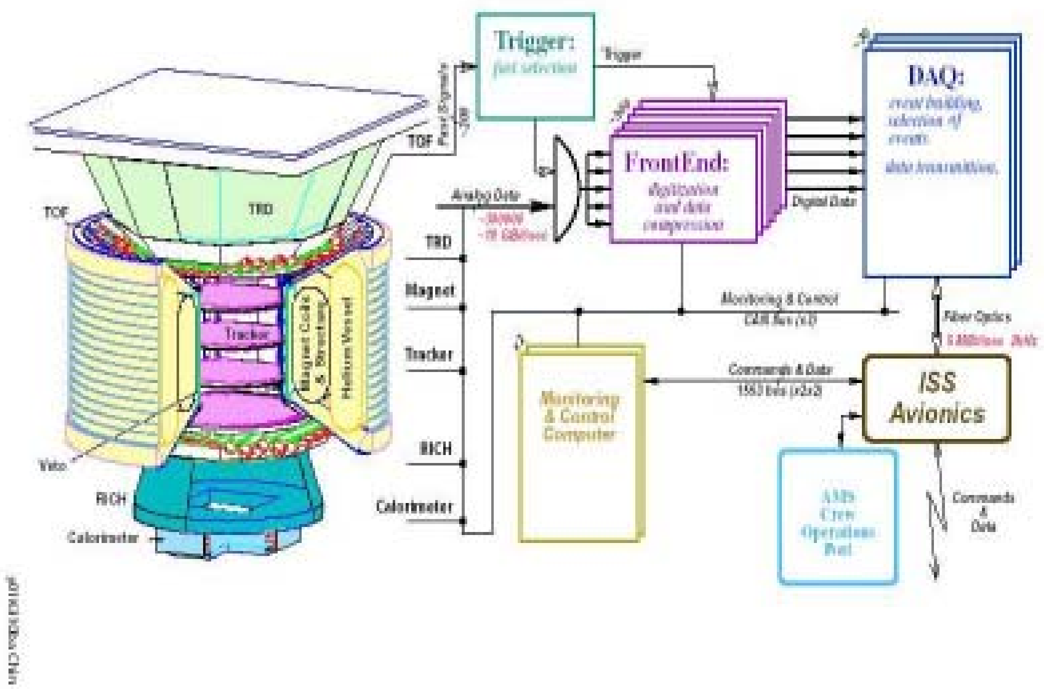


Fig. 3　　Electronics system for AMS-02

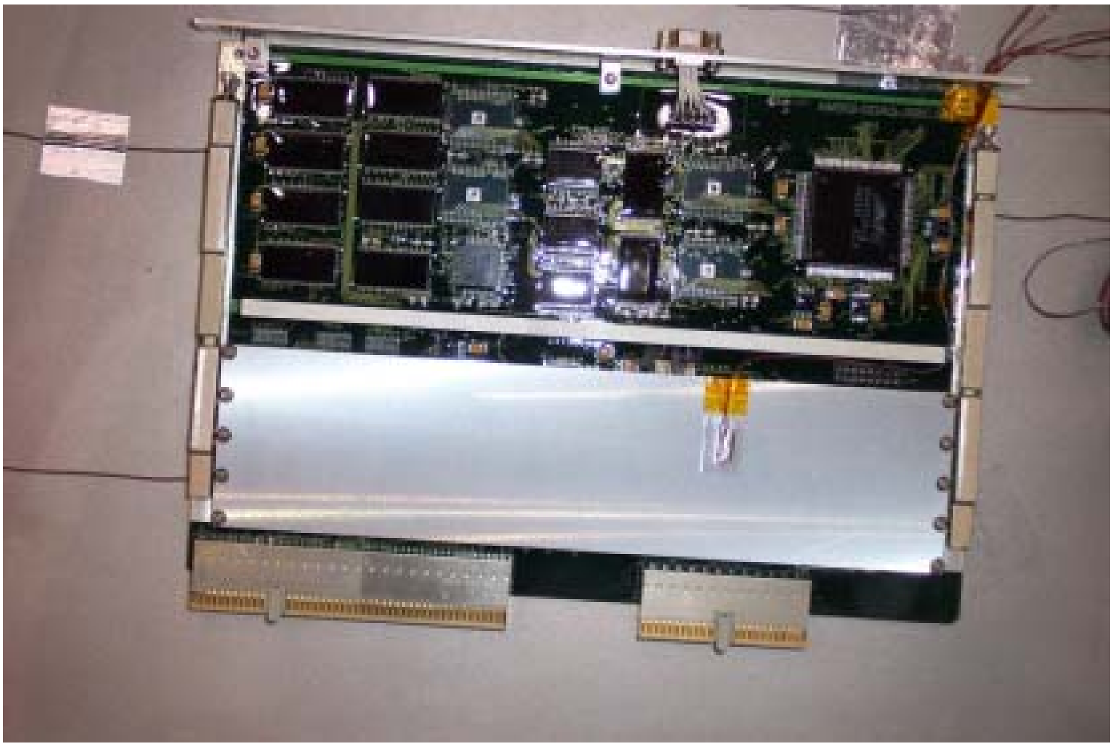


Fig. 4 Qualification module JSBC

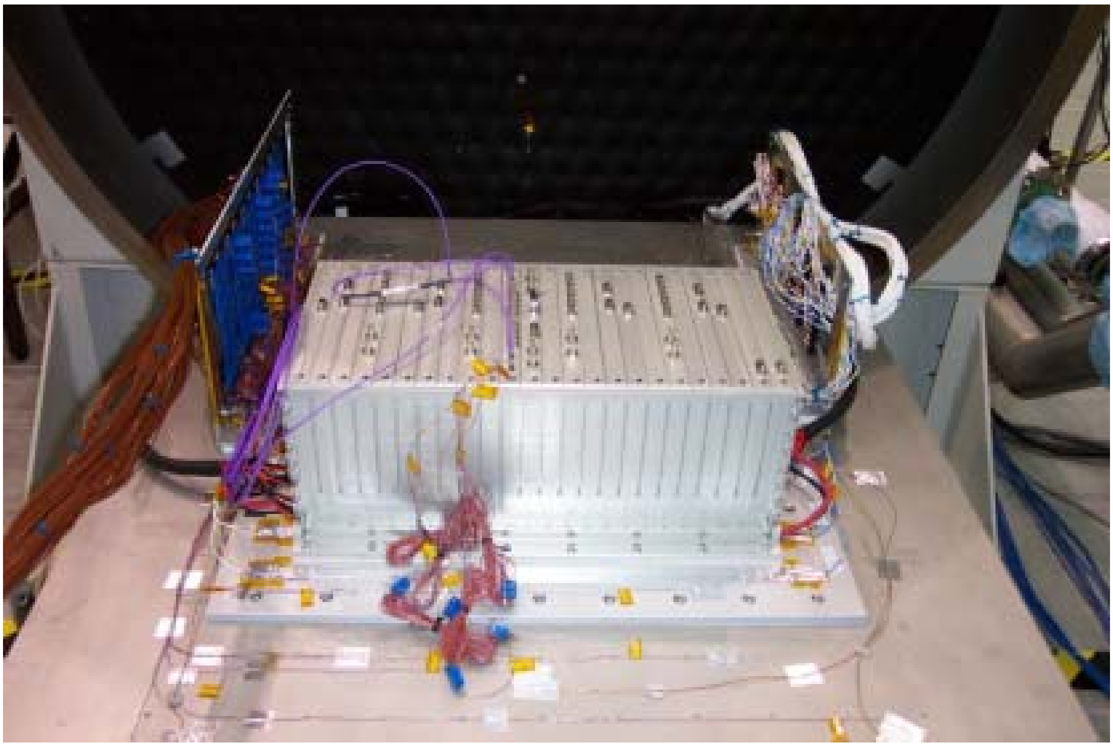


Fig. 5 Qualification Crate

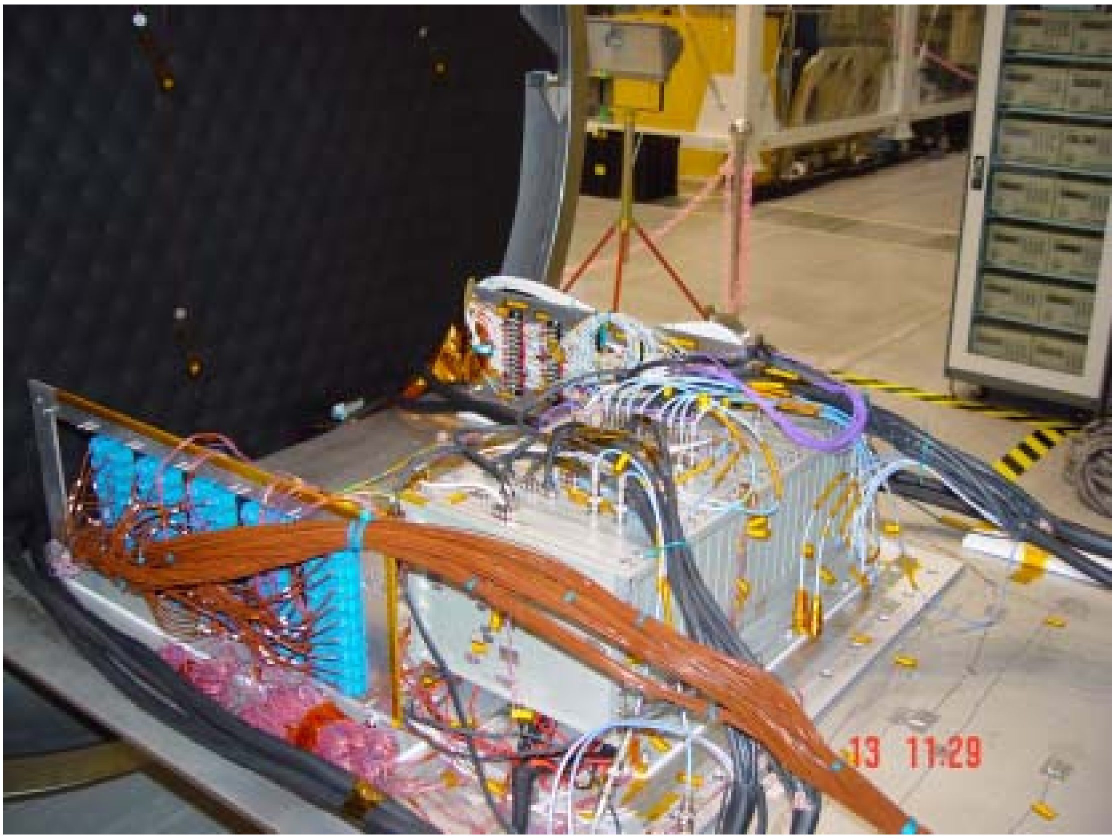


Fig. 6 Flight qualification test (thermal vacuum)

Extensive detector simulation will be carried out starting 2003 and continued throughout the AMS-02 experiment in order to analyze the beam test data and to facilitate data analysis during the ISS flight. The computing resources of the AMS Collaboration need to be pooled to achieve our goal. We plan to construct a 50 node PC farm during 2004~2005 for this project.

AMS Collaboration is building the first superconducting magnet in Space (Fig. 7). ETH is responsible for the design and construction of the superconducting magnet as well as the thermal system for AMS-02. Recently, Taiwan has the opportunity to play a bigger role in both the construction of the superconducting magnet and the thermal system. With the support from Academia Sinica, the Second Institute of CSIST had constructed the test magnet for AMS-02. The Fifth Institute of CSIST will collaborate with NASA and Yardney/Lithion Inc., the company that produced lithium ion batteries for Mars Mission and for B2 B2 bomber, to design and produce the cryomagnet uninterruptible power source (CUPS) for the cryomagnet self-protection (CSP) system of AMS-02 (Fig. 8). CSIST will also actively involved in other projects of CSP.

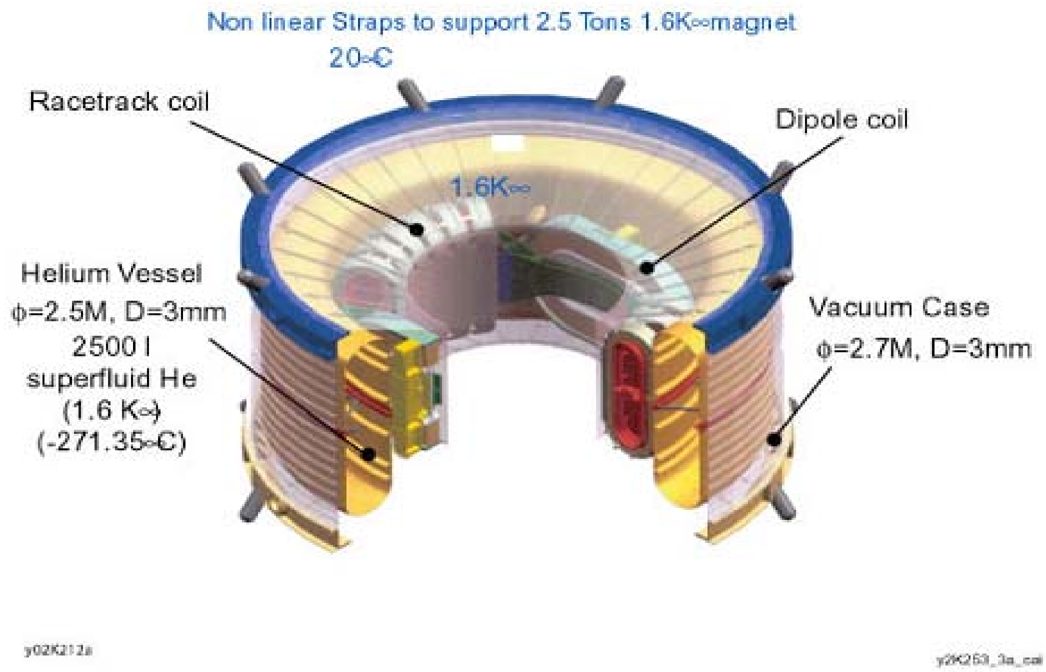


Fig. 7 AMS-02 superconducting magnet

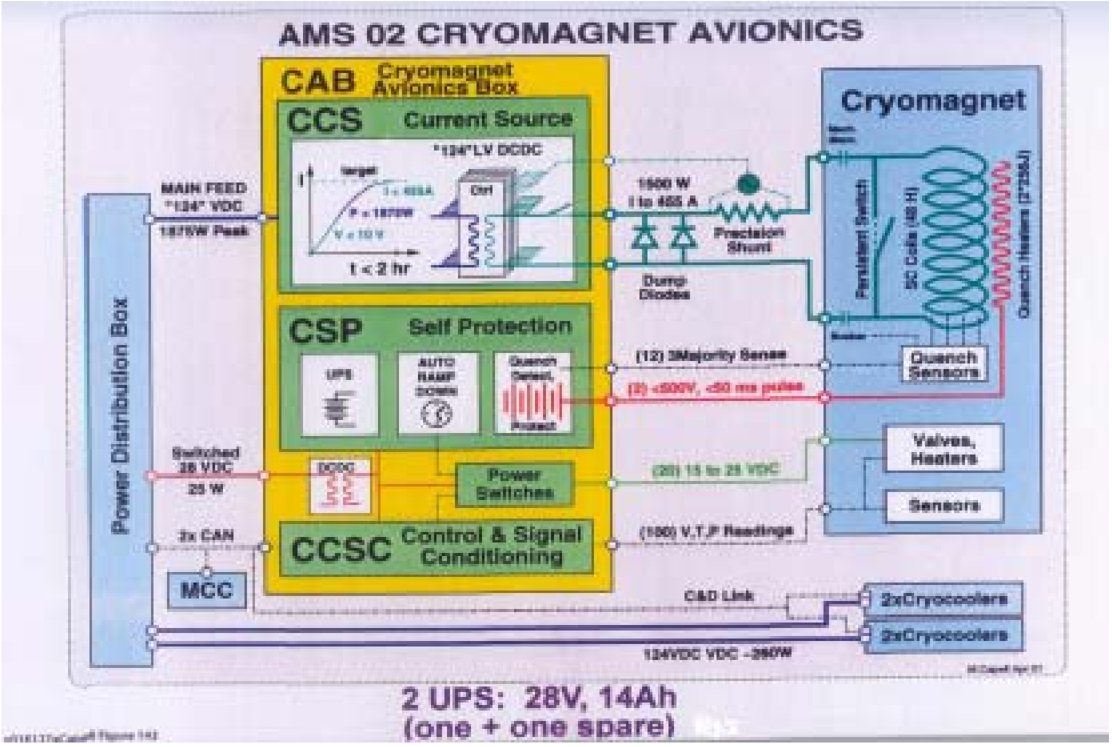


Fig. 8　AMS-02 CSP

NCKU had expressed interest in joining AMS. After about a year of contact and preparation, they were accepted by the AMS Collaboration. NCKU will share the cost of constructing the superconducting magnet and actively involved in the operation of the magnet as well as design and construction of the upgrade. In particular, they will be responsible for field mapping for the AMS-02 superconducting magnet, which requires the design and construction of a precision three-dimensional field measuring equipment to map the field over a large volume at both ETH and Johnson Space Center (JSC), Houston. NCKU will collaborate with ETH and ILK (Institute for Cryotechnology, Dresden) to design and produce high reliability and high efficiency cryocooler for use in AMS-02 upgrade. The Department of Physics is expected to actively participate in the data processing and data analysis for AMS-02.

The National Space Program Office (NSPO) of Taiwan had been actively involved in the thermal design and test for the electronics crates that the Taiwan team is constructing for AMS-02. We expect NSPO to become a full member of the AMS Collaboration soon and to collaborate with NASA、ETH、MIT and Carlo Gavazzi Sapace of Italy in designing and constructing of the thermal system for AMS-02 (Fig. 9). AMS-02 consists of several sub-detector systems with close to a million readout channels and consumes 2KW of power. The superconducting magnet operates at below 1.9 Kelvin while the Transition Radiation Detector (TRD) needs to have a uniform temperature of 20℃± 0.1℃ over the entire detector volume (over 1m^2 in crossection and 30 cm in height). The Silicon Tracker (ST) inside the magnet dissipates about 1KW of heat while the sensors of the Tracker needs to operate near 0 ℃ for maximum performance. The detector environmental temperature varies over ±65℃ every 1.5 hour, a period of ISS revolution around Earth. It is clear that the design、construction and verification of the thermal system is a nontrivial job and will require a lot of effort from the Collaboration including NSPO.

