

IPMU ANNUAL REPORT 2008

October 2007—March 2009



IPMU

INSTITUTE FOR THE PHYSICS AND
MATHEMATICS OF THE UNIVERSE



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History of IPMU

(October 2007 - March 2009)

- 2007 Oct Launch of IPMU under WPI Program of MEXT
- 2007 Dec Focus Week: LHC Phenomenology
- 2008 Jan Hirosi Ooguri Wins Inaugural Leonard Eisenbud Prize
- 2008 Mar IPMU Opening Symposium and Reception
Focus Week: Neutrino Mass
Masahiro Takada Wins ASJ Young Astronomer Award
Humboldt Research Award to Hirosi Ooguri
External Advisory Board Meeting
Asian Mathematicians and Theoretical Physicists Conference
- 2008 Apr Site Visit by JSPS and MEXT
- 2008 May First WPI Follow-up Meeting
Moonshiney Conference
- 2008 Jun Focus Week: Second Workshop on LHC Phenomenology
- 2008 Jul Public Lecture for Kashiwa Citizens at Kashiwa Campus
- 2008 Aug IUPAP Young Scientist Prize to Naoki Yoshida and Eiichiro Komatsu
- 2008 Sep Focus Week: Quantum Black Hole
Workshop on Micro-local Analysis of Symplectic Manifolds
Kamioka Satellite Office Opens
- 2008 Oct One Year Anniversary of IPMU: Press Conference and Reception
Yukawa-Kimura Prize to Shigeki Sugimoto
- 2008 Nov Focus Week: Messengers of Supernova Explosions
External Advisory Board Meeting
- 2008 Dec Site Visit by JSPS and MEXT
Inoue Science Prize to Masayuki Nakahata
JSPS Prize to Kunio Inoue
- 2009 Jan Construction of New IPMU Building Began
Public Lecture at Yayoi Hall of Hongo Campus
- 2009 Feb "Science Cafe - Universe" (5 public lectures in 5 weeks during February and March)
at Tama Rokuto Science Museum
- 2009 Mar Focus Week: Determination of Masses and Spins of New Particles at the LHC

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Editorial board members

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1. Mission

The Institute for the Physics and Mathematics of the Universe (IPMU) was launched in October 2007, as one of the World Premier International Research Center Initiative (WPI) of the Ministry of Education, Culture, Sports, Science and Technology (MEXT). This new research institute will integrate the traditionally separate disciplines, mathematics, statistics, theoretical and experimental physics, and astronomy, with a new organizational structure to address deep mysteries of the universe.

What is the universe made of?

How did it begin?

What is its fate?

What fundamental laws govern it?

Why do we exist at all?

The aim of IPMU is to address these rather simple questions human beings had pondered for millennia using the power of forefront science. For example, we have learned amazing facts about the universe in the last ten years. Much of the component of the universe is not made of the kind of matter we know well, namely atoms, but rather of substances called dark matter and dark energy. Their true identity, called “dark” because they don’t emit light and therefore we can’t see directly, is totally unknown at this moment. To address such deep mysteries we need to create new data, to develop new statistical methods to analyze them, to build new physical theories to understand them, and create new mathematics to formulate them.

The IPMU scientists will advance their research by exploiting the giant Subaru telescope built by Japan to “observe” the dark sector of the universe, and the Large Hadron Collider (LHC) that smashes protons at extremely high energies to mimic the condition of the Big Bang. They will also fully utilize the Super-Kamiokande experiment to better understand neutrinos and the puzzle of vanished anti-matter in the universe, and initiate new experiments, for example, to reveal the identity of the dark matter. In addition to this multifaceted experimental approach to the mysteries of the universe, we will pursue new theories of the universe by close collaboration of theoretical physics and advanced mathematics.



