YITP Annual Report

Yukawa Institute For
Theoretical Physics
Kyoto University

2001 — 2003

Foreword

This is an ‘annual report’ of the Yukawa Institute for Theoretical Physics to give a report on our activities for three years from 2001 to 2003.

So far we have reported the activities of our institute in various forms. However, except for a brief report contained in the bulletin of Kyoto University, most of them have been in Japanese and not accessible for researchers outside Japan. This year 2004, taking advantage of the opportunity that all national universities including Kyoto University were turned into independent administrative corporations, we decided to innovate our WWW homepage and start the publication of annual reports in English, in order to get people in the world more acquainted with the members and activities of our institute. Thus, this is the first English annual report of our institute.

This report contains information concerning institute members including graduate students, visitors, research contents, publications, workshops, schools and conferences of the academic years 2001–2003. The reason why this annual report contains the three-year data is that no report on these three years has been published for some reasons. We have also included some brief highlight reports by individual members on their recent research achievements.

Thus, the contents of the annual report are limited to the research activities in this institute and the supporting activities of domestic as well as international collaborative researches, in general in each year. Materials that are not specific to each year, such as the history, organisation, services and facilities of our institute, can be found in the WWW homepage, http://www.yukawa.kyoto-u.ac.jp/ , which includes the html version of this report as well.

We hope this report will help physicists in the world know our institute much better and make it easier to access our research services.

Director
Taichiro Kugo

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Chapter 1

People

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1.1 Regular Staff and Guest Researchers (2001 April – 2004 March)

Regular Staff

Taichiro Kugo
Professor (**Director**) [2003.4.1 –]

Masao Ninomiya
Professor (E)

Kenichi Shizuya
Professor (E)

Hideo Kodama
Professor (A)

Teiji Kunihiro
Professor (N)

Shin Mineshige
Professor (A) [2001.4.1 –]

Hirokazu Tsunetsugu
Professor (C) [2002.4.1 –]

Misao Sasaki
Professor (A) [2003.4.1 –]

Takao Ohta
Professor (C) [2004.1.1 –]

Yasuhisa Abe
Associate Professor (N)

Ryu Sasaki
Associate Professor (E)

Masatoshi Murase
Associate Professor (C)

Hiroshi Kunitomo
Associate Professor (E)

Mihoko Nojiri
Associate Professor (E)

Naoki Sasakura
Associate Professor (E)

Tetsuya Onogi
Associate Professor (E) [2001.4.1 –]

Keisuke Totsuka
Associate Professor (C) [2003.4.1 –]

Shigehiro Nagataki
Associate Professor (A) [2004.3.16 –]

Kunihiko Terasaki
Research Associate (E)

Takao Morinari
Research Associate (C)

Kouichi Hagino
Research Associate (N)

Shigeki Sugimoto
Research Associate (E) [2003.4.1 –]

Rika Endo
Research Associate (Project Manager) [2004.4.1 –]

Toshihide Maskawa
Professor (E) [– 2003.3.31]

Takashi Nakamura
Professor (A) [– 2002.3.31]

Ken Sekimoto
Professor (C) [– 2002.12.11]

Akira Furusaki
Associate Professor (C) [– 2003.3.31]

Takahiro Tanaka
Associate Professor (A) [– 2003.5.16]

Masafumi Fukuma
Research Associate (E) [– 2002.3.31]

Yuko Fujita
Research Associate (Project Manager) [– 2004.3.31]

In this list, the symbols A, C, E and N in the parenthesis are the following abbreviations of research fields:

A: Astrophysics and Cosmology
C: Condensed Matter and Statistical Physics
E: Elementary Particle Theory
N: Nuclear Physics Theory

Visiting Professors

Prof. Gary Gibbons
(DAMTP, Univ. of Cambridge)
2000.1.5 — 2000.4.30
Quantum Gravity and Black Hole

Prof. Vadim Kuzmin
(Inst. Nucl.Res., Russian Academy of Sciences)
2000.5.15 — 2000.9.30
Phenomenology of Particle Physics

Prof. Ivan Kostov
(Service de Physique Theorique de Saclay)
2000.10.15 — 2001.1.14
Gauge Theory and Superstring Theory

Prof. Grigori Vilkovisky
(Lebedev Phys. Inst.)
2001.2.1 — 2001.6.30
Study of Quantum Field Theory and Superstrings

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Prof. Robert M. Wald
(Chicago Univ.)
2001.7.5 — 2001.10.5
Thermodynamics of Black Holes and the Structure of the Space Times

Prof. Alexey Zamolodchikov
(Univ. Montpellier II)
2001.10.15 — 2002.3.14
Liouville Field Theory and Application to Two-Dimensional Quantum Gravity

Prof. Alexander D. Dolgov
(INFN & ITEP)
2002.6.24 — 2002.9.29
Neutrino Oscillations and Neutrino Cosmology

Prof. Bill Sutherland
(Univ. of Utah)
2002.10.1 — 2002.12.31
Theoretical Study on Low-Dimensional Many-Body Systems

Prof. Nathalie Deruelle
(Ecole Polytechnique & IAP)
2003.4.1 — 2003.6.30
Braneworld Gravity and Cosmology

Prof. Valentine Zakharov
(Max-Planck Inst.)
2003.7.1 — 2003.9.30
Study of QCD Monopole on Lattice

Prof. Serguei A. Brazovskiy
(Lab. de Phys. Theor. et Modeles Statistiques)
2003.10.1 — 2004.1.31
Topological Character of Excitations in Strongly Correlated Electron Systems

COE Foreign Researchers

Prof. Bertrand Giraud
(CEA, Saclay, Senior researcher)
2001.10.1 — 2001.12.31

Prof. Jaime Garriga
(Universitat de Barcelona, Professor)
2001.11.1 — 2002.1.31

Prof. Chirstopher Marc Mudry
(Paul Scherrer Institut, Research Scientist)
2001.12.11 — 2002.3.10

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1.2 Research Fellows and Students (2001 April – 2004 March)

Research Fellows

Kazuki Hasebe
JSPS fellow (E) [2003.4.1 –]

Hiroshige Kajiura
JSPS fellow (E) [2003.4.1 –]

Sachiko Ogushi
JSPS fellow (E) [2001.4.1 –]

Ayumu Sugita
JSPS fellow (N) [2003.4.1 –]

Takashi Umeda
JSPS fellow (E) [2003.4.1 –]

Tsuguhiko Asakawa
JSPS fellow (E) [2001.4.1 – 2004.3.31]

Kouji Hashimoto
JSPS fellow (E) [– 2001.10.15]

Kazuo Hosomichi
JSPS fellow (E) [– 2003.3.31]

Akihiro Ishibashi
JSPS fellow (A) [– 2003.2.13]

Takanobu Jujo
JSPS fellow (C) [2002.4.1 – 2002.5.31]

Hideo Matsufuru
JSPS fellow (N) [2001.4.1 – 2003.9.30]

Yukinori Nagatani
JSPS fellow (E) [– 2002.3.31]

Ken Ohsuga
JSPS fellow (A) [2001.4.1 – 2004.3.31]

Tadakatsu Sakai
JSPS fellow (E) [– 2001.9.7]

Shigeki Sugimoto
JSPS fellow (E) [– 2002.3.31]

Motoi Tachibana
JSPS fellow (E) [– 2002.3.31]

Gen Uchida
JSPS fellow (A) [2001.4.1 – 2002.2.28]

Nariya Uchida
JSPS fellow (C) [2001.4.1 – 2002.4.30]

Ken-ya Watarai
JSPS fellow (A) [2002.4.1 – 2004.3.31]

Toru Goto
COE21 fellow (E) [2003.10.1 – 2004.3.31]

Noriyuki Nakai
COE21 fellow (C) [2003.10.1 – 2004.3.31]

Wade Naylor
COE21 fellow (A) [2003.11.20 – 2004.3.31]

Toru Takahashi
COE21 fellow (N) [2003.10.1 – 2004.3.31]

Jian-Min Wang
COE21 fellow (A) [2003.11.25 – 2004.3.31]

Kazunori Kohri
COE fellow (A) [2001.4.1 – 2002.9.30]

Isao Kishimoto
COE fellow (E) [2001.4.1 – 2002.3.31]

Yukio Nemoto
COE fellow (N) [2001.4.1 – 2001.8.31]

Katsuhiko Sato
COE fellow (C) [2001.4.1 – 2002.3.31]

Masahisa Tsuchiizu
COE fellow (C) [2001.4.1 – 2002.3.31]

Masatomi Yasuhira
COE fellow (N) [2001.9.1 – 2002.2.28]

Hiroaki Abuki
YITP fellow (N) [2003.4.1 – 2004.3.31]

Yoshiaki Himemoto
YITP fellow (A) [2003.1.1 – 2003.3.31]

Kenji Hotta
YITP fellow (E) [2003.11.1 – 2004.3.31]

Yoshifumi Hyakutake
YITP fellow (E) [2002.4.1 – 2003.3.31]

Sanjay Jhingan
YITP fellow (A) [2002.4.1 – 2002.12.15]

Kengo Maeda
YITP fellow (A) [2003.4.1 – 2004.3.31]

Toshihiro Matsuo
YITP fellow (E) [2002.4.1 – 2003.3.31]

Yoshiyuki Morisawa
YITP fellow (A) [2003.10.16 – 2004.3.31]

Tadafumi Ohsaku
YITP fellow (C) [2003.11.1 – 2004.3.31]

Ayumu Sugita
YITP fellow (N) [2002.4.1 – 2003.3.31]

Toshiaki Tanaka

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YITP fellow (E) [2003.5.1 – 2003.10.14]

Dan Tomino
YITP fellow (E) [2003.11.1 – 2004.3.31]

Masahisa Tsuchiizu
YITP fellow (C) [2002.4.1 – 2003.3.31]

Masatomi Yasuhira
KU research fellow (N) [2001.4.1 – 2001.8.31]

Akira Fujii
KU part-time lecturer (E) [2001.4.1 – 2001.5.31]

Toru Goto
KU part-time lecturer (E) [2001.10.1 – 2002.3.31]

Jianzhong Gu
KU part-time lecturer (N) [2003.10.20 – 2004.3.31]

Nobuyuki Ishibashi
KU part-time lecturer (E) [2004.1.1 – 2004.3.31]

Hideharu Ishida
KU part-time lecturer (A) [2002.10.1 – 2003.3.31]

Tomoi Koide
KU part-time lecturer (N) [2001.4.1 – 2003.1.23]

Kohkichi Konno
KU part-time lecturer (A) [2002.4.1 – 2002.12.31]

Shoujirou Mizutori
KU part-time lecturer (N) [2001.10.1 – 2002.3.31]

Yoshiyuki Morisawa
KU part-time lecturer (A) [2003.1.1 – 2003.10.15]

Yukinori Nagatani
KU part-time lecturer (E) [2002.4.1 – 2002.9.30]

Noriyuki Nakai
KU part-time lecturer (C) [2003.4.1 – 2003.9.30]

Satoshi Nakamura
KU part-time lecturer (N) [2003.10.1 – 2004.3.31]

Shin Nakamura
KU part-time lecturer (E) [2001.4.1 – 2001.9.30]

Takashi Okamoto
KU part-time lecturer (A) [2001.6.1 – 2001.9.30]

Toru Takahashi
KU part-time lecturer (N) [2003.4.1 – 2003.9.30]

Eliani Ardi
Research assistant (A) [2003.5.1 – 2004.3.31]

Shizuo Iwamoto
Research assistant (A) [2003.4.1 – 2004.3.31]

Graduate Students

Hidenori Fukaya (E) [2001.4.1 –]

Wataru Hikida (A) [2001.4.1 –]

Takashi Hosokawa (A) [2002.4.1 –]

Hiromitsu Kaneko (A) [2002.4.1 –]

Norita Kawanaka (A) [2003.4.1 –]

Youhei Ota (E) [2003.4.1 –]

Kazuyoshi Takahashi (E) [2001.4.1 –]

Rohta Takahashi (A) [2002.4.1 –]

Tomohisa Takimi (E) [2002.4.1 –]

Tatsuya Tokunaga (E) [2003.4.1 –]

Masato Minamitsuji (A) [2003.4.1 –]
(from Osaka Univ.)

Kiki Vierdayanti (A) [2003.10.1 –]
(Visiting student from Indonesia)

Ewa Czuchry (A) [2003.10.1 –]
(Visiting student from Poland)

Axel Grzesik (C) [2003.10.6 –]
(Visiting student from Germany)

Yasuo Fujii (E) [– 2003.3.31]

Takeshi Fukuda (E) [– 2004.3.31]

Yoshinobu Habara (E) [– 2003.3.31]

Yoshifumi Hyakutake (E) [– 2002.3.31]

Yoshiaki Kato (A) [– 2004.3.31]

Tsutomu Kobayashi (A) [2001.4.1 – 2002.3.31]

Hideaki Kudo (A) [– 2002.3.31]

Mitsuhiko Matsukawa (E) [– 2002.3.31]

So Matsuura (E) [– 2003.3.31]

Yoshiyuki Morisawa (A) [– 2002.3.31]

Takenori Nakayama (E) [– 2004.3.31]

Osamu Seto (A) [– 2003.3.31]

Toshiyuki Tanaka (E) [– 2003.3.31]

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Chapter 2

Research Activities

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2.1 Research Summary

Astrophysics and Cosmology Group

The final goal of this group is to acquire a comprehensive understanding of the whole evolution of our universe from its birth to the present as well as its rich structures and diverse activities at present, on the basis of fundamental laws of nature and observations. Due to this basic nature, researches in this group are always cross-disciplinary and cover a quite wide range of subjects from mathematical studies of spacetimes to phenomenological modeling of astronomical objects. Further, major topics are strongly influenced by new developments in investigations of fundamental laws as well as in observations.

Now, we give the summary of major research activities and achievements by this group in 2003.

Black-hole Astrophysics

Magnetohydrodynamical Accretion Flows and Jet: We performed three-dimensional (3D) magnetohydrodynamical (MHD) simulations of radiatively inefficient accretion flow around black holes, and, for the first time, succeeded in producing a jet from a rotating torus threaded by weak, localized poloidal magnetic fields. This jet is derived by vertically inflating toroidal fields and is thus called as ‘magnetic tower’. (Y. Kato, S. Mineshige, K. Shibata) We also calculated the emergent spectra of the MHD flows, finding that the simulated MHD flows can account for the observed spectrum of Sagittarius A* in the flaring state. (K. Ohsuga, Y. Kato, S. Mineshige) Fe line emission profiles are under investigation. (N. Kawanaka, R. Takahashi, S. Mineshige)

Photon trapping effects in black hole accretion flows: Some Ultra-Luminous X-ray sources (ULXs) and narrow-line Seyert 1 galaxies (NLS1s) show rather peculiar behavior in the X-ray H-R diagram; namely, flow temperature decreases as luminosity increases. We carefully examined the photon trapping effects, finding that the behavior of ULXs and NLS1s can be understood, since hard photons originating from deep inside the flow are more effectively trapped and only soft photons can go out. (K. Ohsuga, S. Mineshige)

Relaxation Oscillations of a Microquasar GRS 1915+105: To understand the bursting behavior of the microquasar GRS 1915+105, we calculated time evolution of a black-hole accretion disk undergoing limit-cycle oscillation between the slim-disk and standard-disk branches. We find an abrupt, transient increase in the maximum disk temperature and a temporary decrease in the innermost radius during a burst,which are actually observed in GRS 1915+105. (K. Watarai, S. Mineshige)

Dynamical Evolution of Rotating Stellar Clusters: The effect of rotation on the dynamical evolution of collisional single-mass stellar clusters up to core-collapse is investigated. We confirm that rotation plays an important role in accelerating the dynamical evolution of stellar cluster, in particular to accelerate the core collapse. Large amount of initial rotations develop high density cores than in the non-rotating cases, which may support the growth of black holes inside stellar clusters. (E. Ardi, R. Spurzem, S. Mineshige)

Microlensing and Black Hole Shadows: In order to determine the nature of baryonic dark matter, I have investigated light trajectories and light curves of astrometric microlensing phenomena caused by finite-size lenses. Also, I have investigated shapes and positions of black hole shadows in accretion disks in Kerr metric.(R. Takahashi)

Braneworld Cosmology

There has been a growing interest in the cosmological implications of the braneworld scenario. In the braneworld scenario, our universe is a (mem)brane in a higher-dimensional spacetime, and any observational evidence that proves the existence of extra dimensions outside our world will drastically change our picture of the universe. In particular, the scenario proposed by Randall and Sundrum, which is based on 5-dimensional Einstein gravity plus a negative cosmological constant, has attracted much attention because it includes gravity in a self-consistent way and the standard 4-dimensional Einstein gravity is recovered in the low energy limit.

We investigated some variances of the Randall-Sundrum scenario. One of them is to include the Gauss-Bonnet term in the 5-dimensional action. We found that inclusion of it drastically alters the short distance behavior of gravity on the brane. Namely, it makes the theory like the 4-dimensional Brans-Dicke type scalar-tensor theory rather than the 5-dimensional gravity. This gives rise to an intriguing possibility that the size (curvature radius) of the extra dimension may be as large as 10 km. (Nathalie Deruelle and Misao Sasaki)

Another is to consider a non-trivial dynamical field in the 5-dimensional bulk spacetime and to understand the effect of the bulk dynamics on the brane. Assuming a spatially homogeneous and isotropic brane, we derived two closely related local conserved charges in the bulk. One of them is the local mass, which is a natural extension of conserved energy in an asymptotically flat, spherically symmetric spacetime. The other is a component of the Weyl tensor, which we call the Weyl charge. The difference between these two is found to be given by some components of the local energy momentum tensor in the bulk. Using these conservation laws, we clarified the relation between the bulk dynamics and cosmology on the brane. (Masato Minamitsuji and Misao Sasaki)

We also investigated the quantum effect of a bulk field. Except for some simple cases, there has been no systematic method to derive the effective potential or the expectation value of the energy momentum tensor in the bulk, particularly in the presence of a cosmological brane. We formulated a new method that can deal with such a situation. Applications of it to specific models are now under progress. (Nino Flachi, Alan Knapman, Wade Naylor, Oriol Pujolas, Misao Sasaki)

Gravitational Radiation

Thanks to recent advances in technology, an era of gravitational wave astronomy has arrived. There are already several ground-based laser interferometric gravitational wave detectors that are in operation(LIGO, GEO600 and TAMA300), and there is a future space-based interferometric detector project LISA. In the LISA project, we expect to detect gravitational waves from solar-mass compact objects orbiting supermassive black holes. To extract out physical information of such binary systems from detected gravitational wave signals, it is essential to know the evolutionary path of the system accurately, which includes the self-force correction on a small-mass body.

We formulated a new semi-analytical method for calculating the self-force acting on a small-mass body. At the expense of post-Newtonian expansion, this new method will be able to treat any orbit in a systematic way. As an example to show the power of this new method, we applied it to a scalar-charged particle and evaluated the self-force in the simple case of a plunge orbit. (Wataru Hikida, Sanjay Jhingan, Hiroyuki Nakano. Norichika Sago, Misao Sasaki, Takahiro Tanaka)

Spacetime Singularities

Formation of spacetime singularities is a quite peculiar but inevitable consequence of general relativity. Although structures and physical effects of singularities have been well studied for spherically symmetric systems, little is known for non-spherically symmetric systems. Such knowledge is indispensable to settle the cosmic censorship issue and clarify the role of singularities in nature. From this point of view, as a first step, we have investigated global structures of the Zipoy-Voorhees-Weyl (ZVW) spacetimes and the Tomimatsu-Sato spacetimes, which are well-known examples of stationary axisymmetric spacetimes with naked singularities. As a result, we have revealed various new features of these spacetimes that have not been recognized so far. In particular, we have shown that the apparently segment-like singularity of the ZVW spacetimes has really a ring-like structure when the deformation parameter δ is greater than unity and provides a rare example of naked singularity with positive mass. We have also shown that these spacetimes have a degenerate horizon with the ring singularity at the equator for $\delta \geq 2$ and that the $\delta = 2$ Tomimatsu-Sato spacetime, which is a rotating version of a ZVW spacetime, has horizons with two connected components. (Wataru Hikida and Hideo Kodama)

Motivated by superstring theory or M-theory, dynamics of spacetimes including the cosmic censorship problem has become an important issue in higher dimensions as well. Concerning this problem, we have given two arguments indicating instabilities of higher-dimensional spacetime. We first showed that a large class of supersymmetric compactifications, including all simply connected Calabi-Yau and G_2 manifolds, have classical configurations with an arbitrary negative energy density as seen from four-dimensions. Physical consequences of the negative energy density include new thermal instabilities. Secondly, we have given a counterexample for the cosmic censorship in an asymptotically AdS spacetime by showing that a naked singularity (or whole spacetime collapses) appears in one-scalar field model satisfying a positive energy theorem. This implies that a class of supergravity models in AdS is unstable. (Kengo Maeda)

Higher-Dimensional Black Holes

Recent developments in unified theories strongly indicate the existence of high-dimensional black holes on microscopic scales, and thereby the investigation of such black holes has become a major subject in the fields of cosmology and particle physics. The most basic issue concerning higher-dimensional black holes is the classification problem. It has been shown so far that asymptotically regular black holes are unique for vacuum and electro-vacuum systems if they are non-rotating, but the uniqueness does not hold, when black holes are rotating or spacetime has non-trivial topology, in spacetimes with dimensions greater than four. In order to make clear the origin of this non-uniqueness, we have taken two lines of approaches.

The first one is to extend the σ-model approach used to prove the uniqueness of axisymmetric black holes in four dimensions to five dimensional black holes. By this approach, we have succeeded in proving the uniqueness of the asymptotically flat black hole solution to the five-dimensional vacuum Einstein equation with the regular event horizon homeomorphic to S^3, admitting two commuting spacelike Killing vector fields and stationary Killing vector field. The solution of this system is determined only by three asymptotic parameters; charges, mass and two angular momenta. Thus, the five-dimensional Myers-Perry black hole solution is unique in this class. This result strongly indicates that regular black holes are unique in five dimensions if the horizon has the spherical topology. (Yoshiyuki Morisawa and Daisuke Ida)

Although this approach is purely non-perturbative and exact, it can only deal with systems with 'axial symmetry'. Therefore, this result does not exclude the possibility that black hole uniqueness might be violated for non-axisymmetric deformations. Further, for a technical reason, it cannot be extended to dimensions greater than 5.

The second approach is the perturbation analysis of higher-dimensional black holes. First, we have developed a gauge-invariant formulation for perturbations of (gen-

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eralized) static black holes and have shown that the Einstein equations for perturbations can be reduced to decoupled second-order ordinary differential equations of the Schrödinger type. Then, by applying this formulation to stationary perturbations, we have proved that regular vacuum black hole solutions that are asymptotically flat, de Sitter or anti-de Sitter are unique at least near the static and spherically symmetric limit, and are given by the Myers-Perry solutions and their extensions to the cases of non-vanishing cosmological constant. Further, with the help of the formulation mentioned above, we have succeeded in proving the perturbative stability of a large class of static black holes in four and higher dimensions; four-dimensional Schwarzschild-de Sitter or -anti-de Sitter black holes with and without charge in four dimensions, higher-dimensional Schwarzschild black holes and so on. (Hideo Kodama and Akihiro Ishibashi)

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Condensed Matter and Statistical Physics Group

The research of our group may be categorized into two areas—condensed-matter physics and non-equilibrium physics. The former is mainly interested in the low-temperature (or, low-energy $E \lesssim$eV) behavior of systems consisting of a macroscopic number of quantum particles (electrons, He-atoms,etc.), while the latter focuses mainly on how complex systems like reaction-diffusion systems behave far from equilibrium. Common to these seemingly different subjects is that both deal with (infinitely) many degrees of freedom which are strongly correlated with each other. One of our main goals is to understand how a combination of many-body correlation (cooperation) and a few fundamental principles like the Pauli principle yields a variety of phenomena such as superconductivity, magnetism, and complex behaviors in chemical- and biological systems.

Currently, we are working on the following themes.

Geometrically frustrated systems

Ground state of the quantum Heisenberg model on the pyrochlore lattice: There have been a lot of interests in low-temperature phases of geometrically frustrated electron/spin systems, and many studies have been performed in both theoretical and experimental sides. We have investigated the ground state of the quantum Heisenberg model on the pyrochlore lattice (a three-dimensional lattice made up of coupled corner-sharing tetrahedra). This system is a typical example of frustrated magnets in three dimensions, and it is realized in many compounds, e.g., B-sublattice of spinel compounds and also pyrochlore compounds. We first derived the low-energy effective model for the Heisenberg model with $S = 1/2$. To this end, starting from the limit where tetrahedral building blocks are isolated, We have included interactions between tetrahedra as perturbation. Each tetrahedron has doubly degenerate spin-singlet ground states, and we have used the $T = 1/2$ pseudospin representation in which scalar chirality is a good quantum number. The non-trivial effective Hamiltonian is obtained by the third-order perturbation, and this describes three-body interactions of chirality pseudospins. Mean-field ground state is determined for this effective model, and it is found that three quarters of chirality pseudospins show a long-range order in their transverse components, while the last one quarter of pseudospins remain disordered. We have also shown that this partial order corresponds to a triple-q order of spin dimerization. Secondly, we have continued to investigate this problem by including the effects of quantum fluctuations around the mean-field ground state. There exist spin-singlet excitations (dimerons) accompanying the partial order of dimerization, and non-ordered pseudospins are interacting to each other through exchange of two dimerons. Because of the large energy gap in dimeron energy dispersion, this interaction between non-ordered pseudospins is short ranged, and represented as an anisotropic Heisenberg-type Hamiltonian. The ground state of this Hamiltonian is determined up to the level where the Gaussian fluctuations are examined such that the Casimir energy is minimized. The determined ground state is a uniform order of either dimers or tetramers, and they coexist with the triple-q order of dimerization. In addition to gapful dimeron excitations, there are another type of spin-singlet excitations accompanying the uniform order of subsystem, and they are gapless. These two types of excitations have different energy scales, and this is one of important manifestations of frustration effects. (H. Tsunetsugu)

Magnetic properties of coupled tetrahedral systems: In some cases, a perturbative approach from isolated tetrahedra as in the above is naturally suggested by lattice structures. A family of Cu^{2+}-based compounds called tellurates ($Cu_2Te_2O_5X_5$) provides a typical example. Motivated by the recent discovery of these compounds, we have studied magnetic behavior of a system of coupled spin-tetrahedra in one- and three dimensions. We derived an effective Hamiltonian to describe the low-energy spin-singlet physics and obtained a semi-quantitative phase diagram. We have investigated high-field magnetization process as well and shown that our coupled tetrahedra has two different kinds of magnetization plateaus. (K. Totsuka and H-J. Mikeska).

Anomalous low-temperature metallic behavior in lithium vanadate: LiV_2O_4 is a metallic system and shows many anomalous low-temperature behaviors, which are similar to those in heavy fermion systems containing 4f or 5f elements. Considering that electron correlations are not particularly large in vanadium ions, it is not reasonable to expect the Kondo-type mechanism in this compound. There are two important features in this system: geometrically frustrated sublattice of vanadium ions and unquenched orbital degrees of freedom. We have investigated the effects of the second point with taking account of the frustrated lattice structure. We employed a three-band Hubbard model on the pyrochlore lattice, which is the structure of vanadium sublattice, with hopping integrals tailored for this compound, and investigated the effects of intra-atomic Coulomb repulsion on various types of density fluctuations within the random phase approximation. It is found that even in the non-interacting case, where the Coulomb repulsion is switched off, the wave-vector dependence of susceptibility of various density fluctuations is very small. With increasing Coulomb repulsion, the enhancement of susceptibility takes place with almost no wave-vector dependence. Most importantly, the dominant mode of fluctuations is a combination of orbital polarization and spin polarization. The fact that many different modes of fluctuations are simultaneously enhanced with small wave-vector dependence may explain heavy-fermion like behaviors at low temperatures. In this way, it is found that the presence of orbital degrees of freedom is an important ingredient of anomalous low-temperature behavior. (H. Tsunetsugu)

Correlation effects in frustrated metal: Kagomé lattice is a typical frustrated lattice in two dimensions. We have investigated the effects of electron correlation in this system to answer the question of if the frustration enhances the coherence of electron dynamics or suppresses. To this end, we have used the Hubbard model on the Kagomé lattice at half-filling. By introducing anisotropic electron hopping on the lattice, we control geometrical frustration and clarify how the lattice geometry affects physical properties. By means of the fluctuation exchange (FLEX) approximation, we calculated the spin- and charge susceptibilities, the one-particle spectral function, the quasiparticle renormalization factor, and the Fermi velocity. It is found that geometrical frustration of the Kagomé lattice suppresses the instability to various ordered states through the strong reduction of the wavevector dependence of susceptibilities, thereby stabilizing the formation of quasiparticles due to the almost isotropic spin fluctuations in the Brillouin zone. These characteristic properties have been discussed in connection with the effects of geometrical frustration in the strong coupling regime. (Y. Imai, N. Kawakami, and H. Tsunetsugu)

Cooperative order of spins and orbitals in vanadium spinels: $A\mathrm{V}_2\mathrm{O}_4$ (A=Zn, Mg, Cd) show two phase transitions at low temperatures. We have proposed a scenario for the two phase transitions in based on an effective spin-orbital model on the pyrochlore lattice. At high temperatures, spin correlations are strongly frustrated due to the lattice structure, and the transition at $\sim$50 [K] concerns an orbital order, supported by Jahn-Teller lattice distortion. This orbital order introduces spatial modulation of spin exchange couplings depending on the bond direction. This partially releases the frustration, and leads to a spin order at $\sim$40 [K]. We have also studied the stable spin configuration by taking account of third-neighbor exchange couplings and quantum fluctuations. The result is consistent with the experimental results. We have continued investigation with using Monte Carlo calculations to study temperature dependence. We have found that the model exhibits two transitions at low temperatures. First, a discontinuous transition occurs with an orbital ordering assisted by the tetragonal Jahn-Teller distortion. The orbital order reduces the frustration in spin exchange interactions, and induces antiferromagnetic correlations in one-dimensional chains lying in the perpendicular planes to the tetragonal distortion. Secondly, at lower temperatures, a three-dimensional antiferromagnetic order sets in continuously, which is stabilized by the third-neighbor interaction among the one-dimensional antiferromagnetic chains. Thermal fluctuations are crucial to stabilize the collinear magnetic state by the order-by-disorder mechanism. The results well reproduce the experimental data such as transition temperatures, temperature dependence of the magnetic susceptibility, changes of the entropy at the transitions, and the magnetic ordering structure at low temperatures. The effect of quantum fluctuation has also been examined by the linear spin wave theory at zero temperature. The staggered moment in the ground state is found to be considerably reduced from saturated value, and agrees reasonably with the experimental data. (H. Tsunetsugu and Y. Motome)

Mechanism of high-temperature superconductivity

We have proposed a mechanism of high-temperature superconductivity. The theory is based on an assumption that the doped holes induce the skyrmion excitations in localized spin systems. This picture is consistent with the rapid destruction of antiferromagnetic long-range order. The Lorentz-like force between the skyrmions leads to the d-wave Cooper pairing. The system has a characteristic excitation with the momentum (π,π) and the excitation energy of twice of the superconducting gap.