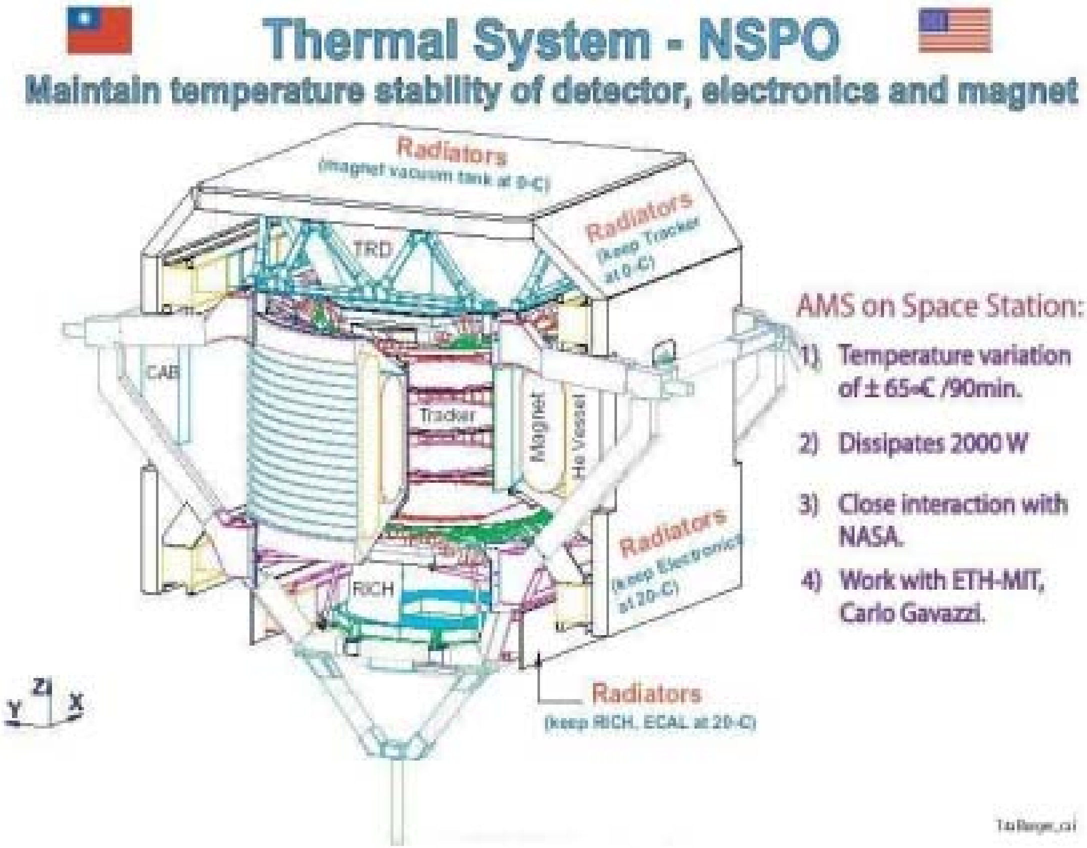


Fig. 9 AMS-02 thermal system

The AMS-02 detector needs to be at the Kennedy Space Center (KSC) 6 months before launch for integration with the shuttle and to go through extensive pre-launch tests to ensure the safe and successful operation on ISS. Because of the heavy involvement of Taiwan in the electronics system, the thermal system and the superconducting magnet system, key members of the Taiwan team need to station at KSC to participate in the tests.

During and after launch, a team of experts from NASA and AMS-02, including members from Taiwan, will take shifts to monitor the operation of AMS-02. Data will downlink through relaying satellites in real time. They will be processed immediately at the data centers at MIT、CERN and other sites yet to be determined. Processed data will be analyzed in real time by the Collaboration for interesting events. A fraction of the data will be monitored for its quality so that the operation conditions as will as trigger selections can be adjusted by uplink of commands and programs.

The participating institutions including CSIST, NSPO and NCKU will provide financial and managerial support for their respective design and construction responsibilities as well as other operational activities. However some material for the construction may be provided by AMS-02 Collaboration or by Academia Sinica and will be supported by the Program Project of Academia Sinica. Moreover, travel compensations for team members especially those from CSIST, are supported by the Program Project. The National Central University and Academia Sinica have been partially supported by grants from the National Science Council since 1996. The efforts of the Taiwan team is coordinated by Academia Sinica.

During the period of 2004~2006, the focus of AMS Collaboration will shift gradually from detector construction to detector operation as well as computing and physics. The Taiwan team played a significant role in several discoveries of novel phenomena about high energy charged particles in near Earth orbit analyzing the AMS-01 test flight data. In order to contribute significantly to the discoveries expected for AMS-02 ISS flight, we need to expand on the available computing facility and to recruit new research assistants and postdoctors.

While there is no lack of expertise in particle detection in AMS Collaboration and a lot of experience about simulating cosmic rays around the Earth and its interaction with the atmosphere had been accumulated in analyzing AMS-01 data, the ability to simulate cosmic rays in the galactic and cosmic scales is yet to be developed within the Collaboration. This is one area that the Taiwan team may work on.

Due to the budget overrun, NASA has decided that there will only be three crews station on ISS, instead of the planned seven, until 2007 or later[9]. As a result, most scientific projects for basic research were cancelled or delayed indefinitely. AMS-02 is the only approved large scale experiment for basic physical science on ISS. Moreover, the experiment scheduled to succeed AMS-02 is indefinitely delayed. This increases the chance for an upgrade of AMS-02 to continue to operate on ISS after the initial three-year period. Possible upgrade of AMS-02 will be investigated in the coming years.

Great discoveries had been made through observations of the cosmic microwave background (CMB), radio waves, visible light, X-ray and γ-ray. In particular, recent observations indicated the existence of dark matter, most likely consisting of weakly interacting particles not known to physicists. Moreover, the Universe seems to be accelerating in its expansion contrary to the prediction of the Standard Cosmology. These puzzling phenomena add to the mystery of large scale matter-antimatter asymmetry, i.e. why the Universe seems to be made of matter only, that AMS set out to tackle in the first place.

The International Space Station offers a unique chance for the 7-ton AMS-02 to observe charge particles in space, over the energy range from 0.5 GeV/nucleon to a few TeV/nucleon, with unprecedented precision. The charge Z, mass number A and the momentum of every one of the expected 10^{10} charge particles entering AMS-02 during the three year period on ISS will be documented. The observation of a single anti-helium will indicate the existence of primordial antimatter while the observation of a single anti-carbon will indicate the existence of anti-star. Observation of charge particles with anomalously small value of Z/A will indicate the existence of new form of matter, such as strangelet, which was predicted to exist but has not been observed.

AMS-02 will observe not only charge particles but also γ-rays over the energy range of a few GeV to a few hundred GeV with unprecedent angular resolution (Fig. 10). The unique nature of AMS-02 to observe high energy charge particles and γ-ray simultaneously greatly enhances its discovery potential.

High energy charge particles in Space is a new frontier unexplored by mankind before. The discoveries AMS-02 will make could very well alter our view of the Universe forever. The mission will establish a new milestone in our exploration of the Universe.

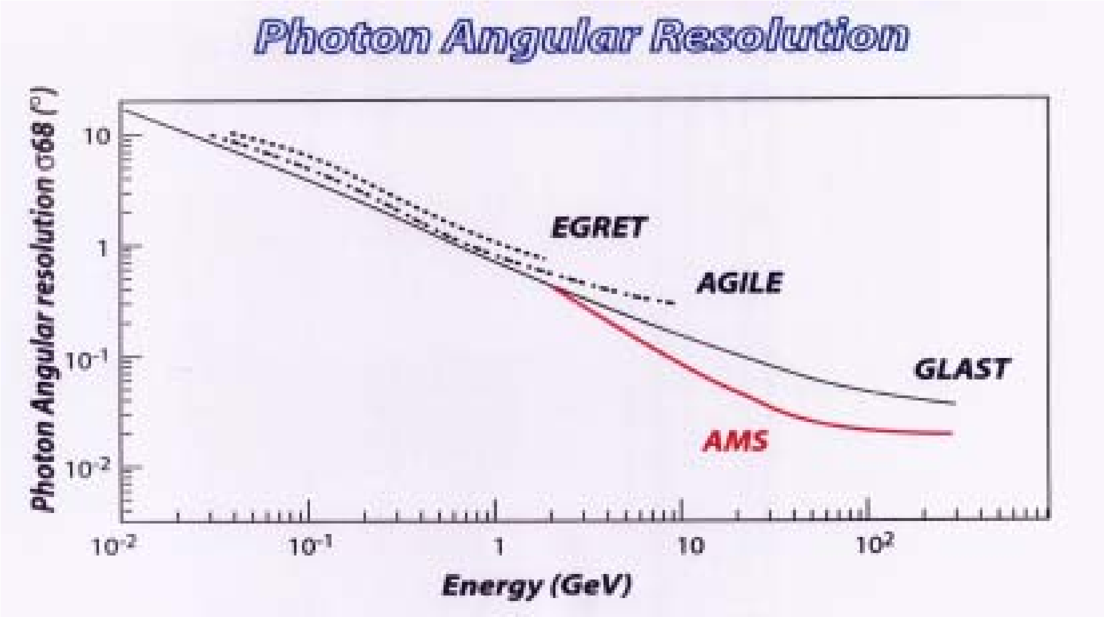


Fig. 10 Angular resolution of AMS-02 for γ -ray

2. Particle Phenomenology

(1) Study of charmless and charmful baryonic *B* decays

Inspired by the claim of an observation of the decay modes $p\overline{p}\pi^{\pm}$ and $p\overline{p}\pi^{+}\pi^{-}$ in *B* decays by ARGUS in late 80's (ruled out by CLEO later), baryonic *B* decays have been studied extensively around early 90's with focus on the two-body decay modes, e.g. $B \to p\overline{p}$, $\Lambda\overline{\Lambda}$. Up to date, none of the two-body baryonic *B* decays has been observed. Many of earlier model predictions are too large compared to experiment. For example, the previous limit on $\overline{B}^0 \to p\overline{p} < 7\times10^{-6}$ set by CLEO has been recently pushed down to the level of 1.6×10^{-6} by Belle, whereas the model predictions are either too large or marginally comparable to the experimental.

We study the two-body and three-body charmful baryonic *B* decays: $\overline{B}^0 \to \Lambda_c\overline{p}$ and $\overline{B} \to \Lambda_c\overline{p}\pi(\rho)$. The factorizable *W*-exchange contribution to $\overline{B}^0 \to \Lambda_c\overline{p}$ is negligible. Applying the bag model to evaluate the baryon-to-baryon weak transition matrix element, we find $B(\overline{B}^0 \to \Lambda_c\overline{p}) \le 7.2\times10^{-6}$ and hence the predicted branching ratio is well below the current experimental limit. The factorizable contributions to $B^- \to \Lambda_c\overline{p}\pi^-$ can account for the observed branching ratio of order 6×10^{-4}. The branching ratio of $B^- \to \Lambda_c\overline{p}\rho^-$ is larger than that of

$B^- \to \Lambda_c \bar{p} \pi^-$ by a factor of about 2.6. We explain why the three-body charmful baryonic *B* decay has a larger rate than the two-body one, contrary to the case of mesonic *B* decays.

We present a systematical study of two-body and three-body charmless baryonic *B* decays. Branching ratios for two-body modes are in general very small, typically less than 10^{-6}, except for the decays with a Δ resonance in the final state. For example, the branching ratio of the tree-dominated decay $B^- \to p\overline{\Delta}^{--}$ can be as large as 6×10^{-6}, and the penguin-dominated decay $B^- \to \Sigma^+\overline{\Delta}^{--}$ is at the level of 1×10^{-6}. For three-body modes we focus on octet baryon final states. The leading three-dominated modes are $\overline{B}^0 \to p\bar{n}\pi^-(\rho^-)$, $n\bar{p}\pi^+(\rho^+)$ with a branching ratio of order 3×10^{-6} for $\overline{B}^0 \to p\bar{n}\pi^-$ and 8×10^{-6} for $\overline{B}^0 \to p\bar{n}\rho^-$. The first measurement of the penguin-dominated decay $B^- \to p\bar{p}K^-$ by Belle indicates that the q^2 dependence of heavy-to-light baryon form factors is favored to be of the monopole form. The penguin-dominated decays $B^- \to p\bar{p}K^{-(*)}$ and $\overline{B}^0 \to p\bar{n}K^{-(*)}$, $n\bar{n}\overline{K}^{0(*)}$ all have appreciable rates. In contrast, the branching ratios of $\overline{B}^0 \to \Lambda\bar{p}\pi^+(\rho^+)$ are at most on the verge of 10^{-6}. We explain why some of charmless three-body final states in which baryon-antibaryon pair production is accompanied by a meson have a larger rate than their two-body counterparts: either the pole diagrams for the former have an anti-triplet bottom baryon intermediate state, which has a large coupling to the *B* meson and the nucleon, or they are dominated by the factorizable external *W*-emission process. (H.-Y. Cheng and K.-C. Yang)

(2) Nonresonant three-body decays of *D* and *B* mesons

The three-body decays of heavy mesons are in general dominated by intermediate (vector or scalar) resonances, namely, they proceed via quasi-two-body decays containing a resonance state and a pseudoscalar meson. The analysis of these decays using the Dalitz plot technique enables one to study the properties of various resonances. The nonresonant contribution is usually a small fraction of the total 3-body decay rate. Nevertheless, its study is important for several reasons.

Nonresonant three-body decays of *D* and *B* mesons are studied. It is pointed out that if heavy meson chiral perturbation theory (HMChPT) is applied to the heavy-light strong and weak vertices and assumed to be valid over the whole kinematics region, then the predicted decay rates for nonresonant charmless 3-body *B* decays will be too large and especially $B^- \to \pi^- K^+ K^-$ greatly exceeds the current experimental limit. This can be understood as chiral symmetry has been applied there twice beyond its region of validity. If HMChPT is applied only to the strong vertex and the weak transition is accounted for by the form factors, the dominant B^* pole contribution to the tree-dominated direct three-body *B* decays will become small and the branching ratio will be of order 10^{-6}. The decay modes $B^- \rightarrow (K^-h^+h^-)_{NR}$ and $\overline{B}^0 \rightarrow (\overline{K}^0 h^+h^-)$ for h= π, *K* are penguin dominated. We apply HMChPT in two different cases to study the direct 3-body *D* decays and compare the results with experiment. The preliminary FOCUS measurement of the direct decay $D_s^+ \rightarrow (\pi^+\pi^+\pi^-)$ may provide the first indication of the importance of final-state interactions for the weak annihilation process in nonresonant *D* decays. Theoretical uncertainties are discussed. (H.-Y. Cheng and Kwei-Chou Yang)

(3) Weak annihilation and the effective parameters a_1 and a_2 in nonleptonic *D* decays

The purpose of this work is twofold: First, we will utilize the reduced quark-graph amplitudes extracted from the data to determine the complex parameters a_1 and a_2 appearing in the factorization approach. This enables us to test the factorization hypothesis and see how important the nonfactorizable correction is. Second, we will study weak annihilations induced from nearby quark-antiquark intermediate states. This allows us to explore the effect of inelastic FSIs and see if the sign of the *W*-exchange topology in Cabibbo-allowed $D \rightarrow VP$ decays is governed by nearby resonances.

Based on SU(3) flavor symmetry, many of the quark-graph amplitudes in two-body nonleptonic decays of charmed mesons can be extracted from experiment, which enable us to see the relevance and importance of weak annihilation topologies and to determine the complex parameters a_1 and a_2 to test the factorization approach. It is found that a_2/a_1 in $D \rightarrow \overline{K}^*\pi$ and $D \rightarrow \overline{K}\rho$ can be different by a factor of 2, indicating that nonfactorizable corrections to the latter are far more important than the former. The relative phase between a_1 and a_2 is about 150^0. Weak annihilation topologies induced by nearby resonances via final-state rescattering can be described in a model-independent manner. Although the *W*-exchange contribution in $D \rightarrow PP$ decays is dominated by resonant final-state interactions (FSIs), its amplitude in *VP* decays (*V*: vector meson, *P*: pseudoscalar meson) receives little contributions from FSIs in the quark-antiquark resonance formation. As a consequence, the sign flip of the *W*-exchange amplitude in $D \rightarrow \overline{K}^*\pi$ and $\overline{K}\rho$ decays, which is needed to explain the relatively real decay amplitudes of $D \to \overline{K}\rho$, remains unexplained. SU(3) symmetry is badly broken in some Cabibbo-suppressed modes and it can be accounted for by the accumulation of some modest SU(3) violation in individual quark-graph amplitudes. (H.-Y. Cheng)

(4) Hadronic $D \to SP$ decays

The nonleptonic weak decays of charmed mesons into a scalar meson and a pseudoscalar meson are studied. The scalar mesons under consideration are σ, κ, $f_0(980)$, $a_0(980)$ and $K_0^*(1430)$. Studies of the mass spectrum of scalar mesons and their strong as well as electromagnetic decays imply that the light scalars below or near 1 GeV form an SU(3) flavor nonet and are predominately the $q^2\overline{q}^2$ states, while the scalar mesons above 1 GeV can be described as a $q\overline{q}$ nonet. Hence, we designate $q^2\overline{q}^2$ to σ, κ, $a_0(980)$, $f_0(980)$ and $q\overline{q}$ to K_0^*. In general, it is not easy to differentiate between the two-quark and four-quark pictures for the $f_0(980)$ produced in the hadronic charm decays.

The topological quark-diagram scheme for $D \to SP$ decays is more complicated than the case of $D \to PP$. One can have two different external W-emission and internal W-emission diagrams, depending on whether the emission particle is a scalar meson or a pseudoscalar one. The quark-diagram amplitude for the case when the emitted particle is a scalar meson is largely suppressed relative to the one when the pseudoscalar meson is emitted. Moreover, the former amplitude vanishes in the limit of SU(3) symmetry. Sizable weak annihilation contributions induced from final-state interactions are essential for understanding the data. Except for the Cabibbo doubly suppressed decay mode $D^+ \to f_0K^+$, the data of $D \to \sigma\pi$, $f_0(980)$ (π,K), $K_0^*(1430)\pi$ can be accommodated in the generalized factorization approach. However, the predicted rates for $D \to a_0(980)(\pi,K)$ are too small by one to two orders of magnitude when compared with the preliminary experimental results. (H.-Y. Cheng)

(5) PQCD study of exclusive B decays k_T factorization theorem

Both collinear and k_T factorizations are the fundamental tools of perturbative QCD (PQCD), where k_T denotes parton transverse momenta. For inclusive processes, consider deeply inelastic scattering (DIS) of a hadron, carrying a momentum ρ, by a virtual photon, carrying a momentum q. Collinear factorization and k_T factorization apply, when DIS is measured at a large and small Bjorken variable $\chi_B \equiv -q^2/(2p.q)$, respectively. The cross section is written as the convolution of a hard subprocess with a hadron distribution function in a parton momentum fraction χ in the former, and in both χ and k_T in the latter. When χ_B is small, $\chi \geq \chi_B$ can reach a small value, at which k_T is of the same order of magnitude as the longitudinal momentum χp, and not negligible. For exclusive processes, such as hadron form factors, collinear factorization was developed in. The range of a parton momentum fraction χ, contrary to that in the inclusive case, is not experimentally controllable, and must be integrated over between 0 and 1. Hence, the end-point region with a small χ is not avoidable. If there is no end-point singularity developed in hard amplitude, collinear factorization works. If such a singularity occurs, indicating the breakdown of collinear factorization, k_T factorization should be employed. Since k_T factorization theorem was proposed by Li and Sterman, there had been wide applications to various processes. However, a rigorous proof is not yet available.