■ Figure 1: Hitoshi Murayama, IPMU Director



2. Introduction

This report covers the progress of IPMU during the period of October 2007 and March 2009 corresponding to a latter half of JFY 2007 and a whole of JFY 2008. The IPMU, starting from zero at the time of its launch in October 2007, now has 125 scientific staff, including joint appointments and long term visitors, and 33 administrative staff, including 22 research support staff. Mandate imposed by the WPI to establish an institute which is "visible worldwide" is comfortably fulfilled by the fact that 54% of the 46 full-time scientific staff are non-Japanese. Moreover, 48% of the 33 administrative staff are bilingual.

IPMU had active one and half year. We hosted 11 international conferences and 180 seminars. Among the 540 visitors, 168 came from abroad. A total of 178 papers have been written, and 70 were published in refereed journals. IPMU scientists received several honors and awards. H. Ooguri received the inaugural Eisenbud Prize and the 2009 Humboldt Research Award. S. Sugimoto received the 2008 Yukawa-Kimura Prize. The 2008 IUPAP Young Scientist Prize was awarded to N. Yoshida in computational physics, and to E. Komatsu (U Texas, joint appointment with IPMU) in astrophysics. M. Nakahata received the 2008 Inoue Prize, and K. Inoue received the 2008 JSPS Prize. IPMU has been engaged in aggressive communications with scientific community, with funding agencies, and with general public.

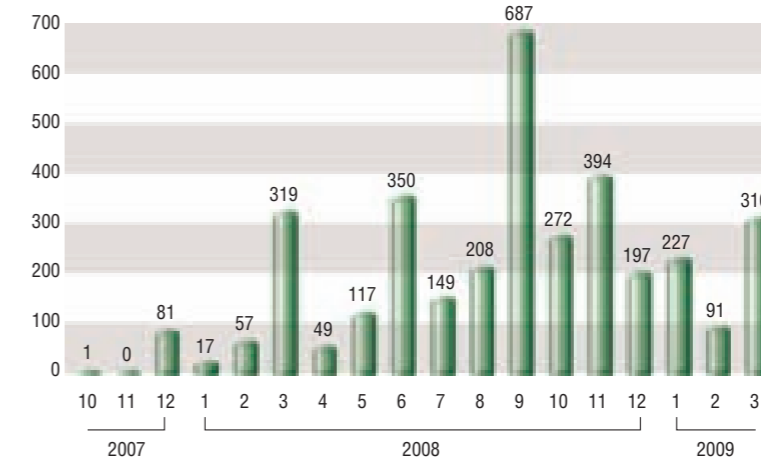
■ Table 1: Number of IPMU Research staff

	Number	Foreign	Female
Principal Investigators	20	3	1
Faculty (not including 4 PIs)	15	3	0
Postdoctoral Fellows	21	17	3
Joint Appointments	49	19	1
Long-term Visitors	14	13	1
Students	6	5	0
Total	125	60	6

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Visitor x Day vs Month



■ Figure 2: Number of visitor times day per month

3. Organization

■ Table 2: Research Activities at IPMU in JFY2007 and JFY2008

	JFY2007	JFY2008
Conferences	4	7
Seminars	24	156
Visitors (foreign)	168 (65)	372 (103)
Preprints	30	148
Publications	2	68

The construction of anxiously waited new laboratory building began in January 2009 on the ground of Kashiwa campus. An expected completion date is October 2009. For the past one and half years, we have been forced to work in offices at Kashiwa campus that are scattered around in the General Research Building and several temporary buildings behind it. The new laboratory building was designed with a strong emphasis on active interactions among the researchers. We look forward to establishing a center where on-site researchers and visitors, physicists and mathematicians, gather and engage in active discussion. The construction of new Kamioka Satellite Office was completed in February 2009. Located near the Kamioka Observatory of ICRR, it provides support for IPMU's experimental activities that are conducted at Kamioka.



■ Figure 3: Aerial view of the Kashiwa campus.



■ Figure 4: IPMU temporary buildings.