Duality in the $S = 1/2$ two-dimensional antiferromagnetic Heisenberg model: In order to obtain a different view on the mechanism of high-temperature superconductivity, we have examined the effective theories of the two-dimensional $S = 1/2$ antiferromagnetic Heisenberg model, which describes the undoped parent compounds of the high-temperature superconductors. The bosonic theory in terms of the Schwinger boson leads to the CP^1 model as the effective theory. On the other hand, the fermionic theory leads to the Schwinger model by taking the π-flux phase as the mean field. We have shown that there is duality between these two effective theories. The Dirac fermion excitation in the fermion theory, which is the vortex excitation in the boson theory and has an excitation energy gap proportional to the staggered magnetization in the ordered phase, becomes the low-lying excitation in the disordered phase. This fermion excitation turns out to be the skyrmion excitation. (T. Morinari)

Stability of antiferromagnetic long-range order in the doped two-dimensional Hubbard model: In the high-temperature superconductors, antiferromagnetic long-range order is rapidly suppressed by doping holes. Naive expectation would be that this is caused by the hopping of doped holes. We have examined this effect on antiferromagnetic long-range order in the two-dimensional Hubbard model. We found that the effect of hopping is rather ineffective in destroying antiferromagnetic long-range order. The quantum disordered phase, which is identical to that discussed by Chakravarty-Halperin-Nelson on the basis of the renormalization group analysis of the non-linear sigma model, is characterized by localized spin moments less than a critical value.(T. Morinari)

Alternative formalism for the slave particle mean field theory of the t-J model: As a theory for high-temperature superconductivity, the slave particle formalism of the t-J model has been studied intensively. The theory is based on a crucial assumption that there exists a deconfining phase of the U(1) gauge field associated with the gauge symmetry that preserves the electron operator invariant. Whether or not there is the deconfining phase is still in controversy. We have proposed an alternative formalism of the theory starting from the spin-fermion model, which is a multi-band model so that the fermion and the boson field are independent fields. Taking the strong coupling limit leads to the same d-wave superconducting state. However, the number of the pseudogap temperatures is not two but one. So the theory may be related to the electron doped systems rather than the hole doped systems. The theory could be applied to other systems, such as the Kondo lattice model (T. Morinari).

Vortices in Type II superconductors

Stable arrangements of vortices in Type II superconductors: The observation of vortices tells us the nature of type II superconductors. We have studied the relationship between electronic structures and the observed arrangement of vortices. Here, concerning electronic structures, the Fermi velocity, the superconducting gap, and the multi-band structure are important factors in this problem. In the presence of anisotropies in the electronic structures, the arrangement of vortices depends both on temperature and on applied magnetic field. If the arrangement of vortices has a periodicity like a lattice, the transformation of vortex lattices can be observed by the small angle neutron scattering experiments, the decoration method or the scanning tunneling microscopy.

In order to understand the transformation of vortex lattices, we have investigated the stable arrangement of vortices in anisotropic superconductors by using the quasi-classical theory. That is, for each possible arrangement of vortices, the free energy is calculated and the most stable arrangement is determined by comparing the values of the free energy obtained in this way.

If the direction of the applied field is perpendicular to the plane in which the electronic structure has a strong anisotropy with the tetragonal symmetry, the arrangement of vortices favors a square lattice rather than a triangular lattice in intermediate- or high fields. Whether the Fermi-velocity anisotropy or the gap anisotropy affects depends on temperature and the applied field. Thus we have concluded that the two effects are separable. (N. Nakai)

Low-energy excitations around vortices in type II superconductors: In recent years, there has been much attention focused on such exotic superconductors as high-T_c cuprates, $CeCoIn_5$, UPt_3 and Sr_2RuO_4. These superconductors stimulate many interests in condensed matter physics. One of the main interests is the symmetry of the paring function in the exotic superconductors.

Measurements of the dependence of several physical quantities (e.g. the Sommerfeld coefficient) in the vortex state on the direction and the amplitude of the field give information on the pairing function of these exotic superconductors. In this context, we have studied the spatial structures of low-energy excitations around vortices in the type II superconductors again by using the quasi-classical theory. If the pairing function or the Fermi velocity is anisotropic, the Sommerfeld coefficient (a linear coefficient of low-temperature specific heat) in the vortex state shows a characteristic dependence on the field. When the direction of the field is changed, the Sommerfeld coefficient in the vortex state exhibits a oscillation pattern which depends on the relative angle between the applied-field direction and the anisotropy axis of the pairing function or the Fermi velocity. The field-amplitude dependence of the oscillation is different between the case of anisotropic pairing and the case of anisotropic Fermi velocity. Thus we have obtained the information on the paring function.

When the amplitude of the field is varied, on the other hand, the Sommerfeld coefficient shows a singularity at a characteristic field which marks a change from a linear dependence to a non-linear one. The characteristic field depends on the size of anisotropy in the paring function and this enables us to estimate the pairing anisotropy for a given system by measuring the field dependence. (N. Nakai)

Low-dimensional quantum magnetism

Not only quantum spin Hamiltonians are often used to describe the low-energy phenomena of insulators the physics contained in them is interesting in its own right. In particular, quantum spin systems with low spin quantum numbers and low dimensionalities sometimes show unexpected behaviors due to strong quantum fluctuations and have been providing intriguing issues in condensed-matter physics.

Effect of disorder on high-field magnetization process: In these years, it has been recognized that the classical picture for the magnetization process of antiferromagnets (as is seen in many standard textbooks on magnetism) is *not* always true; in many cases magnetization curves (plots of the induced magnetization for applied magnetic fields) have remarkable step-like structures called *plateaus*. Our current understanding of plateaus is based on the existence of effective magnetic particles and ‘insulating’ states formed by them. These insulating states are supported by strong repulsions between the effective magnetic particles and realize *only* at special (commensurate) values of magnetization which depend both on the lattice structure and on the spin quantum number. Therefore a natural question arises as to the competition between correlation-induced insulators (plateaus, which may be compared to Mott- or charge-density-wave insulators) and disorder-induced phases (the Griffiths phase, the Bose glass etc.). This kind of questions may be relevant to recent experiments on the K-substituted $TlCuCl_3$.

By applying bosonization and renormalization group (RG) to a replicated theory, we have investigated this problem for generic antiferromagnetic spin systems in one dimension and derived criteria for the stability of plateaus against (imposed) disorder. We have carried out strong-coupling expansions as well for several typical cases to obtain results consistent with those of field theory. (K. Totsuka)

SO(6) symmetry in spin ladder systems: Recent progress in (quasi) 1D electron/spin systems reveals that novel phases with broken T-symmetry (typically the so-called *flux phase* and *scalar-chiral phase a la* Wen-Wilczek-Zee) do exist in some ladder systems. Remarkably, they

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are related to more conventional (T-symmetric) phases by unitary transformations. Motivated by this, we have investigated generalized spin ladders by mapping onto a low-energy effective field theory. We have observed: (i) (at least in the vicinity of a point with a high symmetry called SU(4)-point) there are *four* generic infrared RG-trajectories along which SU(4)-symmetry is asymptotically restored, (ii) each of these trajectories corresponds to a massive phase with a broken translational symmetry, and (iii) the four phases are separated from each other by quantum phase transitions dominated by novel *spin-singlet* fluctuations. Generic perturbation from the SU(4) point drives the spin-sector (described by the SU(3) Gross-Neveu model) massive and the low-energy sector of our model is governed by *spin-singlet* degrees of freedom. The effective field theory describing these spin-singlet fluctuations have been shown to be the so-called Tomonaga-Luttinger model (K. Totsuka and P. Lecheminant).

Non-equilibrium Physics

Open systems far from thermodynamic equilibrium, such as non-equilibrium systems including living systems, provide a wide variety of self-organizing cooperative processes leading to the spontaneous formation of spatial and temporal order. Attempts are made not only to understand the principle governing such a variety of self-organization phenomena at various levels of physical, chemical and biological systems, but also to develop a synthetic theory typical of 'living state'.

Evolution of living systems: It is the central problem of the emergence of life when aggregation of matter obeying only elementary physical laws first began to constrain individual molecules to a collective behavior. Most studies on this problem have been focused on the emergence of self-replicating units. However, there must be one serious dilemma: without evolutionary process no evolving units arise, but without evolving units no evolutionary process could begin. To solve this dilemma, a new principle of endo-exo circulation has been proposed. (M. Murase)

Biological effects of electromagnetic fields: Although electromagnetic fields produce biological responses at very low intensities, underlying mechanisms have not been identified yet. A hypothesis was proposed that electromagnetic fields cause hormonal effects. For living cells, signal transduction pathways are limited, whereas environmental factors are almost infinite. This means that the signal transduction pathways can interact synergistically, a phenomenon known as 'cross talk'. This cross talk not only increases the degree of amplification of signal, but also enhances mutual interaction leading to the formation of feedback loops. In addition, there are the so-called amplifier enzymes like G-proteins. Once such enzymes are activated, they can transmit signal for a while. All these mechanisms had evolved to detect and amplify various kinds of environmental factors. As a result, some responses to such environmental factors can help learning and adaptation, whereas others cause the onset of environmental illness. The present hypothesis predicted that some amplifier enzymes like G-proteins can be the targets for very weak electromagnetic fields. (M. Murase)

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Nuclear Theory Group

Nuclei are quantum mechanical many-body systems which consist of nucleons, i.e., protons and neutrons. These are self-bound systems with finite number of nucleon, and rich phenomena have been found experimentally and/or predicted by theoretical calculations in there. The primary goal of nuclear physics is to address: i) how do complex systems emerge from simple ingredients? and ii) how do simplicities and regularities in complex systems emerge? In the last two decades or so, nuclear physics has extended its research area to hadrons as well, where quarks are important ingredients. The modern nuclear physics thus deals with both nuclei and hadrons from a point of view of many-body physics. The research areas which we have covered in this academic year include: nuclear many-body problems (nuclear structure and reactions), few-body physics (effective field theory), and hadron physics (hadron spectroscopy and dense quark matter).

Nuclear Structure Physics

The goal of nuclear structure physics is to construct the unified comprehensive microscopic framework which can describe i) bulk nuclear properties (such as masses, radii, moments, and nuclear matter), ii) nuclear excitations (the variety of nuclear collective phenomena), and iii) nuclear reactions. One of the recent important achievements in nuclear structure physics is that nuclei far from the stability line have now been accessible experimentally. In neutron-rich nuclei, where the neutron number is considerably larger than the proton number, many new phenomena have been found, suggesting that many traditional concepts of nuclear physics need to be revised. These nuclei are characterized by a large isosopin and a weak binding, which amplify important features of nuclear many-body problems. Neutron-rich nuclei, therefore, are important to explore in order to deepen our understandings of many-body systems.

One of the theoretical challenges to describe those exotic nuclei is that they are weakly bound, and even a small perturbation may promote valence nucleons to continuum scattering states. One therefore needs to use a consistent treatment for residual interactions (mainly a pairing interaction) and continuum spectra. Also, any theoretical model has to allow broken spatial symmetries, since many neutron-rich nuclei are known to be deformed. This means that one has to use the generalized BCS theory known as the Hartree-Fock-Bogoliubov theory (which is equivalent to the Bogoliubov de Genes theory in condensed matter physics) for the ground state, and the continuum linear response theory with broken symmetries for excited states. Such calculations have been started only in recent years. In this year, we have for the first time performed calculations with the quasi-particle random phase approximation (QRPA) for deformed neutron-rich nuclei [1]. Applying the method to the ^{38}Mg nucleus, we have found that the collectivity of the gamma vibration (the lowest $K^\pi = 2^+$ mode) is significantly enhanced in neutron-rich nuclei if protons and neutrons have different deformations.

Related topics to neutron-rich nuclei include the ground state correlation energy and couplings between nuclear structure and reaction theories. In this connection, we have developed a simple and practical way to compute the ground state energies based on the generator coordinate method [2]. We have also discussed properties of single particle resonances based on the reaction theory [3], and have performed coupled-channels calculations for heavy-ion fusion reactions induced by neutron-rich nuclei at energies around the Coulomb barrier [4, 5].

Large amplitude collective motions

Microscopic understanding of nuclear collective dynamics is a long-term goal of nuclear physics. For instance, spontaneous fission is one of the oldest nuclear decays modes, but its mechanism has not yet been fully understood. An important point is that large amplitude collective motions often manifest many-body quantum tunneling. Typical examples in nuclear physics include nuclear fission, nuclear fusion reactions, and shape coexistence phenomena.

Nuclei whose atomic number is larger than 92 (uranium) do not exist in nature, but can be synthesized in laboratories using nuclear fusion reactions. There has been a theoretical prediction that a nucleus with Z=114 and N=184 is the double magic nucleus next to ^{208}Pb. The region around this nucleus in the nuclear chart is called the island of stability. There have been extensive experimental as well as theoretical activities on synthesis of such superheavy elements (SHE). Reaction mechanisms for fusion reactions to synthesize SHE, however, have not yet been fully clarified. We have recently proposed a new approach to calculate fusion probabilities, where they are given by a product of probabilities for two distinct processes (the two-step approach)[6]: one is the barrier penetrability for a fusion barrier which has to be overcome in order for two fragments to form a touching (sticking) configuration, and the other is for overcoming of a conditional saddle where the sticking configuration evolves its shape to eventually form a compound nucleus. For the latter, we have proposed a transport approach, where a Langevin equation is solved in order to describe the shape evolution dynamically. Notice that this is, in a sense, an inverse Kramers problem which describes a thermal activation of a metastable state[7]. We have found that this model works remarkably well in reproducing the existing experimental data for residue cross sections, by a combined use of the new statistical decay code, KEWPIE [8]. We have also used the model to predict fusion cross sections for future experiments [9].

Another example of large amplitude collective motions in nuclear physics is a shape co-existence phenomenon. This is a phenomenon where different shape configurations appear in the same energy region. If one would like to take into account a mixing of different configurations, one inevitably has to deal with a large amplitude collective motion. A difficulty is that it is not a simple task at all to extract the collective degree of freedom which describes the shape mixing out of huge numbers of nucleonic degrees of freedom. Sometime ago, a method to determine the collective coordinate in a self-consistent manner has been proposed [10]. This method is called the Self-consistent Collective Coordinate (SCC) method. Recently, two practical methods to solve the SCC equations have been proposed. One is the Adiabatic SCC (ASCC) method [11], where the SCC equations are solved under an assumption of slow collective motion. The other is the coupled SCC method [12], where the SCC equations are first solved at each configuration and then the coupling is introduced among the local solutions. We have compared the ASCC with the coupled SCC, and have confirmed that the ASCC method works well.

Effective field theory

Effective theories are standard in describing low energy dynamics of a system. This method is based on the fact that phenomena at low energies cannot probe details of high energy structure of particles. This leads to a natural separation of energy scale where one treats “soft” (low energy) modes explicitly while integrates out “hard” (high energy) modes to obtain an effective theory for the soft modes. The idea of the effective field theory (EFT) is to construct the most general Lagrangian consistent with fundamental symmetries out of fields for relevant degrees of freedom. Recently, the EFT for two nucleon systems has been proposed which works at energies smaller than the pion mass scale [13]. In this energy regime, the wave length of nucleon is much larger than the Compton wavelength of pions, which characterizes the range of strong interaction. The nucleon-nucleon interaction thus appears to be short ranged, and it may be replaced by a zero range contact interaction. The relevant degree of freedom here is nucleon only, and this approach is called the pionless effective field theory. This theory has been successfully applied to astrophysically relevant reactions, such as $n+p \to d+\gamma$ and $p+p \to d+e^+ + \nu_e$. We have been interested in the foundation of the pion-less effective field theory, and has been attempting to construct it starting from the EFT with pions by integrating out the pion degree of freedom.

Hadron physics and Color superconductivity

The goal of hadron physics is to address i) the properties of the QCD vacuum (i.e., the physics of chiral symmetry breaking and chiral restoration), ii) its hadronic excitations (i.e., the spectrum and structure of hadrons), and iii) its several phase transitions (i.e., the quark matter at high temperature and/or high density), based on the quantum chromodynamics (QCD).

In cold dense quark matters, the existence of color superconductivity has been predicted, where two quarks form a Cooper pair and condensate in the ground state. There have been extensive investigations by many groups in recent years on the properties of the color superconductivity phase. In this year, our group has made an important contribution to it, addressing the following two issues. One is precursory phenomena of color superconductivity. The color superconductivity phase is a strongly correlated Fermion system of quarks, and a large dynamical fluctuation of quark Cooper pairs may be expected. We have investigated the effect of dynamical fluctuation of the quark pairs on the color superconductivity, and have found that the single-particle level density (the density of state) is suppressed around the Fermi surface even at temperatures above the critical temperature for the phase transition between super and normal fluid phases [14]. This is an excellent analog to the pseudo-gap phenomena known in a high-T_c superconductivity in condensed matter physics. The other problem is the color-flavor unlocking transition. In the color superconductivity phase, two different superconducting phases have been predicted. One is called the two flavor pairing (2SC) phase, where only u and d quarks participate in the pairing phenomena, while the other the color-flavor locking (CFL) phase, where all of the u, d and s quarks are involved in the pairing. It is easy to imagine that, when the mass of s quark is infinite, the s quark is decoupled from the rest of u and d quarks and the 2SC phase is realized. In the limit of vanishing s quark mass, on the other hand, u, d and s quarks are equal to each other and the CFL phase appears. However, it had not been clear how the phase transition occurs from the CFL to the 2SC phases as the s quark mass increases. In fact, there had been only naive discussions by Schäfer and Wilczek [15], and by Alford, Berges, and Rajagopal [16], which suggested that the phase transition was the first order. We have carefully re-examined the role of the s quark mass in a more consistent framework [17], and have found that the phase transition is actually the second order, in opposite to what people had believed.

Lattice QCD

The lattice field theory (Lattice QCD) provides a way to perform *ab initio* calculations for systems composed of strongly coupled, ultrarelativistic quarks and gluons. It is applicable even in the non-perturbative regime of QCD, and provides a useful tool to investigate hadron physics. Three important issues which should be investigated by the lattice QCD include i) the understanding the QCD vacuum, which is characterized by non-perturbative phenomena, i.e., the chiral symmetry breaking and the confinement, ii) hadron spectrum and hadronic structure, and iii) hot and dense quark matter. Among them, our group has been working mainly on the hadron spectrum in this year.

The sigma meson plays an important role in hadron physics. There have been a few experimental evidences for the existence of sigma meson, e.g., in the phase shift analyses for $\pi-\pi$ scattering and in decay processes of heavy particles, such as $D \to 3\pi$. There has been, however, a longstanding debate concerning its nature. Four proposed possibilities are i) usual $q\bar{q}$ meson, ii) exotic four quark state $qq\overline{qq}$, iii) pion molecule, and iv) collective $q\overline{q}$ state where the σ meson is identified to a dynamical fluctuation of $q\overline{q}$ pairs. In order to draw a more definite conclusion for the structure of σ meson, we have undertaken Lattice QCD calculations for it[18], which is ab initio and thus does not assume any model. We have successfully shown that there exists a low-mass σ meson, whose mass is between the pion mass and the mass of ρ meson.

The lattice QCD has clarified the string potential between two static quarks, and how it changes if the string is excited. We have extended it to static three quark systems [3]. We have put three quarks in arbitrary locations, and computed the energy of the ground state as well as the first excited state with the lattice QCD. We have found that the ground state energy is parametrized as a superposition of a 2-body Coulomb-like term and a 3-body linear term that depends on the length of the Y-shaped flux tube. The excitation energy, on the other hand, has been found to be a function of the length of a vibrating flux tube. We have also found that the excitation energy exceeds 1 GeV, indicating that gluonic excitations do not contribute to the low-lying hadron spectra.

Summary

Summarizing research activities of the nuclear theory group, we would like to emphasize that nuclear physics deals with a large variety of phenomena in nuclear and quark many-body systems. It is many-body physics for strongly correlated fermion systems. In this sense, nuclear physics shares a similar philosophy with condensed matter physics. Also, nuclear physics plays an important role in astrophysics as well as in interdisciplinary many-body physics, such as trapped fermion gas, microclusters, quantum dots, and small metallic grains.

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Particle Physics Group

The ultimate goal of particle physics is to construct the theory which can explain the nature from a fundamental principle, Theory of Everything (TOE). Superstring theory attracts many particle physicists as TOE, because superstring theory unifies the gravity with the other gauge forces. The discovery of the duality of the string theory gives us an clue to study the non-perturbative aspects of the string theory, such as true string vacuum and application to the model building. It is now even possible to study the gauge theory using the string theory and gravity. Study of constructive formulation of the string theory is also discussed.

On the other hand, low energy phenomena of particles are described correctly by Standard Model (Weinberg Salam model). However, the higgs boson predicted in the model has not been found so far, and theory is expected to face the hierarchy problem beyond TeV scale. Several theories beyond the SM is proposed and the new phenomena are predicted. They are tested in the various on-going and future experiments such as the B factory, LHC and cosmological observations. Possible signals that will be obtained by those experiments and their implication to the models at high energy scales are studied.

Finally, while Standard Model has been successful so far, better understanding of the non-perturbative aspects of QCD is required to see contributions from physics beyond the standard model. The dynamics of QCD at low energy is also very attractive by its own. Also, new phenomena are expected at finite temperature and/or finite density, which are not yet fully understood. Lattice simulation is applied to compute the weak matrix elements of the B meson system and the spectral functions in QGP. New methods to implement the lattice fermion with an exact chiral symmetry is also studied.

Field theory is also studied actively by our member. The supersymmetric field theory and integrable systems have interesting mathematical structures, and non-trivial non-perturbative structures can be studied. Field theory is also an important building block of the string theory. It is an important tool for condensed matter as well. The application to the QH effects are studied by our members.

String Theory and Quantum Gravity

We studied superstrings in four-dimensional NS-NS plane waves using the hybrid formalism in a manifest supersymmetric manner. This is obtained through a field redefinition of the RNS worldsheet fields and defined as a topological N=4 string theory. We studied the physical spectrum to find boson-fermion asymmetry in the massless spectrum. (Kunitomo) We are also studying superstrings in $AdS_3 \times S^1$ using the same formalism. The spacetime supersymmetry is manifest and closed in off-shell extending the infinite dimensional superconformal symmetry. (Kunitomo)

Using Noether's identities, we defined a superpotential with respect to a background for the Einstein Gauss-Bonnet gravity. As an example, we show that the conserved charge associated with it yields the "gravitational" mass of a D-dimensional Gauss-Bonnet black hole in an anti-de Sitter spacetime. (Ogushi, Deruelle) We also wrote an article about AdS/CFT correspondence in a general japanese magazine. (Ogushi)

We considered a closed string field theory with an arbitrary matter current. We found that the source must satisfy the covariant conservation law as a consequence of the BRST invariance of the theory. We then considered the boundary state (D-brane) as an example. By perturbative expansion, We derived a recursion relation which represents the bulk backreaction and the D-brane recoil. (Asakawa, Matsuura)

Motivated by recent work on "Time-like Liouville Theory" by Strominger et.al., We tried to extend their work to more realistic backgrounds, such as a supersymmetric one and inhomogeneous ones, and clarify physics in such situations (D-brane, tachyon condensation, and so on). (Fukuda)

We found a D-brane configuration that realizes 2 and 4 dimensional QED in string theory and discussed its possible applications. In particular, since 2 dimensional QED is known to be a solvable quantum field theory, we can apply various field theory techniques, such as bosonization, to string theory and obtain some new insights in the D-brane physics. (Sugimoto, Takahashi)

We proposed a new type of cosmological model in which it is postulated that not only the temperature but also the curvature is limited by the mass scale of the Hagedorn temperature. We found that the big bang of this universe is smoothly connected to the big crunch of the previous universe through a Hagedorn universe, in which the temperature and curvature remain very close to their limiting values. (Ninomiya)

Supersymmetry

In certain supersymmetric theories topological charges acquire a new type of anomalies. We have presented a superfield formulation of the central charge anomaly in supersymmetric theories with solitons, by use of a superfield supercurrent. The one-loop effective action is also constructed to verify the anomaly and the BPS saturation of the soliton spectrum. (Shizuya)

By a simple deformation of the type A N-fold supercharge, we found a new family of N-fold supersymmetric quantum systems, which we referred to as 'type B'. Regarding to the intimate connection with quasi-solvability, it was found that the type B models consist of two of the quasi-solvable models which preserve 'gap modules' of Post–Turbiner type. (Tanaka)

We considered a long standing problem in field theories as to why there is no sea as boson vacuum contrary to the fermion vacuum, Dirac sea. We have shown with the help of supersymmetry that the boson vacuum is also sea in which the negative energy states are all filled analogous to Dirac sea and that a hole produced by annihilating one negative energy boson is nothing but an anti-particle. (Ninomiya)

Quantum Hall systems

We have constructed a long-wavelength effective theory for the fractional quantum Hall effect by use of the single-mode approximation without referring to the composite-boson or composite-fermion picture. The effective theory critically deviates from the Chern-Simons theory for collective excitations in bilayer systems, which may be detected by a Hall-drag experiment. (Shizuya)

In bilayer quantum Hall (BLQH) systems at $\nu = 2$, three different kinds of ground states are expected to be realized, i.e. a spin polarized phase (spin phase), a pseudospin polarized phase (ppin phase) and a canted anti-ferromagnetic phase (C-phase). We discussed an origin of the C-phase based on the $SU(4)$ group analysis and showed that peculiar operators in the $SU(4)$ group play a key role to its realization. (Hasebe)

We constructed higher dimensional quantum Hall systems based on fuzzy spheres. It was shown that fuzzy spheres are realized as spheres in colored monopole backgrounds. The noncommutativity is related to spins. In $2k$-dimensional quantum Hall systems, topological objects are $(2k-2)$-branes which obey fractional statistics. Higher dimensional quantum Hall systems exhibit a dimensional hierarchy, where lower dimensional branes condense to make higher dimensional incompressible liquid. (Hasebe)

Noncommutative Geometry

Since our universe is expanding, time-evolution of "quantum" geometry would be worth discussing. We applied pure-into-mixed-state process to formulate time-evolution of nonocommutative geometry. We gave an explicit example of evolving fuzzy two-sphere, and constructed field theory on it. (Sasakura)

We considered matrix models on the most simple homogeneous spaces: fuzzy S^2 and fuzzy $S^2 \times S^2$. Noncommutative gauge theory can be constructed with these models, and we studied quantum corrections of these spaces through the gauge theory. We studied effective actions and discussed about stability of these models. Next, we studied a gauge invariant correrator and discussed about geometries which are corrected with quantum corrections. (Tomino)

Integrable Systems

In order to understand and formulate quantum field theory 'beyond perturbation', we investigated various examples of completely solvable models in low dimension. The classical and quantum integrability are shown to be very closely related for Calogero-Moser and Ruijsenaars-Schneider systems, in particular, the frequencies of small oscillations at equilibrium and the quantum spectrum. (Sasaki)

We have proven a general theorem, applicable both to non-integrable and integrable systems, relating the quantum energy eigenvalues to the classical frequencies of normal mode oscillations at classical equilibrium of any multi-particle dynamics(Loris-Sasaki). The calogero-Moser systems provide an infinite family of non-trivial examples. (Loris-Sasaki)

New families of quasi-exactly solvable quantum systems are proposed by 'crossing' affine Toda molecule and Sutherland systems for each affine root system. That is the multi-particle potentials are $1/\sin^2$(distance) which are determined by affine simple roots. The eigenvalues are related to "affine Toda masses". (Loris, Sasaki)

We also wrote Two review articles on the quantum and classical integrable multi-particle dynamics, in particular, the Calogero-Moser systems for NATO Advanced Research workshop and for "Encyclopedia of Mathematical Physics". (Sasaki) An introductory article on 'Field Theory', covering most topics of quantum field theory, meant for undergraduate and graduate students, will be published as a chapter in 'Encyclopedia of Physics'. (Sasaki)

We studied the tensor product of the higher-spin representations of the elliptic quantum group $E_{\tau,\eta}(sl_n)$ $(\geqslant 3)$ and generalize the algebraic Bethe ansatz method to diagonalize the transfer matrix of the modules associated $E_{\tau,\eta}(sl_n)$. This enables us to get the spectrum problem of many elliptic integrable models, for example *higher spin generalized $\mathbb{Z}_n$-Belavin models* with periodic boundary condition. (Sasaki,Yang)

We use the method developed by us to get eigenvalues of all types (elliptic, trigonometric and rational) of Ruijsenaars-Schneider models with a discrete coupling constant ($\gamma = lw$ with l being a positive integer) and Calogero-Moser model with a discrete coupling constant ($\gamma = l$ with l being a positive integer) associated A_{n-1} root system in Bethe ansatz formulas. (Sasaki, Yang)

We have studied $\mathbb{Z}_n$ Belavin model with integrable open boundary condition which are described by two *non-diagonal* boundary K-matrix $K^-(u)$ and its dual $K^+(u)$ with $n+1$ free boundary parameters. We successfully constructed the corresponding pseudo-vacuum state $|\Omega\rangle$ and apply the algebraic Bethe ansatz method to diagonalize the corresponding *double-row transfer matrices*. The eigenvalues of the transfer matrices and associated Bethe ansatz equations are obtained. (Sasaki, Yang)

We studied the quantum version of the supersymmetric KdV equation, as it shows clear connections to 2 dimensional superconformal field theories. Using a lattice discretisation, we found a Lax operator and a monodromy matrix, which satisfies the so-called braided Yang-Baxter equation for the R-matrix of the quantum affine algebra $sl(2|1)$. This allows calculations to be performed exactly, using Bethe Ansatz technique. However, the continuous limit of such a monodromy matrix - which should describe superconformal field theories - is still to be understood. (Rossi)

Physics beyond the Standard Model

B factory in KEK and SLAC have been studying B meson decays and the experiment will increase its sensitivity in future by upgrading into Super B factory. We have shown that CP asymmetries and other observables in the B meson decay may deviate significantly from the SM predictions, and the pattern of deviations will be useful to discriminate the different models in future B experiments. (Goto)

Assuming Frogatt-Nielsen mechanism and the Frogatt-Nielsen U(1) charges respect the SU(5) GUT structure, we show that the quark mass data necessarily implies the large 2-3 mixing in the MNS mixing matrix U_{MNS}. If we further add the neutrino data, it further implies that the 1-2 mixing in U_{MNS} is large, so explaining the bi-large mixing. This analysis also predicts U_{e3}, which will be measured in future Long base line experiments. We also add an argument that E_6 GUT is favored. (Kugo)

Large hadron collider will start to operate from 2007. If supersymmetry is realized in nature, we expect clear signal of sparticles, and the nature of sparticles can be studied. The $\tilde{t}$ receives large radiative correction by Yukawa RGE running and left-right mixing. We have shown by doing numerical simulations, $m_{\tilde{t}}$ and the left-right mixing as well as their decay branching ratios are constrained by LHC measurement by reconstructing the top and bottom quark arise from $\tilde{g} \to \tilde{t}$ decay. (Nojiri) We have also shown that the kinematics of SUSY decay processes at LHC can be solved from the observed lepton and jet momentum, although LSPs escape from detection for sufficiently long cascade decays. In such a case, the mass and decay distribution of a sparticle can be measured. Especially, the study of the polarization dependence of the sparticle interaction becomes possible. (Nojiri).