We have proved the factorization theorem with the k_T dependence included into two-parton meson wave functions and into hard amplitudes. In our previous works we have proposed a simple all-order proof of collinear factorization theorem for the exclusive process $\pi\gamma^* \rightarrow \gamma(\pi)$ and $B \rightarrow \gamma(\pi) l \bar{\nu}$ up to the two-parton twist-3 level. The proof of k_T factorization theorem follows the similar procedures. We stress that it is more convenient to perform k_T factorization in the impact parameter b space, in which infrared divergences in radiative corrections can be extracted from parton-level diagrams explicitly. We have explained how to construct a gauge-invariant b-dependent meson wave function defined as a nonlocal matrix element with a special path for the Wilson link. (M. Nagashima and H-n. Li)

(6) Threshold resummation

It has been shown that fixed-order evaluation of B meson semileptonic decay amplitudes in the framework of collinear factorization theorem suffers the end-point singularities from a parton momentum fraction $\chi \rightarrow 0$. On the other hand, the double logarithms $\alpha_s \ln^2 \chi$ appearing in higher-order corrections to these decays have been observed. We argue that when the end-point region is important, $\alpha_s \ln^2 \chi$ cannot be treated as a small expansion parameter, and should be summed to all orders. A systematic treatment of these logarithms has been proposed by grouping them into a quark jet function, whose dependence on χ is governed by an evolution equation. A Sudakov form factor, obtained by solving the evolution equation, decreases fast enough at the end point. The above procedure is referred to as threshold resummation. It turns out that in a self-consistent analysis, where the original factorization formulas are convoluted with the Sudakov factor, the end-point singularities do not exist. Therefore, it is not necessary to introduce arbitrary infrared cutoffs for momentum fractions χ even in the collinear factorization theorem, such as the QCD factorization (QCDF) approach to exclusive B meson decays. The same observation has been made recently in the framework of soft-collinear effective theory.

We have examined the double logarithmic corrections to all the topologies of two-body nonleptonic B meson decay amplitudes, including charmless and charmful modes. The topologies contain both emission and annihilation, which are further divided into factorizable and nonfactorizable types. Our results for the charmless and charmful decays are the same, and summarized as follows. The double logarithmic corrections are crucial for factorizable (regardless of charmless or charmful, emission or annihilation) contributions due to the presence of the potential linear end-point singularities. As to nonfactorizable contributions, the double logarithmic corrections exist, and carry a color factor different from that in the factorizable cases. However, they are less crucial for charmless decays, since the end-point singularities are at most logarithmic: there exists soft cancellation between a pair of nonfactorizable emission diagrams near the end point due to the color-transparency argument. For charmful decays, the hierarchy that the b quark mass is much larger than the c quark mass is the necessary condition for perturbative QCD (PQCD) to be applicable. Under this hierarchy, the soft cancellation between a pair of nonfactorizable emission amplitudes holds approximately. The factorization formulas for nonfactorizable (charmless and charmful) annihilation amplitudes involve the overlap integrals of three meson distribution amplitudes, such that the end-point singularities become milder. (K. Ukai and H-n. Li)

(7) Three-body nonleptonic B decays

Three-body nonleptonic B meson decays have been observed recently. Viewing the experimental progress, it is urgent to construct a reliable framework for these modes. Motivated by its theoretical self-consistency and phenomenological success, we shall generalize PQCD to three-body nonleptonic B meson decays. A direct evaluation of the hard amplitudes, which contain two virtual gluons at lowest order, is, on one hand, not practical due to the enormous number of diagrams. On the other hand, the region with the two gluons being hard simultaneously is power-suppressed and not important. Therefore, a new input is necessary in order to catch dominant contributions to three-body decays in a simple manner. The idea is to introduce two-meson distribution amplitudes, by means of which the analysis is simplified into the one for two-body decays (number of diagrams is greatly reduced). Both nonresonant contributions and resonant contributions through two-body channels can be included. Moreover, the application of this formalism to three-body baryonic decays is straightforward. (C.H. Chen and H-n. Li)

(8) Symmetry breaking effects in heavy mesons

Symmetry breaking effects in the static and transition properties of heavy mesons are studied. Heavy mesons are particles consisting of one heavy valence quark (bottom or charm) and one light valence quark (up, down, or strange). It is well known that in the hypothetical limit where the heavy quark masses taken to be infinite, we have heavy quark symmetry that relates the properties of heavy mesons with different flavors and spins. Of course, this is only a zeroth order approximation. In the real world, heavy quarks have finite masses, and it is both necessary and important to consider the various symmetry breaking effects. In this work, we study the effects due to finite heavy quark mass, which breaks heavy quark symmetry. Moreover, we also considered SU(3) symmetry breaking due to light quark (u, d, s) mass difference and electromagnetic effects. (Chi-Yee Cheung, Chien-Wen Hwang and Wei-Min Zhang)

(9) Out of equilibrium and RHIC physics

It had been shown by Baier et al. (2001) in the limit $Q_S >> \Lambda_{QCD}$ corresponding to very large nuclei and/or very high collision energy, thermalization occurs relatively fast while the system is still undergoing one-dimensional expansion. These authors' analysis indicated that thermalization indeed occurs in the following steps. During the first period of time the most important process is the emission of soft gluons which overwhelm, in terms of number, the primary hard gluons at time $\tau \sim \alpha^{-5/2} Q_S^{-1}$. These soft gluons then quickly equilibrate and form a thermal bath, which initially carries only a small fraction of the total energy. The thermal bath then draws energy from the hard gluons. Full thermalization is achieved when the primary hard gluons have lost all their energy. We have introduced a real-time kinetic description, which naturally accounts for the finite lifetime and nonequilibrium aspects of this bottom up QGP equilibration. (H.-L. Yu)

(10) Direct photons: A nonequilibrium signal of the expanding quark-gluon plasma at RHIC energies

Direct photon production from a longitudinally expanding quark-gluon plasma (QGP) at Relativistic Heavy Ion Collider (RHIC) and Large Hadron Collider (LHC) energies is studied with a real-time kinetic description that is consistently incorporated with hydrodynamics. Within Bjorken's hydrodynamical model, energy nonconserving (anti)quark bremsstrahlung $q(\bar{q}) \to q(\bar{q})\gamma$ and quark-antiquark annihilation $q\bar{q} \to \gamma$ are shown to be the dominant nonequilibrium effects during the transient lifetime of the QGP. For central collisions we find a significant excess of direct photons in the range of transverse momentum $1\text{-}2 \leq p_T \leq 5$GeV/c as compared to equilibrium results. The photon rapidity distribution exhibits a central plateau. The transverse momentum distribution at midrapidity falls off with *a power law* $p_T^{-\nu}$ with $2.5 \leq \nu \leq 3$ as a consequence of these energy nonconserving processes, providing a distinct experimental *nonequilibrium signature*. The power law exponent ν increases with the initial temperature of the QGP and hence with the total multiplicity rapidity distribution dN_π/dy. (S.-Y. Wang, D. Boyanovsky, and K.-W. Ng)

(11) Photon production from nonequilibrium disoriented chiral condensates in a spherical expansion

We study the production of photons through the non-equilibrium relaxation of a disoriented chiral condensate formed in the expanding hot central region in ultra-relativistic heavy-ion collisions. It is found that the expansion smoothes out the resonances in the process of parametric amplification such that the non-equilibrium photons are dominant to the thermal photons over the range 0.2-2 GeV. We propose that to search for non-equilibrium photons in the direct photon measurements of heavy-ion collisions can be a potential test of the formation of disoriented chiral condensates. (Y.-Y. Charng, K.-W. Ng, C.-Y. Lin, and D.-S. Lee)

(12) Field theory

In the past few years, I have mainly engaged (together with Hung Cheng of MIT and Er-Cheng Tsai of the National Taiwan University) in the development of a consistent method of renormalization of the Standard Model in particle physics in four-dimensional space-time. In the area of renormalization, most people nowadays are using the method of dimensional regularization. However, in the renormalization of gauge theories that are incorporated with chiral fermions, the main problem is how to handle γ_5. It is well known that the definition of γ_5 is ambiguous in the method of dimensional regularization. On the other hand, γ_5 can be rigorously defined in four dimensions. Thus, a perturbative calculation strictly done in four dimensions should be mostly welcome. In our work, we have used the method of subtraction, with the use of Ward-Takahashi identities and developed a consistent method of renormalization in four dimensions. Practical calculations using this method have just begun. (S.-P. Li)

(13) Nonperturbative bound on high multiplicity cross sections in ϕ^4 theory in three dimensions from lattice simulation

We look for evidence of large cross sections at large multiplicities in weakly coupled scalar field theory in three dimensions. We use spectral function sum rules to derive bounds on total cross sections where the sum can be expressed in terms of a quantity which can be measured by Monte Carlo simulation in Euclidean space. We find that high multiplicity cross sections remain small for energies and multiplicities for which large effects had been suggested. (Y. -Y. Charng and R. S. Willey)

(14) *p*-brane production in fat brane or universal extra dimension scenario

Inspired by the recently development in string theory, the fundamental scale of quantum gravity could be as low as TeV. One of the most dramatic consequences of low-scale (~ TeV) quantum gravity is copious production of mini black holes at future colliders and in ultra-high-energy cosmic ray collisions. Hawking radiation of these black holes is constrained mainly to our (3+1)-dimensional world and results in rich phenomenology. However, besides mini black holes, *p*-branes can also be produced at such high-energy collisions. In some cases the *p*-brane production cross section is comparable to that of the mini black hole. We found that in fat brane or universal extra dimension scenario the *p*-brane production cross section can be much larger than that of the mini black hole hence opening the exciting possibility of finding new physics in the decay of *p*-branes. (Kingman Cheung and C-H. Chou).

(15) Quantum Bit Commitment

In a quantum bit commitment (QBC) protocol, the sender, Alice, is secretly committed to a bit *b* (0 or 1), which she wants to communicate to the receiver, Bob, at a later time. She then sends Bob a quantum mechanical wave function that can later be used to verify her honesty. A QBC protocol is secure if (a) Alice cannot change her mind, and (b) Bob can gain no information about *b* before Alice discloses it. A protocol is unconditionally secure if it is not breakable even if Alice and Bob had unlimited computational power. It is generally believed that unconditionally secure QBC is ruled out in principle by a "no-go theorem". We point out that the theorem only establishes the existence of a cheating unitary transformation in any scheme of QBC, however there is no proof that Alice always knows the required unitary operator. Hence it does not necessarily follow that QBC is insecure. An explicit example is constructed to illustrate this point. (Chi-Yee Cheung)

3. Particle Astrophysics and Cosmology

(1) Primordial magnetic fields from dark energy

Evidences indicate that the dark energy constitutes about two thirds of the critical density of the universe. If the dark energy is an evolving pseudo scalar field that couples to electromagnetism, a cosmic magnetic seed field can be produced via spinoidal instability during the formation of large-scale structures. (D.-S. Lee, W.-L. Lee and K.-W. Ng)

(2) Constraining evolution of quintessence with CMB and SNIa data

The equation of state of the hypothetical dark energy component, which constitutes about two thirds of the critical density of the universe, may be very different from that of a cosmological constant. Employing a phenomenological model, we investigate semi-analytically the constraints imposed on the scalar quintessence by supernovae observations, and by the acoustic scale extracted from recent CMB data. We show that a universe with a quintessence-dominated phase in the dark age is consistent with the current observational constraints. This may have effects on the evolution of density perturbations and the subsequent structure formation.
(W.-L. Lee and K.-W. Ng)

(3) Time-dependent correlation of primordial cosmic perturbations in the inflationary cosmology

The time dependent correlation of inflationary primordial perturbations is detectable via the local scale-scale correlation of the CMB fluctuations. We show that a large correlation time of super-Hubble sized perturbations is likely to be a generic feature for models with free scalar inflation, i.e. the perturbations were induced only by a gravitational particle creation and the subsequent quantum-to-classical transition. Hence, if the CMB local scale-scale correlation is as weak as suggested by the COBE-DMR data, the interaction of the inflation must take place during the slow-roll phase.（W.-L. Lee and L.-Z. Fang）

(4) Observational strategies of CMB temperature and polarization interferometry experiments

We have simulated the interferometric observation of the Cosmic Microwave

Background (CMB) temperature and polarization fluctuations for the forthcoming AMiBA experiment. We have constructed data pipelines from the time-ordered raw visibility samples to the CMB power spectra which utilize the methods of data compression, maximum likelihood analysis, and optimal subspace filtering. They are customized for three observational strategies, such as the single pointing, the mosaicking, and the drift-scanning. For each strategy, derived are the optimal strategy parameters that yield band power estimates with minimum uncertainty. The results are general and can be applied to any close-packed array on a single platform. We have also studied the effects of rotation of the array platform on the band power correlation by simulating the CBI single pointing observation. It is found that the band power anti-correlations can be reduced by rotating the platform and thus densely sampling the visibility plane. This enables us to increase the resolution of the power spectrum in the l-space down to the limit of the sampling theorem ($\Delta l = 226 = \pi / \theta$), which is narrower by a factor of about $\sqrt{2}$ than the resolution limit ($\Delta l = 300$) used in the recent CBI single pointing observation. The validity of this idea is demonstrated for a two-element interferometer that samples visibilities uniformly in the uv-annulus. From the fact that the visibilities are the Fourier modes of the CMB field convolved with the beam, a fast-unbiased estimator (FUE) of the CMB power spectra is developed and tested. It is shown that the FUE gives results very close to those from the quadratic estimator method even though it does not require large computer resources. (C.-G. Park, K.-W. Ng, C. Park, G.-C. Liu, and K. Umetsu)

(5) SPOrt: an experiment aimed at measuring the large-scale cosmic microwave background polarization

SPOrt (Sky Polarization Observatory) is a space experiment to be flown on the International Space Station during Early Utilization Phase aimed at measuring the microwave polarized emission with FWHM = 7^0, in the frequency range 22-90 GHz. The Galactic polarized emission can be observed at the lower frequencies and the polarization of Cosmic Microwave Background (CMB) at 90 GHz, where contaminants are expected to be less important. The extremely low level of the CMB Polarization signal (<1uK) calls for intrinsically stable radiometers. The SPOrt instrument is expressly devoted to CMB polarization measurements and the whole design has been optimized for minimizing instrumental polarization effects. In this contribution we present the receiver architecture based on correlation techniques, the analysis showing its intrinsic stability and the custom hardware development carried out to detect such a low signal. (E. Carretti et al.)

SOLID STATE PHYSICS AND BIOPHYSICS

1. Surface, Nano Science and Thin Films

(1) Structure and diffusion of small Ir and Rh clusters on Ir(001) surface
(2) Creating a Pd-covered single-atom sharp W pyramidal tip
(3) Complementary Alternation of Vertical Charge Oscillations in Two Types of Thin Pb Islands on Si(111)
(4) Formation of Multi-layer 2D Pb islands on Si(111)7×7 at Low Temperature: From Nucleation to Growth
(5) Dynamic behavior of Si magic clusters on Si(111) surfaces
(6) Adsorption of an O_2 molecule on Si(111) surfaces
(7) Direct observation of atomic steps in dissociation of single H_2O molecules at Si(111)-7×7 surfaces
(8) Diffusion of Adsorbed Si Atom on Si(111)-(7×7) Surface
(9) Theory of Quantum Size Effects in Thin Pb(111) Films
(10) Ultra high resolution X-ray micro-radiography using phase contrast enhancement.
(11) Synchrotron radiation based spectromicroscopy using photoelectron emission microscope
(12) Development synchrotron radiation techniques in the characterization of nanostructured materials.

2. Magnetism

(1) The planar hall effect in permalloy films
(2) Magnetostriction of Co-rich Co-Fe-Ni films
(3) Magnetic properties of Fe films grown on Ag nanometer dots
(4) Physical property of phase change materials
(5) Tunneling magnetoresistance
(6) Surface Magneto-Optical Kerr Effect
(7) Magnetic fluid study
(8) Nano and submicron magnetic structures
(9) Physical properties of ferromagnet/superconductor multilayers
(10) Iron-based tunable microwave devices

3.Quantum Size Effects and Nanostructures

(1) Size-Induced Transition from Magnetic Ordering to Kondo Behavior in (Ce, Al) Compounds

(2) Size effects on superconductivity and magnetism in $CeCo_2$

(3) Magnetic Ordering and Spin Reorientation in $ErGa_3$

(4) Nano-electronics

(5) Trapped atomic gases and Bose-Einstein condensation

4. Crystal Growth and Optical Properties of Non-linear Crystals

(1) Single crystal growth and their optical properties

(2) Semiconductor spectra study

5. Strongly Correlated Many-body Systems

(1) Existence of superconductivity in the t-J model

(2) New theory for lightly doped Mott insulators

(3) Magnetic polarization induced by nonmagnetic impurities in high Tc cuprates

6. Biophysics

(1) Transverse Wave Propagation Equation in Circulatory System and Its Application to Physiology.

(2) E-M Field Effect on Biological System and Its Applications.

(3) Pulse Spectrum Analysis and Chinese Medicine.

(4) Optimization problems for computational biology

1. Surface, Nano Science and Thin Films

(1) Structure and diffusion of small Ir and Rh clusters on Ir(001) surface

It is known that Ir adatoms diffuse on Ir(001) surface by atomic-exchange mechanism, whereas Rh adatoms diffuse on this surface by atomic-hopping mechanism. The question is how about their clusters, and how the mechanisms can affect their diffusion behavior and energetics. Using the field ion microscope, we have measured diffusion parameters of individual Rh and Ir adatoms and small clusters on Ir(001) surfaces. We also show how the activation energy changes as a function of the cluster size and shape. From the probability of observing different atomic configurations during diffusion, different diffusion mechanisms are investigated. By considering the energetics of different atomic processes, it appears that atomic-exchange is still favored for Ir dimers. But for clusters larger than trimers, the exchange mechanism is no longer favored. (T-Y Fu and T. T. Tsong).

(2) Creating a Pd-covered single-atom sharp W pyramidal tip

Single-atom sharp pyramidal W tips, wrapped in a Pd overlayer, having atom-perfect wedges can be routinely and repeatedly created using a surface-science technique. This single-atom tip is thermally stable up to 1000 K because of exceptionally large surface-energy anisotropy of the Pd covered W(111) surface. We conclude from atom-by-atom analysis that the W tip is covered with only one physical monolayer of Pd. We also investigate the mechanism and energetics of the atomic processes involved in its formation. (T-Y Fu, L. C. Cheng, C. H. Nien and T. T. Tsong).

(3) Complementary Alternation of Vertical Charge Oscillations in Two Types of Thin Pb Islands on Si(111)

2D Pb islands of a few atomic layers are grown on the incommensurate Si(111)-Pb surface at low temperatures. Among them, two types of islands stacked differently with the substrate at the interface are observed. These islands respectively display an alternating image contrast with their thickness. Besides, the contrasts of the islands of different type are complementary to each other layer by layer. These intriguing behaviors do not show significant bias-dependency throughout the range from –3V to +3V and can be explained by the vertical charge oscillation with the growth of a new layer. The charge oscillation in the out-of-plane direction originates from electron scattering by the in-plane potential variation at the Pb/Si interface. (W. B. Jian, W. B. Su, C. S. Chang and T. T. Tsong).

(4) Formation of Multi-layer 2D Pb islands on Si(111)7×7 at Low Temperature: From Nucleation to Growth

The morphology of Pb islands formed on Si(111)7×7 at low temperature has the characteristics of both 3D and 2D structures as they are of multi-layer thickness but have a flat-top surface. We use scanning tunneling microscopy to observe the growth behavior from the nucleation stage to the formation of islands. Our observations show that the growth is 3D (SK mode) right after the nucleation but there is a transition from 3D to 2D when the nucleus reaches a certain size. This transition is driven by the quantum size effect, and it changes the growth behavior of Pb islands to be similar to that of single-layer islands in homoepitaxy systems. This similarity allows us to apply the scaling theory to analyze the size distribution of Pb islands, and also to conclude the critical size to be three atoms at the nucleation stage. (W. B. Su, S. H. Chang, H. Y. Lin, Y. P. Chiu, T. Y. Fu, C. S. Chang and T. T. Tsong).