■ Figure 5: The Kamioka Satellite Office building.



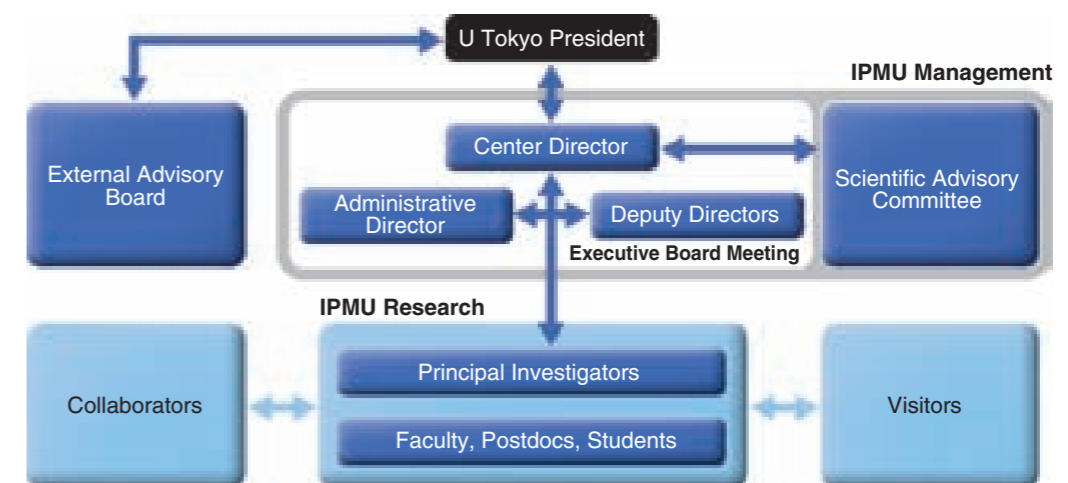
■ Figure 6: New laboratory under construction.

The IPMU Director is appointed by the President of the University of Tokyo and reports directly to the President. The Director has a complete authority of making a wide range of decisions including proposing recruitment of the Principal Investigators to the President, and appointing other research staff and administrative staff. The Director is assisted by two Deputy Directors and Administrative Director. They hold the Executive Board Meeting (EBM) regularly to ensure smooth operation of the Institute. The EBM has direct access to the Office of the President for consultations on both scientific and administrative matters.

The Scientific advisory Committee (SAC) gives advice to the Director on hiring scientific staff and setting scientific strategies. As of August 2008, the members consist of two Deputy Directors and five among IPMU's twenty Principal Investigators (T. Kohno, H. Ooguri, K. Saito, D. Spergel, T. Yanagida), all appointed by the Director.

The External Advisory Board (EAB), appointed by the University President, reviews annually the scientific achievement and activities of the Institute and advises the President on scientific priorities and the research activities to keep the Institute stay on the course of their objectives.

IPMU has rather unique approach in organizing the research objectives, where the world's leading scientists in their research fields are appointed as the Principal Investigators. There are twenty of them at the moment and they are affiliated to IPMU and other departments in the Host Institution (U of Tokyo) as well as other institutions. The Principal Investigators have a large autonomy in the research they conduct. They can make proposals to the Director to hire research staff at IPMU to help their research. The Director's approval on the proposed appointments will reflect the scientific vision and priorities set by the Director, who may consult the SAC as needed.



■ Figure 7: IPMU's research activities are conducted with a flat organization comprising of principal investigators as a core, IPMU staff including junior researchers, collaborators, and visitors.

4. Staff

■ Table 3: The EAB members as of August 2008

J. Ellis	CERN
M. Gonokami	U of Tokyo
N. Kaifu	NAOJ
Y.K. Kim	Fermilab/U of Chicago
S. Kojima	Titech
D. Morrison	UC Santa Barbara
R. Peccei	UCLA; Chair
N. Reshetikhin	UC Berkeley/U of Amsterdam

The administrative staff is an integral part of the Institute. Providing the best possible environment to the researchers in the Institute is essentially important for the IPMUs mission. This part is headed by the Administrative Director. Its function also enables the Director to spend more time to consider the Institute at large and focus on the direction of the research.