We studied the pair annihilation processes of the higgsino or wino like dark matter. We found that the attractive Yukawa potentials induced by the EW gauge bosons may enhance the cross section by several orders of magnitude. The γ ray from the DM annihilation may be found by the GLAST satellite detector and the Air Cherenkov Telescope (ACT) arrays in such a case.(Nojiri)

Lattice theory and strong interactions

Ginsparg-Wilson relation and Admissibility Condition is a key feature to formulate chiral symmetries on the lattice. We developed a new method to study the topology and chiral symmetries on the lattice. Especially theta vacuum is formulated on the lattice by dividing the path integrals into topological sectors. The applicability of the formulation is explicitly checked in 2 dim massive Schwinger model. (Fukaya, Onogi)

Formation of Quark Gluon Plasma is studied in RHIC & SPS experiments, and the expected signal of the QGP formulation is studied theoretically. Using anisotropic lattices and (a) Maximum entropy method (b) least-square fitting, it is shown that that the spectral function of charmonium has peak structure even above Tc. (Umeda, Matsufuru)

The transition matrix element of B meson is important to measure the CKM matrix element and FCNC. Lattice calculation was utilized to for the precise determination of the B decay constant and Bag parameter without quenching approximations. The simulation is current best non-quenching calculation. It is also found the f_{B_d} calculation shows numerical instability in the chiral limit. This shows the chiral symmetry on the lattice is important for B physics study as well. (Onogi with JLQCD collaboration).

Recently, a 5-quark, ”Penta-quark, baryon is found by the LEPS collaboration at Spring 8. The BELLE experiment at KEK also found a new charmed strange resonance. We have proposed an assignment of the newly observed charmed strange scalar meson to the $I_3 = 0$ component of iso-triplet four-quark mesons and have predicted existence of additional narrow scalar resonances. (Terasaki)

Newly observed B decays also have been studied by assuming that the amplitude is given by a sum of factorizable and non-factorizable ones, and it has been shown that non-factorizable amplitude can compensate for color and helicity suppressions. (Terasaki)

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2.2 Research Highlights

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θ vacuum on the lattice

Hidenori Fukaya and Tetsuya Onogi (YITP)

"Topology" is one of the important aspects of gauge field theories. In terms of topology we can understand a number of nontrivial features of QCD such as chiral anomalies , θ vacua and U(1) problems. It ,however, seems difficult to realize topological properties on the lattice since all the fields are on the discretized spacetime.

The Ginsparg-Wilson relation [1];

$$D\gamma_5 + \gamma_5 D = aD\gamma_5 D, \tag{1}$$

plays an important role on this subject. It gives a redefinition of the exact chiral symmetry on the lattice. Moreover, it has been proven that the Dirac oparator which satisfies this relation has an index corresponding to the Atiyah-Singer index.

The index of the Dirac operator should be equal to the topological charge which denotes the number of instantons. This charge is realized if link variables satisfy Lüscher's bound [2];

$$||1 - P_{\mu\nu}(x)|| < \varepsilon \quad \text{for all } x, \mu, \nu, \tag{2}$$

where $P_{\mu\nu}$ denotes the plaquette variable and ε is a fixed constant.

We have studied the topological properties of 2-dimensional QED in the lattice simulation using Ginsparg-Wilson fermions and Lüscher's action which satisfies Eq.(2). Our result shows that the topological properties are actually realized very well [3]. For example, integrating the anomalous Ward identity;

$$\partial_\mu J^5_\mu = 2im\bar{\psi}\gamma_5\psi + 2i\frac{1}{4\pi}\varepsilon_{\mu\nu}F_{\mu\nu}, \tag{3}$$

over the spacetime at a fixed topological charge , one obtains the following expectation value

$$-\langle\bar{\psi}\gamma_5\psi\rangle^Q = \frac{Q}{mV}, \tag{4}$$

where Q denotes the topological charge and V is the volume of the spacetime. As FIG.2.1 shows, our results are in complete agreement with this equation.

We have also developped a new method to simulate the path integrals in the $\theta \neq 0$ vacuum. In order to evaluate the total expectation values, we divide the path integrals into topological sectors;

$$\begin{aligned}
\langle O\rangle^\theta &= \frac{\int DAD\psi O e^{-S_g - S_f - iS_\theta}}{\int DAD\psi e^{-S_g - S_f - iS_\theta}} \\
&= \frac{\sum_Q e^{i\theta Q}\int DA^Q D\psi O e^{-S_g - S_f}}{\sum_Q e^{i\theta Q}\int DA^Q D\psi e^{-S_g - S_f}} \\
&= \frac{\sum_Q e^{i\theta Q}\langle O\rangle^Q Z^Q}{\sum_Q e^{i\theta Q} Z^Q},
\end{aligned} \tag{5}$$

where S_g, S_f are the actions of gauge fields and fermions respectively, $S_\theta = -\int d^2x\theta\varepsilon_{\mu\nu}F_{\mu\nu}/4\pi$ denotes so-called θ term and Z^Q is the partition function in each topological sector. By calculating the ratio Z^Q/Z^0 in the simulation, we evaluate the observables in θ vacuum. Our results show a good coincidence with the continuum theory (See FIG.2.2).

Application to the 4-dimensional theory would be important in order to obtain reliable numerical result when we investigate the topological effects of QCD.

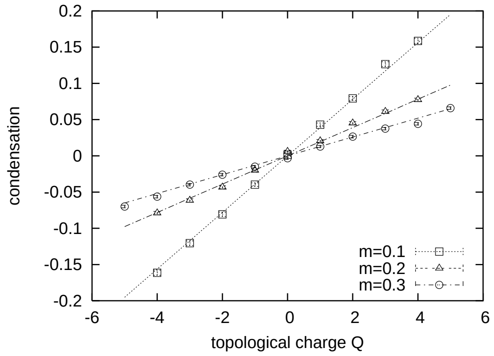

Figure 2.1: $-\langle\bar{\psi}\gamma_5\psi\rangle$ in each topological sector at $g = 1.0$ in 2-dimensional QED. The dashed lines show Q/mV. The data realize Eq.(4) quite well.

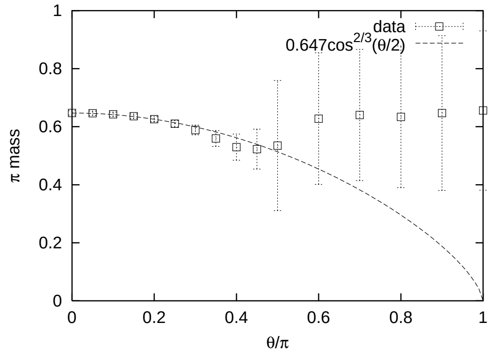

Figure 2.2: θ dependence of the pion mass in QED$_2$. The dashed line shows the continuum result.

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Application of the Self-consistent Collective Coordinate Method to Multi-O(4) Model

Jianzhong Gu (YITP), Masato Kobayasi and Kenichi Matsuyanagi (Dept. of Physics)

Microscopic description of large amplitude collective motions in nuclei is a long-standing fundamental subject of nuclear structure physics. The self-consistent collective coordinate (SCC) method which was developed by a Japanese group in 1980s [1] is a promising theory for this subject. It deeply roots in the time-dependent Hartree-Fock theory and has a beautiful and compact mathematical formulation. The SCC method has been successfully applied to kinds of anharmonic vibrations and high spin rotations, mainly by Kenichi Matsuyanagi and his co-workers [2]. The successful application substantiated the SCC method and illuminated its beauty and power.

The SCC method allows us to derive a collective Hamiltonian which describes the collective motion of a system. The collective Hamiltonian predicts the energy spectrum and transition strength of collective motion of the system. Being observable, the predicted ones can be tested by experimental data. The O(4) model captures the main features of nuclear forces and is suited to simulate the competition between the pairing of nucleons and deformation of nuclei. Based on the SCC method, we have derived the collective Hamiltonians for the single-shell O(4) model and for the multi-shell O(4) model in the spherical case. In the deformed case, the collective Hamiltonian for the multi-shell O(4) model was also calculated, which serves a starting point to study nuclear shape coexistence phenomena. We developed computer codes to calculate the spectra of the collective Hamiltonians and the quadrupole transition strengths among low-lying states. When the collective state vector evolves from a spherical point our results are consistent with those given by the exact solution of the multi-O(4) model [3].

We studied microscopically and self-consistently the nuclear shape coexistence phenomena by using the coupled-configuration SCC method suggested by Fukui [4]. The diabatic picture is used in this approach. Namely, one first, based on the SCC method, defines two diabatic configurations which correspond to the prolate and the oblate states, neglecting the couplings between them. The couplings between the two kinds of states are then treated in a manner similar to the well-known coupled channel method. We applied the coupled-configuration SCC method to the multi-shell O(4) model. We have calculated the couplings, low-lying states and transition strengths. They are in good agreement with the exact solutions, those given by the adibatic SCC [5] and those given by the generator coordinate method [6]. In future we will apply the coupled configuration SCC method to a model with pairing-plus-quadrupole interactions, and finally to a model with realistic interactions. We shall pay our particular attention to the dynamical origin of the shape coexistence. This research will clarify the mechanism of the shape coexistence, then enrich and deepen our understanding of the shape coexistence.

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Continuum QRPA response for deformed neutron-rich nuclei

K. Hagino (YITP), Nguyen Van Giai (IPN, Orsay) and H. Sagawa (University of Aizu)

Without an exception, stable nuclei with a neutron number N=20 or 28, as well as their neigbouring nuclei, have a spherical intrinsic shape. Heavy neutron-rich nuclei, however, often exhibit deformed characters even around the shell closure. Typical examples include ^{32}Mg, ^{34}Mg, and ^{44}S. This phenomenon is often interpreted as a disappearance of spherical magic shells.

We have been interested in the excitation structures of neutron-rich nuclei. In this work, we have specifically investigated the excitation structures of such *deformed* neutron-rich nuclei within the framework of quasi-particle random phase approximation (QRPA). These nuclei are weakly bound systems, and it is important to treat residual interactions (mainly a pairing interaction) and continuum spectra in a consistent manner. The most robust and consistent framework to deal with these effects on the ground state properties is the Hartree-Fock-Bogoliubov (HFB) method. The continuum QRPA framework based on the HFB approximation has also been developed recently. A problem with the HFB method, however, is that it can be computationally very demanding. For this reason, the application of the continuum QRPA on top of the HFB ground state has been limited only to spherical systems so far. In this work, we have avoided this difficulty by using the BCS approximation. This is an approximation to the HFB method, where one takes only time-reversed pairs in the Bogoliubov transformation. Notice that the BCS method has been shown a reasonable approximation to the HFB even for nuclei close to the neutron drip line [2].

Another difficulty related to a deformed QRPA calculation is that the configuration space can be quite large. In the past, QRPA calculations for a deformed nucleus have been done either with a simple separable interaction or with a drastic truncation of the configuration space. In this work, we have used the response function method in the coordinate space [3], which is most suitable to a zero-range interaction, eliminating these limitations. Together with the BCS approximation for the pairing interaction, deformed QRPA calculations now becomes feasible within a reasonable computation time.

The figure shows the low-lying part of the isoscalar quadrupole response ($K^\pi = 2^+$) of the ^{38}Mg nucleus. We assumed a Woods-Saxon form for the mean-field potential. We took the deformation parameter β_2 from the results of HFB calculations with a Skyrme interaction by Terasaki *et al.* [4]. For ^{38}Mg, the deformation parameters are 0.33 and 0.28 for protons and neutrons, respectively. The dotted and the dashed curves are for the case where the proton and the neutron deformations are set to be the smaller value 0.28 and the larger value 0.33, respectively. The solid line is obtained by using the deformation parameters suggested by the Skyrme HFB calculation. We notice that, when the deformation is different between proton and neutron, the excitation energy of this state becomes significantly smaller and at the same time the strength is increased considerably. The effect of a larger proton deformation parameter simply changes the dotted curve to the dashed curve. There appears an additional effect originating from the different proton and neutron deformations, that enhances the collectivity of the gamma vibration.

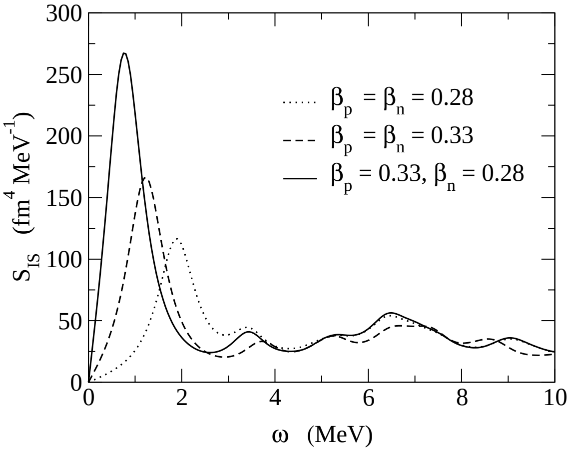

Figure 2.3: The isoscalar quadrupole response ($K^\pi = 2^+$) of the deformed neutron-rich ^{38}Mg nucleus.

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Large-angle scattering and quasi-elastic barrier distributions

K. Hagino (YITP) and N. Rowley (IReS, Strasbourg)

Heavy-ion collisions at energies around the Coulomb barrier provide an ideal opportunity to study quantum tunneling phenomena in systems with many degrees of freedom[1]. In a simple model, a potential barrier for the relative motion between the colliding nuclei is created by the strong interplay of the repulsive Coulomb force with the attractive nuclear interaction. In the eigenchannel approximation, this barrier is split into a number of distributed barriers due to couplings of the relative motion to intrinsic degrees of freedom (such as collective inelastic excitations of the colliding nuclei and/or transfer processes), resulting in the subbarrier enhancement of fusion cross sections [2]. It is now well known that a barrier distribution can be extracted experimentally from the fusion excitation function $\sigma_{\text{fus}}(E)$ by taking the second derivative of the product $E\sigma_{\text{fus}}(E)$ with respect to the center-of-mass energy E, that is, $d^2(E\sigma_{\text{fus}})/dE^2$[1]. The extracted fusion barrier distributions have been found to be very sensitive to the structure of the colliding nuclei, and thus the barrier distribution method has opened up the possibility of using the heavy-ion fusion reaction as a “quantum tunneling microscope” in order to investigate both the static and dynamical properties of atomic nuclei.

Channel couplings also affect the scattering process. In Ref. [3, 4], it was suggested that the same information as the fusion cross section may be obtained from the cross section for quasi-elastic scattering (a sum of elastic, inelastic, and transfer cross sections) at large angles. In this work, we have argued that the measurement of quasi-elastic barrier distributions is well suited to future experiments with low-intensity exotic beams [5]. To illustrate this fact, we have discussed as an example, the effect of quadrupole excitations in the neutron-rich ^{32}Mg nucleus on quasi-elastic scattering around the Coulomb barrier.

The figure shows the excitation function of the quasi-elastic scattering (upper panel) and the quasi-elastic barrier distribution (lower panel) for the ^{32}Mg + ^{208}Pb reaction. The solid and dashed lines are results of coupled-channels calculations where ^{32}Mg is assumed to be a rotational or a vibrational nucleus, respectively. One can see well separated peaks in the quasi-elastic barrier distribution both for the rotational and for the vibrational couplings. Moreover, the two lines are considerably different at energies around and above the Coulomb barrier, although the two results are rather similar below the barrier. We can thus expect that the quasi-elastic barrier distribution can indeed be utilized to discriminate between the rotational and the vibrational nature of the quadrupole collectivity in ^{32}Mg. In this way, we expect that the barrier distribution method will open up a novel means to allow the detailed study of the structure of neutron-rich nuclei in the near future.

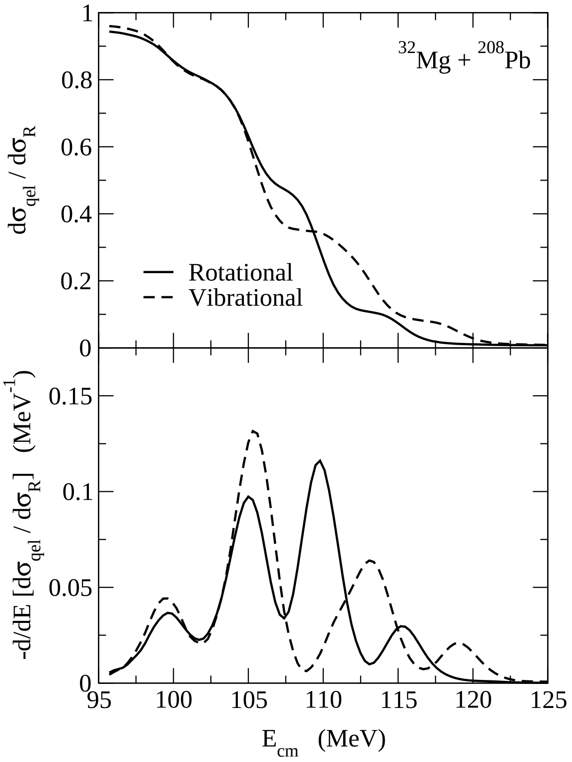

Figure 2.4: The excitation function of the quasi-elastic scattering (upper panel) and the quasi-elastic barrier distribution (lower panel) for the ^{32}Mg + ^{208}Pb reaction.

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Dimensional Hierarchy in Quantum Hall Effects on Fuzzy Spheres

Kazuki Hasebe (YITP)

Quantum Hall systems are realized in two dimensional plane with perpendicular $U(1)$ strong magnetic field at low temperature. The quantum Hall systems are interesting from such points, (1) Incompressible liquid, (2) Fractional statistical excitations, (3) Noncommutative geometry, etc. With the use of stereographic projection, this system is mapped to the 2-dimensional sphere with the Dirac magnetic monopole background. The underlying mathematical structure of the Dirac monopole system is the 1-st Hopf map. Recently, Zhang et al. have succeeded to construct 4 and 8 dimensional quantum Hall systems [1] based on the 2nd and 3rd Hopf map. Their systems are realized under the $SU(2)$ and $SO(8)$ colored magnetic monopole background. Yusuke Kimura and I have generalized their model to all even dimensional spaces based on the higher dimensional fuzzy spheres [2].

The exotic properties of the higher dimensional fuzzy sphere is the appearance of the "new" space which is not included in the original manifold [3]. For instance, 4 dimensional noncommutaive sphere or 4 dimensional fuzzy sphere is not 4 dimensional manifold but a 6 dimensional manifold which is locally given as $S^4 \otimes S^2$. The symplectic structure is essential to incorporate the noncommutaive geometry. The original 4 dimensional sphere is not a symplectic manifold. Then, an extra 2 dimensional sphere is needed to incorporate the symplectic structure. In general, the $2k$ dimensional fuzzy sphere is locally given as the product of the lower dimensional internal spheres; $S_F^{2k} \approx S^{2k} \otimes S^{2k-2} \otimes \cdots S^2$. We found that the S_F^{2k} is physically realized as S^{2k} with $SO(2k)$ colored magnetic monopole background. Then, our set-up for $2k$-dimensional quantum Hall systems can be considered as S^{2k} with $SO(2k)$ colored monopole magnetic background. Thus, our model naturally incorporates Zhang and Hu's 4 and 8 dimensional quantum Hall liquids.

It was shown that the interesting properties in the 2 dimensional quantum Hall systems are inherited to the higher dimensional quantum Hall systems as seen in the table below.

For instance, in $2k$ dimensional qunatum Hall systems, $(2k-2)$-dimensional extended object or $(2k-2)$-branes obey fractional statistics. We also found that the interesting noncommutative algebra,

$$[X_\mu, X_\nu] = i\ell_B^2 \eta_{\mu\nu}^a t^a, \tag{1}$$

where $\eta_{\mu\nu}^a$ is 'tHooft symbol given as $\eta_{\mu\nu}^a = \varepsilon_{\mu\nu a4} - \delta_{\mu a}\delta_{\nu 4} + \delta_{\mu 4}\delta_{\nu a}$ in 4 dimension, $\{t^a\}$ is $SO(2k)$ spin generator. This equation indicates the noncommutativity is related to the internal spin by the noncommutative scale ℓ_B.

The filling factor in $2k$-dimensional quantum Hall systems is given as,

$$\nu = m^{-\frac{1}{2}m(m+1)} = \frac{1}{m}\frac{1}{m^2}\frac{1}{m^3}\cdots\frac{1}{m^k}. \tag{2}$$

Each factor in the last right hand side is the one on each of the internal spheres. The product of these filling factor reproduces the total filling factor on the fuzzy sphere, which physically indicates that the lower dimensional quantum Hall liquids condense to make higher dimensional quantum Hall liquid. Namely, 2-dimensional quantum Hall liquids condense to make 4-dimensional quantum Hall liquid, and 4-dimensional Hall liquids condense to make 6-dimenaional quantum Hall liquid ...., which we have named the dimensional hierarchy. This reminds the matrix theory picture, where the lower dimensional D-branes construct higher dimensional D-brane. The dimensional hierarchy suggests the deep connection between the matrix theory and the quantum Hall physics.

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dimension of QH systems	2	4	2k
fuzzy sphere	S_F^2	S_F^4	S_F^{2k}
colored monopole	$U(1) \approx SO(2)$	$SU(2)(\otimes SU(2)) \approx SO(4)$	$SO(2k)$
nontrivial structure	$\pi_1(U(1)) = \mathbb{Z}$	$\pi_3(SU(2)) = \mathbb{Z}$	$\pi_{2k-1}(SO(2k)) = \mathbb{Z}$
imconpressible liquid	Laughlin liquid	Zhang-Hu liquid	Laughlin-like liquid
fractioanl statistical soliton	0-brane (vortex)	2-brane	(2k-2)-brane
Hopf map (Linking number)	$\pi_3(S^2) = \mathbb{Z}$	$\pi_7(S^4) = \mathbb{Z}$	$\pi_{4k-1}(S^{2k}) = \mathbb{Z}$
noncommutative structure	$[X_i, X_j] = il_B^2 \varepsilon_{ij}$	$[X_\mu, X_\nu] = i\ell_B^2 \eta_{\mu\nu}^a \frac{1}{2}\sigma^a$	$[X_\mu, X_\nu] = i\ell_B^2 \eta_{\mu\nu}^a t^a$

Uniqueness and Stability of Black Holes in Higher Dimensions

Hideo Kodama (YITP)

Does a gravitational collapse always lead to formation of a black hole? What kind of black holes can exist in nature? Can realistic black holes be well described by stationary solutions? These are among the most important problems in general relativity and have been studied for long time. Although we do not have a definite answer to the first question yet, we have rather well established answers to the others: in four dimensions, the Kerr solution is the only regular asymptotically flat vacuum stationary black hole solution and is stable for perturbations[1].

Recent developments in unifying theories, however, suggest the possibility that the universe has dimensions greater than four on microscopic scales, and that mini black holes might be produced in elementary particle processes in colliders and cosmic shower events. Inspired by this new possibility, many people are trying to find answers to the same questions as above concerning higher-dimensional black holes. Results obtained in this investigation are quite exciting: the uniqueness of black hole solutions does not hold in higher dimensions. For example, Emparan and Reall[2] recently discovered a new 5-dimensional rotating solution whose black hole surface is $S^2 \times S^1$, in addition to the Myers-Perry solution[3], which is a higher-dimensional analogue of the Kerr solution and has a spherical horizon. Emparan and Myers[4] further argued that the Myers-Perry solution with high angular momentum may be unstable and lead to a new family of solutions in spacetime dimensions greater than 5. It has been also shown that for Kaluza-Klein-type spacetimes with topology $\mathbb{R}^5 \times S^1$ there exist at least two types of black string solutions[5].

In contrast to these examples, the higher-dimensional extension of the Schwarzschild solution has been shown to be the unique regular asymptotically flat *non-rotating* vacuum solution in higher dimensions[6]. Hence, it is suggested that the non-uniqueness of higher-dimensional black holes is closely connected with non-trivial horizon topology or rapid rotation. In order to make clear this point, we have studied the behavior of perturbations of higher-dimensional static black holes with spherically symmetric horizon. For that purpose, we have developed a gauge-invariant formulation for perturbations of such black holes and showed that the Einstein equations for perturbations can be reduced to decoupled second-order ordinary differential equations of the Schrödinger type in arbitrary dimensions[7]. In particular, we have found that the effective potentials of these equations have a negative region in higher dimensions as illustrated in the figure, and the depth of the potentials in this negative region increases with the spacetime dimension. In spite of this bad behavior of the potentials, we have succeeded in proving the stability of higher-dimensional spherically symmetric and asymptotically flat black holes for the first time in the world[8]. Further, by examining stationary solutions to the perturbation equations, we have shown that the Myers-Perry solution and its extension to non-vanishing cosmological constant[9] are the unique regular vacuum solutions for small angular momentum in arbitrary dimensions[10].

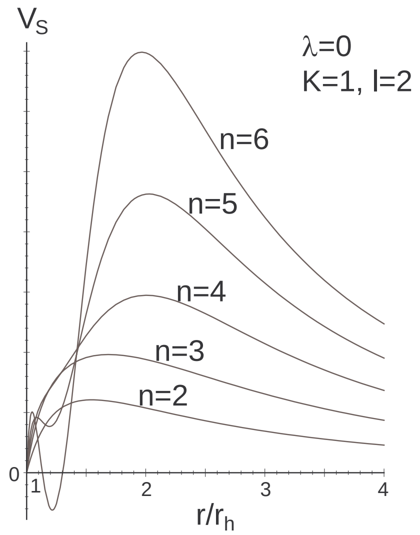

Figure 2.5: Examples of the behavior of effective potentials for (scalar) perturbations of a spherically symmetric black hole in dimensions $d = n + 2$.

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Pseudogap Phenomena of Color Superconductivity in Heated Quark Matter

Teiji Kunihiro

In extremely high density matter, quarks and gluons are expected to be deconfined to make a quark matter. If the quark matter is a Fermi liquid having a Fermi surface at low T, the attractive quark-quark interaction in some channel gives rise to a Cooper instability leading to the so called color superconductivity (CS) where the color-gauge symmetry is broken[1]. The CS may have a relevance not only to phenomena in the cores of neutron stars where T is vanishingly small but also to the core of proto neutron stars and heavy-ion collisions as well, where the effect of finite T plays an important role. One should notice that these systems are at relatively "low" density ρ and the strong coupling nature of QCD may show up. In fact, it has been shown [2] that the precursory fluctuations of the pair field can have a prominent strength and may give rise to physically significant effects even above the critical temperature (T_c) in such a system.

The existence of the large fluctuations suggests us that the CS may share some basic properties with the high-T_c superconductivity (HTSC) of cuprates rather than with the usual superconductivity in metals. One of the most characteristic phenomena of HTSC is the existence of the *pseudogap*, i.e., the anomalous depression of density of state (DOS) $N(\omega)$ as a function of the fermion energy ω around the Fermi surface above T_c. Although it is fair to say that the mechanism of the pseudogap in HTSC is still controversial, precursory fluctuations of the pair field and the quasi-two dimensionality of the system seem to be basic ingredients to realize the pseudogap[3]. Thus, one may naturally expect that although the relativistic kinematics may introduce additional complications, the pseudogap of the quark density of states exists as a precursory phenomenon of the CS at finite T. In [4], we have shown that it is the case using a chiral model. As was shown in [2], the fluctuating diquark pair field develops a collective mode (the *soft mode* of the CS) at T above but in the vicinity of T_c, in accordance with the Thouless criterion[5]. Our point is that the soft mode in turn contributes to the self-energy of the quark field, thereby can modify the DOS so much to give rise to a pseudogap.

The quark self-energy Σ owing to the soft mode may be given by the infinite series of the ring diagrams. A numerical calculation shows that ReΣ shows a rapid increase around the Fermi energy $\omega = 0$ at $k = k_F$, which gives rise to a similar behavior of the quark dispersion relation $\omega = \omega(k)$; the rapid increase of $\omega(k)$ around the Fermi momentum implies that $\partial\omega(k)/\partial k$ becomes large around this momentum. Thus, the density of states proportional to $(\partial\omega_-/\partial k)^{-1}$ becomes smaller near the Fermi surface, which suggests the existence of a pseudogap. The numerical calculation also shows that there is a peak of $|\text{Im}\Sigma|$ around the Fermmi energy, which means that the quasiparticles with about this energy are strongly dumped owing to the decaying process of a quark to a hole and a diquark, q→h+(qq); this process is enhanced around $\omega = 0$. This enhanced decaying process, or "Cherenkov" radiation of the pair soft mode by a quasi-quark, is found to be responsible for the depression of the quark density of states, i.e., the pseudogap.

The numerical calculation shows[4] that a clear pseudogap structure survives even at $(T - T_c)/T_c \equiv \varepsilon = 0.05$. One may thus conclude that there is a pseudogap region within the QGP phase above T_c up to $T = (1.05 \sim 1.1)T_c$ at $\mu = 400$MeV, for instance. This wide range of T is just a reflection of the strong coupling nature of the QCD at intermediate density region. Our result obtained for a three-dimensional system tells us that a considerable pseudogap can be formed without the help of the low-dimensionality as in the HTSC and that the pseudogap phenomena in general may be universal in any strong coupling superconductivity. We remark that our work is the first calculation to show the formation of the pseudogap in the relativistic framework. We also note that a preliminary calculation [6] shows that the specific heat C_V is also anomalously enhanced owing to the precursory soft mode above but in the vicinity of T_c.

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Local Mass, Weyl Charge and Dark Radiation in Cosmological Braneworld

Masato Minamitsuji (Osaka University/ YITP)

Recent progress in particle physics and string theory suggests that our universe might be a four-dimensional subspace, called a “brane”, embedded into the higher-dimensional spacetime, so-called “bulk” . In the braneworld picture, ordinary matter is confined to the brane and only gravity can propagate into the bulk. Many models of braneworld have been proposed and discussed in terms of the cosmological context in terms of whether it can be variable alternative to standard cosmology, especially for the early, high energy era.

The second model proposed by the L. Randall and R. Sundrum [1], in which one flat brane with positive tension is embedded into the bulk with negative cosmological constant and standard gravity is recovered at the linear perturbation level in the long distance with some Kaluza-Klein corrections, has been pulled much attention from the gravitational and cosmological point of view as the simple realization of the non-compactified extra-dimension. Cosmological extension of the Randall-Sundrum model is discussed e. g. in [2]. The Friedmann equations induced on the brane are modified by two correction terms due to the presence of the extra-dimension. One is the squared density term. In the high regime, this term can dominate the evolution of the brane universe. The other term behaves as the usual radiation term, so-called the “dark radiation”. This term is completely determined only by the mass of the central black hole in the bulk. In the geometrical approach developed in [3], the dark radiation term is given solely by the electric part of bulk Weyl tensor, which represents the all gravitational effects from the bulk to the brane. In the early universe and high energy era, these terms can modify the background cosmological evolution. These terms are severely constrained by the observations of cosmological parameters discussed e g. in [4].

From the stringy point of view, there might be many other fields such as dilaton or moduli fields other than solely cosmological constant in the bulk. Considering a bulk scalar field with a quadratic potential, the bulk scalar field can mimic the standard inflaton field on the brane in the low energy regime, [5]. As the correction effects, the bulk scalar field decays into the “dark radiation” itself [6] or via the coupling to the brane tension [7], which might be possible observational signal to the model. On the other hand, the brane can emit “gravitons” into the bulk via the decay of the ordinary matter on the brane. From the point of view, one can interpret the emission as the transformation of the brane matter to the “dark radiation” as discussed in e. g. [8].

However, it is the non-trivial problem that one clarify the decomposition of the bulk gravitational effects into the “dark radiation” term and another bulk energy-momentum contribution for the general dynamical bulk. We can give the unique decomposition in terms of the local conservation laws satisfied in the bulk as discussed in [9].

We clarify the relation between bulk dynamics and brane cosmology, focusing on the homogeneous and isotropic cosmological brane. We can derive some local conservation laws and find associated charges. One of the charges is the local mass, in analogy with spherical symmetric spacetimes in four dimension [10]. The local mass in five dimensional spacetime gives the natural extension of the “dark radiation” for the general dynamical case. It is worth noticing that the generalized “dark radiation” does not behave as the usual radiation term. Another is the charge associated with the bulk Weyl tensor, which we call the “Weyl charge”. The “Weyl charge” denotes the all of the bulk gravitational effect onto the brane. The local mass and the Weyl charge are uniquely related in the bulk. So, on the brane, this relation gives the unique decomposition of the bulk gravitational effects into the generalized dark radiation and remaining bulk energy-momentum.