(5) Dynamic behavior of Si magic clusters on Si(111) surfaces

In an STM study of Si(111) surfaces from room temperature (RT) to 600°C, we find a special type of clusters which are not only stable with respect to surface diffusion, but are also the fundamental unit in mass transport phenomena, step fluctuations, and epitaxial growth. The structure of the magic clusters is characterized at various tunneling biases. These clusters are mobile at temperatures above ~400°C. Most of the time, the cluster hops within a half-cell of Si(111)-(7×7). Sometimes it hops out of its original half, and moves to a spot usually a few hundred Å away. Using Arrhenius analysis, we derive path specific hopping rate parameters for these clusters. We also find that Si(111) steps fluctuate at elevated temperatures through detachment and attachment of magic clusters. In addition, the filling of 2D Si craters and the decay of 2D Si islands at elevated temperatures also proceed through attachment and detachment of Si magic clusters at step edges. When a 2D islands decay below a threshold size, it will suddenly decompose into several Si magic clusters. We believe the concept of magic clusters may have important implication on the fundamental mechanism in epitaxial growth of many covalently bonded semiconductors. In addition, we have observed electromigration of Si on Si(111)-(7×7) surfaces and have identified the diffusion species to be Si magic clusters. Effects of the directed motion along the direction of the heating current in electromigration and those in thermal migration are determined separately and quantitatively. We also observe the preferential filling of two-dimensional (2D) Si craters and the preferential detachment of Si magic clusters from the edges of 2D Si islands near the cathode side. The driving force for this anisotropic behavior is much stronger than previously realized. (I. S. Hwang, M. S. Ho, and T. T. Tsong)

(6) Adsorption of an O_2 molecule on Si(111) surfaces

By collaborating with Prof. M. –H. Tsai, theoretical study of single O_2 molecules on Si(111) was carried out. Using first-principles energy minimization calculations, we find an O_2 molecule is stably adsorbed atop the Si adatom in a tilted grif configuration. The O-O bond is a single bond with a length 0.3Å longer than the double bond of a free O_2 molecule. The O derived partial density of states agrees well with ultraviolet photoemission spectroscopy (UPS) data. The contour plot of the local charge density of the filled states within 2eV from the Fermi level shows that the observed scanning tunneling microscopy single bright spot is the image of the O-O bond charge. The calculations also show the existence of an O_2 molecule lying between the adatom and the rest atom and the local charge density contour plot also agrees with our previous STM observations. (M. –H. Tsai, Y. –H Tang, I. S. Hwang and T. T. Tsong)

(7) Direct observation of atomic steps in dissociation of single H_2O molecules at Si(111)-7×7 surfaces

The adsorption of single water molecules on Si(111)-7×7 surface is investigated by scanning tunneling microscopy at elevated temperatures. A water molecule decomposes right away into H and OH upon adsorption on the surface at ~300 ^{o}C. The OH radical can hop between neighboring adatom sites. At temperatures above 290 ^{o}C, it can further decompose into an H-atom and an O-atom, resulting in the complete dissociation of the water molecule. Thus surface diffusion of single O-atoms is studied quantitatively for the first time with diffusion parameters derived from Arrhenius plots. Two main adsorption states for O-atoms appear as protruded spots but with different image brightness. They can switch from one state to the other randomly at an adatom site. This study will cast light on the fundamental mechanisms in the very early stage of wet oxidation of silicon surfaces by water. (R. L. Lo, I. S. Hwang and T. T. Tsong)

(8) Diffusion of Adsorbed Si Atom on Si(111)-(7×7) Surface

By collaborating with Prof. C. M. Chang, we present first-principles calculations which provide a detailed diffusion picture of an adsorbed Si atom on Si(111)-(7×7) surface. Several diffusion paths for the adsorbed Si atom are established by mapping out the total energy as a function of its positions on the surface. For diffusion between the faulted and unfaulted halves, the energy barriers range from 0.96 to 1.21 eV, while remarkable low energy barriers from 0.3 to 0.7 eV are discovered within the faulted and unfaulted regions. (C. M. Wei)

(9) Theory of Quantum Size Effects in Thin Pb(111) Films

By collaborating with Prof. M. Y. Chou, we have carried out first-principles calculations of Pb (111) films up to 25 monolayers to study the oscillatory quantum size effects exhibited in the surface energy and work function. These oscillations are correlated with the thickness dependence of the energies of confined electrons, which can be properly modelled by an energy-dependent phase shift of the electronic wave function upon reflection at the interface. It is found that a quantitative description of these quantum size effects requires full consideration of the crystal band structure. (C. M. Wei)

(10) Ultra high resolution X-ray micro-radiography using phase contrast enhancement.

We have reached highest lateral resolution in X-ray radiography using hard-X-ray—0.2 micrometer. Using an opticsless approach to apply phase contrast enhancement allows direct observation of small biological specimen with high lateral resolution, high contrast and time resolution.

Real time applications to the biological specimens, including small insects and animals have been tested in Taiwan and Korea synchrotron facilities. Large scale collaborative team has been formed to implement this technique to the medical diagnosis and therapy.

The application in materials science has generated a number of interesting observation. Grain boundaries in pure materials—metal as well as polymer—was first time observed by X-ray radiography. High speed in radiology using phase contrast effect enables us to identify a tensile stress induced Ga diffusion in the Al alloy. Real time observation of the Zn electroplating process revealed a very special growth mode—Zn growth on H_2 bubbles—which links to very common growth defects.

With these successful applications, a beamline capable of producing hard-x-ray by using a wavelength shifter insertion device at SRRC (Synchrotron Radiation Research Center), was approved and is scheduled to operate at the summer 2003. The beamline will be dedicated to phase contrast radiology and eventually becomes a general user facility. (Yeukuang Hwu)

(11) Synchrotron radiation based spectromicroscopy using photoelectron emission microscope

High lateral resolution (<100nm), high time resolution (video rate) and high energy resolution (<0.1 eV) spectromicroscopy has been established. This was the first successful SR spectromicroscopy in Taiwan and its applications include the observation of small local difference in the surface chemical state and the magnetic domain structures. An unique application of this technique in the hard-X-ray region has generate very high resolution capable to capture phase enhanced radiology. Similar spectroscopy under development in SRRC(Synchrotron Radiation Research Center) which will be opened to general users. (Yeukuang Hwu)

(12) Development of synchrotron radiation techniques in the characterization of nanostructured materials.

Due to the lack of long range order in the structure of nanostructured materials, we have been collaborating with various materials research groups to develop suitable characterization methods, using synchrotron radiation, to characterized and analyze the structural and electronic properties of nanostructured materials.

Several methods, including EXAFS(Extended X-ray Absorption Fine Structure), XANES(X-ray Absorption Near Edge Structure), DAFS(Diffraction Anomalous Fine Structure) and SR-XRD(X-ray diffraction) have been applied in an integrated and complementary fashion. Such approach has been proven useful to provide additional information in the investigation of nanostructured materials. (Yeukuang Hwu)

2. Magnetism

(1) The planar hall effect in permalloy films

We have studied the transverse field effect on the planar Hall effect sensitivity of 79 Permalloy films. This phenomenon was explained by considering the Zeeman-energy and the effective single-domain-rotation effects. In particular, for the square sample, it was found that the PHE sensitivity is as high as 310 Ω/T at the film thickness t = 500 Å, and the inoperative range for the transverse field becomes the narrowest among all the samples. (S. U. Jen)

(2) Magnetostriction of Co-rich Co-Fe-Ni films

Co-rich Co-Fe-Ni ternary alloys were made either in a bulk or in a thin-film form.

The strain-gauge method was employed to measure saturation magnetostriction λ_S of the bulk samples. In addition, the optical-cantilever method was used to measure λ_S of the thin-film samples. Firstly, in the case of bulk sample, we found that in the Co-rich corner of the Co-Fe-Ni ternary diagram, if e/a = 26.9, λ_S is zero, if e/a>26.9, λ_S is positive, and if e/a<26.9, λ_S is negative. The existence of the zero-λ_S line is closely related to the drastic sign changes of λ_{100} and λ_{111} in the region and to the structural transition from the fcc to the bcc phase near e/a = 26.9. Secondly, in the case of thin-film sample, we found that the zero-λ_S line is greatly bent toward the Co-Ni axis. λ_S is a function of the film thickness. (S. U. Jen)

(3) Magnetic properties of Fe films grown on Ag nanometer dots

We have successfully grown 3-dimensional Ag(100) nanometer dots with {111} sidewalls on the Si(100) substrates and manipulated the interface roughness between Ag and Fe layers via the variation of thickness and deposition temperature of Ag layer. An in-plane magnetic anisotropy transition correlated to the 45^o rotation of the Fe lattice on the Ag layer was found in this Fe/Ag bilayers system. Moreover, the Fe film that deposited on the sidewalls of Ag nanometer dots contributed to the perpendicular magnetic anisotropy. The magnetic domains nucleation and 180^o-like wall formation on the sidewalls of the nanometer dots were first observed. These phenomena can be realized by the epitaxial structure and perpendicular magnetic anisotropy of Fe films. (Y. D. Yao and Y. Liou)

(4) Physical property of phase change materials

Optical recording technology has developed rapidly over the past few years, encouraging a renewed interest in phase change materials for use as erasable media. These materials, usually chalcogenide thin films, are switched between amorphous and crystalline states using the heat of a focusde laser beam. In general ,rouduy 20% reflectivity differences between the amorphous and crystalline states are required for recording purpose. Various phase change materials e.g. GeSbTeSe etc. have been febricated, and their physical properties will be investigated under this research topic. (Y. D. Yao)

(5) Tunneling magnetoresistance

Micron size ferromagnetic tunnel junctions were made to study the spin dependent tunneling magnetoresistance with different ferromagnetic materials as electrodes, Al_2O_3 as insulating barrier. The spin polarization effect, the oxidation process, and the crystal structures were studied. (Y. D. Yao, Y. Liou, and S. F. Lee)

(6) Surface Magneto-Optical Kerr Effect

A surface magneto-optical Kerr effect system was built by modifying a surface analytical system-VG ESCA Lab. The surface analytical system includes XPS, AES and LEED functions. The modification includes several deposition instrument-e-beam evaporator, filament evaporator, and a Moke instrument with a magnetic inside the vaccum chamber. Ultrathin films of Co deposition on Si or Ge surface have been studied. Perpendicular magnetization and alloy formations have been analyzed. Magnetic dead layers for different substrates and temperatures have been measured. A buffer-layer between Co and substrate in order to prevent alloy formation will influence the Co layer mag1etic property from perpendicular to in-plane magnetization. Co deposited on Si or Ge at room temperature shows no clear crystal structure observed from LEED. Since the crystal structure of Co thin films is undefined, we have difficulty to determine the relationship between the structure and the magnetic property. Co thicker films (>5 monolayers) have only in-plane magnetization but thinner films (<5 monolayers) have both in –plane and perpendicular magnetization.(Y. D. Yao)

(7) Magnetic fluid study

In recent year, a great deal of efforts has been made on the understanding of the physical phenomena in various magnetic fluids. Magnetic field induced optica1 transmission studies in some magnetic f1uid system have been investigated by us recently. In this year, we will continue to study magnetic and optical properties of some magnetic ferrofluids and magnetic fluids of colloidal particles as functions of the macro-size magnetic colloidal particles, the concentration of SDS, incident optical wavelengths, and applied magnetic fields etc. (Y. D. Yao)

(8) Nano and submicron magnetic structures

Magnetism and magneto-transport effects were studied in small magnetic structures having designed shapes. Real time Magnetic Force Microscope images under applied field agree well with micromagnetic simulations. Designed half-ring-in-series and S-in-series shape wires have the advantage that Anisotropic magnetoresistance is cancelled out at saturation. Thus, contributions from domains walls can be studied. Intentional shape defect is used to pin the domain wall motion. Possible magnetic logic operation unit is under investigation. (Y. D. Yao, Y. Liou, and S. F. Lee)

(9) Physical properties of ferromagnet/superconductor multilayers

Electric and magnetic properties of trilayers and multilayers of superconducting Nb, NbTi, and ferromagnetic Co are studied. When superconducting layer thickness is reduced, a crossover from three-dimensional behavior to two-dimensional one was observed. Form the upper critical field versus applied field angle, we see the bell shape crossover to cusp shape behavior for NbTi, but all Nb sample showed bell shape. This observation cannot be well-described by the theory. Current perpendicular to plane resistance in these multilayers was studied. Interface resistance was isolated quantitatively. (S. F. Lee)

(10) Iron-based tunable microwave devices

The high quality Fe-based band-stop filters were fabricated in our MBE EL-10A system. The frequency tuning ranges for ferromagnetic resonance absorptions were 0 to 50 GHz, which is the widest tuning ranges of the world. A resonance equation, which considered the magnetic anisotropy, was served for predicting the frequency tuning behavior. A very large transmission loss, namely, –50dB/cm, was obtained via the flip-chip technique. For the consideration of application, a series of poly-crystal films were fabricated at room temperature too. We found that structural defects or interface diffusion between film and substrate constitute an important factor that affects the degree of microwave absorption. Inserting an ultra-thin metal buffer eliminated the defect structure of the poly-crystal Fe film and greatly improved both the frequency range and the strength of the FMR absorption

3.Quantum Size Effects and Nanostructures

(1) Size-Induced Transition from Magnetic Ordering to Kondo Behavior in (Ce, Al) Compounds

Magnetic ordering and Kondo behavior coexist in three (Ce,A1)-based compounds, $CeA1_2$, Ce_3Al and Ce_3Al_{11}. A common feature apparently independent of crystal structures also prevails in terms of the size-induced transition between these two magnetic phenomena. Calorimetric data show that, as the particle sizes are reduced to nano-scale, the specific heat anomaly associated with the magnetic ordering diminishes. Meanwhile, he increased coefficient γ of the linear term in specific heat indicates a large enhancement of the Kondo behavior. In 80Å-$CeAl_2$, for example, magnetic ordering completely disappears and the extrapolated γ reaches 9500 mJ $molCe^{-1}$ K^{-2} at absolute zero. This value falls in the highest range ever reported for heavy fermion compounds. (Y. Y. Chen, Y. D. Yao, T. K. Lee etc.)

(2) Size effects on superconductivity and magnetism in $CeCo_2$

Both Ce and Co are essentially nonmagnetic in Pauli-paramagnetic $CeCo_2$, which undergoes a superconducting transition near 1 K. When made into 50-Å nanoparticles, the compound becomes paramagnetic with an effective magnetic moment of 6.1 μ_B/f.u. and undergoes a spin glass transition at $T_f \sim 12$ K. Meanwhile, based on heat capacity measurements, the nanoparticles remain to be non-superconducting down to 0.4 K but exhibit a low-temperature Kondo anomaly with γ~350 mJ/mol K^2 at 0.4K. Such intriguing effects are consequences of the size reduction-induced changes in band structure as well as in electronic spectrum's mean level spacing. (Y.Y. Chen, C.R. Wang, Y.D. Yao etc.)

(3) Magnetic Ordering and Spin Reorientation in $ErGa_3$

Calorimetric measurements between 0.3 and 10 K have been made on a single crystal of the $AuCu_3$-type cubic compound $ErGa_3$. The temperature dependence of specific heat exhibits an antiferromagnetic ordering-induced peak near 2.7 K, a second peak at 2.5 K due to spin reorientation, and a Schottky anomaly with crystal field parameters x = 0.17 and W = 0.22 K, all being in agreement with the results from neutron studies. The sum of the calculated entropies associated with the order-disorder process (Rln2) and the crystal-field effect, respectively, is lower by 0.1R than the experimentally derived magnetic entropy values at approximately 6 to 10 K. This difference provides an estimate of a 2-J/mol latent heat for the spin rotation process. An anticipated transition from an amplitude-modulated magnetic structure to an equal magnetic moment structure at temperatures near $T_N/2$ was not observed. (Y.Y. Chen, Y.D. Yao, C.R. Wang, and S.H. Lin A.Czopnik, M.R. Ali and J.C. Ho)

(4) Nano-electronics (C. D. Chen)

Taking advantage of modern electron-beam lithography technology, we are able to fabricate various nanometer-scaled electronic devices with the critical dimension as small as 30 nm. The objective is two-fold: to study novel (quantum) effects associate the small length scale of the devices and to utilize these effects for applications such as signal detection or information processing. The relevant length scales range from electron wavelength to phase breaking length, or spin relaxation length in magnetic systems. The materials that may be employed are superconductors, ferromagnets, semiconductors and novel materials such as carbon nanotubes and other synthesized nanowires, colloidal particles. These materials are patterned or arranged into one-dimensional narrow wires, quantum dots and point contacts. When incorporated with tunnel barriers, they can be configured into single electron transistors. The following is a brief to our recent research activities:

A. Suppression of superconductivity by spin imbalance in ferromagnetic-superconductor-ferromagnetic single electron transistors

We present here an experimental demonstration for suppression of superconductivity by spin imbalance. This effect is manifested under spin-polarized quasiparticle current injection in ferromagnet-superconductor-ferromagnet (Co/Al/Co) single electron transistors. The measured superconducting gap as a function of magnetic field reveals a dramatic decrease when the magnetizations of the two leads are misaligned. The effect of suppression increases with increasing source-drain voltage. A comparison with numerical calculations for single electron transistor in sequential tunneling regime is performed. The imbalance of spins is a nonequilibrium process. For this process to be effective, a sufficiently long spin relaxation time and a short energy relaxation time are required. Various factors that may affect this process are considered. This method may render it applicable to control superconductivity at low temperatures within low fields. For details, please see Physical Review Letters, 88, 047004 (2002).

Accumulation of excess spins is maximized when the magnetizations of the two ferromagnetic leads are in antiferromagnetic alignment. In our case, the AF alignments are caused by random domain distributions in the two Co leads, and the observed hysteresis in the superconducting gap as a function of applied field is simply a sign of magnetization reversal in probably a single domain. This then enables measurement of the magnetization relaxation time of a small domain. Experimentally, this relaxation time is found to be very long at low temperature (T~250mK) and has strong temperature dependence. The dynamics of small domains is of interest as it is related to the response time of nano-spintronics.

B. Gate-controlled spin polarized current in ferromagnetic single electron transistors

We theoretically investigate spin dependent transport in ferromagnetic/normal metal/ferromagnetic single electron transistors by applying master equation calculations using a two dimensional space of states involving spin and charge degrees of freedom. When the magnetizations of ferromagnetic leads are in anti-parallel alignment, the spins accumulate in the island and a difference of chemical potentials of the two spins is built up. This shift in chemical potential acts as charge offset in the island and alternates the gate dependence of spin current. Taking advantage of this effect, one can control the polarization of current up to the polarization of lead by tuning gate voltages. For details, please see Physical Review B, 65, 104427 (2002).