Director

H. Murayama, Theoretical Physics

Deputy Directors

H. Aihara, Particle Physics
Y. Suzuki, Observational Particle Physics

Principal Investigators

H. Murayama, Theoretical Physics
H. Aihara, Particle Physics
Y. Suzuki, Observational Particle Physics
M. Fukugita, Astrophysics
K. Inoue, Experimental Physics
M. Jimbo, Mathematics
T. Kajita, Experimental Physics
S. Katsanevas, Experimental Physics
T. Kohno, Mathematics
M. Nakahata, Experimental Physics
M. Nojiri, Theoretical Physics
K. Nomoto, Astronomy
H. Ooguri, Theoretical Physics
K. Saito, Mathematics
K. Sato, Astrophysics
H. Sobel, Experimental Physics
D. Spergel, Astrophysics
N. Sugiyama, Astrophysics
A. Tsuchiya, Mathematics
T. Yanagida, Theoretical Physics

Faculty Members

S. Hellerman, String Theory, Particle Physics
K. Hori, Theoretical Physics
S. Kondo, Mathematics
K. Maeda, Astrophysics
K. Martens, Experimental Physics
S. Mukohyama, Cosmology
H. Murayama, Theoretical Physics
K. Nomoto, Astronomy
K. Saito, Mathematics
S. Sugimoto, Theoretical Physics
M. Takada, Observational cosmology
F. Takahashi, Theoretical Physics
T. Takayanagi, Theoretical Physics
A. Tsuchiya, Mathematics
Y. Toda, Mathematics
M. Vagins, Experimental Physics
N. Yasuda, Astronomy
N. Yoshida, Astrophysics

T. Watari, Theoretical Physics

Postdoctoral Fellows

C. Bambi, Theoretical Physics
C.R. Chen, Theoretical Physics
D.A. Easson, Theoretical Particle Cosmology
S. Harashita, Mathematics
I. Kayo, (JSPS Fellow) Astrophysics
A. Kozlov, Experimental Physics
W. Li, Theoretical Physics
Y.T. Lin, Extragalactic Astrophysics
T. Nozawa, Astronomy
D. Orlando, Theoretical Physics
S.C. Park, Theoretical Physics
M. Pichot, Mathematics
B.A. Powell, Cosmology
S. Reffert, Theoretical Physics
K. Shackleton, Mathematics
K. Shimizu, (JSPS Grant-in-Aid), Astrophysics
J. Shu, Theoretical Physics
J. Schumann, Experimental Physics
J.Y. Tan, Cosmology
M. Valdes (JSPS Fellow)
K. Wang, Particle Phenomenology

Students

D.F. Gao (UC Berkeley), String Theory
T. Imoto (Nagoya), Astrophysics
W. L. Klemm (UC Berkeley), Theoretical Physics
S. Mandal (UC Berkeley), Theoretical Physics
V. Rantala (UC Berkeley), Theoretical Physics
J.V.M. Avelino (Valencia U), Theoretical Physics

Joint Appointments

K. Abe (Tokyo ICRR), Experimental Physics
P. Decowski (NIKHEF), Experimental Physics
M. Doi (U Tokyo), Astronomy
Y. Efremenko (U Tennessee), Experimental Physics
T. Eguchi (Kyoto YITP), Theoretical Physics
S. Enomoto (Tohoku U), Experimental Physics
A. Ferrara (S.N.S. Pisa), Astronomy
S. Freedman (LBNL), Experimental Physics
B. Fujikawa (LBNL), Experimental Physics
M. Fukushima (Tokyo ICRR), Experimental Physics
K. Hagiwara (KEK), Theoretical Physics
L. Hall (UC Berkeley), Theoretical Physics
K. Hamaguchi (U Tokyo), Theoretical Physics
Y. Hayato (Tokyo ICRR), Experimental Physics