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Mechanism of $d_{x^2-y^2}$-wave superconductivity based on skyrmion excitations

Takao Morinari (YITP)

Since the discovery of high temperature superconductivity in copper oxides, much experimental and theoretical effort has been invested to clarify its mechanism of superconductivity. It is generally agreed now that there are two established phases in the phase diagram of the high temperature superconductors. One is the Mott insulating phase. The conventional band theory is not applicable to this phase due to the strong on site Coulomb repulsion that is responsible for the formation of localized spin moments at the copper sites. Low-energy properties of this phase is well described by the two-dimensional $S = 1/2$ antiferromagnetic Heisenberg model. The other is the superconductive phase. Although there is no established theory on the mechanism of high temperature superconductivity, the symmetry of the Cooper pair has been established as $d_{x^2-y^2}$-wave.

In this short note, I briefly describe a mechanism for high temperature superconductivity. It is based on the picture of skyrmion excitations induced by doped holes.

Doped holes.- The ground state of the undoped compound is the Néel ordered state. The low-lying excitations are well described by the Schwinger boson mean field theory.[1] The Néel ordered state is described by the Bose-Einstein condensation of the Schwinger bosons.[2, 3] In Ref.[4], Ng argued that a vortex excitation in the Schwinger boson condensation is described by two spices of four component Dirac fermions. The dynamics of the Dirac fermions is described by the Schwinger model in 2+1D.[5]

The picture here is that the doped holes are introduced in the system as these fermions. As shown in Ref.[6], a spin-orbit coupling term, which is arising from buckling of the CuO_2 plane, leads to rotation of the doped hole spin at every hopping process. This rotation introduces strong frustration effect through the Kondo coupling between the doped hole and the localized spin moment. This frustration effect is described as a formation of the (half-)skyrmion excitation that is identical to the vortex excitation in the Schwinger boson mean field theory.

Gauge field.- In order to describe the vortex excitation in the localized spin system, it is convenient to use a gauge field. Since there is strong Kondo coupling between the doped holes and the localized spins, it is natural to take a frame in which the doped hole's spin is in the direction of the localized spin moment at the same site. In such a frame, fluctuations of the spin system is described by a SU(2) gauge field. One component of this gauge field describes the phase fluctuation of the spin system. The dynamics of the gauge field is governed by the Chern-Simons like term and the mass term. The mass term is associated with the fact that the antiferromagnetic correlation length is finite in the spin disordered regime. Using this gauge field, the vortex in the Schwinger boson mean field theory is described by the gauge flux.

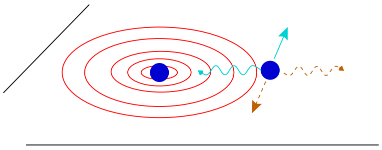

Figure 2.6: Pairing mechanism.

Pairing mechanism.- The gauge flux induced by the doped hole can give rise to a pairing interaction as schematically shown in Fig.2.6. Let us consider a system of two doped holes. If one doped hole passes the region of the gauge flux induced by the other doped hole, the Lorentz force is induced between them. This interaction leads to a chiral pairing state. In the high temperature superconductors, there are two chiral pairing states with opposite chiralities due to the antiferromagnetic correlations in the system. The stable pairing state turns out to be the $d_{x^2-y^2}$-wave pairing state.

Summary.- Here it has been argued that the picture of the doped hole induced skyrmion excitation can lead to $d_{x^2-y^2}$-wave superconductivity. In this theory, the pseudogap phase, whose origin is still in controversial,[7] is described by a preformed pairing state as argued in Ref.[8].

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On uniqueness of five-dimensional rotating black holes

Yoshiyuki Morisawa (YITP)

In the context of unified theories, there has been renewed interest in higher dimensional black holes. In particular, the possibility of micro black hole production in linear collider is suggested. Such phenomena are expected to play a key role to get insight into space-time physics; we might be able to prove the existence of the extra dimensions and have some information about the quantum gravity. The black holes produced in colliders will be small enough compared with the size of the extra dimensions and generically have angular momenta, they will be well approximated by higher dimensional rotating black hole solutions found by Myers and Perry [1]. The Myers-Perry black hole which has the event horizon with spherical topology can be regarded as the higher-dimensional generalization of the Kerr black hole. One might expect that such a black hole solution describes the classical equilibrium state continued from the black hole production event if it equips stability and uniqueness like the Kerr black hole in four-dimensions [2].

Recently, uniqueness and nonuniqueness properties of five or higher-dimensional black holes are also studied. Emparan and Reall [3] have found a black ring solution describing a five-dimensional stationary rotating black hole with the event horizon homeomorphic to $S^2 \times S^1$, which can carry the same mass and angular momentum as the Myers-Perry black hole. This might suggest the nonuniqueness of higher-dimensional stationary black hole solutions. For example, Reall [4] conjectured the existence of stationary, asymptotically flat higher-dimensional vacuum black hole admitting exactly two Killing vector fields although all known higher dimensional black hole solutions have three or more Killing vector fields. For supersymmetric black holes and black rings, string theoretical interpretation are given by Elvang and Emparan [5]. They showed that the black hole and the black ring with same asymptotic charges correspond to the different configurations of branes, giving a partial resolution of the nonuniqueness of supersymmetric black holes in five dimensions.

On the other hand, we have uniqueness theorems for black holes at least in the static case [6]. Furthermore, the uniqueness of the stationary black holes is supported by the argument based on linear perturbation of higher dimensional static black holes [7]. This suggests that the higher-dimensional stationary black holes have uniqueness property in some sense, but some amendments will be required. Here we consider the possibility of restricted black hole uniqueness which is consistent with any argument about uniqueness or nonuniqueness. Though the existence of the black ring solution explicitly violates the black hole uniqueness, there still be a possibility of black hole uniqueness for fixed horizon topology as conjectured by Kol [8].

We have considered the asymptotically flat, black hole solution to the five-dimensional vacuum Einstein equation with the regular event horizon homeomorphic to S^3, admitting two commuting spacelike Killing vector fields and timelike Killing vector field. Under this symmetry, the five-dimensional vacuum space-time is described by the $SL(3,\mathbf{R})$ nonlinear σ-model. For this system, it is possible to derive the Mazur identity which is useful to show the coincidence of two solutions satisfying appropriate boundary conditions. We have derived the boundary conditions, which is parameterized by only three asymptotic charges, the mass and the two angular momenta, and then we have shown uniqueness of the asymptotically flat, black hole solution to the five-dimensional vacuum Einstein equation with the regular event horizon homeomorphic to S^3, admitting two commuting spacelike Killing vector fields and stationary Killing vector field [9]. The five-dimensional Myers-Perry black hole solution is unique in this class.

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The Emergnece of life by Means of Endo-Exo Circulation

Masatoshi Murase (YITP)

Most studies on the origin of life have been focused on single self-replicating units : either polymers [1]-[7] or vesicles [8]-[10], but not both. Here, I frame a new theory to attack the origin-of-life problem in two steps. First, I will consider both random polymers and membrane-bounded vesicles. Polymers can be future candidates for self-replicating genetic systems which can help to evolve by natural selection [11]; while vesicles (or endo-systems [12]) have their own boundary membranes which can create the micro-environment favorable for such polymers, as these are isolated from the external environment (or exo-world [12]). Then, I will propose the new paradigm of endo-exo circulation — instead of self-replication — to specify interactive processes between endo-system and exo-world. The endo-exo circulation was possibly driven by cycling environments such as drying-wetting (or dehydration-hydration) cycles in tide pools [13]. The resulting circulation would make the endo-system prebiotically evolve [12],[14] without genetic systems, because many different kinds of molecules, supplied by the exo-world, could be subject to weak selection [7] through inter-molecular interactions. If self-replicating polymers arise de novo as reliable genetic systems, they would evolve through natural selection. Thereafter, life would begin only when an autonomous system of endo-exo circulation could arise to take over the outside 'drive'. It is one principle of endo-exo circulation that would govern the origin and evolution of life.

To develop a new theory for the origin of life, I assume that life's origin and its evolution would be the continuous complexification of initially non-living — yet highly interacting — entities, and therefore, one principle could govern a great diversity of dynamic phenomena at any instance and level of the highly interacting entities. Conversely, we can identify the unique principle essential to the origin of life by investigating the dynamic organization — involving both structures and processes — typical of present-day life.

Within this framework, I first consider both random polymers and membrane-bounded vesicles as the least hierarchical structures required for the origin of life. Strictly, I assume that there were at least two very different kinds of molecules. One is monomeric molecules that can readily form one-dimensional polymers upon dehydration [15]. The other is amphipathic molecules — characterized by both hydrophilic 'heads' and hydrophobic 'tails' on the single molecules like phospholipids — that can spontaneously aggregate to form two-dimensional bilayer membranes and to create three-dimensional closed vesicles (or liposomes) in an aqueous solution [16],[17]. The two different kinds of molecules thus frame quite different degrees of freedom or different levels of hierarchy, and hence, it is easy to create the division of labor among the molecules : linear polymers are plausible candidates for genetic systems, bilayer membranes of a closed vesicle are interfaces between the inside and the outside, and the closed vesicle provides the micro-environment as a chemical reactor where nutrient molecules and energy are constantly supplied by the external environment. Both polymers and vesicles, therefore, must be the least hierarchical structures required for the origin of life.

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Field dependence of the zero energy density of states around vortices in type II superconductors

N. Nakai (YITP), P. Miranović, M. Ichioka, and K. Machida

In recent years there has been much attention focused on exotic superconductors, whose Cooper-pair have an anisotropic paring function. Although many types of exotic superconductors have been discovered, only for a few superconductors the realized pairing function has been determined as for the gap structure and its parity. It is crucial to know these when we understand its pairing mechanism.

One of the standard methods to know the gap structure is to use the temperature dependence of physical quantities, such as the specific heat, the thermal conductivity and the spin lattice relaxation time. These comprise a unique set of characteristic temperature-dependences [1], allowing us to extract the gap topology. In fact some of these temperature-dependences are different from these simple rules by various reasons. Thus it is difficult to determine the gap anisotropy by the temperature-dependence of these quantities alone. We certainly need another methods to supplement this situation.

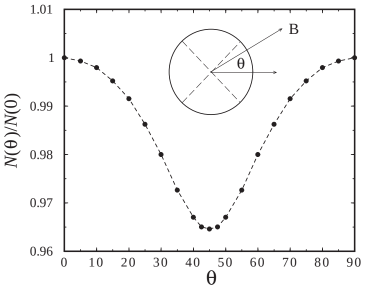
The magnetic field (**B**) in a superconductor adds a new dimension. The specific heat and thermal conductivity measurements in the mixed state as a function of **B** give rise to additional information on low-lying excitation spectrum induced around vortices, which sensitively reflects the gap structure [2, 3, 4, 5, 6, 7, 8].

In order to produce new methods to investigate the gap structure with the magnetic field, we study the property of voices in type II superconductors. We introduce important results on the zero energy density of states $N_{E=0}$ which is proportional to the Sommerfeld coefficient γ.

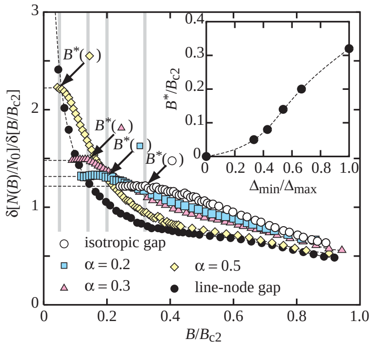
We demonstrate that $N_{E=0}(\theta)$ shows a characteristic oscillation with the relative angle θ between the field direction and the gap anisotropy in Fig. (a) (see Ref. 9 for details). Our result not only covers shortfall caused by other studies, but also show the characteristic field where the oscillation flips. This allows us to precisely determine directions of the minimum and maximum gaps. Moreover we show that the $N_{E=0}(B)$ with the field amplitude B yields an important piece of information on the degree of the gap anisotropy, or the ratio of the minimum and maximum gaps in Fig. (b) (see Ref. 10 for details).

By these theoretical studies, important information about not only each directions but also the ratio of the minimum and maximum gaps can be obtained by the precise measurement of the Sommerfeld coefficient $\gamma(\mathbf{B})$ with the field amplitude and direction as $\mathbf{B} = (B, \theta, \phi)$.

(a)



(b)



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How to integrate out heavy degrees of freedom in effective field theory

Satoshi Nakamura (YITP)

Since the Weinberg's proposal [1], applications of effective field theory (EFT) to few-nucleon systems (nuclear EFT) have been extensively studied. In EFT, one uses the most general Lagrangian ($\mathscr{L}_{eff}$) consistent with symmetries assumed. One explicitly considers degrees of freedom (d.o.f.) relevant to characteristic energy scale of a system under consideration. The other unimportant d.o.f. are integrated out to be absorbed by contact interactions. In nuclear EFT, one derives NN-potential and transition operators from $\mathscr{L}_{eff}$ following a perturbation scheme. One multiplies cutoff functions to the operators thereby integrating out the high momentum states of the nucleons; the operators act on a model-space.

There are many EFT's for different systems with different characteristic energy scales. For low-energy NN-scattering, the nucleon and the pion are d.o.f. to be considered explicitly (EFT(π)). For *very* low-energy NN-scattering, only the nucleon is the important d.o.f. (EFT($\not\pi$)). So far, no attempt has been done to directly connect EFT(π) to EFT($\not\pi$). We are interested in deriving EFT($\not\pi$) from EFT(π) because of the following questions. In principle, the two EFT's are related by integrating out heavier d.o.f. in EFT(π); this is a basic idea of EFT. Is the basic idea really realized ? Besides, we observed differences between the two EFT's in treating the tensor force and in reaction mechanisms of electroweak processes. Are the differences a result of integrating out the pion ? This work is a first step towards solving the questions.

Now our goal here will be specified. In order to derive EFT($\not\pi$) from EFT(π), we have to take two steps: In the first step, we integrate out the nucleon high momentum states thereby reducing the model-space so that EFT($\not\pi$) is applicable; In the second step, we integrate out the pion and renormalize the contact interactions. In this work, we apply some model-space reduction methods to an EFT(π)-based NN-potential. Then, we examine whether the obtained potentials are well simulated by a few terms of the contact interactions in accord with a basic idea of EFT. Through the investigation, we would like to address the following two issues: (1) What is the favorable model-space reduction method ? (2) How should EFT-based potentials be ?

We show our results in Figs.2.7 and 2.8. The solid lines are diagonal components of the EFT(π)-based NN-potential in the momentum space for the $^1S_0$ proton-neutron scattering. The dashed and the dotted lines are obtained from the solid lines by reducing the model-space up to the cutoff Λ=50MeV. In Fig.2.7, we used the renormalization group (RG) equation derived by Birse *et al.*[2] for the model-space reduction. The RG equation keeps the Green's function invariant and has, in this sense, a consistency with the path integral method for integrating out d.o.f. The RG equation introduces on-shell momentum (p) dependence. The dashed (dotted) line is for p=20(30)MeV. The obtained potentials are well simulated by a few terms of contact interactions. We find the large on-shell momentum dependence. Although this dependence has not been considered seriously so far, our result indicates that an EFT-based potential should have the on-shell momentum dependence to be consistent with the basic idea of EFT. In Fig.2.8, we used the $V_{low\ k}$ method [3] to reduce the model-space. This method does not have the consistency with the path integral method and the obtained potential cannot be simulated by the contact interactions; this means that the $V_{low\ k}$ method is not a compatible mode-space reduction in EFT.

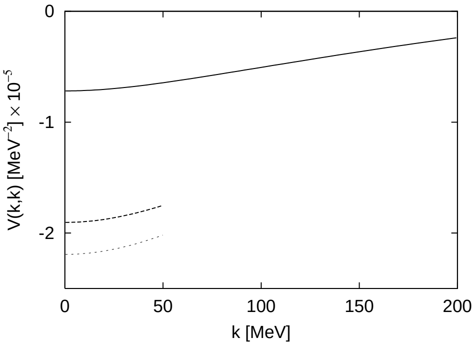

Figure 2.7:

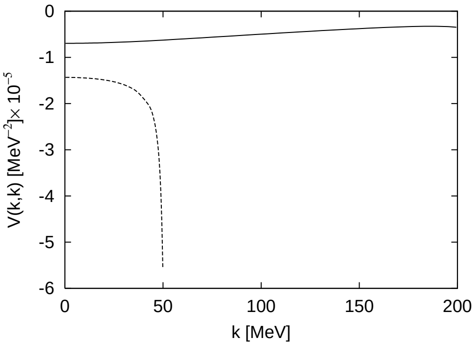

Figure 2.8:

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New Prospects on the Physics Study at LHC

Mihoko M. Nojiri

Supersymmetry(SUSY) is one of the favorable candidates for new physics at the TeV scale. The gauge couplings of standard model unifies naturally at GUT scale if superpartners exist at 1-10 TeV. Also dark matter in our universe must be a non-SM particle, while SUSY offers a natural candidate of the dark matter, the LSP(lightest supersymmetric particle).

Supersymmetry is broken symmetry. Current experimental constraints suggests that the SUSY must be broken in a hidden sector, and SUSY breaking in our sector is transmitted from the hidden sector by some suppressed interactions. The various SUSY breaking mechanisms have been proposed, however current constraints are not strong enough to determine the mechanism realized in nature.

The minimal supersymmetric standard model (MSSM) will be explored up to a few TeV by LHC. LHC is pp collider at CERN, and the experiment starts from 2007. At LHC, the discovery of the SUSY signature is easy. This is because the LSP (likely to be the lightest neutralino $\tilde{\chi}_1^0$) escape from the detection, and total transverse momentum is significantly off from zero compared with background QCD events.

When a signature of SUSY is found at LHC, the signal event must contain the information on the mass and interaction of SUSY particles. We therefore develop the method to determine the MSSM parameters at LHC to determine the SUSY breaking mechanism. This is a project that must have been done under international collaborations of theorists and experimentalists.

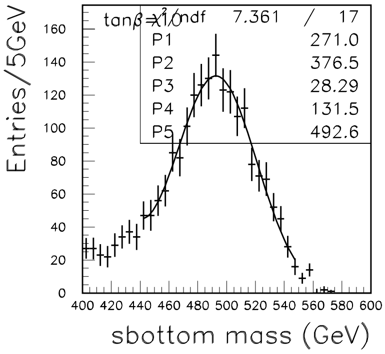
Mass of SUSY particles may be measured at LHC by the "end point technique". The end points of the decay distributions are analytic functions of the sparticle masses involved in the cascade decay. In general, mass of the sparticles can be determined if the sufficient number of end points are measured. For example in the cascade decay $\tilde{q} \to \tilde{\chi}_2^0 q \to \tilde{l} l q \to \tilde{\chi}_1^0 l l q$, the mass of $\tilde{q}$, $\tilde{l}$,$\tilde{\chi}_2^0$ and $\tilde{\chi}_1^0$ would be obtained by measuring the end points of $m_{ll} \equiv m_{ll}(max)$, m_{jll}, m_{jll} for events with $m_{ll} > m_{ll}(max)$, and m_{jl} distributions.

The method is often applied to the study of the decay modes involving leptons. We extend this technique to the purely hadronic final states, by developing a background subtraction technique[1]. We show that LHC can tag top and bottom quarks from the cascade decay in $\tilde{g} \to \tilde{t} t \to \tilde{\chi}^+ t b \to b b W(\to j j) X$ by MC simulations. The end point of the tb distribution is sensitive to $m_{\tilde{t}}$ and the number of the reconstructed tb events and m_{bb} distribution is sensitive to the stop left right mixing. Note $\tilde{t}$ is the third generation superpartner and the mass and mixing angle is sensitive to the SUSY breaking mechanism, GUT scale interactions, and Yukawa coupling. Our study shows LHC can access this important sector.

One needs large statistics to measure end points and LSP momentum left undetermined in this method. The measured decay distribution of the sparticle are smeared by the undetermined momentum. We therefore proposed a new method to reconstruct sparticle masses and the LSP momentum from the observed jet and lepton momentum[2]. This is possible when a cascade decay chain is long enough and sparticles in the cascade decay chains decays into visible SM particle + another sparticle.

As a demonstration, we describe the method in the cascade decay $\tilde{g} \to \tilde{b} b \to b b \tilde{\chi}_2^0 \to b b l \tilde{l} \to b b l l \tilde{\chi}_1^0$. The cascade decay involves five sparticles, and in the five dimensional sparticle mass space, each event determine a four-dim hyper-surface containing the true point. With more than five events a single point in the mass space is determined. In principle mass of the sparticles can be measured with very few statistics. Once all masses are known, the neutralino momentum is solved, because of five mass shell condition. Now, the decay distribution of the sparticle at the rest frame is obtained, and the distribution is sensitive to the sparticle mixing angles.

The above statement is true up to finite resolution, however, it is demonstrated to work in the numerical simulation of the events. Figure shows result of Monte Carlo simulation for ATLAS detector at a sample model point. The method can be applied in many channels, and will be studied in future.



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Determination of the Cabibbo-Kobayashi-Maskawa (CKM) matrix elements from the lattice QCD

Tetsuya Onogi in collaboration with the JLQCD collaboration

Precise determination of the Cabibbo-Kobayashi-Maskawa (CKM) quark-mixing matrix elements from the B factory experiment is one of the fundamental issues in particle physics. Among all the elements, the two smallest elements V_{ub}, V_{td}, V_{ts} are especially interesting as they give a crucial test of the unitarity triangle.

Since the b quark decay inside the B meson, model independent calculation of QCD effects by lattice QCD, is important. However, due to the limitation of computer power, the b quark mass is to heavy for direct calculation. Fortunately in the B meson system the b quark is almost at rest so that the nonrelativistic approximation is adequate. We therefore use nonrelativistic lattice QCD action for the b quark.

The mass difference between two neutral B mesons ΔM_{B_q} ($q = d$ or s) is given by

$$\Delta M_{B_q} \propto |V_{tq}V_{tb}|^2 B M_{B_q} f_{B_q}^2 \hat{B}_{B_q},$$

where f_{B_q} is the B meson decay constant and B_{B_q} is defined as $\langle \bar{B}_q^0 | \bar{q}\gamma_\mu(1-\gamma_5)\bar{q}\gamma_\mu(1-\gamma_5)b(\mu)|B_q^0\rangle \equiv \frac{8}{3}B_{B_q}(\mu) f_{B_q}^2 M_{B_q}^2$. The main problem to extract the CKM element $|V_{td}|$ is in the theoretical calculation of $f_B^2 B_B$. We have carried out unquenched calculation of f_B and B_B on a $20^3 \times 48$ lattice at $\beta = 5.2$ with nonperturbatively $O(a)$-improved Wilson fermion for the two-flavor dynamical fermions [1]. Results for the physically relevant quantities are

$$\begin{aligned} f_{B_d}\sqrt{\hat{B}_{B_d}} &= 215(11)(^{+15}_{-27})\ \text{MeV}, \\ f_{B_s}\sqrt{\hat{B}_{B_s}} &= 245(10)(^{+19}_{-17})\ \text{MeV}, \\ \xi \equiv (f_{B_s}\sqrt{B_s})/(f_{B_d}\sqrt{B_d}) &= 1.14(3)(^{+13}_{-2}). \end{aligned}$$

The differential decay rate for the $B \to \pi l \nu$ decay is written as

$$\frac{d\Gamma(B\to\pi l\nu)}{dq^2} = \frac{G_F^2}{24\pi^3}|V_{ub}|^2[(v\cdot k)^2 - m_\pi^2]^{3/2}|f^+(q^2)|^2,$$

where the form factor $f^+(q^2)$ is defined through $\langle\pi(k)|\bar{q}\gamma^\mu b|B(p)\rangle = f^+(q^2)\left[(p+k)^\mu - \frac{m_B^2-m_\pi^2}{q^2}q^\mu\right] + f^0(q^2)\frac{m_B^2-m_\pi^2}{q^2}q^\mu$, where p and k are momenta of the initial B and final π mesons respectively, and $q^\mu = (p-k)^\mu$ is a momentum transfer to the lepton pair. We have carried out calculation of $B \to \pi l \nu$ form factors on a quenched $16^3 \times 48$ lattice for the light quark [2]. Results for the form factors $f^+(q^2)$ and $f^0(q^2)$ are shown in Figure 2.9 together with the results from other groups. Overall, results for $f^+(q^2)$ are in agreement among four different groups within the error of order 20%, while some disagreement is observed for $f^0(q^2)$. From our calculation we predict that the partial decay rate of $B \to \pi l \nu$ decay for $q^2 > 18$ GeV^2 is

$$\Gamma(q^2 > 18GeV^2) = |V_{ub}|^2(1.1 \pm 0.37 \pm 0.08 \pm 0.31)\ \text{psec}^{-1}.$$

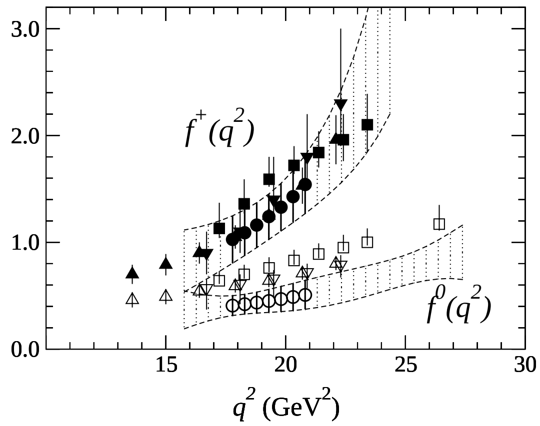

Figure 2.9: q^2 dependence of $B \to \pi l \nu$ form factors $f^+(q^2)$ (filled symbols) and $f^0(q^2)$ (open symbols). Upward triangle, downward triangle, square, circle symbols denotes the data from UKQCD , APE, Fermilab and JLQCD [2] collaborations, respectively.

The above two calculations are the state of the art results in lattice QCD, which are already useful inputs for the determination of the CKM matrix elements. However, in order to give a crucial test of the standard model and the new physics, we need to improve the accuracy to a few percent level. Taking a ratio with the D meson matrix elements such as the Grinstein ratio is one way to reduce the errors [3]. However, we eventually need to develop new ideas for the theoretical formulation of the lattice action for the heavy quark as well as efficient algorithms for simulating a very light the dynamical light quark. These are the next theoretical goals in lattice QCD.

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Dynamics of fuzzy spaces

Naoki Sasakura (YITP)

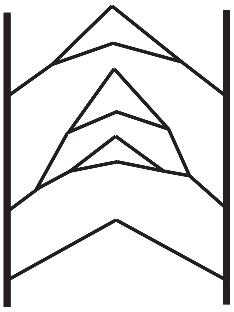
How did our universe get born? Why is the cosmological constant so small but finite? Presently the physicists do not have satisfactory frameworks to tackle these interesting and essential questions. The classical theory of gravity, General Relativity, is not enough [1], but if theory of quantum gravity is formulated properly, these questions may be treated in some way.

A possible route to successfully formulating quantum gravity is to replace the notion of geometry in general relativity. Many physicists have considered thought experiments in the combination of general relativity and quantum mechanics as well as in string theory, and have shown that there exist some fundamental limits in observing geometry [2, 3]. The existence of these limits may suggest that the notion of geometry has to be replaced with 'quantum' geometry, which is fluctuating in essence and can be identified with the classical geometry of general relativity only in the low-energy classical limit. Some examples of such 'quantum' geometry are known as non-commutative geometry [4], whose coordinates do not commute with each other.

In view of the questions in the first paragraph, the evolutionary dynamics of 'quantum' geometry is clearly worth studying. The simplest among the models of the non-commutative spaces is a fuzzy two-sphere [5]. The coordinates of a fuzzy two-sphere are defined by the $su(2)$ generators, and the size of the sphere is roughly the magnitude of the spin of its representation. In the large spin limit, the fuzzy sphere approaches the usual classical two-sphere. Therefore the evolutionary dynamics of a fuzzy two-sphere would be represented by a transformation which maps a field on one representation to that on another representation with a larger spin [6].

The physical requirements for a consistent evolution are the unitarity and some symmetries. On the other hand, since the dimensions of representations are generally distinct, it is usually not possible to construct a unitary transformation between distinct representations respecting the symmetries. To evade this apparent difficulty, the essential idea of [6] is to apply pure-into-mixed-state evolutions [7] to this context. This kind of evolution is not described by a unitary operator but the probability is conserved, so that the usual probability interpretation of quantum mechanics is consistent. The evolutionary process of a representation space is given by emitting 'baby' representation spaces and tracing them out, as is described schematically in the figure. Imposing that the emission process respects the symmetries, a consistent evolutionary process can be obtained. When this idea is applied to the representation space of $su(2)$, a consistent evolutionary process of a fuzzy two-sphere is obtained.

Field theory on the evolving fuzzy two-sphere has been constructed in the following paper [8]. The equations of motion of the field theory are derived from a slight modification of the equation proposed in [9] to describe the general pure-into-mixed-state evolutions. The obtained equations of motion have turned out to be similar to those of the matrix models in their forms. The combined dynamics of the fields on the fuzzy sphere and its 'quantum' geometry can be analyzed based on the formulation of [8]. This question is under investigation.



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QED and String Theory

Kazuyoshi Takahashi (YITP)

The interplay between string theory and quantum field theory has been one of the most successful subject during the second revolution of the string theory. There are many things that we can learn from it. For example, quantum field theory often provides useful tools to study non-perturbative aspects of string theory. Even though the non-perturbative formulation of string theory is not available yet, we can analyze non-perturbative effects using the techniques developed in the quantum field theory once we know the realization of the quantum field theory in string theory. On the other hand, we can apply various string duality (such as S-duality, T-duality, M-theory, open/closed duality, etc.) to quantum field theory. If we are lucky enough, we would be able to obtain a new description of the quantum field theory. However, most of the works along this line is done in supersymmetric situations. Since our goal is to understand the real world, it would be quite important to investigate non-supersymmetric models.

Now we introduce our paper [1], which is motivated by the these opinions.

One of the purpose of this paper is to analyse unstable D-brane systems[1] by using probe D-branes. As a typical example, we consider the $D9$-$\overline{D9}$ system in type IIB string theory and take a Dp-brane ($p = 1, 3$) as a probe.[3] Then, the world-volume theory on the Dp-brane contains $(p+1)$ dimensional QED.

The realization of the four dimensional QED in string theory could be interesting since it is a realistic system. It would be interesting if we could say something realistic using string theory, though we will not consider much about it in this paper.

In the $p = 1$ case, we obtain the two dimensional QED, which is often called as the Schwinger model. The Schwinger model is known to be one of the exactly solvable interacting quantum field theories.[4] Actually, it has been shown that the system is equivalent to a free massive scalar field theory by using bosonization techniques.[8, 9] Being two-dimensional, it is not a realistic model, however there are many features common to the four dimensional QCD (such as confinement, chiral symmetry breaking, axial anomaly, instantons, θ-vacuum etc.) which make this theory even more interesting. We can thus analyze the D-brane dynamics using the field theoretical results in the Schwinger model.