C. Single electron memory device with Au colloidal islands

By combining advanced electron beam lithography and nanophased-material synthesis techniques, we have successfully prepared single electron memory devices with Au colloidal islands linked by C_{60} derivatives. The transport measurements exhibit clear Coulomb blockade type current-voltage characteristics and hysteresis-type current modulation as a function of applied gate voltage. With the guidance provided by Monte Carlo simulation, we proposed a model circuit and gave an estimate of the sample parameters. Details are to be published in Applied Physics Letters, Vol. 81 (2002).

D. Fabrication of Two-Dimensional Arrays of CdSe Pillars Using E-Beam Lithography and Electrochemical Deposition

By combining e-beam lithography and electrochemical deposition techniques, we demonstrate a simply, unique and low-cost method for fabricating 2D arrays of CdSe pillars. With this technique, virtually any type of 2D array patterns can be made, and optical elements such as photon trap/emitters and waveguides can be placed at any designed locations. This technique is compatible with the present-day semiconductor-industry processes, and pillar arrays made of other high refractive index materials such as CdS, TiO_2 can be readily fabricated. These arrays should have potential in optic-device applications such as filters, waveguides, cavity resonators and photonic crystals. Details are to be published in Advanced Materials (2003).

(4) Trapped atomic gases and Bose-Einstein condensation

We are also researching on physics of quantum many-body systems in atomic traps. This is an active field of research opened up by recent experimental advances, in particular the achievement of Bose Einstein Condensation. These trapped gases provide excellent opportunities to study many new quantum systems of theoretical interests. We are working on some of these, such as trapped gases with internal (spin) degrees of freedom, physics of low dimensionality, possibility of (Cooper) pairing in trapped fermions, properties of superfluid mixtures etc. (Wu and Yip)

4. Crystal Growth and Optical Properties of Non-linear Crystals

(1) Single crystal growth and their optical properties

Crystal growth is a science of high application. The various crystals can be used in manufacturing electronic, semiconductor as well as solid state laser devices and also are important materials for optical and instrument industry. Eighty decade is the period of rapid expanding in tunable laser materials. After the successful growing of $Cr:BeAl_2O_4$ and $Ti:Al_2O_3$ laser crystals, there were found more than thirty laser crystals that can produce tunable laser light. In this project we are going to study the doping gannet family about their crystal growth and optical properties measurement.

Due to small and hardy requirement, the laser crystals are usually pumped by LD so that the efficient stability and reliability obtained great improvements. The aim of the first year project is to study the growth and optical properties of Nd: YAG crystal. The remaining time is then go to the study of those tunable doped YAG laser crystal and also other tunable laser materials.

The doped gannet crystals of large diameter can be grown by Czochralski pulling technique. X-ray diffraction and other optical measurements are employed to identify the structure and to inspect the quality of different doped garnet laser rods. It is hoped that the final outcome of this project can successfully manufacture some tunable solid state lasers for application usage. (W. -S. Tse)

(2) Semiconductor spectra study

We use a high resolution Fourier Transform infrared spectrometer to measure the electronic excitation spectra of various donor and acceptor impurities in silicon and germanium. The measurements are made mostly with the sample cooled to liquid helium temperature. Due to the very high resolution of the spectrometer, the positions of the peaks of the absorption lines can be determined precisely. Weak lines can also be resolved and observed. The shape and the width of the absorption lines from the high resolution measurements are also used to study the possible reasons for the line broadening phenomenon.

Right now we are studying the behavior of a novel impurity center, i.e. magnesium-oxygen complex in silicon, which has never been reported in the literature before. Magnesium is well-known to be interstitial donor impurities in silicon. When diffused into silicon containing oxygen, the excitation spectrum observed clearly demonstrates for the first time that magnesium can complex with dispersed oxygen in silicon to form magnesium-oxygen complex donors. During the course of studying the behavior of this novel complex impurity, we have further found an unexpected phenomenon, which indicates that this complex impurity pair can even be formed in silicon at temperatures as low as ordinary room-temperature. The result of such an unusual feature has been published in Physica B 302-303, 197-200 (2001). Considering that silicon is the material to be widely used in many important semiconductor industries today, it should be quite interesting to be aware of the possibility that the basic characteristic of this material might change on its own at room-temperature.

Recently, we have also successfully observed the excitation spectrum for singly ionized magnesium-oxygen complex impurities in silicon. Our observation clearly demonstrates that the magnesium-oxygen complex donor, similar to isolated magnesium double donor, behaves as a double donor in silicon as well. This result has been accepted to be published in Physica Status Solidi in early 2003. (T. -M. Ho)

5. Strongly Correlated Many-body Systems

(1) Existence of superconductivity in the t-J model

t-J model has been the most studied model for high temperature superconductors since its discovery. However whether the t-J model is enough to provide the strong superconductivity has been the focus of hot debates since our paper published in 1998. (D-wave pairing correlation in the two-dimensional t-J model, Phys. Rev. Lett., 81, 1294-1297 (1998). by C.T. Shih, Y.C. Chen, H. Q. Lin and T.K. Lee) We showed that there is very small pairing correlation in the ground state of t-J model. Recently Sorella et al. had claimed an exactly opposite result. A comment of this paper by us has been accepted by Phys. Rev. Lett.. This issue will remain to be an important subject for discussion in the near future. (T.K. Lee)

(2) New theory for lightly doped Mott insulators

Based on the variational approach recently we have constructed a new theory to describe the Mott insulators with light doping of holes or electrons. New trial wave functions, constructed explicitly from the unique Mott insulating state with antiferromagnetic order, are proposed to describe the ground state of a Mott insulator slightly doped with holes or electrons. A rigid band is observed as charged quasi-particles with well-defined momenta being realized in these states. These states have much less superconducting correlations than previously studied ones. Small Fermi patches obtained are consistent with recent experiments on high Tc cuprates doped lightly with holes or electrons.

In addition to the quasi-particle states mentioned above, there is another kind of states at low energy. Quasi-particle states with well-defined momenta for doped holes are found to have a robust momentum-energy dispersion relation. Each quasi-particle state in which an unpaired spin is bound to a hole can be excited with spin waves. The resulting states show a suppression of antiferromagnetic order around the hole with the profile of a spin bag. These spin-bag states form a continuum of low energy excitations. In addition to the energy-momentum distributions, these two kinds of states have very different properties in their spectral weight, momentum distribution function, spin-hole correlation, and spin-spin correlation around holes. These results are shown to be in good agreement with the exact diagonalization studies of small clusters up to 32 sites. (T. K. Lee)

(3) Magnetic polarization induced by nonmagnetic impurities in high Tc cuprates

The magnetic polarization induced by nonmagnetic impurities such as Zn in high Tc cuprates is studied by the variational Monte Carlo method. The variational wave function is constructed from the eigenstates obtained from Bogoliubov-de Gennes mean-field Hamiltonian for the two-dimensional t-J model. A Jastrow factor is introduced to account for the induced magnetic moment and the repulsion between holes and the impurity. A substantial energy gain is obtained by forming an antiferromagnetic polarization around the impurity. We also find the doping dependence for the induced magnetic moment consistent with experiments. (T. K. Lee)

6. Biophysics

(1) Transverse Wave Propagation Equation in Circulatory System and Its Application to Physiology.

(2) E-M Field Effect on Biological System and Its Applications.

(3) Pulse Spectrum Analysis and Chinese Medicine.

Rats will be used as the experimental animal to study the effect of organ on the blood pressure wave and flow.

Energy in the circulatory system is mainly in the form of pressure. Kinetic energy is only a few percent. The pressure wave is the main energy source to push the blood flow. This project will study the relation between blood pressure wave and blood flow especially the blood pressure wave and the blood flow into organs. The main organ is kidney.

We will study the change of its elasticity and resistance effect on the blood pressure wave as well as the blood flow.

Besides, we have derived the transverse wave propagation equation in the artery and is studying the wave propagation property at the branch point. Organ or vascular bed will be included in this equation. Studies of the flow in the renal artery aorta and microcirculation in the kidney have been performed to evaluate the accuracy of the equation. In clinical application, blocking of the small artery, changing of elasticity of the arterial wall... all will be shown in the resonant frequency of this organ. This model is closely related to Chinese Medicine which also emphasizes the pressure pushes the blood flow(氣行血). (W.-K. Wang)

(4) Optimization problems for computational biology

The goal of this project is to construct a method to greatly increase the speed and accuracy of determining the optimal solutions for a number of optimization problems like x-ray crystallography for macromolecules, geometric shape for the lowest energy conformation of atomic clusters, and protein structure prediction, etc.. We have developed a new algorithm based on the mean-field approach to treat global optimization problems. In this approach mean-field order parameters are calculated to guide the configuration search for the global minimum in our Monte Carlo algorithm. Allowing fluctuations and improvement of mean-field values iteratively, this method successfully identified global minima for several difficult optimization problems. Application of this method to HP lattice model for protein folding problem has found a new lowest energy state and conformation for an N = 100 sequence that were not found by other methods before. Results for Lennard-Jones clusters are also presented. (T. K. Lee)

STATISTICAL AND COMPUTATIONAL PHYSICS

1. Equilibrium Phase Transitions

(1) Exact amplitude ratio and finite-size corrections for the $M \times N$ square lattice Ising model.

(2) Random-cluster multi-histogram sampling for the q-state Potts model.

(3) Surface critical behavior of random systems at the special transition.

(4) Evolution and structure formation of the distribution of partition function zeros.

(5) Exact finite-size corrections for the square-lattice Ising model with Brascamp-Kunz boundary conditions.

(6) Exact partition functions of the Ising model on M x N planar lattices with periodicaperiodic boundary conditions.

(7) Exact asymptotic expansions for free models of statistical mechanics on torus.

(8) Universal finite-size scaling functions with exact non-universal metric factors.

(9) Exact finite-size corrections of the free energy for square lattice dimer model under different boundary conditions.

(10) Level statistics of Hessian matrices: random matrices with conservation constraints.

2. Nonequilibrium Statistical Physics

(1) Spiral cracks in drying precipitates.

(2) Statistical properties of quasi-static fracture: theory and simulation studies.

3. Chaos and Nonlinear Dynamics

(1) Multistability and chaos in a semiconductor microwave device with time-delay feedback.

(2) Universality and scaling in waves of a sandpile model on regular and random lattices.

(3) Renormalization group study of a sandpile model on planar lattices.

(4) Finite Size Behavior of the Asymmetric Avalanche Process.

(5) The Asymmetric Avalanche Process.

4. Macromolecules and Complex Fluids

(1) Strong light scattering in polymer solutions with multicomponent solvent.

(2) Energy landscape paving for X-ray structure determination of organic molecules.

5. Theoretical and Computational Biological Physics

(1). Parallel tempering simulations of HP-36.

6. Complex Human and Social Systems.

(1) A Stochastic Dynamic Model for Stock-Stock Correlations.

(2) Universal life indication of heartbeat intervals discriminates the stage of patients in the intensive care unit.

STATISTICAL AND COMPUTATIONAL PHYSICS

The faculty members of this research group are Chin-Kun Hu, Kwan-Tai Leung, and Simon C. Lin.The postdoctoral fellows are Shura Hayryan , Chai-Yu Lin (left in October 2002), A. M. Povolotsky,Ming-Chya Wu, Wen-Jong Ma (came in June 2002), and Cheng-Hsiao Lin (came in Oct. 2002). The visiting associate research fellow is N. Sh. Izmailian (December 2001-July 2003).

We have established Laborotory of Statistical and Computational Physics (LSCP) in the 6th. floor of the Institute of Physics. LSCP is devoted to frontier research in statistical and computational physics (SCP), applications of SCP to problems in physical, biological, and social sciences, sponsoring meetings in SCP, and promoting education and research of SCP in developing countries

During January-December 2002, we have organized one international symposium and several small workshops. The details of such activities can be found at LSCP website: http://www.sinica.edu.tw/˜statphys. The proceedings of the international symposium will be published in Physica A as a regular issue.

During January-December 2002, we have published 10 papers in SCI journals, including one paper in Physical Review Letters, six papers in Physical Review E, two paper in Journal of Phys. A: Math.and Gen., and one paper in Acta. Crystallogr. A.

We have submitted elevan manuscripts to SCI journals; six of them have been accepted by SCI journals, including three in Physica A, one in Journal of Statistical Physics, one in Journal of the Physical Society of Japan, and one in Proteins – Structure, Function and Genetics.

Our main research results are listed below.

1. Equilibrium Phase Transitions

(1) Exact amplitude ratio and finite-size corrections for the $M \times N$ square lattice Ising model.

Let f, U and C represent, respectively, the free energy, the internal energy and the specific heat of the critical Ising model on the $M \times N$ square lattice with periodic boundary conditions, and f_∞ represents f for fixed M/N and $N\to\infty$. We find that f, U and C can be written as: $N(f - f_\infty) = \sum_{i=1}^{\infty} f_{2i-1}/ N^{2i-1}$,$U = -\sqrt{2} + \sum_{i=1}^{\infty} u_{2i-1}/ N^{2i-1}$ and $C = 8 \ln N/\pi + \sum_{i=0}^{\infty} c_i / N^i$, i.e. Nf and U are odd function of N^{-1}. We also find that $u_{2i-1}/c_{2i-1} = 1/\sqrt{2}$ and $u_{2i}/c_{2i} = 0$ for $1 \le i < \infty$ and obtain analytic equations for f, U, and C up to orders $1/N^5$, $1/N^5$, and $1/N^3$, respectively, which implies an analytic equation for c_5 [N. Sh. Izmailian and C.-K. Hu, Phys. Rev. E 65, 036103 (2002)].

(2) Random-cluster multi-histogram sampling for the q-state Potts model.

Using the random-cluster representation of the q-state Potts models we consider the pooling of data from cluster-update Monte Carlo simulations for different thermal couplings K and number of states per spin q. Proper combination of histograms allows for the evaluation of thermal averages in a broad range of K and q values, including non-integer values of q. Due to restrictions in the sampling process proper normalization of the combined histogram data is non-trivial. We discuss the different possibilities and analyze their respective ranges of applicability. [M.Weigel, W. Janke, C.-K. Hu, Phys. Rev. E 65, 036109 (2002)].

(3) Surface critical behavior of random systems at the special transition.

We use a three dimensional massive field theory up to the two-loop approximation to study the surface critical behavior of semi-infinite quenched random Ising-like systems at the special transition. Besides, we extend up to the next-to leading order, the previous first-order results of the $\sqrt{\varepsilon}$ expansion obtained by Ohno and Okabe [Phys. Rev. B 46, 5917 (1992)]. The numerical estimates for surface critical exponents in both cases are computed by means of the Pad´e analysis. Although our $\sqrt{\varepsilon}$ expansion results are consistent with Ohno and Okabe's first-order results, our higher order results are still unreliable because they imply a negative value of the critical exponent η. In the case of the massive field theory we also perform Pad´e-Borel resummation of the resulting two-loop series expansions for surface critical exponents and obtain $\eta_{\|}$ = - 0.238, Δ_1 = 1.098, $\eta_{\perp}$ = -0.104, β_1 = 0.258, γ_{11} = 0.839, γ_1= 1.426, δ_I = 6.521, and δ_{II} = 4.249. These values are quite consistent with those obtained from the Pad´e analysis and they imply $\eta = 2\eta_{\perp} - \eta_{\|} = 0.030$ consistent with six-loop renormalization group calculation by Pelissetto and Vicari [Phys. Rev. B 62, 6393, (2000)]. These values are different from critical exponents for pure semi-infinite Ising-like systems and show that in a system with quenched bulk randomness the plane boundary is characterized by a new set of surface critical exponents at the special transition [Z.E.Usatenko and C.-K. Hu, Phys. Rev. E 65, 066103 (2002)].

(4) Evolution and structure formation of the distribution of partition function zeros.

The distribution of partition function zeros of the two-dimensional Ising model in the complex temperature plane is studied within the context of triangular decorated lattices and their triangle-star transformations. Exact recursion relations for the zeros are deduced for the description of the evolution of the distribution of the zeros subject to the change of decoration level. In the limit of infinite decoration level, the decorated lattices essentially possess the Sierpinski gasket or its triangle-star transformation as the inherent structure. The positions of the zeros for the infinite decorated lattices are shown to coincide with the ones for the Sierpinski gasket or its triangle-star transformation, and the distributions of zeros all appear to be a union of infinite scattered points and a Jordan curve, which is the limit of the scattered points [T. M. Liaw, M. C. Huang , Y. L. Chou, and S. C. Lin, Phys. Rev. E. 65, 066124 (2002)].

(5) Exact finite-size corrections for the square-lattice Ising model with Brascamp-Kunz boundary conditions.

Finite-size scaling, finite-size corrections, and boundary effects for critical systems have attracted much attention in recent years. Here we derive exact finitesize corrections for the free energy F and the specific heat C of the critical ferromagnetic Ising model on the$M\times 2N$ square lattice with Brascamp-Kunz (BK) boundary conditions [J. Math. Phys. 15, 66 (1974)] and compared such results with those under toroidal boundary conditions. When the ratio $\xi/2 = (M+1)=2N$ is smaller than 1 the behaviors of finite-size corrections for C are quite different for BK and toroidal boundary conditions; when ln(ξ =2) is larger than 3, finite-size corrections for C in two boundary conditions approach the same values. In the limit $N\to\infty$ we obtain the expansion of the free energy for infinitely long strip with BK boundary conditions. Our results are consistent with the conformal field theory prediction for the mixed boundary conditions by Cardy [Nucl. Phys. B 275, 200 (1986)] although the definitions of boundary conditions in two cases are different in one side of the long strip [N. S. Izmailian, K. B. Oganesyan, and C.-K. Hu, Phys. Rev. E 65, 056132 (2002)].

(6) Exact partition functions of the Ising model on M x N planar lattices with periodicaperiodic boundary conditions.

The Grassmann path integral approach is used to calculate exact partition functions of the Ising model on M x N square (sq), plane triangular (pt) and honeycomb (hc) lattices with periodic-periodic (pp), periodic-antiperiodic (pa), antiperiodic- 2 periodic (ap) and antiperiodic-antiperiodic (aa) boundary conditions. The partition functions are used to calculate and plot the specific heat, C/k(B), as a function of temperature, $\theta = k_B T / L$. We find that for the $N \times N$ sq lattice, C/k_B for pa and ap boundary conditions are different from those for aa boundary conditions, but for the $N\times N$ pt and hc lattices, $C=k_B$ for ap, pa and aa boundary conditions have the same values. Our exact partition functions might also be useful for understanding the effects of lattice structures and boundary conditions on critical finite-size corrections of the Ising model [M. C. Wu and C.-K. Hu, J. Phys. A: Math. Gen. 35, 5189 (2002)].

(7) Exact asymptotic expansions for free models of statistical mechanics on torus.

For the free models of statistical mechanics on torus, including the Ising model, dimer model and Gaussian model, exact asymptotic expansions of free energy, internal energy and specific heat in the vicinity of the critical point are found. It is shown that there is a direct relation between the terms of the expansion and Kronecker's double series. The latter can be expressed in terms of the elliptic theta-functions in all orders of the asymptotic expansion. [E. V. Ivashkevich, N. Sh. Izmailian, and C.-K. Hu, J. Phys. A. Math. Gen. 35, 5543 (2002)].

(8) Universal finite-size scaling functions with exact non-universal metric factors.

Using exact partition functions and finite-size corrections for the Ising model on finite square, plane triangular, and honeycomb lattices, we obtain universal finite-size scaling functions for the specific heat, the internal energy, and the free energy of the Ising model on these lattices with exact non-universal metric factors [M. C. Wu , C.-K. Hu and N. Sh. Izmailian].