5. Research Program

K. Heeger (Wisconsin), Experimental Physics
 R. Hirschi (U Keele), Astronomy
 J. Hisano (Tokyo ICRR), Theoretical Physics
 G. Horton-Smith (U Kansas), Experimental Physics
 S. Hosono (U Tokyo), Mathematical Physics
 K. Izawa (Kyoto YITP), Theoretical Physics
 K. Kaneyuki (Tokyo ICRR), Experimental Physics
 M. Kashiwara (Kyoto U), Mathematics
 M. Kawasaki (Tokyo ICRR), Theoretical Physics
 A. Kato (U Tokyo), Mathematical Physics
 E. Kearns (Boston U), Experimental Physics
 M. Koga (Tohoku U), Experimental Physics
 E. Komatsu (U Texas), Cosmology
 Y. Koshio (Tokyo ICRR), Experimental Physics
 T. Kubota (Osaka U), Theoretical Physics
 A. Kusenko (UCLA), Theoretical Physics
 M. Limongi (INAF Rome), Astronomy
 S. Moriyama (Tokyo ICRR), Experimental Physics
 T. Moroi (Tohoku U), Theoretical Physics
 K. Nakamura (Tohoku U), Experimental Physics
 T. Nakaya (Kyoto U), Experimental Physics
 S. T. Petkov (SISSA), Theoretical Physics
 A. Piepke (U Alabama), Experimental Physics
 Y. Saito (U Tokyo), Mathematics
 K. Scholberg (Duke U), Experimental Physics
 H. Sekiya (Tokyo ICRR), Experimental Physics
 M. Shiozawa (Tokyo ICRR), Experimental Physics
 M. Smy (UC Irvine), Experimental Physics
 J. Stone (Boston U), Experimental Physics
 Y. Takeuchi (Tokyo ICRR), Experimental Physics
 A. Taruya (Tokyo RESCEU), Astrophysics
 E. L. Turner (Princeton U), Astrophysics
 C.W. Walter (Duke U), Experimental Physics
 J. Yokoyama (Tokyo RESCEU), Astrophysics
 K. Yoshikawa (U Tokyo), Mathematics

Long-term Visitors (more than 1 month)
 J. Alwall, Stanford (US)

M. Bersten, Chile (Chile)
 S. Blinnikov, ITEP (Russia)
 A. Bondal, Aberdeen (UK)
 S. Gorchinskiy, Steklov Math Inst (Russia)
 A. Hanany, MIT (US)
 M. Kiermaier, MIT (US)
 K. Nagamine, Nevada (US)
 I. Nisoli, Pisa (Italy)
 A. Rosly, ITEP (Russia)
 E. Sorokina, ITEP (Russia)
 M. Verbitsky, Moscow (Russia)
 J. Xiao, Tsinghua (China)
 F. Xu, Tsinghua (China)

Administrative Division (* section head)

Director K. Nakamura
Head T. Yamanaka
Chief A. Ito
General Management and Personnel
 F. Sakamoto*, N. Kurita, F. Miyazoe, M. Miura,
 Y. Enomoto, T. Shiga, K. Kawajiri
Salary and Travel Expenses
 K. Sunaga*, N. Ishida, H. Yoshida
International Relations
 M. Ozawa*, H. Furuya, R. Ujita, K. Hara,
 H. Kuboshima, M. Nishikawa
Finance Planning and Budget Control
 Y. Kato*, T. Yamanaka
Contract and Purchasing
 N. Abe*, H. Ezawa, S. Utsumi
Library K. Kubota
Computer and Network H. Tanaka, A. Tsuboi
Documentation K. Abe
Kamioka Satellite
 M. Nishikawa*, Y. Shimizu, M. Kanazawa,
 S. Higashi
Facilities N. Watanabe