The $D9$-$\overline{D9}$ system is an unstable D-brane system and it is known that there is a tachyon field created by the open string stretched between the $D9$-brane and the $\overline{D9}$-brane. When the tachyon field homogeneously condenses, the $D9$-$\overline{D9}$ pairs are believed to be annihilated. More interestingly, when the tachyon field takes a vortex configuration, it represents a $D7$-brane. The lower dimensional D-branes can be similarly constructed by non-trivial tachyon configurations in the $D9$-$\overline{D9}$ system. [2, 5] When we put the D-brane probe in this system, the tachyon field is interpreted as the fermion mass parameter in the world-volume theory. We will observe these phenomenon in terms of the bosonized description of the Schwinger model.

When we compactify the direction tangent to the D-brane probe to a torus, we can T-dualize the system to obtain a lower dimensional description of QED. The T-duality prescription given in [6, 7] can also be applied to the world-volume theory on the D-brane in the presence of the $D9$-$\overline{D9}$ pairs. Actually, since the essential step in the prescription is just the Fourier transformation, it is applicable to any field theory compactified on a torus. By T-dualizing all the space-time directions, we obtain a matrix theory description. The size of the matrix variables here is infinite, since there are infinitely many copies of the D-branes in the covering space. We shall show that when we regularize the matrix size to be finite in this matrix theory description, we naturally obtain usual lattice gauge theory.

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The lattice QCD study of the gluonic excitation in the static three quark system

Toru T. Takahashi (Yukawa Institute for Theoretical Physics)

In spite of the masslessness of gluons, we cannot find any hybrid hadrons with the gluonic excitation modes, such as $q\bar{q}G$ or $qqqG$, in the low-lying hadron mass spectra. Due to this absence of the gluonic excitation modes in hadrons, the simple quark model without explicit gluonic degrees of freedom has been very successful in reproducing the low-lying hadron mass spectra for years. *Why are the gluonic excitation modes invisible?* On the other hand, hybrid hadrons are probable candidates of the exotic hadrons with the quantum numbers such as $J^{PC} = 0^{--}, 0^{+-}, 1^{-+}, 2^{+-}, \ldots$, which cannot be constructed within a simple quark model. It is then worth investigating the gluonic excitation modes using lattice QCD, from the experimental viewpoint as well as the theoretical viewpoint [2].

As for the ground-state potential of the static three-quark(3Q) system, which is directly responsible for baryon properties and its internal structure, we carried out the detailed lattice QCD analysis and found that the ground-state 3Q potential $V_{3Q}^{\rm g.s.}$ can be well reproduced with the following form [1] $V_{3Q} = -A_{3Q}\sum_{i<j}\frac{1}{|\mathbf{r}_i-\mathbf{r}_j|} + \sigma_{3Q}L_{\rm min} + C_{3Q}$. Here, $L_{\rm min}$ is the total length of the Y-type flux-tube shown in Fig. 2.10. The linearly arising term $\sigma_{3Q}L_{\rm min}$ implies the Y-type flux-tube formation in the 3Q system.

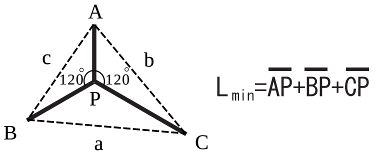

Figure 2.10: The flux-tube configuration in the 3Q system with the minimal length of the Y-type flux-tube $L_{\rm min}$.

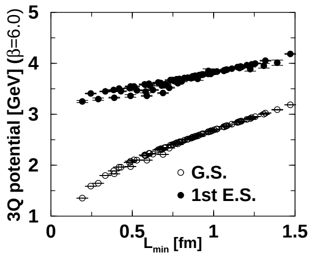

Figure 2.11: The lattice QCD results of the ground-state 3Q potential $V_{3Q}^{\rm g.s.}$ (open circles) and the 1st excited-state 3Q potential $V_{3Q}^{\rm e.s.}$ (filled circles) as the function of $L_{\rm min}$.

In Fig.2.11 we show the latest lattice QCD results about the excited-state potential in the static 3Q system obtained with $16^3 \times 32$ lattice at $\beta = 6.0$ at the quenched level [3]. Here, horizontal axis denotes the total length of the Y-type flux-tube $L_{\rm min}$, and the vertical axis denotes the energy induced by the spatially-fixed three quarks. Taking into account that the gluonic excitation modes appear as the excited-state potential in the static quark system, where there is no valence quark motion, $\Delta E \equiv V_{3Q}^{\rm e.s.} - V_{3Q}^{\rm g.s.}$ represents the gluonic excitation energy itself. As a remarkable fact, we find that the gluonic excitation energy ΔE is more than 1 GeV at the typical hadronic scale as $0.5 \leq L_{\rm min} \leq 1.5$. The energy gap $\Delta E \sim 1$ GeV is large in comparison with the excitation energies of quark origin such as a spin-orbit interaction. *This large energy gap leads to the absence of the gluonic excitation modes in the low-lying hadron mass spectra.* Such a gluonic excitation contribution would be significant in the highly-excited baryons with the excitation energy above 1 GeV, and the lowest hybrid baryon [2], which is described as $qqqG$ in the valence picture, is expected to have a large mass of about 2 GeV.

Finally, we give the functional form of the excitation energy ΔE_{3Q}. Phenomenologically, the excitation energy ΔE_{3Q} seems to be well reproduced by the form, $\Delta E_{3Q} = \frac{A}{L_{\bar{Y}}} + C$, at the typical hadronic scale as $0.5 \leq L_{\rm min} \leq 1.5$. Here, $L_{\bar{Y}}$ is defined as $L_{\bar{Y}} \equiv \sum_i \sum_{j\neq i} \overline{P_iQ_j}$ in Fig. 2.12, where three quarks are put on Q_i. This form may indicate the global oscillation modes of the 3Q system.

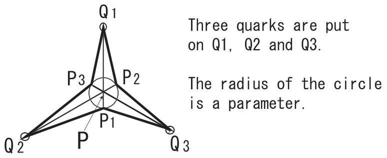

Figure 2.12:

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Charmed scalar mesons as a new window of hadron physics

K. Tearasaki

Hadronic weak interactions of charm mesons have a long standing puzzle [1],

$$\frac{\Gamma(D^0 \to K^+K^-)}{\Gamma(D^0 \to \pi^+\pi^-)} = 2.88 \pm 0.15.$$

However, it can be solved in a overall consistent way [2] by taking account of contributions of hypothetical four-quark mesons. Therefore, their observation has been awaited for long time.

Recently, a new narrow scalar $D_{s0}^+(2.32)$ meson has been observed at the B-factories [3] and its measured mass has been much lower than theoretical expectations [4]. Therefore, among various models [5, 6], I have proposed to assign it to the $I_3 = 0$ member, $\hat{F}_I^+$, of scalar iso-triplet four-quark mesons, $\hat{F}_I \sim [cn][\overline{sn}]$, $(n = u, d)$ [5], where four-quark mesons can be classified into the following four types [7], $\{qq\overline{qq}\} = [qq][\overline{qq}] \oplus (qq)(\overline{qq}) \oplus \{[qq](\overline{qq}) \pm (qq)[\overline{qq}]\}$. Here the square brackets and the parentheses denote that the wave functions are antisymmetric and symmetric, respectively, under the exchange of flavors between them. As the consequence, it has been predicted that there exist additional narrow charmed scalar mesons such as the other members, $\hat{F}_I^0$ and $\hat{F}_I^{++}$, of the iso-triplet and an iso-doublet, $\hat{D} \sim [cn][\overline{nn}]$. The mass of another iso-doublet, $\hat{D}^s \sim [cs][\overline{ns}]$, is expected to be around the threshold of the OZI allowed decay, $\hat{D}^s \to D\eta$. Therefore, it is not clear if the decay is allowed kinematically and, even if allowed, its rate will be very small because of its small Q-value. The iso-singlet counterpart, $\hat{F}_0^+$, of the $\hat{F}_I^+$ cannot decay into the DK final state because of its low mass so that its main decay will be $\hat{F}_0^+ \to D_s^+\pi^0$ which can proceed through iso-spin non-conserving interactions and therefore its width will be extremely narrow. The multiplet, $[cq][\overline{qq}]$, $(q = u, d, s)$, contains an exotic scalar meson, $\hat{E}^0 \sim [cs][\overline{ud}]$. Since it is expected that $m_{\hat{E}^0} \simeq m_{\hat{F}_I}$, it will decay through weak interactions [8].

In addition to the four-quark mesons, the ordinary scalar $\{c\bar{q}\}$ mesons, D_0^* and D_{s0}^*, are expected to be around 2.35 GeV and 2.45 GeV [4], respectively. Their widths are predicted to be $\sim (60 - 90)$ MeV and $\sim (40 - 70)$ MeV by comparing with the scalar $K_0^*(1.43)$ which has been considered as the scalar $\{n\bar{s}\}$ meson. The charmed scalar mesons are summarized in Table 1. Since the masses of the other four-quark mesons are expected to be much higher (probably > 2.7 GeV) than the ones studied above, they do not disturb the known mass spectrum which is understood as the P-wave $\{c\bar{q}\}$ system.

Confirmation of the existence of four-quark mesons will open a new window of hadron physics, not only spectroscopy but also hadronic weak interactions.

Table 1. Charmed scalar four-quark $[cq][\overline{qq}]$ and ordinary $^3P_0$ $\{c\bar{q}\}$, (q=u, d, s) mesons.

S	I	States	Mass (GeV)	Width (MeV)
1	1	$\hat{F}_I^{++}$ $\hat{F}_I^{+}$ $\hat{F}_I^{0}$	2.32(‡)	~ 10 ~ 10(‡) ~ 10
1	0	$\hat{F}_0^{+}$	2.32	$\ll 1$
0	$\frac{1}{2}$	$\hat{D}^{+}$ $\hat{D}^{0}$	2.22	~ 15
		$\hat{D}^{s+}$ $\hat{D}^{s0}$	2.42	(very narrow)
-1	0	$\hat{E}^{0}$	2.32	(weak decay)
1	0	D_{s0}^{*+}	2.45	$\sim (40 - 70)$
0	$\frac{1}{2}$	D_0^*	2.35	$\sim (60 - 90)$

(‡) Input data

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Deformed IIB Matrix Model and Quantum Corrections on Fuzzy Sphere

Dan Tomino

IIB matrix model is a promising approach to understand non-perturbative aspects of superstring. In present stage, however, we still have needed deeper understanding of matrix dynamics to determine the string vacuum. To further investigation, matrix models on fuzzy homogeneous spaces may be useful tools.

Fuzzy homogeneous space G/H is a curved noncommutative space, and the coordinate operator $\hat{x}$ on G/H is represented by the Lie algebra of G They can be written explicitly by finite size matrix, so various choice of large N limit in matrix model is possible . It is a remarkable property of fuzzy homogeneous spaces. To realize such spaces, we consider IIB matrix model deformed with cubic Myers term as the following

$$\begin{aligned} S &= -\frac{1}{4}\mathrm{Tr}[A_\mu, A_\nu]^2 + \frac{1}{2}\mathrm{Tr}\bar{\Psi}\Gamma^\mu[A_\mu, \Psi] \\ &\quad + \frac{i}{3}\alpha f_{\mu\nu\rho}\mathrm{Tr}[A_\mu, A_\nu]A_\rho \ . \end{aligned}$$

where α is some constant and $f_{\mu\nu\rho}$ is structure constant of Lie algebra associated with G. Fuzzy homogeneous spaces are realised as a classical solution. Expanding matrices around classical solution, we can obtain a gauge theory on fuzzy homogeneous space. We are interested in quantum aspects of the gauge theory. In matrix model space-time and matter field are emerged from same matrix, therefore quantum fuzzy space can be investigated through quantum gauge theory. Especially, fuzzy sphere SU(2)/U(1) has the simplest structure in such fuzzy homogeneous spaces, and it is a good starting point for study.

We discussed vacuum energies and stability of fuzzy sphere gauge theories by using loop expansion[1][2], and found a natural large N limit; $N \to \infty$, $\alpha^4 N$ is fixed. Under this large N limit fuzzy S_2 becomes stable in all order of loop expansion. Furthermore we find that fuzzy S_2 is more favourable than fuzzy $S_2 \times S_2$ by the matrix model with Myers term but original IIB matrix model (without Myers term) favours $S_2 \times S_2$ rather than S_2. We regard it as a evidence that 4-dimension likely to be realized in IIB matrix model. In recent study we evaluate expectation values of gauge invariant operators and discussed about these results[3]. A parts of our results were checked by Monte Carlo simulation and good agreement with it in week coupling region[4]. The most important result is that we find a structure which is like branched-polymer in fuzzy $S_2 \times S_2$ case.

The lessons obtained from the deformed IIB matrix model should be applied to original IIB matrix model or supermatrix models. And we should investigate on other fuzzy homogeneous spaces ($CP^2, CP^3 \ldots$ etc.) also. They are left as future works.

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Charmonium spectral function near the deconfinement transition

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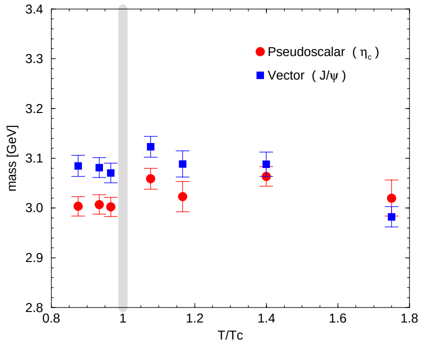
The charmonium systems have been payed much attention as a signal of the QCD phase transition. Due to a change of the interquark potential by thermal effects, the J/ψ mass is expected to decrease when approaching the phase transition [1]. Above T_c, the screening of the interquark potential may dissolve the charmonium states, and the resulting J/ψ suppression has been regarded as one of the most important signals for detecting the formation of the plasma state [2, 3].

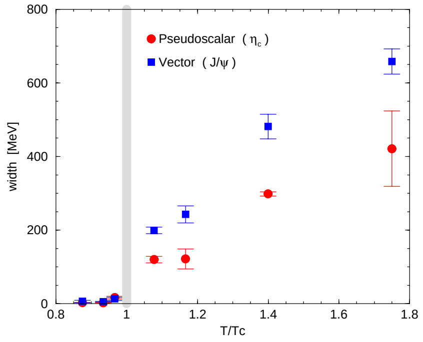
In principle, lattice QCD simulations can provide information on such excitation modes based on a nonperturbative and model independent framework, since the correlation functions in the Euclidean temporal direction measured on a lattice are related to the real time retarded and advanced Green functions by analytic continuation from a single spectral function. In practice, however, the extraction of reliable information from numerical data for correlators becomes increasingly difficult as the temperature increases. Because the imaginary time formalism of the finite temperature field theory demands shortness of temporal extent, $1/T$, which makes it difficult to extract the correct low energy structure of the spectral function.

In order to extract the spectral function at finite temperature, we propose two analysis procedures: the maximum entropy method (MEM) for the extraction of the spectral function without assuming a specific form, to estimate the shape of the spectral function, and the constraint curve fitting, which is sophisticated extension of the standard χ^2 fitting, using typical forms in accordance with the result of MEM, for a more quantitative evaluation. Furthermore anisotropic lattices are used in order to have sufficient numbers of degrees of freedom in the Euclidean temporal direction and we focus on the low energy structure of the spectral function, corresponding to the ground state in the hadron phase, by applying the smearing technique to enhance the contribution to the correlator from this region.

In our study, charmonium correlators are investigated using lattice QCD simulations in the quenched approximation.

Below the deconfining temperature, up to $T \simeq 0.97T_c$, the reconstructed spectral function has a strong peak corresponding to the ground state, with almost the same mass as at $T = 0$ and narrow width consistent with zero. In contrast to the potential model analysis [1], the charmonium mass is not changed up to this temperature. Similar tendencies have been reported in previous lattice QCD calculations for the mesonic channels [4]. Considering the rather quantitative success of the potential model approach for the charmonium systems at $T = 0$, it is important to explain this discrepancy.





Above the T_c, up to $T \simeq 1.8T_c$, we observed an indication that the spectral functions still has strong peaks at almost the same positions as $T < T_c$, and its peaks become broaden as temperature increases. This result presumably indicates the existence of quasi-stable bound-state-like structures persistent up to this temperature. Finally, also above T_c the observations are not in accord with the expectation from the potential model approach. This result implies that the plasma phase has a nontrivial structure at least near the critical temperature.

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11. Y. Abe, C. Shen, G. Kosenko and D. Boilley, *Theory of Fusion for Superheavy Elements*, Int. Conf. on Heavy Ion Physics (May 27- June 1, 2002, Dubna, Russia).

12. Y. Abe, Invited lectures: *1. Langevin Dynamics for Collective Motions, 2. Applications to Superheavy Element Formation*, Study Week on Nuclear Collective Dynamics (July 29-Aug.2, 2002, F. Gursey Institute, Istanbul, Turkey).

13. Y. Abe, D. Boilley, G. Giraud, G. Kosenko and C. Shen, *Fusion Theory for Synthesis of the Superheavy Elements*, Int. Symp. on Nuclear Clusters (Aug. 2-9, 2002, Rauischholzhausen, Germany).

14. E. Uegaki and Y. Abe, *Angular Correlations in* $^{28}Si + ^{28}Si$ *Resonances*, Int. Symp. on Nuclear Clusters (Aug. 2-9, 2002, Rauischholzhausen, Germany).

15. Y. Abe, D. Boilley, G. Kosenko and C. Shen, *Reaction Mechanisms for Synthesis of Superheavy Elements*, XXXVII Zakopane School of Physics (Sept. 3-10, 2002, Zakopane, Poland).

16. Y. Abe, B. Bouriquet, C. Shen and G. Kosenko, *Theory of fusion hindrance and synthesis of the superheavy elements*, ISPUN02 ; Int. Symp. on Physics of Unstable Nuclei (Nov. 20-25, 2002, Halong Bay, Vietnam).

17. Y. Abe, B. Bouriquet, G. Kosenko and C. Shen, *Theoretical Predictions of Residue Cross Sections for Superheavy Elements*, NN2003 ; Conf. on Nucleus-Nucleus Collisions (June 17-21, 2003, Moscow, Russia).

18. Y. Abe, Fusion-Fission Dynamics and Synthesis of the Superheavy Elements, *NANUF03 ; Int. Workshop on New Applications of Nuclear Fission (Sept. 7-12, 2003, Bucharest, Rumania).*

19. Y. Abe, B. Bouriquet and G. Kosenko, *Dissipation-Fluctuation Dynamical Approach to Fusion Leading to the Superheavy Elements*, NATO Advanced Studies Institutes ; Structure and Dynamics of Elementary Matter (Sept. 22- Oct. 2, 2003, Kemer, Turkey).

20. B. Bouriquet, G. Kosenko and Y. Abe, *Theoretical predictions of cross-sections of the super-heavy elements*, FUSION03 ; From a Tunneling Nuclear Microscope to Nuclear Processes in Matter (Matsushima, Japan).

21. Y. Abe, *Recent Advances in the Understanding of Synthetic Paths to the Heaviest Elements*, Review talk at 2nd Int. Conf. on Chemistry and Physics of Transactinide Elements (Napa, California, Nov.16-20, 2003).

Hideo KODAMA

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1. Hideo Kodama, *Backreaction problem in braneworld models* The 16th Int. Conf. on General Relativity and Gravitation (15-21 July, 2001, Durban, South Africa).

2. Hideo Kodama, *Dynamical degrees of freedom of spatially compact Bianchi models* The 16th Int. Conf. on General Relativity and Gravitation (15-21 July, 2001, Durban, South Africa).

3. Hideo Kodama and Akihiro Ishibashi, *Stability of Generlised Black Holes in Higher Dimensions* (invited talk), The 7th Hungarian Relativity Workshop (10-15 Aug. 2003, Sarospatak, Hungary).

4. Hideo Kodama, *Uniqueness and Stabilityof Higher-Dimensional Black Holes* (invited talk), The 6th APCTP Int. Conf. on Gravitation and Astrophysics (6 – 9 Oct. 2003, Ehwa Womans Univ., Seoul, Korea).

Shin MINESHIGE

1. Shin Mineshige, *Accretion Flow Theory* (invited talk), New Century of X-ray Astronomy (6 – 8 March 2001, Yokohama, Japan).

2. Shin Mineshige, *Theories of X-ray Emission from thin disks, slim disks, and ADAFs*, an inviated talk at the special session of the Annual Meeting of the American Astronomical Society (June 2001, Pasadena, USA).

3. Shin Mineshige, *X-Ray Spectral Variation of Cygnus X–1 and Simulated MHD Flow* (invited talk), The 2nd KIAS Astrophysics Workshop (September 2001, Seoul, Korea).

4. Shin Mineshige, *Time-Dependent Properties of Black-Hole Accretion Disk*, IAU meeting of the Asia-Pacific region (July 2002, Tokyo, Japan).

5. Shin Mineshige, *Astrophysical Black Holes* (invited talk), The International Conference on Stellar-mass, Intermediate-mass, and Supermassive Black Holes (Octobor 2003, Kyoto, Japan).

Mihoko NOJIRI

1. M. Nojiri, *Implication of dark matter searches on particles physics*, The 6th RESCEU International Symposium, Frontier in Astroparticle Physics and Cosmology (4 - 7 November 2003 ,Tokyo, Japan).

2. M. Nojiri, *SUSY Dark Matter - A Collider Physicist's Perspective*, PASCOS '03 IXth International Symposium on Particles, Strings and Cosmology (Institute of Fundamental Research, Mumbai, India, January 3-8, 2003).

3. M. Nojiri, *Study of Third Generation Squarks at LHC*, PASCOS '03 IXth International Symposium on Particles, Strings and Cosmology (Institute of Fundamental Research, Mumbai, India, January 3-8, 2003).

Tetsuya ONOGI

1. T. Onogi [JLQCD Collaboration], *Study of B $\to$ pi l nu decay with lattice QCD*, 4th International Conference on B Physics and CP Violation (BCP 4), Ago Town, Mie Prefecture, Japan, 19-23 Feb 2001.

2. S. Hashimoto, T. Ishikawa and T. Onogi, *Nonperturbative Calculation Of Z(A) / Z(V) For Heavy Light Currents Using Ward-Takahashi Identity*, 19th International Symposium on Lattice Field Theory (Lattice 2001), Berlin, Germany, 19-24 Aug 2001.

3. T. Onogi, *Lattice QCD Results On B Physics*, 5th KEK Topical Conference: Frontiers in Flavor Physics (KEKTC5), Tsukuba, Ibaraki, Japan, 20-22 Nov 2001.

4. T. Onogi *et al.* [JLQCD Collaboration], *Precise Determination Of The Grinstein Ratio Of Heavy-Light Decay Constant In Unquenched QCD*, The XX International Symposium on Lattice Field Theory (Lattice 2002), MIT Cambridge, Massachusetts, USA, June 24-29, 2002.

5. T. Onogi, *Review of lattice calculation of light–cone wavefunction*, the Miniworkshop on QCD for B decays, March 4 2003. Yukawa Institute, Kyoto, Japan,

6. T. Onogi, *Lattice determination of semileptonic form factors*, 2nd Workshop on the CKM Unitarity Triangle, Durham, England, 5-9 Apr 2003.

Misao SASAKI

1. Misao Sasaki, *Brane-world cosmology* (invited lectures), RESEARCH SEMESTER ON GRAVITATION AND COSMOLOGY (June 1-July 31, 2003, Feza Gursey Institute, Istanbul, Turkey).

2. Misao Sasaki, *Self-force regularization in the black hole perturbation approach* (invited talk), Workshop on MATHEMATICS OF GRAVITATION II (September 1 – 9, 2003, Stefan Banach International Mathematical Center, Warsaw, Poland).

3. Misao Sasaki, *Braneworld cosmology and bulk inflaton model* (invited talk), VI APCTP International Conference of Gravitation and Astrophysics (ICGA6) (October 6 - 9, 2003, Ewha Womans University, Korea).

Ryu SASAKI

1. Ryu SASAKI, *Quantum Calogero-Moser models: universality and symmetries*, invited talk, in International Workshop “The Calogero-Moser System 30 Years Later”, 23-27 May, 2001 Roma Tre University, Italy.
2. Ryu SASAKI, *Hierarchies of Spin Models related to Calogero-Moser Models*, RIMS Workshop “Bilinear Methods in Integrable Systems and Applications”, 2-4 July 2001, Kyoto University.
3. Ryu SASAKI, *Calogero-Moser models: integrability for all root systems*, invited talk in ICMS Workshop, “Classical and Quantum Integrable Systems and their Symmetries”, 2-8 December 2001, Heriot-Watt University, Edinburgh, UK.
4. Ryu SASAKI, *Quantum vs Classical Calogero-Moser Systems*, invited talk in the NATO Advanced Research Workshop “Bilinear Integrable Systems: from Classical to Quantum, Continuous to Discrete”, Elba, Italy, 14-21 September 2002.
5. Ryu SASAKI, *Quantum vs Classical Integrability in Calogero-Moser systems*, invited talk in miniworkshop “Seminari su Systemi Integrabili”, 10 October 2002, Department of Physics, University of Rome Uno, Italy.
6. Ryu SASAKI, *Quantum Calogero-Moser Models: integrability for all root systems*, invited talk of Mini-Workshop, 4-5 October 2003, Department of Mathematics, University of Queensland, Brisbane, Australia.

Naoki SASAKURA

1. N. Sasakura *De Sitter domain wall solutions and their analytic continuations*, KEK Theory Workshop 2002, March 18-20, 2002, KEK.

Shigeki SUGIMOTO

1. Shigeki Sugimoto, *Exact description of D-branes in K-matrix theory*, invited talk at the 17th Nishinomiya-Yukawa Memorial Symposium (Nov. 13, 2002, Shukugawa City Hall, Nishinomiya).
2. Shigeki Sugimoto, *String Theory and Tachyon*, invited talk at the JPS annual meeting (Mar. 28, 2003, Tohoku Gakuin University).

Kunihiko TERASAKI

1. Kunihiko Terasaki, *The BABAR Resonance as a Four-quark Meson*, The 10th International Conference on Hadron Spectroscopy, (August 31 - September 6, 2003, Aschaffenburg, Germany).

▷ Fellows, Students and Visitors

Eliani ARDI

1. Eliani Ardi *Dynamical evolution of rotating stellar cluster*, 80-th year Anniversary of Bosscha Observatory, October 22, 2003, Bandung Institute of Technology, Indonesia.

Tsuguhiko ASAKAWA

1. Tshuguhiko Asakawa, *Noncommutative Gauge Theories from Deformation Quantization*, the workshop ”Quantum field theory 2001” (July, 2001, YITP).
2. Tshuguhiko Asakawa, *D-brane, K-homology and new Matrix model*, the JPS Sectional Meeting in autumn 2001 (Sep.22, 2001, Okinawa-kosukai University).
3. Tsuguhiko Asakawa, *K-theory and Noncommutative Geometry in String Theory*, the workshop ”Approach to open Calabi-Yau manofolds from algebraic geometry and string theory” (Dec.13 and 14, 2001, Hokkaido University).
4. Tshuguhiko Asakawa, *D-brane Actions from K-matrix Theory*, the JPS Sectional Meeting in autumn 2002 (Sep.14, 2002, Rikkyo University).
5. Tsuguhiko Asakawa, *Exact Description of D-branes in K-matrix theory*, Sapporo Winter school 2003 (Jan.11, 2003, Furano hotel).

Hidenori FUKAYA

1. Hidenori Fukaya *Topology and lattice gauge theories*, QFT2003, Aug. 5, 2003, YITP.
2. Hidenori Fukaya, *Numerical study of topology on the lattice*, the JPS Sectional Meeting in autumn 2003, Sep. 12, 2003, Miyazaki world convension center sumit.
3. Hidenori Fukaya, *The eta meson and the fermion condensation in theta vacuum on the lattice*, Hadron physics and lattice QCD, Jan. 29, 2004, KEK.

Toru GOTO

1. Toru Goto, *B physics and SUSY*, post-NOON mini workshop, Dec. 10, 2001, Kyoto University.
2. Toru Goto, *B physics and SUSY – an update*, 2nd Workshop on Higher Luminosity B Factory, Jan. 29, 2002, KEK.
3. Toru Goto, Yasuhiro Okada, Yasuhiro Shimizu, Tetsuo Shindou and Minoru Tanaka, *Distinguishing supersymmetric models by the flavor physics*, the 57th annual JPS meeting, Mar. 25, 2002, Ritsumeikan University.

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Kazuki HASEBE

1. Kazuki Hasebe, *Dimensional hierarchy in quantum Hall effects on fuzzy spheres*, the JPS Meeting in spring 2004, Mar. 30, 2004, Kyusyu University.

Kenji HOTTA

1. Kenji Hotta, *Gravitatinal Background of Spacetime-Filling Branes,* the JPS 59th Annual Meeting , Workshop on “Singularity, spacetime and related physics,” Dec. 21, 2003, Keio University.
2. Kenji Hotta, *Gravitatinal Background of Spacetime-Filling Branes*, the JPS 59th Annual Meeting, Mar. 27, 2004, Kyushu University.

Kengo MAEDA

1. Kengo Maeda, *Are supersymmetric compactifications unstable?,* The 13th Workshop on General Relativity and Gravitation, December 1-4, 2003, Osaka City University.

Masato MINAMITSUJI

1. Masato Minamitsuji, *Local conservation law and dark radiation in brane models,* Mini Workshop on Brane World, October 30-31, 2003, Tokyo Institute for Technology.

Satoshi NAKAMURA

1. Satoshi Nakamura, *How to integrate out heavy degrees of freedom in effective field theory*, Yukawa Institute workshop on ”Fundamental Problems and Applications of Quantum Field Theory”, Dec. 24-26, 2003, Kyoto University.

Sachiko OGUSHI

1. Sachiko Ogushi, Nathalie Deruelle,
   Black Hole Entropy in Gauss-Bonnet Gravity, the JPS Sectional Meeting in autumn 2003, Sep. 9, 2003, Miyazaki World Convention Center.
2. Sachiko Ogushi,
   Holographic Entropy on the Brane
   in de Sitter Schwarzschild Space.,
   the JPS Meeting in Spring 2002, March. 27, 2002, Ritumeikan Univ.

Oriol PUJOLAS

1. Oriol Pujolas, *Stabilization of the hierarchy in brane models,* Mini Workshop on Brane World, Tokyo Institute of Technology, 30-31 October 2003.

Gurrieri SÉBASTIEN

1. Gurrieri Sébastien, *Supergravity with torsion and Mirror Symmetry*, Sep. 19, 2003, YITP, Kyoto University.

Ayumu SUGITA

1. Ayumu Sugita, *Maslov index of Gutzwiller’s trace formula in terms of the phase space path integral,* International workshop on MASLOV INDICES IN SEMICLASSICAL QUANTISATION (Mar. 23, 2004, Regensburg, Germany).

Kazuyoshi TAKAHASHI

1. Kazuyoshi Takahashi, *QED and String Theory*, the JPS Sectional Meeting in spring 2004, Kyusyu University.
2. Kazuyoshi Takahashi, *Holography in two dimension*, the JPS Sectional Meeting in spring 2004, Tohokugakuinn University.

Toru TAKAHASHI

1. Toru T. Takahashi, *Y-type flux-tube formation in baryons*, International symposium on color confinement and hadrons in Quantum ChromoDynamics “CONFINEMENT2000”, 21-24 July 2003, Wako, Japan.
2. Toru T. Takahashi, *Lattice QCD study of the gluonic excitation in the three-quark system*, the 2003 autumn meeting of Physical Society of Japan, 9-12 September 2003, Miyazaki, Japan.