(9) Exact finite-size corrections of the free energy for square lattice dimer model under different boundary conditions.

We express the partition functions of the dimer model on the square lattice under five different boundary conditions (free, cylindrical, toroidal, M¨obius strip and Klein bottle) in terms of the partition functions with twisted boundary conditions $Z_{\alpha,\beta}$ with (α,β)= (1=2; 0); (0; 1=2) and (1=2; 1=2). Based on such expressions, we then extend the algorithm of Ivashkevich, Izmailian and Hu [J. Phys. A 35, 5543 (2002)] to derive the exact asymptotic expansion of the logarithm of the partition function for all above mentioned boundary conditions. We find that finite-size corrections depend sensitively on boundary conditions and even or odd of the number of lattice sites in the vertical or horizontal directions of the lattice. We have also established several groups of new identities relating dimer partition functions for the different boundary conditions [N. S. Izmailian, K. B. Oganesyan, and C.-K. Hu].

(10) Level statistics of Hessian matrices: random matrices with conservation constraints.

We consider the Hessian matrices of simple liquid systems as a new type of random matrices. By numerically comparing the distribution of the nearest-neighbor level spacing(LS) of the eigenvalues with the Wigner's surmise, we found that the level statistics is akin to the generic Gaussian Orthogonal Ensemble(GOE), in spite of the constraints due to the summation rules and the presence of the correlation among the components inherited with the underlying spatial configuration. The distribution is in good agreement with the Wigner's prediction if only the extended eigenstates are considered. Indeed, our theoretical analysis shows that the ensemble of real symmetric matrices with full randomness, but constrained by the summation rules, is equivalent to the GOE with matrices of the rank lower ed by the spatial dimension [W.-J. Ma, T.-M. Wu, J. Hsieh, and S.-L. Chang].

2. Nonequilibrium Statistical Physics

(1) Spiral cracks in drying precipitates.

We investigate the formation of spiral crack patterns during the desiccation of thin layers of precipitates in contact with a substrate. This symmetry-breaking fracturing mode is found to arise naturally not from torsion forces but from a propagating stress front induced by the foldup of the fragments. We model their formation mechanism using a coarse-grain model for fragmentation and successfully reproduce the spiral cracks. Fittings of experimental and simulation data show that the spirals are logarithmic. Theoretical aspects of the logarithmic spirals are discussed. In particular we show that this occurs generally when the crack speed is proportional to the propagating speed of stress front. [Z. Neda, K.-t. Leung, L. Jozsa, and M. Ravasz, Phys. Rev. Lett. 88, 095502 (2002)].

(2) Statistical properties of quasi-static fracture: theory and simulation studies.

We consider the slow generation of crack networks as a problem of pattern formation. Statistical properties pertaining to pattern selection are addressed by means of a detailed study of a discrete spring-block model. Developed after observations of desiccation experiments, the model describes the nucleation and propagation of cracks in an overlayer in contact with a frictional substrate. Competition between stress concentration at crack tips and pinning effect by friction leads to a cellular, hierarchical pattern of cracks. We characterize the events prior to cracking by a growth of correlation in the stress field, and those during cracking by progressive damages manifested in the number of broken bonds and energy released. Qualitatively distinct regimes are shown to correspond to different stages of the evolution. Consistent with experimental observations, fragment area is found to be quadratic in the sample thickness, and to diminish with increasing friction. [K.-t. Leung and Z. Neda].

3. Chaos and Nonlinear Dynamics

(1)Multistability and chaos in a semiconductor microwave device with time-delay feedback.

We propose a tunable microwave device consisting of a Gunn diode with time-delay feedback, which will emit high-dimensional chaotic waves. The wavelength is controlled by two incident laser beams which trigger the moving multiple Gunn-domains. Predicted phenomena include the coexistence of stationary and chaotic states, complicated hysteresis loops, persistent bistabiliy, transient and high-dimensional chaos, *etc.*. This device is potentially useful for secure microwave communications, memory devices, applications involving photorefractive effects, *etc.* [Y.-H. Shiau, H.-P. Chiang, Y.-C. Cheng, and C.-K. Hu].

(2)Universality and scaling in waves of a sandpile model on regular and random lattices.

Rice pile experiments suggest that self-organized criticality (SOC) might not be as "universal" and insensitive to the details of the system as ordinary systems driven to criticality by a turning parameter (Nature 379, 49, 1996). Here we use Monte Carlo simulations to calculate probability distributions of areas of all, last, dissipating, and dissipating-last waves of Bak-Tang-Wiesenfeld sandpile model of SOC on triangle, honeycomb, and random lattices with various linear dimensions. We find that such distributions have very nice finite-size scaling behaviors and these lattices have the same set of critical exponents as those of the square lattice [C.-Y. Lin and C.-K. Hu and C.-K. Hu].

(3)Renormalization group study of a sandpile model on planar lattices.

One important step in the renormalization group (RG) approach to a lattice sandpile model is the exact enumeration of all possible toppling processes of sandpile dynamics inside a cell for RG transformations. Here we first propose a computer algorithm to carry out such exact enumeration for cells of planar lattices and we consider both the reduced-high RG equations proposed by Pietronero, Vespignani, and Zapperi (PVZ) [Phys. Rev. Lett. 72, 1690 (1994)] and real-height RG equations proposed by Ivashkevich [Phys. Rev. Lett. 76, 3368 (1996)]. Using this algorithm we are able to carry out RG transformations with large cell size, e.g. 3 £ 3 cell for the sq lattice in PVZ RG equations, which is the largest cell size at the present, and find some mistakes in a previous paper [Phys. Rev. E 51, 1711 (1995)]. For square (sq) and plane trianglar (pt) lattices, we obtain the only attractive fixed point for each lattice and calculate the avalanche exponent ¿ and the dynamical exponent z. Our results suggest that the multiple toppling events, which was negected in PVZ RG equations, should be included in the construction of RG equations in order to get accurate ¿ and z [C.-Y. Lin and C.-K. Hu, Phys. Rev. E 66, 021307 (20020).

(4)Finite Size Behavior of the Asymmetric Avalanche Process.

We study the behavior of particle flow in the asymmetric avalanche process with partially asymmetric diffusion below the line separating phases of intermittent and continuous flow. Besides the average velocity of flow, that can be obtained in the limit of infinite system size, we obtain the other quantities, such as the dispersion of flow, that does not survive in the thermodynamic limit. Particularly, the generating function of distance travelled by particles is shown to have universal form, specific for Kardar-Parisi-Zhang universality class. To obtain these quantities we apply the method of calculation of finite size corrections to the infinite system size solution based on the Bethe ansatz solution of master equation [A.M. Povolotsky, V.B. Priezzhev, and C.-K. Hu].

(5)The Asymmetric Avalanche Process.

An asymmetric stochastic process describing the avalanche dynamics on a ring is proposed. A general kinetic equation which incorporates the exclusion and avalanche processes is considered. The Bethe ansatz method is used to calculate the generating function for the total distance covered by all particles. It gives the average velocity of particles which exhibits a phase transition from an intermittent to continuous flow. We calculated also higher cumulants and the large deviation function for the particle flow. The latter has the universal form obtained earlier for the asymmetric exclusion process and conjectured to be common for all models of the Kardar-Parisi-Zhang universality class [A.M. Povolotsky, V.B. Priezzhev, and C.-K. Hu].

4. Macromolecules and Complex Fluids

(1)Strong light scattering in polymer solutions with multicomponent solvent.

Considering the density-density correlation function of a concentrated polymer solution with multicomponent solvent we find a phase transition due to the heterogeneity of excluded volume constant. This new phase transition implies a strong enhancement of the scattered light intensity in the critical region, which can explain a recent experiment showing strong light scattering from a ternary polymer system consisting of polyethylene oxide (PEO) dissolved in nitroethane and 3methyl-pentane. [Zh.S. Gevorkian and C.-K. Hu].

(2)Energy landscape paving for X-ray structure determination of organic molecules.

The effciency of a recently proposed novel global optimization method, energy landscape paving (ELP), is evaluated with regard to the problem of crystal structure determination from simulated X-ray diffraction data comprising integrated diffraction intensities. The new approach has been tested using the example of 9-(methylamino)-1H-phenalen-1-one 1,4-dioxan-2-y1 hydroperoxide solvate (C14H11NO.C4H8O4). The results indicate that, for this example, ELP outperforms standard techniques such as simulated annealing.

5. Theoretical and Computational Biological Physics

(1). Parallel tempering simulations of HP-36.

We report results from all-atom Monte Carlo simulations of the 36-residue villin headpiece subdomain HP-36.Protein-solvent interactions are approximated by an implicit solvent model. The parallel tempering technique is used to overcome the problem of slow convergence in low-temperature protein simulations. Our results demonstrate that this technique allows to sample native-like structures of small proteins, but also point out the need for improved energy functions [C.-Y. Lin, C.-K. Hu, and U. H. E. Hansmann].

6. Complex Human and Social Systems.

(1) A Stochastic Dynamic Model for Stock-Stock Correlations.

We propose a stochastic dynamic model for stock-stock correlations in terms of correlated walks. In the model, each walk (stock) moves under the c ompetition between the effect of random displacement and the fields of the mean instantaneous positions (the prices) of the whole system (the market) and of a specific group of walks. We analyze the distribution of the eigenvalues for the cross correlation matrix of price changes in our model and find that all main features present in the spectrum for the US stocks [Phys. Rev. Lett.83, 1467 and 1471 (1999)] can be reproduced by assuming a near-critical global field, perturbed with the group mean-fields [W.-J. Ma, C.-K. Hu, and R. E. Amritkar].

(2) Universal life indication of heartbeat intervals discriminates the stage of patients in the intensive care unit.

We analyze the time interval of human heartbeats (R-R intervals) and have found a universal charateristics of heartbeat dynamics among normal people. In terms of this charateristic, we can correctly classify the stage of patients in the intensive care unit (ICU) with one hundred percentage accuracy. The underlying physics of this charateristic is related with the autonomic nerous system which will induce the intrinsic variability in the R-R internals. Our methodology can provide a significant measure for the clinical diagnosis based on around five minutes electrocardiogram (ECG) [Y.-H. Shiau, S.-S. Hseu, and H.-W. Yien].

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[21] N. Sh. Izmailian, K. B Oganesyan and C.-K. Hu. Exact finite-size corrections for the square lattice dimer model with various boundary conditions, Phys. Rev. E, submitted for publication.
[22] Zh.S. Gevorkian and C.-K. Hu. Strong light scattering in polymer solutions with multicomponent solvent, submitted for publication.
[23] W.-J. Ma, C.-K. Hu, and R. E. Amritkar. A stochastic dynamic model for stock-stock correlations, submitted for publication.
[24] Y.-H. Shiau, S.-S. Hseu, and H.-W. Yien. Universal life indication of heartbeat intervals discriminates the stage of patients in the intensive care unit, submitted for publication. 400

III

List of Ongoing Research Projects

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中央研究院物理所九十一年度計劃清單一覽表

(2001 年 8 月~ 2003 年 7 月)

主持人	計 畫 名	執行期間	計 畫 編 號
陳啟東	單電子電晶體的量子效應研究(2/3)	89.08.01-91.07.31	NSC89-2112-M-001-101
鄭天佐	奈米材料和大分子中指定原子與分子鍵結特性的研究 (1/3)	89.08.01-92.10.31	NSC89-2119-M-001-010
曾忠一	半拉格朗日法在雲模式上的應用	90.08.01-91.09.30	NSC90-2111-M-001-003
王建萬	在Spring-8研究光致向量介子產生(IV)	90.08.01-91.10.31	NSC90-2112-M-001-025
余岳仲	重離子誘發原子之M-層游離截面研究	90.08.01-91.10.31	NSC90-2112-M-001-026
陳志強	神經網路中同步發火現象之研究(1/2)	90.08.01-92.01.31	NSC90-2112-M-001-027
吳建宏	贗標量場之宇宙學	90.08.01-91.01.31	NSC90-2112-M-001-028
杜其永	顆粒流堵塞之實驗研究(II)	90.08.01-91.10.31	NSC90-2112-M-001-034
梁鈞泰	裂紋路徑之不穩性(1/2)	90.08.01-91.07.31	NSC90-2112-M-001-035
章文箴	在Spring-8研究光致向量介子產生中之核物質效應(II)	90.08.01-91.07.31	NSC90-2112-M-001-036
王子敬	微中子及天文粒子物理與探測器之研	90.08.01-91.10.31	NSC90-2112-M-001-037
侯書雲	重夸克及強作用物理之實驗探討(總計畫)-重夸克及強 作用物理之實驗探討(總計 畫)及子(計畫一)-CDF實驗	90.08.01-91.10.31	NSC90-2112-M-001-038
鄧炳坤	重夸克及強作用物理之實驗探討-(子計畫二):CDF及相 關實驗粒子偵測器	90.08.01-91.10.31	NSC90-2112-M-001-039
王明哲	重夸克及強作用物理之實驗探討-(子計畫三):CDF實驗 之電腦模擬與數據	90.08.01-91.07.31	NSC90-2112-M-001-040
李世昌	以精密質譜儀探測宇宙中之反物質及暗物質(III)(總計畫)-及(子計畫一)探測反物質及暗物質(III)	90.08.01-91.07.31	NSC90-2112-M-001-041
李世昌	參與ATLAS實驗搜尋新物理 現象	90.08.01-91.10.31	NSC90-2112-M-001-042
曾詣涵	奇異數1或2之超核系統(3/3)	90.08.01-91.10.31	NSC90-2112-M-001-045
張志義	強子結構與非微擾量子色動力學(3/3)	90.08.01-91.10.31	NSC90-2112-M-001-046
鄭海揚	B物理與CP破壞(3/3)	90.08.01-91.10.31	NSC90-2112-M-001-047
余海禮	微擾QCD與非平衡系統(2/3)	90.08.01-91.07.31	NSC90-2112-M-001-049
陳洋元	非傳統超導及不尋常磁性之研究(2/3)-子計畫三:重費 米子系統之非傳統超導及量子相轉變研究	90.08.01-91.07.31	NSC90-2112-M-001-055
李定國	高溫超導的機制(2/3)	90.08.01-91.07.31	NSC90-2112-M-001-056
謝雲生	壓電晶體La3Ta0.5Ga5.5014之單晶生長與表面聲波及碳奈米結構物理化學性質研究(2/2)	90.08.01-91.07.31	NSC90-2112-M-001-057
陳啟東	單電子電晶體的量子效應研究(3/3)	90.08.01-92.07.31	NSC90-2112-M-001-059
何侗民	矽與鍺中新雜質中心之形成及其特性之研究(3/3)	90.08.01-91.10.31	NSC90-2112-M-001-060

主持人	計　　畫　　名	執行期間	計　畫　編　號
葉崇傑	介觀超導與原子陷阱中之超流體(2/3)	90.08.01-91.09.30	NSC90-2112-M-001-061
魏金明	單原子在面心立方晶體(100)表面的擴散機制(3/3)	90.08.01-91.07.31	NSC90-2112-M-001-062
任盛源	外應力對磁膜內磁阻或電阻之影響	90.08.01-91.10.31	NSC90-2112-M-001-063
李尚凡	超導/鐵磁多層薄膜的邊際 效應與電流垂直平面電阻的量測(1/3)	91.08.01-91.09.15	NSC90-2112-M-001-064
姚永德	超薄磁性金屬膜之物理性質研究(III)	90.08.01-91.12.31	NSC90-2112-M-001-065
張嘉升	奈米系統中的區限效應對其相變的影響(1/3)	90.08.01-91.10.31	NSC90-2112-M-001-066
黃英碩	表面上動態過程與奈米結構性質之研究(1/3)	90.08.01-91.07.31	NSC90-2112-M-001-067
胡宇光	相對比X光顯微術及能譜顯 微術	90.08.01-91.07.31	NSC90-2112-M-001-072
胡進錕	統計物理在跨領域之應用(1/3)	90.08.01-91.12.31	NSC90-2112-M-001-074
陳洋元	磁性超微粒之量子尺寸效應	90.08.01-91.10.31	NSC90-2112-M-001-075
鄭天佐	奈米材料和大分子中指定原子與分子鍵結特性的研究(2/3)	90.08.01-91.07.31	NSC90-2119-M-001-006
李世昌	參與ATLAS實驗搜尋新物理 現象	90.08.01-91.10.31	NSC90-2119-M-001-008
王唯工	正常鼠與高血壓之鼠腎臟脈動微循環與主動脈血壓波關聯之異同(3/3)	90.08.01-91.07.31	NSC90-2314-B-001-006
黃榮鑑 張建成	含自由液面與複雜幾何邊界二維流場之數值研究	90.08.01-91.10.31	NSC90-2611-E-001-001
黃榮鑑	二維方柱體渦漩逸出流場之研究(2/3)	90.08.01-91.07.31	NSC90-2611-E-001-002
李湘楠	B物理與CP破壞(2/3)	90.08.01-91.07.31	NSC90-2112-M-001-077
王唯工	體外聲波對主動脈血壓波形之影響	90.08.01-91.07.31	NSC90-2213-E-001-036
鄧炳坤 李世昌	高密度暨寬頻光纖通信模組	90.10.15-91.05.31	捷耀光通訊股份有限公司
謝雲生	環境偵測用之生物感測計- 以整齊排列之碳奈米管作生化偵檢器	91.01.01-91.12.30	財團法人生物技術開發中心
簡來成	開發解析三維Maxwell方程 式之電磁場數位模擬技術	91.01.01-91.12.31	NSC91-2623-7-001-003
吳茂昆	奈米國家型科技計畫規劃 l	91.02.01-91.08.31	NSC91-3011-P-001-001
謝雲生	大功率固態雷射晶體(Yb-YAG)之研究(Ⅱ)	91.01.01-91.12.31	NSC91-CS-7-001-003
曾忠一	半拉格朗日法雲模式的改進(Ⅰ)	91.08.01-92.07.31	NSC91-2111-M-001-005
張志義	強子結構之研究	91.08.01-92.07.31	NSC91-2112-M-001-024
曾詣涵	超核系統之研究(1/3)	91.08.01-92.07.31	NSC91-2112-M-001-025
吳建宏	電磁性黑暗能量的宇宙意義	91.08.01-92.07.31	NSC91-2112-M-001-026
杜其永	顆粒流堵塞之實驗研究(III)	91.08.01-92.07.31	NSC91-2112-M-001-027
侯書雲	重夸克及強作用物理之實驗探討(總計劃)-及(子計畫三)CDF實驗之電腦模擬與數據分析	91.08.01-92.07.31	NSC91-2112-M-001-031
鄧炳坤	重夸克及強作用物理之實驗探討:-(子計畫二)CDF及相 關實驗粒子偵測器	91.08.01-92.07.31	NSC91-2112-M-001-033