Alternative Gravity Theories

Einstein's theory of relativity unifies a 3-dimensional space and a 1-dimensional time as a spacetime and describes gravity as a fabric of curved spacetime. This picture has been very successful in explaining and predicting many gravitational phenomena. Experimentally, however, we do not know how gravity behaves at distances shorter than 0.01 mm. At shorter distances, gravity may behave completely differently from what we expect. For example there may be hidden dimensions at short distances. In fact, many theories, including superstring theories and M-theory, require the existence of such extra dimensions. Extra dimensions may exist everywhere in our universe, but they are somehow hidden from us. One possibility recently investigated very actively is called the brane-world scenario. In this scenario our universe is supposed to be a 3-dimensional surface, called brane, floating in higher-dimensional space. Although we cannot see extra-dimensions directly, we may hope to detect some indirect evidence of extra-dimensions in high-energy experiments or cosmological observations.

Gravity at very long distances (for example, billions of light-years) may also be as weird as at short distances. Precision observational data recently revealed that the expansion of our universe is accelerating. If Einstein's theory is correct, this requires that more than 70% of our universe is filled with negative pressure, energy. This energy is named dark energy, but we do not know what it really is. This situation reminds us of a story in the 19th century: when the perihelion shift of Mercury was discovered, some people hypothesized the existence of an invisible planet called Vulcan, a so-to-speak dark planet, to explain the anomalous behavior of Mercury. However, as we all know, the dark planet was not real and the correct explanation was to change gravity, from Newton's theory to Einstein's. With this in mind, we wonder if we can change Einstein's theory at long distances to address the mystery of dark energy.

■ Table 4: Alternative Gravity Theories Group

Member	Main Interest
Cosimo Bambi	General Relativity. Examination of its predictions in contexts such as the universe and black hole physics.
Damien Easson	Alternatives to dark energy to explain the acceleration of the Universe. Constraining gravitational models using observational data and theoretical considerations.
Shinji Mukohyama	Brane world scenarios and the Higgs phase of gravity.
Seong Chan Park	Study of various approaches.
Naoshi Sugiyama	Testing alternative gravity theories using observational data.
Jun'ichi Yokoyama	Model building and constraints on dark energy.

Collider Phenomenology

IPMU collider phenomenology group members pursue a broad range of research in testing physics of the standard model and beyond standard model at the colliders, especially the CERN Large Hadron Collider (LHC). With the upcoming LHC turn-on in 2009, we will have great opportunities in exploring physics at the TeV scale. This machine will enable us to systematically investigate electroweak symmetry breaking, to probe new physics like low energy supersymmetry, extra dimensions or other unexpected exotics. Researchers in the group are now preparing the theoretical tools to investigate these exciting physics. We also seek the connection between collider physics and dark matter/cosmic ray physics.

■ Table 5: Collider Phenomenology Group

Member	Main Interest
Chuan-Ren Chen	Collider phenomenology of the Standard Model (SM) and Models Beyond the Standard Model (BSM).
Koichi Hamaguchi	BSM, in particular, SUSY models, their LHC phenomenology and application to cosmology (baryogenesis, BBN constraints, dark matter and its signatures).
Junji Hisano	Flavor physics and collider physics of BSM.
William Klemm	How to discover BSM and distinguish from one another at collider. Determination of spins of new particles.
Hitoshi Murayama	Determination of spin and mass of BSM particles.
Mihoko Nojiri	New physics searches and measurements at LHC
Seong Chan Park	Search for BSM, in particular, extra dimensions and black holes at the LHC. Search for golden channel for finding black holes at the LHC. MC generator for black hole events (BlackMax).
Vikram Renteria	Spin determination of new particles using quantum interference at the LHC.
Jing Shu	Physics of top, Z', and higgs.
Kai Wang	Search for BSM and test of SM at the LHC.