Dan TOMINO

1. *N=2 3d-Matrix Integral with Myers Term*, Winter school 2004 at Niseco, 11. Jan. 2004

Takashi UMEDA

1. Takashi Umeda, *An analysis of the spectral function of finite temperatur lattices*, Thermal Quantum Fields and Their applications, 20-22 Aug. 22-22, 2003, YITP, Kyoto, Japan
2. Takashi Umeda, *Charmonium spectrum with the disconnected diagram in full QCD*, JPS meeting Sep. 9-12, 2003, World conventional center samit, Miyazaki, Japan
3. Takashi Umeda, *The hyperfine splitting of charmonium in lattice QCD*, Quarkonium Workshop Sep. 20-22, 2003, FNAL, Illinois, USA

2.4 Seminars, Colloquia and Lectures

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4. 6 Bei Lok Hu (Maryland University), *Vacuum Energy Fluctuations and Validity of Semiclassical Gravity*

4. 17 Andreas Kronfeld (FNAL/Tsukuba University), *B Physics and Lattice QCD*

4. 20 David I. Olive (University of Wales, Swansea), *Spin and Electromagnetic Duality*

4. 24 Ken-Ichi Hikasa (Tohoku University), *Old and New Physics vs* $(g-2)_\mu$

4. 27 Akira Fujii (YITP), *BSFT and boundary integrable models*

4. 27 G. Roepke (Rostok University, Germany), *Isospin singlet pairing and quartetting in nuclear matter and finite nuclei*

5. 10 Shin Mineshige (YITP), *Black-Hole Accretion Flow: Recent Topics*

5. 11 V.I. Inozemtsev (BLTP JINR, Dubna, Russia), *Invariants of linear combinations of transpositions*

5. 14 Avinash Dhar (Tata Institute), *Loop equation and Wilson line correlators in non-commutative gauge theory*

5. 15 Isao Kishimoto (YITP), *Fuzzy Sphere and Hyperbolic Space from Deformation Quantization*

5. 18 Shin Nakamura (YITP), *Hunt for new bosonic-string vacua*

5. 22 Sachiko Ogushi (YITP), *AdS Black Hole with Dynamical Brane*

5. 25 Tetsuya Onogi (YITP), *Two B's or not two B's?*

5. 28 Shigehiro Nagataki (Tokyo University), *Specifying the Environments around GRB, Explaining Fe line in the X-Ray Afterglow of GRB000214*

5. 29 Osamu Kiriyama (RCNP, Osaka University), *Chiral phase transition of QCD in the improved ladder approximation*

6. 1 Vladimir Kazakov (Ecole Normale Superieure), *Matrix model for the 2D black hole*

6. 5 Kenichi Naito (RIKEN), *Chiral transition at finite temperature and density in non-perturbative renormalization group approach*

6. 11 Masahiro Morikawa (Ochanomizu University), *On the Power Spectrum Density of Gamma Ray Bursts*

6. 13 Kouichi Hagino (YITP), *Coupled-channels approach to proton-emission decays*

6. 15 Kazumi Okuyama (KEK), *Open String Fields are Matrices*

6. 22 George Tsitsishvili (Tohoku University), *On the diagonalization of the electron interaction in the lowest Landau level*

6. 25 Apoorva Patel (Indian Institute of Science/Tsukuba University), *Transverse lattice QCD at strong coupling and large N*

6. 29 Shinji Komine (Tohoku University), *Muon g-2 and minimal SUGRA model*

7. 4 R. Wald (YITP/Chicago), *Lecture Series; Black Hole Thermodynamics and Quantum Field Theory in Curved Spacetime: 1) Black Holes and Cosmic Censorship*

7. 6 Kenji Fukushima (Tokyo University), *Topological Susceptibility at Finite and Zero Temperature in the Nambu-Jona-Lasinio Model*

7. 10 R. Wald (YITP/Chicago), *Lecture Series; Black Hole Thermodynamics and Quantum Field Theory in Curved Spacetime: 2)*

7. 13 Itzhak Bars (University of Southern California), *Noncommutative Gauge Field Theory Formulation of 2T-physics*

7. 13 Shyamoli Chaudhuri (The Pennsylvania State University), *The New String Thermodynamics: Absence of Hagedorn Transition and the Instability of Flat Space Without Background Fields*

7. 25 R. Wald (YITP/Chicago), *Lecture Series; Black Hole Thermodynamics and Quantum Field Theory in Curved Spacetime: 3)*

7. 27 Fumihiko Sugino (Saclay/KEK), *U-duality from Matrix Membrane Partition Function*

8. 1 R. Wald (YITP/Chicago), *Lecture Series; Black Hole Thermodynamics and Quantum Field Theory in Curved Spacetime: 4)*

8. 3 R. Wald (YITP/Chicago), *Lecture Series; Black Hole Thermodynamics and Quantum Field Theory in Curved Spacetime: 5)*

8. 6 R. Wald (YITP/Chicago), *Lecture Series; Black Hole Thermodynamics and Quantum Field Theory in Curved Spacetime: 6)*

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8. 9 Yoichiro Suzuki (Kamioka Observatory, ICRR, Tokyo Univ.), *Future of the non-accelerator particle physics*

9. 4 Peter Weisz (Max Planck Institute/ Tsukuba University), *Do the lattice and form-factor-bootstrap constructions of* 2d *non-linear* $\sigma-$*models yield the same theories?*

9. 5 Victor M. Yakovenko (University of Maryland), *Edge states and determination of pairing symmetry in superconducting* $Sr_2Ru\ O_4$

9. 6 Serguei Brazovskii (Landau Institute/ CNRS & University Paris–XI; LPTMS), *Topological Character of Excitations in Quasi One-Dimensional Electronic Systems: Confinement and Dimensional Crossover*

9. 13 E. Corrigan (University of York), *Boundary bound states in sinh-Gordon*

9. 14 Tsuguhiko Asakawa (YITP), *D-branes, Matrix Theory and K-homology*

9. 18 Junji Haba (KEK), *Discovery of CP Violation in B-meson system – Recent achievement of KEKB and Belle*

9. 20 Yuri Makeenko (Hokkaido University/ ITEP/Copenhagen U), *Investigating noncommutative Wilson loops*

9. 20 Dimitri Polyakov (KEK), *Brane-like states and non-perturbative aspects of string and string field theory*

9. 27 Dmitri Kazakov (KEK/Bogoliubov Lab., Dubna, JINR), *Renormalization Properties of Softly Broken SUSY Gauge Theories*

9. 27 Hartmut Monien (University of Bonn), *What is wrong with “para-magnons”?*

10. 10 N. Sandulescu (RCNP, Osaka Univ./ Bucharest, IAP), *Pairing correlations in nuclei close to the drip line*

10. 11 S. Suzuki (Tohoku University), *Dynamics and elementary excitations of fractional quantum Hall systems*

10. 19 K. Sugiyama (Kyoto University), *Superstring on* G_2 *Manifold and Cascade of Holonomy Groups*

10. 24 Alexei B. Zamolodchikov (Montpellier Univ./YITP), *Perturbed conformal field theory in spherical geometry*

10. 26 Toichiro Kinoshita (Cornell University), *Current status of the theory of muon g-2 in the Standard Model*

10. 26 Aurel Bulgac (University of Washington), *Local density approximation for systems with pairing intercations*

11. 2 Philippe Chomaz (GANIL), *Breath taking anharmonicities in Nuclei*

11. 2 L. Ferreira (Lisbon, IST), *The nuclear Equation of State*

11. 2 E. Maglione (University of Padova), *Proton Emission from drip line nuclei*

11. 2 M. Nozaki (Tokyo University), *Formation of Spherical D2-brane from Multiple D0-branes*

11. 21 Adam Sobiczewski (Soltan Institute for Nuclear Studies), *Structure and properties of superheavy nuclei*

11. 30 Gyuri Wolf (KFKI, Budapest), *Meson-Nuclear Scattering and Vector Mesons in Nuclear Matter*

11. 30 Shin’ichi Imai (Kyoto University), *Comments on orientifold projection in the conifold and SO x USp duality cascade*

12. 4 Bruce Bassett (University of Portsmouth), *Recent progress in preheating after inflation*

12. 6 Jaime Garriga (Universitat de Barcelona/ YITP), *Cosmological perturbations in the 5D Big Bang*

12. 7 Bertrand Giraud (CEA, Saclay/YITP), *Three questions about the complex scaling method*

12. 7 Toru Goto (YITP), *B physics in SUSY models*

12. 10 Changrim Ahn (Ewha Women’s University), *Reflection Amplitudes of Boundary Toda Theories and Thermodynamic Bethe Ansatz*

12. 14 Koichi Yoshioka (Tohoku University), *A four-dimensional view of bulk symmetry breaking*

12. 18 Jun Goryo (ISSP, Tokyo University), *Feedback effect in p-wave superconductors*

12. 21 Albert Schwarz (UC Davis), *Noncommutative gauge theory and duality*

12. 25 Shaojin Qin (Inst. Thoretical Physics, Beijing/Kyushu Univ.), *One dimensional Hubbard model with alternating site potentials*

1. 15 Dorin Mircea Stelian Poenaru (Central Institute of Physics, Bucharest, Rumania), *Nuclear Quasi-Molecules in Ternary Fission*

1. 25 Yukiko Ohtake (Tokyo University), *Stability of D-branes on Calabi-Yau 3-folds*

2. 1 Pascal Baseilhac (YITP), *The sine-Gordon model on the half-line with a dynamical boundary*

2. 20 Christopher Mudry (YITP/Paul Scherrer Institut), *Unusual aspects of 2d conformal field theories describing disordered system: From multifractal zero modes to Liouville field theory*

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2. 21 Christopher Mudry (YITP/Paul Scherrer Institut), *Unusual aspects of 2d conformal field theories describing disordered system: The random phase XY model*

2. 22 Nobuhiko Taniguchi (Tsukuba University), *Renormalized conductivity in disordered electrons: Supermatrix approach*

2. 22 Bohdan Grzadkowski (Institute of Theoretical Physics, Warsaw University), *Vacuum stability and triviality bounds in the Higgs boson mass*

3. 1 Yukinari Sumino (Tohoku University), *Understanding Heavy Quarkonium Systems in Perturbative QCD*

3. 6 Paolo Gondolo (Case Western Reserve University), *Dark halo (sub)structure and WIMP signals*

3. 6 Konstantin Matchev (Florida University), *The quest for the next high energy frontier*

3. 7 Sheldon L. Glashow (Boston University/ Professor Emeritus of Harvard University), *YITP Special Lecture "Topics in Neutrino Physics (The Nobel Prize Laureate in Physics, 1979)*

3. 8 Hartmut Monien (University of Bonn), *Extensions of the Dynamical Mean Field Theory : Nonequilibrium and Spatial Correlations*

3. 12 Kazuhiro Tanaka (Juntendo University), *B meson light-cone distribution and amplitudes and heavy-quark symmetry*

3. 14 Nobuo Sasaki (Hiroshima University), *Present status and future perspective of the event generator URASiMA*

3. 19 Ramesh Narayan (Harvard CfA), *Evidence for the Black Hole Event Horizon*

3. 20 Jae Sik Lee (KEK), *Decays of the MSSM Higgs bosons with Explicit CP Violation*

3. 22 Mordecai-Mark Mac Low (American Musuem of Natural History), *cosmological feedback from starbursts in dwarf galaxies*

3. 22 M. A. K. Lodhi (Texas Tech University), *Mixed flavor heavy meson spectroscopy*

3. 22 J. Wess (Munich, Max Planck Institute & Munich Univ.), *Noncommutative Coordinates and Gauge Theory*

3. 28 J. Maharana (Institute of physics, Bhubaneswar, India), *Duality and integrability property of two dimensional string effective action*

3. 28 Yasuhiko Tsue (Kochi University), *A description of Iso-spin Rotation based on a generalized mean-field approximation*

3. 28 Takashi Nakatsukasa (Tohoku University), *Atomic spectra in a helium bubble*

3. 29 Hiroyuki Kawamura (DESY Zeuthen, Germany), *Factorization of hadronic B decay and B meson wave functions*

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4. 11 Alan Cornell (YITP/Melbourne Univ.), *Weak Scale Quantum Gravity Effects for $\gamma\gamma \to ZZ$ in the TeV region*

4. 12 Ignace Loris (YITP/Vrije Universiteit, Brussel), *Integrable systems: symmetry reductions and tau-functions*

4. 19 Tadashi Takayanagi (Tokyo University), *PPWave Limit of Less Supersymmetric String Models*

4. 22 Hirokazu Tsunetsugu (YITP), *Frustrated Magnets*

4. 24 Kouichi Hagino (YITP), *Broken Symmetries in Nuclear Density Functional Theory*

5. 2 Kohkichi Konno (YITP), *Perturbative approach to relativistic magnetized stars*

5. 10 Michihiro Naka (Tokyo University), *Various wrapped branes from gauged supergravities*

5. 16 D.K. Ghosh (Taiwan National University), *Study of R-parity Violating SUSY at Next Generation Linear Collider*

5. 17 Takeo Moroi (Tohoku University), *Cosmic Density Perturbations from Late-Decaying Scalar Condensations*

5. 24 Satoshi Fujimoto (Kyoto University), *Topics on strongly correlated electron systems with geometric frustration*

5. 24 Toshihiro Matsuo (YITP), *Mean Field Approximation of IIB Matrix model and Emergence of Four Dimensional Space-Time*

5. 28 Ryuichiro Kitano (Tohoku University), *Detailed calculation of muon-electron conversion rate for various nuclei*

5. 30 Mio Murao (Tokyo University), *Entanglement and remote processing of quantum information*

5. 31 Nobuhiro Maekawa (Kyoto University), *A road to the standard GUT*

6. 5 Hiroki Takemoto (Shinshu University), *Direct Determination of the Madelung Constant Free from Conditional Convergence*

6. 7 Shin Nakamura (RIKEN), *Off-shell Crosscap State and Orientifold Planes with Background Dilatons*

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6. 14 Tatsu Takeuchi (Virginia Tech), *Phenomenological Implications of the Minimal Length Uncertainty Relation*

6. 17 Tatsu Takeuchi (Virginia Tech), *String Theory, Penning Traps, and the Precession of Mercury*

6. 20 Hideki Maeda (Waseda University), *A role of self-similar solutions in gravitational collapse*

6. 20 Sergey Kun (Australian National University), *Critical phenomena and quantum chaos in complex finite systems: Nonergodic molecules in continuum*

6. 21 Koji Hashimoto (Tokyo University), *Dynamical Decay of Brane-Antibrane and Dielectric Brane*

6. 26 Daisuke Jido (RCNP, Osaka University), *Medium effects to N(1535) resonance and eta mesic nuclei*

6. 27 Motoi Tachibana (RIKEN), *Neutrino Rates in Color Flavor Locked Quark Matter*

6. 28 Yasuaki Hikida (Tokyo University), *Orientifolds of SU(2) / U(1) WZW Models*

7. 2 Yasushi Mino (Washington University at St. Louis), *Gravitational Self-force Problem*

7. 2 Koichi Hamada (Tokyo University), *Electron d-density wave order in the 2-dimensional t-J model*

7. 5 Pascal Baseilhac (YITP), *Coupled minimal models versus Non-abelian Toda theories: Parity breaking in perturbed conformal field theory*

7. 8 Shuichi Murakami (Tokyo University), *Berry's Phase and Anomalous Hall Effect*

7. 8 Bhabani Prasad Mandal (Ochanomizu University), *Problems in Coulomb gauge and Generalized BRST Transformation*

7. 9 Alexander Dolgov (YITP/INFN & ITEP), *Lecture Series "Neutrino in Cosmology": Lecture 1*

7. 16 Kenn Kubo (Aoyama Gakuin University), *Properties of a multi-spin exchange model on the triangular lattice*

7. 16 Alexander Dolgov (YITP/INFN & ITEP), *Lecture Series "Neutrino in Cosmology": Lecture 2*

7. 18 Sumio Ishihara (Tohoku University), *Ground state and orbital fluctuations in electron systems with orbital degeneracy*

7. 19 S. A. Gurvitz (Weizmann Institute of Science/Hokkaido University), *Two-potential approach to multi-tunneling problem and cluster decay*

7. 22 Alexander Dolgov (YITP/INFN & ITEP), *Baryogenesis and cosmic antimatter*

7. 23 Alexander Dolgov (YITP/INFN & ITEP), *Lecture Series "Neutrino in Cosmology": Lecture 3*

7. 25 David Parkinson (Institute of Cosmology and Gravitation, Portsmouth University), *Condensation and metamorphosis: models of dark energy*

7. 30 John Ellis (CERN), *Supersymmetric Dark Matter*

8. 5 Masayuki Tanimoto (Yale University), *Gauge-invariant perturbations of locally homogeneous spacetimes and their asymptotic stabilities: Bianchi III case*

8. 6 Alexander Dolgov (YITP/INFN & ITEP), *Lecture Series "Neutrino in Cosmology": Lecture 4*

8. 8 Gungwon Kang (KEK), *Classical Stability of Charged Black Branes and the Gubser-Mitra Conjecture*

8. 20 A. H. MacDonald (University of Texas at Austin), *Superfluid Properties of Quantum Hall Ferromagnets*

8. 28 Yshai Avishai (Ben Gurion University), *Dynamical Symmetries in Kondo Tunneling through Complex Quantum Dots*

8. 28 Catherine Pépin (CEA-Saclay), *the enigma of the 3D hevy fermion quantum critical point*

8. 29 J. Feinberg (Technion), *Non-Hermitean random matrices: phase transitions and the single ring theorem*

8. 29 Edmond Orignac (Ecole Normal Superiere), *Edge states and magnetization profiles of open spin-1 chains and open spin ladders*

8. 29 Manfred Sigrist (ETH Zurich), *Multiband effects in superconductors: When does it matter?*

8. 30 Dmitri Ivanov (ETH Zurich), *Topological order in the dimer liquid on the triangular lattice*

9. 12 Klaus D. Rothe (Heidelberg University), *Lagrangean versus symplectic algorithm for constrained systems: a critical view*

9. 13 Seiji Yunoki (SISSA, Trieste), *A possible path to a new class of ferromagnetic and half metallic ferromagnetic materials*

9. 17 Chris Done (University of Durham), *X-ray spectra of black holes and neutron starts: signature of a surface*

9. 18 Steffen A. Bass (Duke University), *The Physics of the Quark-Gluon-Plasma - Status and Outlook*

9. 27 Ichiro Oda (Edogawa University), *Covariant Quantization Of Green-Schwarz Superstrings*

10. 2 Sigurd Hofmann (GSI, Darmstadt), *Sythesis and Properties of Superheavy Elements*

10. 4 G. 't Hooft (Utrecht University & Spinoza Institute, 1999 Novel Prize Laureate Professor), *Determinism in Quantum Mechanics*

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10. 4 Keisuke Totsuka (Aoyama Gakuin University), *Frustrated magnets with unusual geometric structure*

10. 11 Tadakatsu Sakai (Tel-Aviv University), *Penrose limits and gauge theories*

10. 18 Takashi Yokono (Kyoto University), *Gravitational approach to Tachyon matter*

10. 25 Masashi Hamanaka (Tokyo University), *Gauge Fields on Tori and T-duality*

10. 28 Bill Sutherland (Univ. of Utah/YITP), *What I've Learned About Exactly Solved Models*

11. 8 Raju Venugopalan (BNL), *Is QCD at high energies a Color Glass Condensate?*

11. 11 Chetan Nayak (UCLA/Nihon University), *Hilbert Spaces of Topological Phases of Correlated Electron Systems*

11. 12 Chetan Nayak (UCLA/Nihon University), *D-density wave order in the high-Tc cuprates*

11. 12 Yukitoshi Motome (National Inst. of Advanced Industrial Science and Technology), *Randomness in Double-Exchange System*

11. 14 William G. Lynch (Michigan State University), *Towards the Equation of State of Asymmetric Nuclear Matter*

11. 14 Joachim A. Maruhn (Institute for Theoretical Physics, Johann Wolfgang Goethe-University), *Nuclear Mean-Field Models and their Extrapolation to the Superheavy Region*

11. 18 Giulio Casati (International Center for the study of dynamical systems, Universita' degli Studi dell'Insubria), *Quantum computers and quantum chaos*

11. 19 Francesco Ravanini (INFN), *Recent Developments in Destri DeVega Equation*

11. 19 M. Lakshmanan (Bharathidasan University, India), *Shape Changing Collisions of Solitons in Integrable Coupled Nonlinear Schroedinger Equations: Linear Fractional Transformations and Logic Gates*

11. 20 Mitsuhiro Arikawa (University of Melbourne), *Spin dynamics in the supersymmetric t-J model with* $1/r^2$ *interaction*

11. 20 Yoshifumi Morita (Tokyo University), *Vortex in a doped Mott insulator*

11. 22 Yoji Michishita (Korea Inst. Advanced Study), *Worldsheet Analysis of D-branes in pp-wave backgrounds*

11. 27 Stefano Mattiello (Rostock University), *Three-quark Correlations in Hot and Dense Matter*

11. 29 Wlodek Kluzniak (Zielona Gora University), *Millisecond oscillators in accreting neutron stars and black holes*

12. 2 Tsutomu Momoi (Tsukuba University), *Spin-chirality duality and scalar chiral order in the spin ladder with four-spin exchanges*

12. 2 Masashige Matsumoto (ETH Zurich/ Shizuoka University), *Magnon dispersion in the magnetically ordered phase of* $Tl\,Cu\,Cl_3$

12. 3 Roberto Emparan (CERN), *Quantum black holes as holograms*

12. 17 N. Kirova (University of Angers), *Topological coupling of disclocations and magnetization vorticity in spin density waves*

12. 18 S. Brazovskii (ISSP, Tokyo University/LPTMS, Orsay), *Theory of subgap spectra in one-dimensional systems: Instanton approach to pseudogaps*

12. 20 Hiroyuki Fuji (Tokyo Institute of Technology), *Comments on Effective Superpotentials via Matrix Models*

1. 16 Bruce H. J. McKellar (University of Melbourne), *SU(N) Hamiltonian Lattice Gauge Theory in 2+1 dimensions for* $N \leq 25$

1. 17 Yutaka Matsuo (Tokyo University), *Moyal Formulation of Open String Field Theory*

1. 28 Takao Morinari (YITP), *Duality in high temperature superconductors*

1. 30 Hikaru Kawamura (Osaka University), *Magnetic ordering in frustrated magnets*

1. 31 Shigenori Seki (Kobe University), *Comments on Quiver Gauge Theories and Matrix Models*

2. 7 Tetsuyuki Muramatsu (Tokyo University), *Power of Supersymmetry in D-particle Dynamics*

2. 13 Pradip Kumar Sahu (Institute of Physics, Bhubaneswar), *Collective flow at AGS energies*

2. 18 M. Stanishkov (NRNE, Sophia, Bulgaria), *Duality in N=2 Super Liouville Field Theory*

2. 28 Hiroaki Abuki (Tokyo University), *Color superconductivity and phase transitions in Dense QCD – Approach from Schwinger-Dyson method –*

2. 28 Alexander Abramovich Belavin (Landau Institute), *Central elements of elliptic quantum group in roots of unity*

3. 4 Kenji Fukushima (Tokyo University), *Effects of chiral restoration on the behavior of the Polyakov loop*

3. 4 Aya Kubota (ISAS), *X-ray observation of stellar-mass black hole, application to ULXs, and expectation for multi-wavelength data analysis*

3. 5 Kenji Fukushima (Tokyo University), *Thermodynamic limit of the canonical partition function with respect to the quark number in QCD*

3. 5 R. Johnson (University of Surrey), *The 'Frozen Halo' Approximation for the Scattering of Halo-nuclei*

3. 6 Kenji Fukushima (Tokyo University), *Spectral functions in the sigma channel near the critical end point*

3. 6 Hirotsugu Fujii (Tokyo University), *Scalar density fluctuation at critical end point in NJL model*

3. 12 Koji Hukushima (Tokyo University), *Chirality mechanism and spin-glass transition*

3. 13 Karlo Penc (Research Institute for Solid State Physics and Optics), *The physics of SU(4) Heisenberg models*

3. 14 Yasuhiro Sekino (Tokyo Institute of Technology), *Penrose Limit and Enhancon Geometry*

3. 18 Toby Wiseman (Department of applied mathematics and theoretical physics), *From Black Strings to Black Holes*

3. 25 Masayuki Uehara (Saga University), *Problems with the Low-Mass Scalar Mesons – Is the sigma meson really indispensable? –*

▷ 2003.4.1 — 2004.3.31

4.3 Masud Chaichian (University of Helsinki), *Latest Developments in Noncommutative Quantum Field and Gauge Theories*

4. 9 Martinus J.G. Veltman (Professor Emeritus of University of Michigan), *Very Elementary Particles*

4. 11 Joseph Silk (Oxford University), *Dark Matter and Galaxy Formation*

4. 14 Naoshi Sugiyama (NAOJ), *Cosmic Microwave Background Radiation: Recent Progress*

4. 17 Nathalie Deruelle (YITP/IAP), *Lecture Course "Topics in Braneworld Cosmology" Lecutre 1*

4. 22 Jean Peter (LPC/ISMRA), *The quest for Super-Heavy Elements: an experimentalist's approach*

4. 22 Naoki Kawashima (Tokyo Metropolitan University), *Quantum Monte Carlo Methods – Recent Developments*

4. 23 David Brink (Oxford University), *Breakup reactions with halo nuclei*

4. 24 Nathalie Deruelle (YITP/IAP), *Lecture Course "Topics in Braneworld Cosmology" Lecutre 2*

4. 25 Yasumichi Aoki (RIKEN), *Analyzing QCD with Domain-Wall Fermions and an Improved Gauge Field on the Lattice*

5. 6 Artem Starodubtsev (Perimeter Institute, Waterloo University), *Topological excitations around the vacuum of quantum gravity*

5. 6 L. Frankfurt (Tel Aviv University), *Color transparency and color opacity phenomena*

5. 8 Nathalie Deruelle (YITP/IAP), *Lecture Course "Topics in Braneworld Cosmology" Lecutre 3*

5. 8 Satoshi Takagi (Nagoya University), *Phase structure of hot and/or dense QCD with the Schwinger-Dyson equation*

5. 9 Rabin Banerjee (KEK), *Anomalies and Seiberg Witten Transformation in Noncommutative Gauge Theories*

5. 9 Masahisa Koga (Osaka University), *Quantum Phase Transitions in Orthogonal-Dimer Systems*

5. 13 Toru Takahashi (YITP), *Detailed Lattice-QCD Study for the Ground-State Three-Quark Potential and the Excited-State Three-Quark Potential*

5. 16 Hiroyuki Hagura (KEK), *Dynamical Regge Calculus*

5. 22 Etsuko Itou (Osaka University), *A New Class of Conformal Field Theories with Anomalous Dimensions*

5. 23 Kazuki Hasebe (YITP), *Topological Isospin Excitations in Multilayer Quantum Hall Systems*

5. 23 Taeko Matsuura (Tokyo University), *Thermal Fluctuation of Gauge Fields and First Order Transition in Color Superconductivity*

5. 29 Shin Miyahara (Aoyama Gakuin University), *Magnetization plateaux in a two-dimensional orthogonal-dimer system* $SrCu_2(BO_3)_2$ *– spin structures and lattice distortion*

5. 30 Takashi Umeda (YITP), *Charmonium near the deconfining transition on the lattice*

6. 3 Chihiro Sasaki (Nagoya University), *Vector Manifestation in Chiral Phase Transition at Finite Temperature*

6. 6 Hiroshige Kajiura (YITP), *Homotopy algebraic structures in string field theories*

6. 11 Masatsugu Isse (Hokkaido University), *Mean-field effects in High energy heavy-ion Collisions*

6. 13 Toshiaki Tanaka (YITP), *N-fold supersymmetry and quasi-solvability: overview and recent progress*

6. 16 Misao Sasaki (YITP), *Cosmic inversion problem — Reconstructing the primordial spectrum from CMB data —*

6. 19 Shizuo Iwamoto (YITP), *Wien Fireball Model of Relativistic Outflows in Active Galactic Nuclei*

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6. 20 Yusuke Kimura (RIKEN), *On Higher Dimensional Fuzzy Spherical Branes*

6. 23 Takeo Inami (Chuo University), *Nonlinear Sigma Models in 3 Dimensional Space/Noncommutative Space*

6. 27 Hiromitsu Takayanagi (Tokyo University), *Boundary States for D-branes with Traveling Waves*

6. 30 Hermann Nicolai (Max Planck Institute), *Maximal gauged supergravities in three dimensions*

7. 4 Bernard de Wit (Utrecht University), *Gaugings of maximal supergravities*

7. 14 M.A. Stephanov (Illinois, RIKEN BNL), *QCD and dimensional deconstruction*

7. 16 Motoi Tachibana (RIKEN), *QCD with color superconductivity*

7. 17 Hiroshi Sudou (Gifu University), *Detection of a supermassive black hole binary in radio galaxy 3C66B*

7. 17 Makoto Miyoshi (NAOJ), *Confirmation of circumnuclear disk and jet eruption in Galactic center black hole Sgr A**

7. 17 Masahiro Shiroishi (ISSP, Tokyo University), *Exact calculation of correlation functions for the one-dimensional Heisenberg model — recent progress*

7. 18 Matsuo Sato (Osaka Univ.), *Hamilton-Jacobi Method and Effective Actions of D-brane and M-brane in Supergravity*

7. 18 Matthias Staudacher (Max Planck Institute for Gravitational Physics, Golm), *Integrable Super Spin Chains and Rotating Superstrings*

7. 22 Paul Mackenzie (Fermilab), *New Actions for Heavy Quarks on the Lattice*

7. 24 Rainer Spurzem (Astronomisches Rechen-Institut, Heidelberg), *Single and Multiple Black Holes in Dense Stellar Systems*

7. 25 I.-O. Stamatescu (FEST and Institut fuer Theoretische Physik, Univ. Heidelberg), *Matter Determinants in Background Fields Using Random Walk World Line Loops on the Lattice*

7. 29 L. Lellouch (Marseille, CPT), *New approaches to lattice QCD*

7. 30 Tadashi Takayanagi (Harvard University), *Evolution of D-branes under Closed String Tachyon Condensation*

8. 1 Victor Kagalovsky (Negev Academic College of Engineering NACE), *Various facets of Chalker-Coddington network model*

8. 1 Tadakatsu Sakai (Tel Aviv University), *Probing Flavored Mesons of Confining Gauge Theories by Supergravity*

8. 4 Taichiro Kugo (YITP), *What do Neutrino Data Imply on GUTs?*

8. 4 Branislav Jurco (Universitat Munchen), *Non-abelian bundle gerbes*

8. 6 Naoto Nagaosa (Department of Applied Physics, Tokyo University), *Electron-Phonon Interaction in High-Tc Cuprates*

8. 11 Ishwaree Neupane (National Taiwan University), *Cosmology from Hyperbolic Compactifications*

8. 25 Manfred Sigrist (ETH Zurich), *Superconductivity and magnetism in single-layer ruthenates*

8. 26 Shuichi Murakami (Tokyo University), *Electric-field-induced spin current in semiconductors*

8. 27 Kenichi Konishi (Universita‘ di Pisa), *Recent Developments in Supersymmetric Gauge Theories*

8. 28 Alexander Dolgov (RESCEU/INFN & ITEP), *New BBN limits for active-sterile neutrino mixing*

9. 4 Kengo Maeda (YITP), *Gravity coupled to a scalar field with negative potential*

9. 19 Sebastien Gurrieri (YITP), *Supergravities with torsion and mirror symmetry*

9. 25 Hartmut Monien (University of Bonn), *Fictive Impurity Models: An Alternative Formulation of the Cluster Dynamical Mean Field Method*