主持人	計　　畫　　名	執行期間	計　畫　編　號
章文箴	在SPring-8研究光致向量介子產生中之核物質效應(III)	91.08.01-92.07.31	NSC91-2112-M-001-035
王子敬	微中子及天文粒子物理與相關實驗技術之研究	91.08.01-92.07.31	NSC91-2112-M-001-036
李世昌	以精密質譜儀探測宇宙中之反物質及暗物質(III)	91.08.01-92.07.31	NSC91-2112-M-001-037
鄭海揚	重強子現象學之研究(1/3)	91.08.01-92.07.31	NSC91-2112-M-001-038
余仲岳	重離子在薄膜中的阻止本領研究	91.08.01-92.07.31	NSC91-2112-M-001-040
任盛源	鐵鎳合金多層膜之機械性，磁性，與電性研究(1/3)	91.08.01-92.07.31	NSC91-2112-M-001-042
陳啟東	奈米電子元件中的散亂電子雜訊(1/3)	91.08.01-92.07.31	NSC91-2112-M-001-046
蘇維彬	利用4.2K超高真空掃描穿隧顯微儀研究碳六十分子在銀薄膜中的電荷轉移	91.08.01-92.07.31	NSC91-2112-M-001-047
謝雲生	矽酸鐠單晶生長與物理性質研究(1/2)	91.08.01-92.07.31	NSC91-2112-M-001-048
梁鈞泰	裂紋路徑之不穩性(2/2)	91.08.01-92.07.31	NSC91-2112-M-001-049
陳志強	神經網路中同步發火現象之研究(2/2)	91.08.01-92.07.31	NSC91-2112-M-001-052
李湘楠	B物理與CP破壞(3/3)	91.08.01-92.07.31	NSC91-2112-M-001-053
余海禮	微擾QCD與非平衡系統(3/3)	91.08.01-92.07.31	NSC91-2112-M-001-055
胡進錕	統計物理在跨領域之應用(2/3)	91.08.01-92.07.31	NSC91-2112-M-001-056
魏金明	金屬薄膜的量子井態(1/2)	91.08.01-92.07.31	NSC91-2112-M-001-057
何侗民	半導體內雜質之高解析度紅外線吸收光譜之研究	91.08.01-92.07.31	NSC91-2112-M-001-059
陳洋元	奈米樣品之磁微結構與高解析交直流共軛比熱量測技術開發(1/3)	91.08.01-92.07.31	NSC91-2112-M-001-062
葉崇傑	介觀超導與原子陷阱中之超流體(3/3)	91.08.01-92.07.31	NSC91-2112-M-001-063
李尚凡	超導/鐵磁多層薄膜的邊際 效應與電流垂直平面電阻的量測(2/3)	91.08.01-92.07.31	NSC91-2112-M-001-064
黃英碩	表面上動態過程與奈米結構性質之研究(2/3)	91.08.01-92.07.31	NSC91-2112-M-001-066
陳洋元	非傳統超導及不尋常磁性之研究-子計畫三:重費米子系統之非傳統超導及量子相轉變研究(3/3)	91.08.01-92.07.31	NSC91-2112-M-001-067
李定國	高溫超導的機制(3/3)	91.08.01-92.07.31	NSC91-2112-M-001-068
張嘉升	奈米系統中的區限效應對其相變的影響(2/3)	91.08.01-92.07.31	NSC91-2112-M-001-069
姚永德	圖案化奈米結構之製作及物性研究	91.08.01-92.12.31	NSC91-2120-M-001-004
鄭天佐	奈米材料和大分子中指定原子與分子鍵結特性的研究(3/3)	91.08.01-92.07.31	NSC91-2120-M-001-005
黃榮鑑	含自由液面的三維複雜流場之數值研究(1/3)	91.08.01-92.07.31	NSC91-2611-E-001-001
黃榮鑑	二維方柱體渦漩逸出流場之研究(3/3)	91.08.01-92.07.31	NSC91-2611-E-001-002
李世昌	參與ATLAS實驗搜尋新物理現象	91.08.01-92.07.31	NSC91-2112-M-001-034

主持人	計　　畫　　名	執行期間	計　畫　編　號
李世昌	參與ATLAS實驗搜尋新物理現象--偵測器組件研製等相關費用	91.08.01-92.07.31	NSC91-2119-M-001-028
胡宇光	超高解析度即時相對比X-光顯術	91.08.01-92.07.31	NSC91-2112-M-001-061
胡進錕	90學年度高級中學基礎科學教學人才培育計畫	91.03.01-93.02.28	中研02-物理
姚永德	用於主軸馬達磁感側元件之開發設計	91.02.01-91.12.31	91S06-J3
張嘉升	碳奈米管探針修整技術研究	91.04.01-91.11.30	財團法人工業技術研究院
黃英碩	掃描式穿隧顯微鏡檢測分析技術合作研究-表面上奈米碳管的STM研究	91.04.01-91.11.30	財團法人工業技術研究院
蕭葆羲	放流管距離及放流水擴散及稀釋效應出評估、建議及改善方案	90.12.14-91.10.20	康城顧問股份有限公司
黃英碩 張嘉升	磁力顯微術與靜電力顯微術	91.10.01-93.9.30	安冠奈米科技股份有限公司

IV

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V

Academic Activities

Attendance in International Conferences

中研院物理所九十一年度出席國際會議表

(2002年1月~2002年12月)

會　議　名　稱	會議期間	舉 辦 地 點	出席人員	經費來源
奈米科技研討會	91.01.05 - 91.01.11	香港	鄭天佐	本院
奈米科學及技術-新穎的結構與現象	91.01.06 - 91.01.11	香港	蘇維彬	本所
第四十屆美國航太科學會議	91.01.10 - 91.01.19	美國	簡來成	本所
量子力學與奈米技術研討會	91.01.10 - 91.01.19	美國	簡來成	本所
第四屆加爾各答統計物理國際研討會	91.01.14 - 91.01.19	印度	胡進錕	本所
弱作用力國際會議	91.01.21 - 91.01.26	紐西蘭基督城	王子敬	國科會
第五屆暗物質國際研討會	91.02.19 - 91.02.22	美國	李沃龍	國科會
同步輻射材料應用研討會	91.02.21 - 91.02.24	新加坡	胡宇光	本所
2002年介觀超導與磁性電子研討會	91.03.04 - 91.03.06	日本東京	陳啟東	本所
微中子物理國際會議	91.03.14 - 91.03.16	日本仙台	王子敬	國科會
2002年美國物理學會三月會議	91.03.17 - 91.03.22	美國	魏金明	國科會
2002年美國物理學會三月會議	91.03.18 - 91.03.22	美國	何侗民	本所
2002年美國物理學會三月會議	91.03.18 -91.03.22	美國	張嘉升	本所
Advanced Statistical Techniques in Partical Physics	91.03.18 - 91.03.22	英國Durham	王明哲	本所
CMMP 2002	91.04.06 - 91.04.12	英國Brington	鄭天佐	本院
The 2002 IEEE International Magnetics Conference	91.04.28 - 91.05.02	荷蘭	陳威全	國科會
Intermag Europe 2002	91.04.28 - 91.05.02	荷蘭	余進忠	本所

會　議　名　稱	會議期間	舉 辦 地 點	出席人員	經費來源
Gordon Research Conference on Magnetic Nanostructure	91.05.12 - 91.05.17	義大利Il Cicco	李尚凡	國科會
Gordon Research Conference on Magnetic Nanostructure	91.05.12 - 91.05.17	義大利Il Cicco	姚永德	本所
Gordon Research Conference on Magnetic Nanostructure	91.05.12 - 91.05.17	義大利Il Cicco	李尚凡	本所
味物理與CP破壞	91.05.16 - 91.05.18	美國	李湘楠	本所
Flavor Physics and Cp Violation	91.05.16 - 91.05.18	美國費城	陳泉宏	本所
味物理與CP破壞	91.05.16-91.05.18	美國	鄭海揚	本所
粒子場論	91.05.24-91.05.28	美國	鄭海揚	本所
凝聚態物理與交叉學科研討會	91.05.19 - 91.05.24	中國南京	黎璧賢	本所
2002年美國物理學會-粒子與場論會議	91.05.24 - 91.05.28	美國維吉尼亞州	陳彥竹	本所
微中子2002國際會議	91.05.25 - 91.05.30	德國慕尼克市	王子敬	本所
第二屆表面,屆面和薄膜物理國際研討會	91.05.29 - 91.06.01	中國大陸	張嘉升	本院
Dynamics of Complex and Macromolecular Fluids	91.05.31 - 91.06.14	美國	陳培亮	本所
ES 2002	91.06.05 - 91.06.09	美國San Franscisco	魏金明	國科會
2002年中美科技合作年會 及洛杉磯海外研討會	91.06.07 - 91.06.13	美國	吳茂昆	國科會+本所
62nd Annual PEC	91.06.12 - 91.06.14	美國Atlanta	魏金明	國科會
楊振寧先生八十慶生研討會 及高溫超導理論研討會	91.06.16 - 91.06.23	北京 香港	李定國	國科會
楊振寧先生八十慶生研討會 及高溫超導理論研討會	91.06.16 - 91.06.23	北京 香港	吳茂昆	本所
2002歐洲材料研究學會春季年會	91.06.18 - 91.06.21	法國斯特拉斯堡	黃英碩	本所

會　議　名　稱	會議期間	舉辦地點	出席人員	經費來源
第14屆美國國家理論及應用力學會議	91.06.23-91.06.28	美國	黃榮鑑	本所
2002生物信息學學校	91.06.24 - 91.06.27	北京中國科學院	周子聰	學術審議
十四屆美國理論及應用力學會議	91.06.25 - 91.06.28	美國	黃榮鑑	國科會
ICSM2002國際會議	91.06.29-91.07.05	上海	陳洋元	國科會 本所
複雜流體會議	91.06.30 - 07.05	英國	杜其永	國科會
第十七屆巴黎天文物理會議	91.07.01-91.07.05	法國巴黎	吳建宏	國科會 本所
第十五屆國際真空電子會議 及第四十八屆國際場發射研討會	91.07.07-91.07.11	法國	鄭天佐	本所
第十一屆固態薄膜及表面國際會議	91.07.08-91.07.12	法國	蘇維彬	本院
亞太物理學聯合會	91.07.13-91.07.14	越南	鄭天佐	本所
TH-2002-International Conference on Theoretical Physics	91.07.22 - 91.07.27	法國	伊士麥 林尼可	本所
第六屆國際量子通訊測量及計算會議	91.07.22-91.07.26	美國	張志義	本所
31屆國際高能物理會議	91.07.23-91.07.13	荷蘭	鄭海揚	國科會
第十屆國際半導體內淺能階中心會議	91.07.24 - 91.07.27	波蘭華沙	何侗民	國科會
The DDA Summerschool on Quantum Statistics of Many Particle會議	91.08.03-91.08.10	莫斯科	卜洛斯基	國科會
顯微鏡及微分析2002年研討會	91.08.04-91.08.08	加拿大	姚永德	本所
第十九屆國際結晶學會議	91.08.05-91.08.16	瑞士日內瓦	陳俊榮	本院
第二屆亞太非線性日國際會議	91.08.08-91.08.12	中國杭州	陳志強	國科會
航空太空學會材料製造技術委員會會議	91.08.12-91.08.16	美國	簡來成	本所
Summer Institute 2002會議	91.08.13-91.08.20	日本	陳泉宏	本所

會 議 名 稱	會議期間	舉 辦 地 點	出席人員	經費來源
Summer Institute 2002會議	91.08.13-91.08.20	日本	周忠憲	大會及KEK
第二十二屆低溫物理會議	91.08.20 - 91.08.27	日本	葉崇傑	國科會
第廿三屆低溫物理會議 及IUPAP C5 Commission Committee	91.08.20-91.08.26	日本	吳茂昆	國科會+自理
第二十三屆國際低溫物理會議	91.08.20-91.08.27	日本廣島	王昌仁	本所
第廿三屆低溫物理國際會議	91.08.21-91.08.27	日本廣島	陳洋元	本所
第二屆亞、澳真空及表面科學研討會	91.08.26-91.08.30	香港	張嘉升	本院
經濟學與物理學國際會議	91.08.28-91.08.31	印尼巴里島	胡進錕	國科會
離子束於材料修正國際會議	91.09.01-91.09.06	日本神戶	余岳仲	國科會
第九屆表面物理研討會	91.09.02-91.09.09	布拉格	鄭天佐	本所
第二屆國際廢水海洋放流研討會	91.09.16-91.09.21	土耳其	蕭葆羲	本所
日本磁性學會第廿六屆年會	91.09.16-91.09.21	日本	姚永德	自理
APCTP-ICTP凝態理論物理研討會	91.09.25-91.09.29	韓國	李定國	自理
第五屆國際數學模型會議	91.09.29-91.10.05	莫斯科	胡進錕	國科會
第五屆國際數學模型會議	91.09.29-91.10.07	莫斯科	海耳倫	國科會本院自理
核物理與粒子物理	91.09.30-91.10.04	日本大阪	王子敬	本所
希土磁性材料及新穎磁性材料國際會議	91.09.30-91.10.04	越南	姚永德	國科會
第十六屆國際粒子核子會議	91.09.30-91.10.04	日本	章文箴	國科會
Grid Deployment Board會議	91.10.03-91.10.09	義大利	林誠謙	本所
台日奈米科學研討會	91.10.08-91.10.12	日本	李定國	自理

會　議　名　稱	會議期間	舉辦地點	出席人員	經費來源
台日奈米科學研討會	91.10.08-91.10.12	日本	陳啟東	日方 國科會
台日奈米科學研討會	91.10.08-91.10.12	日本	陳洋元	日方 國科會
第五十三屆國際太空聯盟會員代表大會	91.10.10-91.10.19	美國	簡來成	自理
第八屆溫度研討會	91.10.20-91.1024	美國	陳洋元	國科會
第五屆亞洲電子結構會議	91.10.21-91.10.23	韓國	魏金明	國科會
中國高等科學技術中心顧問委員會議	91.10.21-91.10.24	北京	吳茂昆	本所
第二屆EMBS-BMES聯合會第二十四屆國際電子電機協會醫學工程學會季2002醫學工程學會秋季會及其會前研習會POC醫療儀器通訊規格研討會	91.10.22-91.10.26	美國休士頓	詹明宜	本所
第二屆EMBS-BMES聯合會第二十四屆國際電子電機協會醫學工程學會季2002醫學工程學會秋季會及其會前研習會POC醫療儀器通訊規格研討會	91.10.22-91.10.26	美國休士頓	許昕	本所
第五屆國際流體動力學會議	91.10.31-91.11.02	台南成功大學	邵瑪度	本所
第十屆掃描探針顯微術國際研討會	91.10.31-91.11.06	夏威夷	鄭天佐	教育部
海峽兩岸顆粒技術研討會	91.11.03-91.11.07	大陸桂林	胡宇光	國科會 本所
中國顆粒學會2002年會暨海峽兩岸顆粒技術研討會	91.11.03-91.11.08	大陸	姚永德	基金支助
VERTEX 2002國際會議	91.11.03-91.11.08	夏威夷	侯書雲	本所
奈米科學討論會	91.11.11-91.11.13	日本仙台	鄭天佐	教育部
第47屆磁學與磁性物質年會	91.11.11-91.11.15	美國	李尚凡	本所
第47屆磁學及磁性材料年會	91.11.11-91.11.15	美國	姚永德	國科會
第四十七屆磁性會議	91.11.11-91.11.15	美國	徐嘉宏	國科會

會　議　名　稱	會議期間	舉 辦 地 點	出席人員	經費來源
第四十七屆國際磁學研討會	91.11.11-91.11-15	美國佛羅里達	蔡佳霖	國科會
第四十七屆國際磁學研討會	91.11.11-91.11-15	美國佛羅里達	余進忠	國科會
第十七屆國際加速器在研究及工業應用會議	91.11.12-91.11.16	美國	余岳仲	本所
蛋白質結構分析中的一些問題研討會	91.11.18-91.11.22	北京	鄒忠毅	本院
美國物理學會第五十五屆流體動力學年會	91.11.24-91.11.26	美國	黃榮鑑	本所
2002年落塔微重力科學研討會	91.11.26-91.11.29	日本	簡來成	日本
奈米材料及技術研討會	91.12.04-91.12.12	美德州大學	吳茂昆	國科會
Grid Deployment Board 會議	91.12.06-91.12.13	瑞士日內瓦	林誠謙	本所
The 2nd Cross-Strait Workshop on Nano Science and Technology會議	91.12.08-91.12.12	香港	林思育陳靜儀潘奎竹三人	國科會
第21屆德薩斯國際會議	91.12.09-91.12.13	義大利	吳建宏	國科會 本所

Institute Sponsored Meetings
本所協辦會議

研 討 會 名 稱	會 議 期 間	地點	主辦人
第十屆核子物理春季研習會 The 10th Taiwan Nuclear Physics School	91.01.23~91.01.26	花蓮天祥	章文箴
第五屆超晶格物理特性暨自旋電子元件物性研討會	91.04.26~91.04.27	嘉義中正大學	姚永德
第二屆亞太及第六屆台灣統計物理國際會議 Statphys Taiwan 2002	91.05.26~91.06.01	中研院物理所	胡進錕
亞洲第四屆掃描探針顯微術暨台北奈米科技研討會	91.08.12~91.08.15	台大物理系	張嘉升
二〇〇二年分子與氧化物超導體物理與化學國際會議	91.08.13-91.08.18	新竹清華大學	李定國
台北軟物質物理暑期學校 Taipei Summer School of Soft Matter Physics	91.08.26-91.08.30	台北陽明山	陳志強
慶祝楊振寧院士八秩華誕研討會	91.11.11-91.11.12	中研院物理所	吳茂昆
Workshop on statistical Physics and Complex System	91.11.14-91.11.16	中研院物理所	胡進錕

Seminars

中央研究院物理所九十一年度演講一覽表

(2002 年 1 月- 2002 年 12 月)

演 講 題 目	演講者姓名	所 屬 機 構	日 期
Joint Resummation	李湘楠	中央研究院物理所	91.01.04
The immunological synaptic pattern formation	陳宣毅	中央大學物理系	91.01.07
Fluxbranes in Supergravity	陳江梅	台灣大學物理系	91.01.11
Vortex States and Phase Transitions I High-Tc Superconductivity	胡 曉	筑波大學	91.01.16
Measurement of α_{Ω}, α_{Λ} in the $\Omega^- \rightarrow \Lambda k^-$	陳彥竹	中央研究院物理所	91.01.18
Oxidaton and Barrier formation for TMR	Paulo Freitas	Insitituto de Engenharia de sistemas e computadores	91.01.18
Some Abnormal Magnetic an d Electric Properties in LCMO System	杜鴻模	高雄師範大學物理系	91.01.21
Generalized Parton Distributions and Hard Exc;isove {rpcesses	Marc Vanderhaeghen	University Mainz, Germany	91.02.01
Modern computational surface science: the growth of Vanadium Oxides and Palladium Oxides on Pd(111)	Georg Kresse	Institut fuer materialphysik, Uni Wien	91.02.07
Microfluidics and BioMEMS	周家復	Motorola Labs	91.02.21
顆粒流現象(Granular Flow Phenomenon)	厚美瑛	北京中國科學院物理研究所	91.02.21
Breaking Individual Molecule-Si Bonds	Robert Wolkow	Steacie Institute for Molecular Sciences, National Res. Council of Canada	91.02.27
The Unruh Effect	林世昀	中央研究院物理研究所	91.03.01