9. 26 Yukiko Konishi (RIMS), *Geometric Engineering of Seiberg-Witten Theories with Massive Hypermultiplets*

10. 8 Bertrand Bourquet (YITP), *Formation and disintegration of super-heavy nuclei*

10. 10 Wen-Li Yang (YITP), *The spectrum of completely integrable quantum multi-particle systems associated with* A_{n-1} *root system*

10. 14 Fumihiko Sugino (Seoul National University), *A Lattice Formulation of Super Yang-Mills Theories with Exact Supersymmetry*

10. 14 Takehiko Asaka (University of Lausanne), *Neutrino Masses and Non-thermal Leptogenesis in SO(10)*

10. 15 P.J.E. Peebles (Princeton University), *Models for Physics in the Dark Sector of Cosmology*

10. 23 Enguang Zhao (Institute of Theoretical Physics, Chinese Academy of Science), *Heavy-ion fusion reactions based on DNS* di-nuclear system) model

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10. 24 Ke Wu (Capital Normal University), *Global solution of Einstein-Dirac equation on the conformal space*

10. 28 Cedric Deffayet (Institut d'Astrophy- sique de Paris), *From Branes to Multigravity*

10. 29 Shigeyoshi Aoyama (Kitami Institute of Technology), *Three-body resonances in* ^{11}Li*,* ^{10}He *and* ^{6}He *by using the CSM and the ACCC*

10. 31 Shinpei Kobayashi (Kyoto University), *Closed String Field Theory with Dynamical D-brane*

11. 4 Andrey Illarionov (Lebedev Physical Institute), *Powerful Hard X-Ray Emission of Black Holes*

11. 4 Neal Turner (University of California, Santa Barbara), *Luminous black hole accretion disks*

11. 4 Igor Igumenshchev (Univ. of Rochester), *On the role of magnetic fields in spherical accretion flows*

11. 5 Christian Rummel (Technischen Universitaet Muenchen), *Local harmonic approximations to nuclear barrier problems*

11. 6 David Hinde (Australian National University), *Inhibition of fusion in heavy element formation*

11. 6 G. Pollarolo (Universita di Torino), *A semiclassical model for fusion reactions and grazing collisions*

11. 7 Toru Goto (YITP), *CP violation in SUSY models*

11. 10 G. Baskaran (Institute of Mathematical Sciences, Madras), *Novel Quantum Phases in Doped Two Dimensional Cobalt Oxide*

11. 11 Makoto Katori (Chuo University), *Noncolliding Brownian Particles, Schur Polynomials and GUE/GOE Two-Matrix Model*

11. 13 V. Berezinsky (INFN, Laboratori Nazionali del Gran Sasso), *Cosmological origin of small-scale clumps and DM annihilation signal*

11. 14 Masako Asano (Kyoto University), *PP-Wave Holography for Dp-Brane Backgrounds*

11. 19 M.E. Zhitomirsky (CEA-Grenoble), *Ginzburg-Landau theory of vortices in a two-gap superconductor*

11. 20 Tatsuya Fujii (ISSP, Tokyo University), *Perturbative approach to the nonequilibrium Kondo effect in a quantum dot*

11. 21 Yutaka Ookouchi (Tokyo Institute of Technology), *Matrix Model curve Near the Singularities*

11. 21 Kensuke Yoshida (Rome University), $N = 1$ *SUSY model and glueball potential (An elementary approach to Veneziano-Yankielowicz superpotential)*

11. 25 J. Maharana (Bhubaneswar, Institute of Physics), *Strings in Background Fields and Integrable Model*

12. 1 Alexei K. Kolezhuk (Institute of Magnetism, National Academy of Sciences and Ministry of Education of Ukraine and Institut feur Theoretische Physik, Universiteat Hannover), *Gapped Spin Systems in High Magnetic Field*

12. 3 Zoran Basrak (Ruder Boskovic Institute, Zagreb), *Examples of weakened nuclear opacity from low to high energies*

12. 3 T. Neff (GSI), *Short range central and tensor correlations in nuclear many body systems*

12. 5 Marco Rossi (YITP), *Calculation of conserved charges in two dimensional integrable systems*

12. 10 Chong-Sun Chu (National Tsing-Hua University & University of Durham), *Colliding plane wave in string theory*

12. 12 Tadashi Yoshikawa (Nagoya University), *Possibility of a large electroweak penguin contribution in* $B \to K\pi$ *modes*

12. 16 Kenji Hotta (YITP), *Brane-Antibrane Systems at Finite Temperature and Phase Transition near the Hagedorn Temperature*

12. 19 Hiroaki Kanno (Nagoya University), *Topological Vertex and Five Dimensional Gauge Theories*

12. 22 Piet Hut (Institute for Advanced Study, Princeton), *Setting the Stage for Stellar Collisions and Black Hole Formation: Large-Scale Simulations of Dense Stellar Systems*

1. 9 Ryoichi Seki (California State University), *Thermal properties of simple nucleon matter on a lattice*

1. 13 Hiroyuki Koura (RIKEN), *Properties of unstable nuclei studied with nuclear mass formula*

1. 14 Serguei Brazovskii (LPTMS - CNRS, Orsay, France and Landau Institute, Moscow, Russia), *Excitations in Strongly Correlated Electronic Systems: Confinement and Dimensional Crossover*

1. 20 Juri Poutanen (University of Oulu), *Accreting Millisecond Pulsars*

1. 29 Sergei V. Ketov (Tokyo Metropolitan University), *Partial spontaneous susy breaking and Born-Infeld action*

1. 30 Kenji Nagami (Tokyo Institute of Technology), *Rolling Tachyon with Electromagnetic Field in Linear Dilaton Background*

1. 30 Satoshi Nagaoka (Tokyo University), *Toward Tachyon Condensation on Intersecting D-branes*

2. 5 Holger Baumgardt (RIKEN), *Intermediate Mass Black Holes in Star Clusters*

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2. 5 Annamaria Kiss (University of Maryland), *On off-shell supergravities in* $D = 10$ *and* $D = 11$

2. 6 Grigori Kosenko (Omsk State University), *Calculation of touching cross section in heavy ions reactions near Coulomb barrier*

2. 9 Masaru Onoda (AIST), *Quantized Anomalous Hall Effect in Two-Dimensional Ferromagnets*

2. 9 Naoyuki Itagaki (Tokyo University), *Clustering aspect of light neutron-rich nuclei*

2. 9 Alan Knapman (Newcastle University), *Quantised Bulk Fields in the Randall-Sundrum Brane Model*

2. 10 A.B. Balantekin (University of Wisconsin), *Recent Progress and Prospects in Neutrino Physics and Astrophysics*

2. 13 Jonathan L. Rosner (Enrico Fermi Institute, University of Chicago), *Measuring weak phases using B decays*

2. 17 Andrei Micu (University of Sussex), *G-structures and string compactification*

2. 18 Dongsu Ryu (Chungnam National University), *Shock Waves, Gas, and Cosmic Rays in the Large Scale Structure of the Universe*

2. 19 Kazuhiro Sakai (Tokyo University), *Asymptotic Form of Gopakumar–Vafa Invariants from Instanton Counting*

2. 19 Eitoku Watanabe (Tokyo University), *A universal nonlinear relation among boundary states in closed string field theory*

2. 19 Edison Liang (Rice University), *Particle Acceleration via Relativistic Magnetized Plasma Expansion and Cosmic Gamma-Ray Bursts*

2. 20 Yuji Sugawara (Tokyo University), *Modular Bootstrap for Boundary N=2 Liouville Theory*

2. 20 Laurent Baulieu (LPTHE), *Link between topological gravity and supergravity*

2. 23 Tadafumi Ohsaku (YITP), *On the Recent Progress in Relativistic Quantum Many-body Theory*

2. 24 Yoshio Kikukawa (Nagoya University), *Axial anomaly on lattice*

2. 24 Daisuke Kadoh (Nagoya University), *Local cohomology problem in chiral gauge theories*

2. 25 Tsuyoshi Hondou (Tohoku University), *Equation of state in a small system: Violation of an assumption of Maxwell's demon*

2. 27 Guido Altarelli (CERN), *Neutrino Masses as a Probe of Grand Unification*

2. 27 Mitsuru Tohyama (Kyorin University), *Extended RPA with ground-state correlations*

3. 1 Serguey Petcov (SISSA, Trieste/INRNE, Sofia/YITP), *Neutrino Masses, Mixing, Oscillations and the Nature of Massive Neutrinos*

3. 1 Tsutomu Momoi (RIKEN), *Duality and exotic order in correlated electrons on the ladder*

3. 1 Yukitoshi Motome (RIKEN), *Two-dimen- sional charge ordering in geometrically-frustrated 2-1-4 systems*

3. 4 Takeshi Yamazaki (Tsukuba University), *I=2 S-wave pion scattering phase shift with two flavor dynamical quark effect*

3. 5 Hiroshi Umetsu (KEK), *Gauge Theory on Noncommutative Supersphere from Supermatrix Model*

3. 5 J. Madore (LPT Universie de Paris-Sud, Orsay), *Dynamics of fuzzy space*

3. 8-10 Nobuyuki Ishibashi (Tsukuba University), *String Theory and Matrix Model*

3. 11 Antonio Pineda (Barcelona University), *Non-relativistic Effective field Theories for Heavy Quarkonium*

3. 11 Karlo Penc (Research Institute for Solid State Physics and Optics, Budapest), *Extended Hubbard model on pyrochlore lattice: ice-rules and fractional charges*

3. 15 E.N. Parker (University of Chicago), *Applicability of Hydrodynamics and Magnetohydrodynamics*

3. 16 Yuri Oganessian (Flerov Laboratory of Nuclear Reactions, Joint Institute of Nuclear Research), *Fusion reactions induced by 48Ca-ions and Decay properties of the heaviest nuclei*

3. 19 Luca Amendola (INAF/Osservatorio Astronomico di Roma), *Cosmology and astrophysics of coupled dark energy*

3. 24 Bertrand Giraud (Saclay), *Is friction responsible for the reduction of fusion rates near the Coulomb barrier?*

3. 25 Nabila Aghamin (Universite Paris Sud), *Sunyaev-Zel'dovich Effect and Cluster of Galaixes*

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2.5 Visitors (2001 — 2003)

Kyoto University Guest Scholars

Prof. Vladimir I. Inozemtsev
(JINR, Dubna)
2001. 4. 2 — 2002. 1.31

Prof. David Ian Olive
(University of Wales Swansea)
2001. 4.11 — 2001. 5. 1

Prof. Caiwan Shen
(CJAE, Beijing)
2001. 8. 7 — 2001. 8.27

Prof. Edward Francis Corrigan
(The University of York)
2001. 8.27 — 2001. 9.17

Prof. Paolo Gondolo
(Case Western Reserve University)
2002. 3. 3 — 2002. 3.16

Prof. Konstantin Tzvetanov Matchev
(University of Florida)
2002. 3. 3 — 2002. 3.20

Dr. Patrick Edward Dorey
(University Durham)
2002. 3.20 — 2002. 4.10

Dr. Sergey Kun
(Autralian National University)
2002. 5. 7 — 2002. 7. 5

Prof. Soo-Jong Rey
(Seoul National University)
2002. 6.14 — 2002. 6.27

Prof. David J. Boilley
(GANIL)
2002. 7. 5 — 2002. 8.30

Prof. Jonathan R. Ellis
(CERN)
2002. 7.25 — 2002. 8.16

Prof. Jingdong Bao
(Beijing Normal University)
2002. 8.15 — 2002. 8.29

Dr. Joshua Feinberg
(Technion)
2002. 8.20 — 2002. 9.19

Prof. Wen-Li Yang
(Northeast Normal University)
2002.11.11 — 2003.11.10

Dr. Marian S. Stanishkov
(INRNE, Sophia, Bulgaria)
2003. 1.25 — 2003. 3.25

Dr. Putra Mahasena
(Institute of Technology, Bandung)
2003. 2.10 — 2003. 3. 9

Prof. Alexandre Belavine
(Landau Institute)
2003. 2.16 — 2003. 3.16

Prof. Chrisitopher M. Mudry
(Paul Scherrer Institute)
2003. 3. 2 — 2003. 3.16

Prof. W.J. Swiatecki
(Lawrence Berkeley National Laboratory)
2003. 3.10 — 2003. 3.31

Prof. Patrick Edward Dorey
(University Durham)
2003. 4. 3 — 2003. 4.23

Dr. Jnanadeva Maharana
(Institute of Physics, Bhubaneswar)
2003.11. 1 — 2003.12. 1

Dr. Michael Jitomirski
(CEA)
2003.11.10 — 2003.12. 5

Prof. Yong Zhong Xing
(Tianshui Normal University)
2003.11.10 — 2004. 2.10

Prof. Pieter Hut
(Princeton University)
2003.11.10 — 2004. 1.10

Prof. Natalia N. Kirova
(Moscow University of Angers)
2003.11.25 — 2004. 1.31

Kyoto University Guest Research Associates

Dr. Bifang Liu
(Chinese Academy of Sciences)
2001. 4. 2 — 2002. 3.31

Dr. James Norman Bleach
(Keele University)
2001. 7.31 — 2002. 7.30

Dr. Sanjay Jhingan
(University of Basque Country)
2001.10.21 — 2002.10.20

Dr. Bertrand Bouriquet
(GANIL)
2001.11. 5 — 2002.11. 4

Dr. Pascal Baseilhac

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(University of York)
2001.11.26 — 2002.11.25

Dr. Alan Cornell
(University of Cornell)
2002. 1.12 — 2002. 4.15

Dr. Boris Krippa
(University of Manchester)
2002. 3. 6 — 2002. 3.20

Dr. Ignace Loris
(Vrije Universiteit Brussel)
2002. 3.15 — 2002. 9.13

Dr. Bifang Liu
(Chinese Academy of Sciences)
2002. 4. 1 — 2003. 3.31

Dr. Dilip Kumar Ghosh
(National Taiwan University)
2002. 5.10 — 2002. 5.25

Dr. Bertrand Bouriquet
(GANIL)
2002.11. 5 — 2003.11. 4

Dr. Pascal Baseilhac
(The University of York)
2002.11.26 — 2003.11.25

Mr. Stefano Mattiello
(University of Rostock)
2002.11.12 — 2002.12.11

Dr. Bifang Liu
(Chinese Academy of Sciences)
2003. 2.10 — 2003. 3. 9

Dr. Ignace Loris
(Vrije Universiteit Brussel)
2003. 2.17 — 2003. 8.17

Dr. Toby Wiseman
(DAMTP)
2003. 3.10 — 2003. 3.28

Dr. Wade Naylor
()
2003. 4. 1 — 2003.11.19

Dr. Sebastian Gerald Maartin Gurrieri
()
2003. 7. 2 — 2004. 7. 1

Dr. Oriol Pujolas
()
2003.10.15 — 2004.10.14

Dr. Koendjaja Chatief
()
2003.10.28 — 2004. 1.25

Dr. Marco Rossi
()
2003.11. 4 — 2004.10. 3

Dr. Peter Austing
(Oxford University)
2003.12. 9 — 2004. 1. 5

YITP Visitor Program

▷ 2001

Kenichi Naito
(RIKEN, PD)
2001.6.5-8
Nuclear Physics

Nariyuki Nakagiri
(Ibaraki University, DC)
2001.10.5–11
Condenced Matter Physics

Koichi Hamada
(Tokyo University, D1)
2001.11.26–12.9
Condenced Matter Physics

Shiwei Yan
(Ibaraki University, PD)
2001.12.5–11
Nuclear Physics

Hideki Asada
(Hirosaki University, A)
2001.12.25–28
Astro Physics

Kenichi Naito
(Hokkaido University, PD)
2002.2.26–28
Nuclear Physics

Sumiyoshi Abe
(Tsukuba University, AP)
2002.3.11–15
Nuclear Physics

Nobuyuki Sakai
(Yamagata University, L)
2002.3.21–27
Astro Physics

▷ 2002

Kazumasa Ohkuma
(Yokohama Nat. Univ., PD)
2002.4.15–20
Elementary Particles Physics

Chiho Nonaka
(RIKEN, PD)
2002.4.19–21
Nuclear Physics

Satoru Odake
(Shinshu University, AP)
2002.5.13–15
Elementary Particles Physics

Hiroaki Wada
(Nihon University, A)
2002.6.8–9
Nuclear Physics

Nobuyuki Sakai
(Yamagata University, L)

2002.7.17–8.10
Astro Physics

Hiroaki Wada
(Nihon University, A)
2002.8.9–10
Nuclear Physics

Yukitoshi Motome
(ERATO-SSS, JST, PD)
2002.9.12–20
Condenced Matter Physics

Yasushi Mino
(Washington University, PD)
2002.12.10–24
Astro Physics

Kazunori Kohri
(Tokyo University, PD)
2003.2.7–12
Astro Physics

Hirotsugu Fujii
(Tokyo University, A)
2003.3.5–14
Nuclear Physics

Kazuaki Onishi
(Tokyo University, DC)
2003.3.5–14
Nuclear Physics

Sumiyoshi Abe
(Tsukuba University, AP)
2003.3.10–15
Nuclear Physics

Shin Muroya
(Tokuyama Women's Coll., AP)
2003.3.10–13
Nuclear Physics

Hiroto Imagawa
(Tsukuba University, D3)
2003.3.17–18
Nuclear Physics

Yukio Hashimoto
(Tsukuba University, L)
2003.3.17–18
Nuclear Physics

Yasuhiro Sugawara
(Ibaraki University, M1)
2003.3.19–22
Nuclear Physics

Shigekazu Inayoshi
(Ibaraki University, M1)
2003.3.19–22
Nuclear Physics

Hideo Suganuma
(Tokyo Inst. of Tech., AP)
2003.3.23–24
Nuclear Physics

▷ 2003

Chihiro Sasaki
(Nagoya University, D2)
2003.6.1–14
Nuclear Physics

Masatsugu Isse
(Hokkaido University, D1)
2003.6.9–22
Nuclear Physics

Masashi Hamanaka
(Tokyo University, PD)
2003.6.30–7.15
Elementary Particles Physics

Tomoi Koide
(J.W. Goethe University, PD)
2003.7.3–9
Nuclear Physics

Kazunori Takenaga
(Osaka University, TA)
2003.7.7–10
Elementary Particles Physics

Motoi Tachibana
(RIKEN, PD)
2003.7.14–20
Elementary Particles Physics

Yukio Nemoto
(RIKEN BNL, PD)
2003.7.28–8.1
Nuclear Physics

Yoshio Sato
(Saitama University, M2)
2003.8.27–29
Elementary Particles Physics

Junichiro Makino
(Tokyo University, AP)
2003.11.11–14
Elementary Particles Physics

Eiji Uegaki
(Akita University, P)
2003.12.16–20
Nuclear Physics

Jun Makino
(Tokyo University, AP)
2003.12.23–26
Elementary Particles Physics

Takayuki Takehi
(Tohoku University, D1)
2004.2.1–14
Nuclear Physics

Holger Baumgardt
(RIKEN, PD)
2004.2.2–6
Astro Physics

Kouhei Washiyama
(Tohoku University, M2)
2004.2.11–14
Nuclear Physics

Atom-type Visitors

Masashi Hamanaka (Univ. of Tokyo)
2001.8.27 — 9.20, 2002.1.28 — 2.2
Study of soliton solutions in superstring theories and field theories, with focus on the structure and dualities of their moduli spaces

Kouichi Toda (Ritsumeikan Univ.)
2001.8.29 — 9.25
Mathematical study of higher-dimensional integrable systems: an approach based on the Lax pair

Sei Suzuki (Tohoku Univ.)
2001.10.3 — 10.30
Dynamics of systems with the fractional Hall effect and an elementary-excitation picture for it

Yoshiaki Himemoto (Osaka Univ.)
2001.10.15 — 11.11
Cosmology in higher-dimensional spacetime theories

Kenji Nagami (Tokyo Inst. of Tech.)
2001.11.16 — 12.13
Investigation of the tachion condensation in terms of a string field theory

Takuya Yamano (Tokyo Inst. of Tech.)
2001.11.26 — 12.23
Study of non-additivity and black hole thermodynamics

Ryo Takagi (Tokyo Inst. of Tech.)
2002.1.4 — 2.3
The origin of gamma-ray bursts

Hiroto Imagawa (Tsukuba Univ.)
2002.1.21 — 2.17
Description of nuclear excited states in terms of the real space RPA

Shoichi Ito (Kanazawa Univ.)
2002.3.1 — 3.28
Investigation of a quark confinement mechanics in terms of the lattice gauge theory

Takahiro Aoyama (Hokkaido Univ.)
2002.3.5 — 3.31
Investigation of lower-dimensional physics in terms of field theories

Yoshiki Imai (Osaka Univ.)
2002.4.15 — 5.15
Study of migrating electron systems with geometrical frustration

Kouzou Koizumi (Kyoto Sangyo Univ.)
2002.5.1 — 5.31
q-deformation and its application to elementary particle theories

Ken-ichiro Aoki (Keio Univ.)
2002.5.13 — 6.8
Field theories for non-equilibrium systems and superstring theories

Hideki Maeda (Waseda Univ.)
2002.5.31 — 6.26
Verification of the self-similarity hypothesis in a gravitational theory

Yoshitaka Ishimoto (Univ. Oxford)
2002.6.18 — 7.14
Study of conformal field theories

Koichi Hamada (Univ. of Tokyo)
2002.6.20 — 7.16
Competition of d-density waves and d-wave pairings

Noriyuki Nakai (Okayama Univ.)
2002.7.1 — 7.13
Study of vortex structures in superconductors

Noriaki Ikeda (Ritsumeikan Univ.)
2002.8.21 — 9.20
Study of the foundation of quantum field theories and string theories

Ken-Ichi Tezuka (Chiba Univ.)
2002.11.11 — 12.11
Hamiltonian formulation of non-comutative spacetimes and field theory

Tsutomu Momoi (Tsukuba Univ.)
2002.11.25 — 12.20
Chiral symmetry breaking in a frustrating system

Shinsei Ryu (Univ. of Tokyo)
2002.11.25 — 12.25
Study of material physics

Tokuzo Shimada (Meiji Univ.)
2002.12.15 — 12.26, 2003.1.14 — 1.21
Quantum chaos

Hidetaka Eguchi (Tokyo Inst. of Tech.)
2003.2.23 — 3.22
An effective theory of strings and tachion condensation

So Katagiri (Tsukuba Univ.)
2003.3.1 — 3.31
Study of a string theory in three-dimensional anti-de Sitter space

Shin-ichiro Nagahiro (Tohoku Univ.)
2003.5.12 — 6.7
SPH simulations for collision of a disk and fluid surface

Etsuko Itou (Osaka Univ.)
2003.5.12 — 6.7
Non-perturbative analysis of a non-linear sigma model and its application

Hiromitsu Takayanagi (Osaka Univ.)
2003.6.15 — 7.11
Investigation of the properties of spacetimes with small supersymmetries in terms of superstring theories

Matsuo Sato (Osaka Univ.)
2003.6.20 — 7.20
A correspondence between string theories and gauge

theories

Takehiko Horita (Univ. of Tokyo)
2003.8.7 — 8.22, 2003.9.9 — 9.16
Study of statistical dynamics of non-equilibrium states in terms of dynamical chaos

Fumito Mori (Kyushu Univ.)
2003.8.25 — 9.20
Effects of the network structure on the dynamics of coupled oscillator systems

Takeshi Mizushima (Okayama Univ.)
2003.10.27 — 11.26
Theoretical study of superfluidity in a bose condensed system of neutral atomic gas

Hidetoshi Morita (Univ. of Tokyo)
2003.11.10 — 12.10
Phenomenology of non-equilibrium many-body systems whose dynamical internal states and external responses are mutually dependent

Yutaka Ookouchi (Tokyo Inst. of Tech)
2003.11.17 — 11.30
Duality of gauge theories with $N = 1$ *supersymmetry and matrix models*

Short Visitors

▷ 2001

Kenichi Konishi
(University of Pisa)
2001.3.11 — 2001.3.18

Re'em Sari
(Caltech)
2001.3.13 — 2001.3.19

Sandip Pakvasa
(University of Hawaii)
2001.3.24 — 2001.3.31

D. Ebert
(Humbopdt University.RCNP)
2001.3.4 — 2001.3.9

Kang Yong Lee
(Korea Inst of Advanced Study)
2001.5.15 — 2001.5.22

Valeri P. Frolov
(University of Alberta.Tokyo Inst. Of Tech.)
2001.1.31 — 2001.2.4

Hitoshi Yamamoto
(University of Hawaii)
2001.2.4 — 2001.2.10

C.V. Shen
(China Institute of Atomic Energy)
2001.2.25 — 2001.2.28

J.D. Bao
(Bejing Normal University)
2001.2.25 — 2001.2.28

Shyamoli Chaudhuri
(The Pennsylvania State University)
2001.7.12 — 2001.7.15

Itzhak Bars
(University of Southern California)
2001.7.11 — 2001.7.16

Peter Weisz
(Max Planck Institute)
2001.9.3 — 2001.9.9

Serguei A. Brazovskii
(CNRS)
2001.9.4 — 2001.9.9

Victor M. Yakovenko
(University of Maryland)
2001.9.4 — 2001.9.9

Hartmut Monien
(University of Bonn)
2001.9.25 — 2001.10.1

C.W. Shen
(China Institute of Atomic Energy)
2001.9.30 — 2001.10.4

Philippe Chomaz
(GANIL)
2001.10.31 — 2001.11.3

Ikuko Hamamoto
(Lund University)
2001.11.11 — 2001.11.16

Adam Sobiczewski
(Soltan Institute of Nuclear Studies)
2001.11.17 — 2001.11.22

David Hinde
(Australia National University)
2001.11.18 — 2001.11.20

Bruce Bassett
(University of Portsmouth)
2001.12.3 — 2001.12.7

Changrim Ahn
(Ewha Women's University)
2001.12.7 — 2001.12.13

S. Chaudhuri
(Penn State U.)
2001.9.11 — 2001.9.19

▷ 2002

Chris Done
(Univ. Durham)
2002.9.17 — 2002.9.18

S. Hofmann
(GSI)
2002.10.2 — 2002.10.4

Tadakatsu Sakai
(Tel-Aviv U)
2002.10.7 — 2002.10.13

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J. Wess
(Munich Max Planck Inst. & Munich U.)
2002.3.19 — 2002.3.23

Hartmut Monien
(University Bonn)
2002.3.5 — 2002.3.10

Ramesh Narayan
(Harvard University)
2002.3.17 — 2002.3.23

Mordecai-Mark Mac Low
(American Museum of Natural History)
2002.3.21 — 2002.3.25

A. Lodhi
(Texas Tech U.Hokkaido U)
2002.3.22 — 2002.3.27

Y.Z. Zhuo
(China Inst. Of Atomic Energy)
2002.3.28 — 2002.3.31

Cosimo Signorini
(Padova U.)
2002.4.11 — 2002.4.13

Tatsu Takeuchi
(Virginia Tech)
2002.6.13 — 2002.6.19

P.K. Kabir
(U. Virginia)
2002.7.3 — 2002.7.8

S.A. Gurvitz
(Weizmann Inst of Sci.Hokkaido U)
2002.7.18 — 2002.7.21

Masayuki Tanimoto
(Yale University)
2002.8.4 — 2002.8.5

Allan H. MacDonald
(Univ. of Texas at Austin)
2002.8.19 — 2002.8.20

Manfred Sigrist
(ETH Zurich)
2002.8.26 — 2002.8.30

Edmond Orignac
(Ecole Normal Superiere)
2002.8.29 — 2002.8.31

Dmitri Ivanov
(ETH Zurich)
2002.8.27 — 2002.9.1

Yshai Avishai
(Ben Gurion University)
2002.8.27 — 2002.9.1

Catherine Pepin
(CEA-Saclay)
2002.8.27 — 2002.8.29

Maurice T. Rice
(ETH Zurich)
2002.8.26 — 2002.8.29

Klaus D. Rothe
(Heidelberg University)
2002.9.10 — 2002.9.13

Steffen A. Bass
(Duke University)
2002.9.16 — 2002.9.21

Chetan Nayak
(UCLA.Nihon U)
2002.11.11 — 2002.11.15

W. Kluzniak
(Zielona Gora U)
2002.11.28 — 2002.12.3

S. Brazovskii
(LPTMS, Orsay)
2002.12.17 — 2002.12.19

N. Kirova
(U Angers)
2002.12.17 — 2002.12.19

P. van Nieuwenhuizen
(SUNY, Stony Brook)
2002.12.17 — 2002.12.20

Xizhen Zhang
(CIAE)
2002.12.18 — 2002.12.21

▷ 2003

B. de Wit
(Utrecht University)
2003.7.3 — 2003.7.5

D. Becirevic
(Orsay)
2003.7.22 — 2003.7.26

R. Spurzem
(Astro. Rechen Inst.)
2003.7.23 — 2003.7.27

Tadashi Takayanagi
(Harvard University)
2003.7.28 — 2003.8.2

B. Jurco
(Munich University)
2003.8.2 — 2003.8.6

I. Neupane
(Nat. Taiwan University)
2003.8.11 — 2003.8.14

Alexander Dolgov
(RESCEU.INFN & ITEP)
2003.8.26 — 2003.8.29

Igor Igumenshchev
(University of Rochester)
2003.11.4 — 2003.11.8

Putra Mahasena
(Institut Teknologi Bandung)

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2003.11.4 — 2003.11.8

Mahananda Dasgupta
(Australian National University)
2003.11.4 — 2003.11.10

Aurel Bulgac
(Washington University)
2003.11.5 — 2003.11.9

Giovanni Pollarolo
(University of Torino)
2003.11.5 — 2003.11.11

Venya Berezinsky
(INFN)
2003.11.12 — 2003.11.15

G. Baskaran
(Inst. Math. Sci., Madras)
2003.11.9 — 2003.11.11

Mario Stoitsov
(Bulgarian Academy of Sciences)
2003.11.25 — 2003.11.29

Witold Nazarewicz
(Oak Ridge National Laboratory)
2003.11.26 — 2003.11.29

Kensuke Yoshida
(Roma Univ.)
2003.7.3 — 2003.7.4

Bruce H.J. McKellar
(Melbourne Univ.)
2003.7.22 — 2003.7.25

Michael Stephanov
(Illinois Univ.)
2003.7.14 — 2003.7.14

Popovic Dragan
(Belgrade Univ.)
2003.7.14 — 2003.7.18

Ke Wu
(Capital Normal U.)
2003.10.21 — 2003.10.25

En-guang Zhao
(Chinese Academy of Sciences)
2003.10.21 — 2003.10.25

Volker Oberacker
(Vanderbilt University)
2003.11.24 — 2003.11.29

Jun Terasaki
(University of North Carolina)
2003.11.24 — 2003.11.29

Matthias F. Lutz
(GSI, Darmstadt TU)
2003.11.28 — 2003.12.3

Zoran Basrak
(Ruder Boskovic Institute, Zagreb, Croatia)
2003.11.30 — 2003.12.4

Christian Beck
(Institut de Recherches Subatomiques)
2003.11.30 — 2003.12.3

Evan D. Steward
(KAIST)
2003.4.23 — 2003.4.24

Cedric Deffayet
(Institut d'Astrophysique de Paris)
2003.10.23 — 2003.10.29

Andrey Illarionov
(Hosei University)
2003.11.1 — 2003.11.8

Fumihiko Sugino
(Seoul National University)
2003.10.13 — 2003.10.20

R. Johnson
(Surry University)
2003.3.5 — 2003.3.8

Shigeo Tomita
(Aarhus University)
2003.1.19 — 2003.1.21

Michelangelo Mangano
(CERN)
2003.3.15 — 2003.3.21

Jim Peebles
(Princeton University)
2003.10.12 — 2003.10.17

David J. Hinde
(The Australian National University)
2003.11.2 — 2003.11.9

Matthias Staudacher
(Max Planck Inst.)
2003.7.13 — 2003.7.20

Ken-ichi Konishi
(Pisa Univ.)
2003.8.25 — 2003.8.28

Tomoi Koide
(J.W. Goethe University)
2003.7.3 — 2003.7.9

Yukio Nemoto
(RIKEN BNL)
2003.7.28 — 2003.8.1

P. Mackenzie
(Fermilab)
2003.7.19 — 2003.7.24

Joseph Silk
(Oxford University)
2003.4.11 — 2003.4.14

David Brink
(Oxford University)
2003.4.21 — 2003.4.26

Jean Peter
(LPC.ISMRA)

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2003.4.18 — 2003.4.23

A. Starodubtsev
(Wateroo University)
2003.5.5 — 2003.5.8

Hermann Nicolai
(Max Planck Institute)
2003.6.29 — 2003.7.5

Chapter 3

Workshops and Conferences

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3.1 YKIS and Nishinomiya-Yukawa Symposia

Since 1978, we have held a series of international physics workshops every one or two years, called *Yukawa International Seminar (YKIS)*. We also support *the Nishinomiya Yukawa Memorial Project* sponsored by Nishinomiya city where the late Prof. Hideki Yukawa lived when he wrote his famous papers on the meson theory. As one of the major programs of this project, an international symposium open to public is held every year in Nishinomiya city, and its post-workshop is held at YITP. Here, we list the YITP and Nishinomiya Yukawa symposia held during the past three years.

Yukawa International Seminar (YKIS)

Physics of Unstabel Nuclei

5 – 10 Nov. 2001, chaired by H. Horiuchi, 182 participants (118 from abroad)
proceedings: *Prog. Theor. Phys. Suppl.* No. 146 (2002).

Strings 2003

6 – 11 July 2003, chaired by T. Eguchi, 387 participants (195 from abroad).

Nishinomiya Yukawa Symposium

Order and Disorder in Quantum Spin Systems

13 – 14 Nov. 2001, 73 participants (12 from abroad)
proceedings: *Prog. Theor. Phys. Suppl.* No.145 (2002).

String Theory

12 – 13 Nov. 2002, 97 participants (5 from abroad)
proceedings: *Prog. Theor. Phys. Suppl.* No. 152 (2003).

Strangeness in Nuclear Matter

4 – 5 Dec. 2003.

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3.2 YITP workshops

YITP workshops are one of our main activities. The aim of them is to open new research fields and stimulate mutual collaborations. Workshop plans can be proposed by any researcher and are selected by the Committee on Research Projects of our institute. We also support small workshops and summer schools to educate young researchers.
In the past 5 years, we had more than 20 workshops and 1500 participants per year. The list of the workshops and the number of participants for the last 2 years are given below.

▷ 2001.4.1 — 2002.3.31

YITP-W-01-01
New aspects of Nonequilibrium Systems, Jun. 4, 2001 - Jun. 6, 2001, organized by Shin-ichi Sasa (U of Tokyo). *115* attendance.
(Bussei Kenkyu 77-2)

YITP-W-01-02
Quantum tunneling decay phenomena in nuclear physics, Jul. 2, 2001 - Jul. 4, 2001, organized by K. Hagino (YITP). *35* attendance.
(Soryushiron Kenkyu 104-2)

YITP-W-01-03
Aspects of Particle Physics in new Century, Jul.10, 2001 - Jul.13, 2001, organized by Naoyuki Haba (Mie U), Yusuke Taniguchi, Ken-iti Izawa, Yoshiharu Kawamura, Yukinari Sumino, Hiroaki Nakano, Masayasu Harada, Koichi Funakubo, Maekawa Nobuhiro, Isamu Watanabe. *111* attendance.
(Soryushiron Kenkyu 104-4)

YITP-W-01-04
Quantum Field Theory 2001, Jul.16, 2001 - Jul.19, 2001, organized by Hidetoshi Awata (Nagoya U), Hiroshi Ishikawa, Yosuke Imamura, Nobuyoshi Ohta, Mitsuhiro Kato, Hiroshi Kunitomo, Makoto Sakamoto, Yusuke Taniguchi, Haruhiko Terao, Kenji Hamada. *143* attendance.
(Soryushiron Kenkyu 104-5)

YITP-W-01-05
Thermal Quantum Field Theories and Their Applications, Aug. 6, 2001 - Aug. 8, 2001, organized by Tomohiro Inagaki (Hiroshima U), Hisao Nakagawa. *69* attendance.
(Soryushiron Kenkyu 105-1)

YITP-W-01-06
Gamma Ray Bursts (GRB2001), Aug.23, 2001 - Aug.25, 2001, organized by T. Nakamura (YITP). *50* attendance.
(Soryushiron Kenkyu 105-2)

YITP-W-01-07
Women in Physics, Dec.23, 2001 - Dec.24, 2001, organized by Mihoko Toya (Kyoto U), Atuko Ito, Tomoko Kagayama, Kazuo Kitahara, Eiko Torikai, Mihoko Nojiri, Izumi Nomura, Yuko Fujita, Masako Bando, Eri Yagi. *25* attendance.
(Soryushiron Kenkyu 105-5 & Bussei Kenkyu 80-5)

YITP-W-01-08
International Symposium on Aspects of Quantum Many-Body Systems, Nov.12, 2001 - Nov.14, 2001, organized by Kiyoshi Kato (Hokkaido U), Akira Ohnishi, Yoshiko En'yo, Naoyuki Itagaki. *80* attendance.

YITP-W-01-09
Strings, Branes and Unified Theories, Nov.12, 2001 - Nov.16, 2001, organized by Takeo Inami (Chuo U), Tohru Eguchi, Yoichi Kazama, Taichiro Kugo, Norisuke Sakai, Ryu Sasaki, Tsutomu Yanagida, Masahiro Yamaguchi, Sung-Kil Yang, Yosuke Imamura. *107* attendance.

YITP-W-01-10
Order, Disorder and Dynamics in Quantum Spin Systems, Nov.15, 2001 - Nov.16, 2001, organized by Takashi Tonegawa (Fukui U Tech), Naoki Kawashima, Masaki Oshikawa, Seiji Miyashita, Toru Sakai, Hajime Takayama, Kunimitsu Uchinokura, Kazuo Ueda. *95* attendance.
(Prog.Theor.Phys.,Suppl. 145)

YITP-W-01-11
Excitations and Correlation Effects in Finite Quantum Many-Body Systems, Dec. 3, 2001 - Dec. 5, 2001, organized by Toru Suzuki (Tokyo Metropolitan U), Hideo Aoki, Masahito Ueda, Katsuhiro Nakamura, Kenichi Matsuyanagi, Kazuhiro Yabana. *65* attendance.
(Soryushiron Kenkyu 105-3 & Bussei Kenkyu 78-3)

YITP-W-01-12
Methodologies in Cognitive Sciences, Dec. 5, 2001 - Dec. 7, 2001, organized by Ken Mogi (Sony CSL), Takashi Ikegami. *41* attendance.

YITP-W-01-13
Quantum Field Theories: Fundamental Problems and Applications, Dec.19, 2001 - Dec.21, 2001, organized by Yutaka Hosotani (Osaka U), Aiichi Iwazaki, Teiji Kunihiro, Izumi Tsutsui, Koji Harada. *117* attendance.
(Soryushiron Kenkyu 105-4)

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YITP-W-01-14
The latest topics in strangeness nuclear physics, Dec.25, 2001 - Dec.27, 2001, organized by Taichi Yamada (Kanto Gakuin U), Akira Ohnishi, Hidekatsu Nemura, Emiko Hiyama, Shinichiro Fujii, Makoto Oka, Yasuo Yamamoto, Teiji Kunihiro, Choki Nakamoto, Toru Harada. *52* attendance.
(Soryushiron Kenkyu 106-2)

YITP-W-01-15
Braneworld - Dynamics of spacetime with boundary, Jan.15, 2002 - Jan.18, 2002, organized by Akihiro Ishibashi (YITP), Tanaka Takahiro, Kei-Ichi Maeda, Hideo Kodama, Misao Sasaki, Hideki Ishihara, Jiro Soda, Tetsuya Shiromizu. *52* attendance.
(Prog.Theor.Phys.,Suppl. 148)

YITP-W-01-16
Future and development in gravitational wave physics, Feb.21, 2002 - Feb.23, 2002, organized by Takahiro Tanaka (YITP), Takashi Nakamura, Misao Sasaki, Ken-ichi Oohara, Masatake Ohashi, Shin Mineshige, Masaru Shibata, Makoto Sasaki, Hideyuki Tagoshi, Seiji Kawamura. *52* attendance.
(Soryushiron Kenkyu 106-3)

YITP-W-01-17
Black Holes, Gravitational Lens, and Gamma-Ray Bursts, Mar.18, 2002 - Mar.19, 2002, organized by Shin Mineshige (YITP), Jun Fukue, Kazunari Shibata, Shoji Kato, Ryoji Matsumoto, Ken Ohsuga. *60* attendance.
(Soryushiron Kenkyu 105-5)

YITP-W-01-18
Collective Motions in Nuclei: from RPA to Heavy-Ion Collisions, Mar.22, 2002 - Mar.23, 2002, organized by Kouichi Hagino (YITP), Noboru Takigawa, Kiyoshi Kato, Kenichi Matsuyanagi. *43* attendance.

▷ 2002.4.1 — 2002.3.31

YITP-W-02-01
Phase transitions with novel order parameters, Jun.10, 2002 - Jun.12, 2002, organized by Seiji Miyashita (U of Tokyo). *54* attendance.
(Bussei Kenkyu 79-5)

YITP-W-02-02
Progress in Particle Physics, Jul. 8, 2002 - Jul.11, 2002, organized by Yusuke Taniguchi (U of Tsukuba). *110* attendance.
(Soryushiron Kenkyu 107-4)

YITP-W-02-03
Soft Matter Physics, Jul.15, 2002 - Jul.17, 2002, organized by Ryoichi Yamamoto (Kyoto U), Y.Ohta, A.Onuki, T.Kawakatsu, S.Komura, H.Tanaka, M.Doi, H.Hayakawa, T.Munakata. *133* attendance.
(Bussei Kenkyu 79-2)

YITP-W-02-04
Quantum Field Theory 2002, Jul.23, 2002 - Jul.26, 2002, organized by Yosuke Imamura (U of Tokyo), Hidetoshi Awata, Hiroshi Ishikawa, Nobuyoshi Ohta, Mitsuhiro Kato, Hiroshi Kunitomo, Makoto Sakamoto, Yuji Satoh, Koji Hashimoto, Kenji Hamada. *132* attendance.
(Soryushiron Kenkyu 106-3)

YITP-W-02-05
Flavor mixing, CP violation and Origin of matter, Jul.31, 2002 - Aug. 2, 2002, organized by Takuya Morozumi (Hiroshima U), Tetsuya Onogi, Takashi Kobayashi, Joe Satou, Morimitsu Tanimoto. *25* attendance.
(Soryushiron Kenkyu 106-4)

YITP-W-02-06
Quantum mechanics makes structure, Mar.19, 2003 - Mar.20, 2003, organized by Masahiro Morikawa (Ochanomizu U). *29* attendance.

YITP-W-02-07
Thermal Quantum Field Theories and Their Applications, Aug. 7, 2002 - Aug. 9, 2002, organized by Yabu Hiroyuki (Tokyo Metropolitan U),Tomohiro Inagaki, Masa-aki Sakagami, Hirofumi Sawayanagi, Yasuhiko Tsue, Hisao Nakagawa, Akira Niegawa, Tetsuo Hatsuda, Hideki Matsumoto, Shin Muroya. *63* attendance.
(Soryushiron Kenkyu 106-5)

YITP-W-02-08
TEA(Theoretical-Experimental-Astronomical Particle Physics)02, Aug.21, 2002 - Aug.23, 2002, organized by Mihoko Nojiri (YITP), Masanori Yamauchi, Yoshitaka Kuno, Tsuyoshi Nakaya, Tanimori Toru, Kiyotomo Kawagoe, Tetsuya Onogi, Masahiro Kawasaki, Yasuhiro Okada, Kenichi Hikasa. *103* attendance.
(Soryushiron Kenkyu 107-3)

YITP-W-02-09
Summer School on Astronomy and Astrophysics 2002, Jul.29, 2002 - Aug. 2, 2002, organized by Hiromichi Kozu, Shigeru Eto, Makoto Uemura, Hiroaki Isobe, Takanori Shima. *320* attendance.

YITP-W-02-10
The 47th Summer Seminar for young reserchers of condensed-matter physics, Jul.31, 2002 - Aug. 3, 2002, organized by Yukari Kuramoto (U of Tokyo), Naoki Asakawa. *150* attendance.
(Bussei Kenkyu 79-3)

YITP-W-02-11
YONUPA Summer School, Aug. 1, 2002 - Aug. 7, 2002, organized by Takehiro Azuma (Kyoto U), Satoshi Mishima, Taisuke Nagasawa, Ken-ichi Tezuka, Kouhei Hasegawa, Takashi Shimomura, Yuko Kobashi, Koji Higashiyama, Tadao Terayama,

Takefumi Sora. *270* attendance.
(Soryushiron Kenkyu 108-2)

YITP-W-02-12
Symmetry, Supersymmetry and Breakdown - Particle Physics Institute for New Century 2002 -, Sep. 2, 2002 - Sep. 6, 2002, organized by Masahiro Yamaguchi (Tohoku U.), Mihoko Nojiri. *69* attendance.

YITP-W-02-13
Quantum chaos: Present status of theory and experiment, Sep. 9, 2002 - Sep. 11, 2002, organized by Kazuo Takatsuka (U of Tokyo), Ichiro Ohba, Katsuhiro Nakamura. *73* attendance.
(Soryushiron Kenkyu 107-1 & Bussei Kenkyu 80-1)

YITP-W-02-14
Chiral Restoration in Nuclear Medium, Oct. 7, 2002 - Oct. 9, 2002, organized by Teiji Kunihiro (YITP), Yoshinori Akaishi, Masahiko Iwasaki, Hideto Enyo, Hajime Shimizu, Tetsuo Hatsuda, Atsushi Hosaka, Makoto Oka. *71* attendance.
(Prog.Theor.Phys.,Suppl. 149)

YITP-W-02-15
YITP School on Lattice Field Theory, Oct.21, 2002 - Oct.25, 2002, , organized by Tetsuya Onogi (YITP), Shoji Hashimoto, Sinya Aoki, Kazuyuki Kanaya. *69* attendance.

YITP-W-02-16
Development of Superstring Theory, Nov.15, 2002 - Nov.16, 2002,, organized by Masafumi Fukuma (Kyoto U). *97* attendance.
(Soryushiron Kenkyu 107-6)

YITP-W-02-17
Development of the Theory of Strongly Correlated Electrons with Orbital Degrees of Freedom, Nov.25, 2002 - Nov.26, 2002, organized by Tsunetsugu Hirokazu (YITP), Nagaosa Naoto, Kawakami Norio, Imada Masatoshi, Ueda Kazuo. *58* attendance.
(Bussei Kenkyu 79-6)

YITP-W-02-18
Quantum Field Theories: Fundamental Problems and Applications, Dec.18, 2002 - Dec.20, 2002, organized by Yutaka Hosotani (Osaka U), Izumi Tsutsui. *96* attendance.
(Soryushiron Kenkyu 107-5)

YITP-W-02-19
Extra Dimensions and Braneworld, Jan. 6, 2003 - Jan.10, 2003, organized by Takahiro Tanaka (YITP). *90* attendance.
(Soryushiron Kenkyu 108-1)

YITP-W-02-20
QCD for B decays, Mar. 3, 2003 - Mar. 4, 2003, organized by Tetsuya Onogi (YITP), Takeshi Kurimoto, Jiro Kodaira, Kazuhiro Tanaka, Shoji Hashimoto. *20* attendance.

YITP-W-02-21
Particle Physics at High Energy Frontier, Mar.17, 2003 - Mar.18, 2003, organized by Mihoko Nojiri (YITP), Junji Hisano, Kaoru Hagiwara, Kiyotomo Kawagoe, Shoji Asai, Reisaburo Tanaka. *56* attendance.

YITP-W-02-22
Gravitational Wave physics, Jan.30, 2003 - Feb. 1, 2003, organized by Takahiro Tanaka (YITP), Hideki Asada, Masatake Ohashi, Kenichi Oohara, Seiji Kawamura, Nobuyuki Kanda, Takashi Nakamura, Takashi Sasaki, Hideyuki Tagoshi, Takeshi Chiba. *51* attendance.
(Soryushiron Kenkyu 107-6)

YITP-W-02-23
Highly Excited Complex States and Dissipation Phenomena in Nuclei, Mar.12, 2003 - Mar.14, 2003, organized by Hirokazu Aiba (Kyoto Koka Women's College), Shoujirou Mizutori, Yasuhisa Abe, Noboru Takigawa, Kouji Yoshida, Takahiro Wada. *26* attendance.
(Ssoryushiron Kenkyu 108-2)

YITP-W-02-24
Random matrix theory and related topics, Dec.17, 2002 - Dec.19, 2002, organized by Shinobu Hikami (U of Tokyo) Kazusumi Ino. *26* attendance.

YITP-W-02-25
New Era of Black-Hole Astronomy, Feb.17, 2003 - Feb.19, 2003, organized by Shin Mineshige (YITP). *96* attendance.

YITP-W-02-26
High Energy Emission from Compact Objects, Mar. 5, 2003 - Mar. 7, 2003, organized by Shin Mineshige (YITP). *37* attendance.

YITP-W-02-27
Field Theory in Condensed Matter Physics, Mar.18, 2003 - Mar.19, 2003, organized by Hirokazu Tsunetsugu (YITP), Akira Furusaki, Norio Kawakami, Yusuke Kato. *32* attendance.
(Bussei Kenkyu 80-3)

▷ 2003.4.1 — 2004.3.31

YITP-W-03-01
Electromagnetic Fields and Biological Effects, May 30, 2003 - May 31, 2003, organized by Masatoshi Murase (YITP). *73* attendance.
(Bussei Kenkyu 82-1)

YITP-W-03-02
Sixth Capra Meeting on Radiation Reactionin General Relativity, Jun.23, 2003 - Jun.25, 2003, organized by T. Tanaka (Kyoto U), Misao Sasaki, Takashi Nakamura. *60* attendance.

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YITP-W-03-03
Econophysics - Physics-based approach to Economic and Social phenomena -, Jul.15, 2003 - Jul.16, 2003, organized by Hideaki Aoyama (Kyoto U),Wataru Souma, Yoshihisa Fujiwara. *75* attendance.
(Soryuushiron Kenkyu 108-4 & Bussei Kenkyu 81-4)

YITP-W-03-04
Progress in Particle Physics, Jul.22, 2003 - Jul.25, 2003, organized by Joe Sato (Saitama U). *100* attendance.
(Soryushiron Kenkyu 108-6)

YITP-W-03-05
Summer School on Astronomy and Astrophysics 2003, Jul.28, 2003 - Aug. 1, 2003, organized by Takayuki R. Saitoh (Hokkaido U), Hitoshi Miura, Kumiko Hiroi, Kawakatu Nozomu, Kazutaka Motoyama, Nobuhiro Okabe, Tomoyuki Yasukawa, Hachidai Tanikawa, Koichi Okita. *320* attendance.

YITP-W-03-06
Soft Matter Physics 2003, Jul.30, 2003 - Aug. 1, 2003, organized by Toru Okuzono (JST). *160* attendance.
(Bussei Kenkyu 81-2)

YITP-W-03-07
QFT2003, Aug. 5, 2003 - Aug. 8, 2003, organized by Koji Hashimoto (U of Tokyo),Hiroshi Kunitomo. *126* attendance.
(Soryushiron Kenkyu 108-3)

YITP-W-03-08
The 48th Summer Seminar for young researchers of condensed-matter physics, Aug.11, 2003 - Aug.14, 2003, organized by Noriaki Oba (Kyoto U), Takayuki Arakawa. *150* attendance.
(Bussei Kenkyu 81-5)

YITP-W-03-09
YONUPA Summer School, Aug.18, 2003 - Aug.23, 2003, organized by So Katagiri (U of Tsukuba) . *317* attendance.
(to be published in Soryushiron Kenkyu & Genshikaku Kenkyu)

YITP-W-03-10
Thermal Quantum Field Theories and Their Applications, Aug.20, 2003 - Aug.22, 2003, organized by Hiroshi Yokota (Nara U). *50* attendance.
(Soryushiron Kenkyuu 108-5)

YITP-W-03-11
Nuclear Matter under Extreme Conditions, Dec. 1, 2003 - Dec. 3, 2003, organized by Akira Ohnishi (Hokkaido U), Akira Ono, Yoshio Kanda-En'yo, Toru Harada, Shigeru Nishizaki, Takumi Muto, Teiji Kunihiro, Hirotsugu Fujii, Masayuki Asakawa. *51* attendance.
(to be published in Prog.Theor.Phys., Suppl.)

YITP-W-03-12
Physics of Friction, Oct. 8, 2003 - Oct.10, 2003, organized by Kazushige Kawabata (Hokkaido U). *51* attendance.
(Bussei Kenkyu 81-6)

YITP-W-03-13
New direction of particle physics (TEA03)- from theoretical, experimental and astrophysical aspects, Oct. 15, 2003 - Oct.17, 2003, organized by Mihoko Nojiri (YITP), Tetsuya Onogi, Masashi Hazumi, Yasuhiro Okada, Naoshi Sugiyama, Masayuki Nakahata, Junji Hisano, Tsuyoshi Nakaya. *114* attendance.

YITP-W-03-14
Geometrical Structures of Phase Space in Multi-Dimensional Chaos: Applications to Chemical Reaction Dynamics in Complex Systems, Oct. 26, 2003 - Nov. 1, 2003, organized by Mikito Toda (Nara Women's U),Tamiki Komatsuzaki, Tetsuro Konishi, R. Stephen Berry, Stuart A. Rice. *72* attendance.
(to be published in Bussei Kenkyu)

YITP-W-03-15
Stellar-Mass, Intermediate-Mass, and Supermassive Black Holes, Oct.28, 2003 - Oct.31, 2003, organized by Shin Mineshige (YITP). *183* attendance.
(Soryushiron Kenkyu 108-4)

YITP-W-03-16
Quantum Mechanics and Chaos -From Fundamental Problems through Nanosciences, Nov.12, 2003 - Nov.14, 2003, organized by Kazuo Takatsuka (U of Tokyo), Katsuhiro Nakamura, Ichiro Ohba. *103* attendance.

YITP-W-03-17
Geomorphology from the Aspect of Nonlinear Dynamics, Dec.4, 2003 - Dec.5, 2003, organized by Hiraku Nishimori (Osaka Pref. U), Tsuyoshi Mizuguchi. *30* attendance.
(to be published in Bussei Kenkyu)

YITP-W-03-18
Stochastic models in statistical mechanics, Dec.15, 2003 - Dec.17, 2003, organized by Hisao Hayakawa (Kyoto U), Shinji Takesue, Makoto Katori, Tetsuya Hattori, Shintaro Mori, Tomohiro Sasamoto. *35* attendance.

YITP-W-03-19
Fundamental Problems and Applications of Quantum Field Theory, Dec.24, 2003 - Dec.26, 2003, organized by Izumi Tsutsui (KEK). *135* attendance.
(to be published in Soryushiron Kenkyu)

YITP-W-03-20
Origins — From Big Bang to Life, Jan. 6, 2004 -

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Jan. 8, 2004, organized by Tomonori Totani (Kyoto U), Eiichirou Kokubo, Shuichiro Inutsuka, Hideyuki Kamaya, Shin Mineshige. *80* attendance.
(to be published in Soryushiron Kenkyu)

YITP-W-03-21
Multi-quark Hadrons: four, five and more?, Feb.17, 2004 - Feb.19, 2004, organized by Teiji Kunihiro (YITP), Kenichi Imai, Tetsuya Onogi, Taichiro Kugo, Kunihiko Terasaki, Takashi Nakano. *105* attendance.

YITP-W-03-22
Explosive Phenomena in Magnetized Plasmas - New Development in Reconnection Research, Mar.17, 2004 - Mar.19, 2004, organized by Kazunari Shibata (Kyoto U). *100* attendance.

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3.3 Regional Schools supported by YITP

▷ 2001.4.1—2002.3.31

YITP-S-01-01
The 24th Shikoku seminar, Kochi University, 2001.4.3-4.
Invited speakers: A.Niegawa(Osaka City Univ), S.Wakaizumi(Univ. of Tokushima), Y.Ezawa (Ehime Univ.), K.Koike (Kagawa Univ.), K.Ohkuma (Kobe Univ.), N.Yamada (Ehime Univ)
Participating univ.: Kochi Univ., Kochi Women's Univ., Univ. of Tokushima, Ehime Univ.

YITP-S-01-02
Hokuriku School 2001, Fukui Prefectural Sabae Seinen no Ie, 2001.5.25-27.
Invited speakers: S.Horiuchi (Kyoto.Univ), S.Katsumoto(Univ. of Tokyo), M.Tanimoto (Niigata Univ.), H.So (Niigata.Univ), H.Nakano (Niigata Univ), Y.Igarashi (Niigata Univ), K.Itoh (Niigata Univ.), M. Hirayama (Toyama Univ.)
Participating univ.: Kanazawa Univ., Niigata Univ., Fukui Univ., Toyama Univ.

YITP-S-01-03
Local school organized by nuclear theory group in Kyushu and Yamaguchi, Aso, Kyushu, 2001.6.2-3.
Invited speakers: A.Ohnishi (Hokkaido Univ.)
Participating univ.: Yamaguchi Univ., Kyushu Univ., Kyushu Inst. Of Technology, Fukuoka Univ.

YITP-S-01-04
Takikawa01 –15th Workshop in Hokkaido Nuclear Theory Group–, Takikawa, Hokkaido, 2001.8.25-28.
Invited speakers: M.Asakawa (Kyoto Univ.), H.Hamagaki (Univ. of Tokyo)
Participating univ.: Hokkaido Univ., Hokusei Gakuen Univ., Wakkanai Hokusei Gakuen Univ.

YITP-S-01-05
Chubu Summer School on Particle Physics 2001, Shuzenji Youth Hostel (Shizuoka), 2001.8.30-9.2.
Invited speakers: J.Sato (Kyushu Univ.)
Participating univ.: Shinshu Univ., Tokai Univ., Shizuoka Univ., Shizuoka Prefectural Univ.

YITP-S-01-06
Lectures of Lattice Gauge Theories and Simulation, Niigata Univ., 2001.9.11-13.
Invited speakers: T.Onogi (YITP)
Participating univ.: Niigata Univ. Kanazawa Univ.

YITP-S-01-07
The Gamma-Ray Bursts:thoretical modeling, Yamagata Univ., 2001.9.13.
Invited speakers: T.Nakamura (YITP)
Participating univ.: Yamagata Univ.

YITP-S-01-08
Niigata-Yamagata school, Iide, Yamagata, 2001.11.9-11.
Invited speakers: M.Bando (Aichi Univ.), H.So (Niigata Univ.)
Participating univ.: Niigata Univ., Yamagata Univ., Joetsu Univ. Of Edu., Ohu Univ.

YITP-S-01-09
Shinshu Winter School 2002, Dormitory of Ochanomizu women university in Shiga-Kogen (Nagano), 2002.3.7-10.
Invited speakers: M.Sakamoto (Kobe Univ.), K.Aoki (Kanazawa Univ.)
Participating univ.: Kanazawa Univ., Niigata Univ., Shinshu Univ., Toyama Univ.

▷ 2002.4.1—2003.3.31

YITP-S-02-01
The 25th Shikoku-seminar, Univ. of Tokushima, 2002.4.2-3.
Invited speakers: K.Sasaki (Yokohama National Univ.)
Participating univ.: Tokushima Univ., Ehime Univ., Kagawa Univ., Kobe Univ.

YITP-S-02-02
The XXX Hokuriku School for Particle Physics, Myoko National Children's Center (Niigata), 2002.5.17-19.
Invited speakers: Y.Okada (KEK)
Participating univ.: Fukui Univ. , Kanazawa Univ.

YITP-S-02-03
Chubu Summer School 2002, Tsumagoi Training Center (Tokai Univ.), 2002.8.30-9.2.
Invited speakers: N. Sakai (Tokyo Inst. of Technology)
Participating univ.: Shinshu Univ., Tokai Univ., Shizuoka Univ., Shizuoka Prefectural Univ.

YITP-S-02-04
Takikawa01 –16th Workshop in Hokkaido Nuclear Theory Group–, Hokkaido Univ.(8.19-20), Toyako Hotel (8.21-22), 2002.8.19-22.
Invited speakers: Y.Shimizu (Kyushu Univ.), A. Ozawa (RIKEN)
Participating univ.: Hokkaido Univ., Hokusei Gakuen Univ., Wakkanai Hokusei Gakuen Univ.

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YITP-S-02-05
Niigata-Yamagata School, Iide, Yamagata., 2002.11.8-10.
Invited speakers: S.Tanimura (Kyoto Univ.)
Participating univ.: Niigata Univ., Yamagata Univ., Ohu Univ.

YITP-S-02-06
Shinshu Winter School 2003, Dormitory of Ochanomizu women university in Shiga-Kogen (Nagano), 2003.3.6-9.
Invited speakers: S.Hashimoto (KEK)
Participating univ.: Kanazawa Univ., Niigata Univ., Shinshu Univ., Toyama Univ.

▷ 2003.4.1—2004.3.31

YITP-S-03-01
The 26th Shikoku-seminar, Kagawa Univ., 2003.4.3-4.
Invited speakers: K-I. Kondo (Chiba Univ.)
Participating univ.: Tokushima Univ., Ehime Univ., Kagawa Univ., Kochi Univ.

YITP-S-03-02
Hokuriku-Sinetsu particle physics theory group meeting, Tateyama Shounen no Ie (Toyama), 2003.5.16-18.
Invited speakers: J. Sato (Saitama Univ.), S. Kakei (Rikkyo Univ.)
Participating univ.: Saitama Univ., Niigata Univ., Rikkyo Univ., Kanazawa Univ.

YITP-S-03-03
Chubu Summer School 2003, Yamanakako Seminar House (Tokai Univ.), 2003.8.28-31.
Invited speakers: Y. Matsuo (Univ. of Tokyo)
Participating univ.: Univ. of Tokyo, Shizuoka Univ., Shizuoka Prefectural Univ., Shinshu Univ.

YITP-S-03-04
Niigata-Yamagata school, Iide, Yamagata., 2003.11.7-9.
Invited speakers: J.Nishimura (KEK)
Participating univ.: Niigata Univ., Yamagata Univ., KEK, Joetsu Univ. of Edu.

YITP-S-03-05
Shizunai'03 –17th Workshop in Hokkaido Nuclear Theory Group –, Shizunai, Hokkaido, 2004.1.9-12.
Invited speakers: T. Suzuki (Tokyo Metro. Univ.)
Participating univ.: Tokyo Metro. Univ., Osaka Univ., Hokkaido Univ., Univ. of Tokyo

YITP-S-03-06
Shinshu Winter School 2004, Dormitory of Ochanomizu women university in Shiga-Kogen (Nagano), 2004.3.18-21.
Invited speakers: N.Maekawa (Kyoto Univ.)
Participating univ.: Kyoto Univ., Kanazawa Univ., Shinshu Univ., Toyama Univ