演　講　題　目	演講者姓名	所 屬 機 構	日　期
Raman and Transport Studies of Carbon Nanotubes and Polymer-nanotubes Composites	Serge Lefrant	Institut des materiaux	91.03.01
Global Optimization by Energy Landscape Paving	Ulrich H. E. Hansmann	Dept. of Physics, Michigan Tech. Univ.	91.03.05
Global Event and Local Events in Protein Folding	鄭天佑	Univ. of Minnesota	91.03.06
Chiral Corrections to the Nucleon Parton Distributions	Jiunn-Wei Chen	University of Maryland	91.03.06
磁性形狀記憶合金 Ni_2MnGa 的物性與應用研究	吳光恒	中國科學院物理研究所	91.03.07
Some Surface Science related Researches	Andrew T. S. Wee	University of Singapore	91.03.12
Neutrino Oscillation in Five Dimensions	Chi-Sing Lam	McGill University	91.03.15
Astrophysics and Cosmology on the Bench	Pisin Chen	SLAC	91.03.20
從 Voyager 到 Cassini 之土星探測旅程	葉永烜	中央大學天文所	91.03.20
Lepton Universality and Split Fermions I Extra Dimensions	黃岳華	TRIUMF	91.03.22
On the deformation of spontaneously twisted fluctuating ribbons	周子聰	淡江大學物理系	91.03.25
BioPhysics：A Biologist's Point of View	Shin-Tai Chen	Loma Linda University	91.03.28
從"大霹靂"到"生命的起源"	秦一男	淡江大學物理系	91.03.29
Controlling of Spiral Waves in the BZ reaction	On-Uma Khreowan	Dept. of Chemistry, Mahidol University	91.04.01
Materials aspects in Phase Change Optical Recording	Dimitre Z. Dimitrov	Central Lab. Bulgarlan Academy of Science	91.04.02

演　講　題　目	演講者姓名	所 屬 機 構	日　期
納米 Co 圖型磁化反轉的磁力顯微鏡研究及磁力圖的圖型	韓寶善	中國科學院物理所	91.04.03
台大高能組的回顧與前瞻	侯維恕	台灣大學物理系	91.04.10
NMR Study of Biomembranes	Yawei Hsueh	Dept. of Physics, Simon Fraser Univ.	91.04.12
Physics of the dark ages of the universe	方勵之	University of Arizona	91.04.17
Execusive Nonleptonic B Meson Decays	楊桂周	中原大學物理系	91.04.19
Introduction to Polymer/Clay Nano Composite	H. J. Chi	Inha University	91.04.24
Knots: Science and History	黎璧賢	中央大學物理系	91.04.24
The Time Series of The Super Kamiokande Solar Neutrino Events	C. Y. Chang	Univ. of Maryland	91.04.26
Weak Anchoring Effect of Nematic Liquid Crystals	Chenxu Wu	Dept. of Phys. Of Xiamen	91.04.29
Minimal Models and Protein Structures	Jeff Z. Y. Chen	University of Waterloo	91.04.29
高速公路匝道控制	黃定維	中原大學物理系	91.05.01
Noncommutative Trinification of the Strong and Electro-weak Interaction	何小剛	台灣大學物理系	91.05.03
Calorimetric Studies on the Pairing State of High Tc Superconductors	楊弘敦	中山大學物理系	91.05.08
Collinear Expansion for Exclusive Processes	葉聰文	交通大學	91.05.10
SRRC 發展近況及奈米科技研究	梁耕三	同步輻射研究中心	91.05.15
Fabrications and Applications of Metal and Semiconductors Nanoparticles	陳家俊	師範大學化學系	91.05.16

演　講　題　目	演講者姓名	所 屬 機 構	日　期
High-Energy Neutrinos from Cosmos	Athar Husain	NCTS	91.05.16
Formation and Propagation of Internal Waves	鮑咸平	美國天主教大學校	91.05.20
氣象與防災	顏泰崇	中央氣象局	91.05.22
Two Kinds of Hard-Sphere Suspensions near the Colloidal Glass Transition	Michio Tokuyama	Institute of Fluid Science,Tohoku University	91.05.23
The Hofstadter Problem-An Algebraic Treatment	馮明光	師範大學物理系	91.05.24
稀土過渡族金屬間化合物的磁性	楊應昌	北京大學物理系	91.05.27
Waves in Biological and Chemical Systems	Stefan Muller	Univ. of Magdeburg, Germany	91.05.29
Playing with Extra Dimension	張嘉泓	師範大學物理系	91.05.29
The Reliability of PQCD in Pion Electromagnetic Form Factor	魏正濤	中央研究院物理研究所	91.05.31
Controlling Chaos, Pattern Formation and Turbulence	魏國衛	National University of Singapore	91.06.03
CKM Matrix and CP Violation: Presen Status and Future Prospects	Ahmed Ali	DESY	91.06.04
Cluster Monte Carlo: Extending the range	Henk W. J. Bloete	Delft University of Technology	91.06.05
Generalized Ensemable	Berd Berg	Dept of Physics, Florida State Univ.	91.06.05
量子資訊	張為民	成功大學物理系	91.06.05
CDF Run II Expectations and Reality	Jaroslav Antos	中研院物理所	91.06.07
Advanced Optical Microsdopy: Confocal Microscopy and Its Recent Developments	高甫仁	中山大學物理系	91.06.12

演　講　題　目	演講者姓名	所 屬 機 構	日　期
ISOSPin Violation in B->k*j and other topics	Alex Kagan	Cincinnati University	91.06.12
Measuring Gamma and Alpha-Beta at B Factories	David Atwood	Iowa State University	91.06.14
Coexistence of Christian and Islamic Civilizations: Complex System Point of View	David Saakian	Yerevan Physics Institute	91.06.17
軟磁薄膜的磁疇結構和磁性材料的電子輸運特性	鄭德娟	中國科學院	91.06.19
Accelerator Mass Spectrometry Measurements and Applications	Jiang Shan	China Institute of Atomic Energy	91.06.19
Instroduction to Minority Games in Econophysics	Bing Hong Wang	University of Science and Tec. Of China Hefei	91.06.24
A Test for Long Memory vs Structural Changes	Hwai-Chung Ho	Institute of Statistics, Academia Sinica	91.06.24
A Simple Model for Technical Correction in Stock Markets	R. Amritkar	Physical Researach Lab., Navrangpura, India	91.06.24
Family Name Distribution and its Population Dynamical Model	Bing-Hong Wang	Univ. of Science and Tec. Of China, Hefei	91.06.24
Origin of Peculiar STM Contrast and Local Ordering in C60/Ag(100)	Larry Pai	Center of Condensed Matter Sciences, National Taiwan University	91.06.25
Quantum Fluctuation as a Thermometer for the Unruh Temperature	劉 潤 球	北京中國科學院	91.06.28
Branes, Amti-Boanes and Their Tachyons	王　振	中央研究院物理研究所	91.07.02
Plan for a New Neutron EDM Experiment	彭仁傑	Los Alomos	91.07.05
Controlling Chaos and Hyper-Chaos Using Continuous Proportional Feedback of Dynamical Variables	汪秉宏	Univ. of Sci.and Tech of China, Hefei	91.07.15

演　講　題　目	演講者姓名	所 屬 機 構	日　期
Vector Pattern Matching Techniques and Their Possible Neural Correlates	Fu Chang	Institute ofInformation Science, Academia Sinica	91.07.15
Synchronization in Chaotic Systems	R. Amritkar	Physical Res. Lab., Navrangpura, India	91.07.15
Entropically Driven Interaction Between Colloids and Their Assembly	Keng-Hui Lin	Dept. of Physic, Univ. of Pennsylvania	91.07.15
Ratchet Models Driven by Deterministic Chaotic Maps	Cheng-Hung Chang	NCTS	91.07.15
Methods to Study the Histone-Mediated Transcriptional Regulation	Li-Jung Juan	National Health Research Institute	91.07.16
Constraint from EDM on Chargino Baryogenesis	Wei-Yee Keung	Illionis Univ., Chicago	91.07.19
微機電動態分析及 系統架設原理	宋震國	中正大學機械系	91.07.22
Cooperativity of DNA Stacking or Chain Rigidity	Vladimir F. Morozov	Yerevan State Univ., Armenia	91.07.23
Quantum Electronic Theory of Nano Materials	郭光宇	台灣大學物理系	91.07.26
Open Questions in Stochastic Models of Infectious Disease	Jonathan Dushoff	Dept. of Ecology & Evolutionary Biology, Princeton Univ.	91.07.26
生物信息學的當前進展與物理學的關聯	陳潤生	中國科學院生物物理所	91.07.30
Hidden Nature in the Heartbeat	蕭又新	東華大學物理系	91.07.30
Local Magnetic Characterization of Superconductors bassed on Magneto-Optics	Y. Yeshurun	Bar Ilan Univ., Tel Viv, Israel	91.08.05
Study of High-Tc Superconductivity at an Atomic Scale with a low Temperature STM	潘庶亨	Dept of Physics, Texas Center for Superconductivity	91.08.07

演　講　題　目	演講者姓名	所 屬 機 構	日　期
A New Approach for the Detection of Long-Baseline Accelerator Neurinos	Francois Vannucci	University of Paris, France	91.08.19
Complexation of Polymers and DNA with Srufactants and Amphiphiles	David Andelman	School of Physics and Astronomy, Tel Aviv Universi	91.08.22
NRAM Development	Denny Tang	台基電公司	91.08.28
Bubbles, Foams and other Fragile Objects	Pierre-Gilles de Gennes	College de France & Director of ESPCI, France	91.08.30
Transmission Phases of Electron Measured in Aharonov-Bohm Interferometers	熊詩杰	南京大學物理系	91.09.06
Reactor Neutrino Research Program in Russia	Valery Sinev	Kurchatov Institute, Russia	91.09.09
Evaluation of Reactor Anti-Neutrino Spectra: Past and Present Work	Valery Sinev	Kurchatov Institute, Russia	91.09.09
Surface Plasmon Resonance Related Properties of Metal Nanostructures	王崇人	中正大學	91.09.12
Stretched Polymers in a Poor Solvent	許曉萍	John-von-Neumann Institute for Computing, Germany	91.09.12
Neutrino Telescope for Seeing AGN and Galactic Center	黃明輝	台灣大學	91.09.13
Fast Nanopore Sequencing of Polynucleotides Assisted by a Rotating Electric Field	陳啟明	台灣師範大學	91.09.18
Anisotropy and the Critical Current of High Temperature Superconductor	K. Kitazawa	Japan Science & Technology Corporation	91.09.23
Nanofabricatin of Magnetic Materials Using Focused Ion Beam Milling	S. H. Liou	Dept. of Physics, Nebraska University	91.09.23
K_T Factorization	李湘楠	中央研究院物理研究所	91.09.27

演　講　題　目	演講者姓名	所 屬 機 構	日　期
TESLA - a New Tool for Science	Albrecht Wagner	University of Hamburg & Director of DESY, German	91.10.01
Optical Modulation Instability in Non-instantaneous Nonlinear Medium	石明豐	台大物理系	91.10.02
TeV string resonances from high energy cosmic neutrinos	韓濤	Dept. of Physics, Univ. of Wisconsin	91.10.04
Quantum computing ABC 量子計算淺談	蘇正耀	國家高速電腦中心	91.10.09
Neutrino mass and CP violating B decays in SUSY SO(10)	張達文	國立清華大學	91.10.11
乒乒乓乓的宇宙	陳文屏	中央天文所	91.10.16
Structure Of Matter,Today	Virendra Gupta	CINVESTAV, Merida, Mexico	91.10.23
Digital Physics - Physical Laws from Bits	余海禮	中研院物理所	91.10. 25
Bloch Oscillation since 1928	趙光安	Lund University	91.10. 28
Physics of Dry Granular Systems	杜其永	中研院物理所	91.10.30
Complex Plasma Liquids	伊林	中研院物理所	91.10.30
Baryogenesis and Electric Dipole Moments	張達文	清華大學	90.11.01
Overview of CP violation in kaon decays	熊怡	台大物理系	91.11.06
Sporadic CP Violating Effects in Charm Decays	S. Arunagiri	NTHU	91.11.08
NOnlinear Optical Polymers, from Science to Technology	王進賢	中山物理系	91.11.13
Study of Chromatin Structure Change by Chromatin Immunoprecipitation Assay	阮麗蓉	國家衛生研究院	91.11.15

演　講　題　目	演講者姓名	所 屬 機 構	日　期
Noncommutative Quantum Mechanics from Noncommutative Quantum Field Theory	高賢忠	國立台灣師範大學	91.11.15
Modular assembly and landscapes of local and global events in protein folding	鄭天佑	Univ. of Minnesota, USA	91.11.15
The Lognormal-like Distributions in the Linear Growth Equations	曾文哲	淡江大學物理系	91.11.16
Localized States due to Discrete Nonlinear Schrodinger Equation	Bikash C. Gupta	Dept. of Physics, National Central University, Tai	91.11.19
Growth and Characterization of Nanoscale GaN-based Semiconductor materials	羅奕凱	中山大學物理系	91.11.20
Symmetry breaking in orbifold 5D field theory	張嘉泓	國立台灣師範大學	91.11.22
Live Cell Imaging and Manipulation	林奇宏	陽明大學微生物及免疫所	91.11.25
Magnetic Annealing	Rory Murphy	Trinity College Enterprise Center, Ireland	91.11.26
Temperature from Quantum Entanglement	林秀豪	清華物理系	91.11.27
A duality between superstring theory in pp-wave background and Yang-Mills theory in a new doubles	朱創新	國立清華大學	91.11.29
Recent Development in Cosmic-Microwave-Background Cosmology	吳俊輝	台灣大學	91.12.06
負折射率與完美成像	陳志隆	清華大學物理系	91.12.11
Natural Selection on Genomics	Chung-I Wu	University of Chicago	91.12.12
Focusing Vacuum Fluctuations	Larry Ford	Tufts University	91.12.13
Stochastic Model of Stock Markets	Taisei Kaizoji	International Christian University, Japan	91.12.18

演　講　題　目	演講者姓名	所 屬 機 構	日　期
Optical and X-ray Scattering Studies of Liquid Crystal Compounds Showing Anomalous Electroclinic Effect	黃政哲	University of Minnesota	91.12.19
Kinks in Time and their Relation to Confinement	王振	國立台灣大學	91.12.20
Molecular dynamics simulation of biomolecular systems:1.protein conformations 2.free energy difference	孫英傑	師範大學化學系	91.12.23
Hetero-Structure Research at the Ioffe Institute	Zhores I. Alferov	RAS & Ioffe Physico-Technical Institute	91.12.26
Neutron Researches in Petersburg Institute of Nuclear Physics: Status and Outlooks	Vladimir Nazarenko	RAS Petersburg Nuclear Physics Institute	91.12.26
Stochastic Conformal Maps and Fractal Geometry	P. Wiegmann	University of Chicago	91.12.27
PDF Uncertainties and Inclusive Jet Production	賴宏亮	市立台北師範學院	91.12.27

Visiting Scholars
中央研究院物理所九十年度訪問學人表
(2002 年 1 月- 2002 年 12 月)

訪 問 學 人	所 屬 機 構	訪 問 期 間
閔乃本	中國科學院	2002.01.01-2002.01.31
G. Kreese	奧地利維也納大學	2002.02.07-2002.02.10
厚美瑛	北京中國科學院	2002.02.09-2002.02.23
邱進發	大陸中科院高能物理研究所	2002.02.21-2002.06.20
辛標	大陸原子能研究院	2002.03.01-2002.06.30
On-Uma	泰國 Mahihol University	2002.03.15-2002.05.31
郭子斯	紐約州立大學石溪校區	2002.03.21-2002.03.31
鄭德娟	中國科學院	2002.03.22-2002.06.21
韓寶善	北京中科院物理所	2002.03.22-2002.06.22
Yawei Hsueh	美國 Simon Fraser University	2002.04.10-2002.04.12
David B. Saakian	亞美尼亞 Yerevan Physics Institute	2002.04.19-2002.06.19
汪秉宏	中國科學技術大學	2002.05.01-2002.07.31
岳騫	北京高能物理研究所	2002.05.01-2002.08.31
V.B. Priezzhev	亞美尼亞 Yerevan Physics Institute	2002.05.05-2002.06.03
Ravindra E. Amritkar	印度 Physical Research Laboratory	2002.05.05-2002.08.04
Zoltan Neda	巴西 Babes-Bolyai University, Cluj	2002.05.20-2002.06.19
V. F. Morozov	亞美尼亞 Yerevan Physics Institute	2002.05.24-2002.07.24
Alexander Silchenko	英國 Lancaster University	2002.05.25-2002.06.10
Stefan Muller	德國 Otto-von-Guericke-Universität	2002.05.26-2002.06.01
梁宗嶽	美國 Delaware University	2002.05.28-2002.06.09
何健民	美國 Wichita State University	2002.05.29-2002.06.30
Ahmed Ali	德國 DESY高能實驗室	2002.06.02-2002.06.05
姜山	中國原子能研究院核物理所	2002.06.03-2002.07.02
Yevgenie Mamasakhils	亞美尼亞 Yerevan Physics Institute	2002.06.07-2002.08.06
Cheng-Wei Chiang	美國 Carnegie Mellon University	2002.06.10-2002.06.26
Alex Kagan	美國 Cincinnati University	2002.06.11-2002.06.13

訪問學人	所屬機構	訪問期間
David Atwood	美國 Iowa State University	2002.06.11-2002.11.17
劉明毅	美國 University of Georgia	2002.06.20-2002.07.08
伍法岳	美國 Northeast University	2002.06.23-2002.06.23
劉明毅	美國 University of Georgia	2002.07.08-2002.08.16
熊詩杰	南京大學	2002.07.08-2002.09.07
李匡邦	美國 University of Massachusetts	2002.07.11-2002.08.27
姜偉宜	美國 Illinois University	2002.07.13-2002.07.22
S. H. Pan	美國 Houston University	2002.08.05-2002.08.07
沈志勳	美國 Standford University	2002.08.12-2002.08.18
Bertram Batlogg	瑞士ETH university	2002.08.12-2002.08.18
T. Maurice Rice	瑞士ETH university	2002.08.12-2002.08.18
朱經武	香港科技大學	2002.08.12-2002.08.19
陳晉平	北京大學	2002.08.12-2002.08.26
Kyozi Kawasaki	日本 Kyushu University	2002.08.21-2002.08.24
辛標	大陸原子能研究院	2002.08.30-2002.12.29
Valery V. Sinev	俄國 Kurchatov Institute	2002.09.01-2002.09.15
陸大成	中國科學院半導體研究所	2002.09.01-2002.11.30
劉大治	北京清華大學	2002.09.01-2002.12.31
Koriun Oganesian	亞美尼亞 Yerevan Physics Institute	2002.09.15-2002.11.14
戴長江	中科院高能物理研究所	2002.10.01-2003.01.31
Virendra Gupta	墨西哥 Cinvestav University	2002.10.01-2002.10.31
Edik Hayran	亞美尼亞 Yerevan Physics Institute	2002.11.01-2002.12.31
伍法岳	美國 Northeast University	2002.11.13-2002.11.18
Constantino Tsallis	巴西 Centro Brasileiro de Pesquisas Fisic	2002.11.14-2002.11.17
Jan Busa	俄國 Technical University	2002.12.14-2003.01.19
Lawrence H. Ford	美國 Tufts University	2002.12.17-2002.12.23
Taisei Kaizoji	日本 International Christian University	2002.12.18-2002.12.21
胡比樂	美國 Maryland University	2002.12.20-2002.12.22
李匡邦	美國 University of Massachusetts	2002.12.26-2003.1.24

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