Dark Matter Experiment

We know that about 23% of the total energy and matter of the Universe is dark matter, but we do not know what that is made of. The aim of the dark matter search experiment, XMASS, is to directly observe interactions of the cold dark matter in the large detector placed underground and to reveal the character of dark matter -- its interactions, mass and so on. We use 1 ton liquid Xenon detector cooled down at the temperature of -100 degree Celsius and measure the scintillation light emanated from the interaction of the dark Matter in the detector. The experimental sensitivity is about 2 orders of magnitude better than the current best limit. We hope that we will step in to the discovery region.

In 2008, an underground cavity to house the experiment was completed and following that, the 10m high cylindrical water tank which contains 800 tons of water to shield gamma rays and neutrons from nearby rocks was constructed. The major parts of the detector will be constructed during the summer and autumn in 2009. We aim to start the experiment in November, 2009.

■ Table 6: Dark Matter Experiment Group

Member	Main Interest
Kai Martens	Identification of particle candidates for Dark Matter. Super low background experiments.
Shigetaka Moriyama	Direct detection of Dark Matter.
Masayuki Nakahata	Purification of Xenon for low background experiments.
Yoichiro Suzuki	Discovery of Dark Matter.
Yasuo Takeuchi	Dark Matter search at XMASS.

Inflation and Early Universe

The universe is expanding, and the further away a galaxy is the faster it is moving. We refer to this phenomenon as Hubbles law. This observation suggests that, if we could go back in time, the universe was once small, dense and extremely hot. The evolution of the early universe is described by the Friedmann-Lemaître-Robertson-Walker (FLRW) universe, a homogeneous and isotropic solution of the Einstein equations for general relativity, and the standard big bang theory is based on the FLRW universe. The Hubbles law, big bang nucleosynthesis (BBN) and the cosmic microwave background (CMB) radiation provide key support for the standard big bang theory. These three observations remain important tenets of the early Universe.

Despite its great success the big bang theory is plagued with serious theoretical issues such as the horizon problem, the flatness problem, and the monopole problem. Those problems are beautifully solved by the introduction of an inflationary expansion at the very early stage of the universe. What is more important about inflation is that quantum fluctuations of a scalar field driving the inflation (called an inflaton) generate tiny density perturbations, which can account for the seed of the structures such as galaxies and clusters of the galaxies seen in the current universe. The properties of the density perturbations depend on the inflation models, which can be studied via tiny inhomogeneities in the CMB temperature anisotropy.

The recent progress in observational techniques has enabled us to study the evolution of the early universe with unprecedented precision, and our understanding of the Universe has significantly increased. Nevertheless it is not fully known how the inflation occurred, how the universe was reheated after inflation, how the dark matter as well as the baryon asymmetry were created, whether there is large non-Gaussianity in the density perturbations or not, and so forth. We would like to tackle these questions in order to reveal how the universe evolved from the inflationary epoch into what it looks like at present.

Mathematics

In the 17th century, Newton found differential and integral calculus, giving a language and method to describe the law of dynamics in nature. This is a good example of mathematics providing the scientific community, and sometimes society in general, with a common language and method to describe phenomena in their study. This in turn helps to establish a mathematician's original concepts. Particularly in recent years the interaction between

■ Table 7: Inflation and Early Universe Group

Member	Main Interest
Cosimo Bambi	General Relativity. Examination of its predictions in contexts such as the universe and black hole physics.
Damien Easson	Building concrete models of inflation from string theory. Observable predictions of nonstandard inflationary theories.
Koichi Hamaguchi	BSM, in particular, SUSY models, their LHC phenomenology and application to cosmology (baryogenesis, BBN constraints, dark matter and its signatures).
Ken-iti Izawa	Gauge/gravity-mediated supersymmetry breaking, supersymmetric inflation, united models.
Takeshi Kobayashi	Cosmology of the early universe through string theory.
Shinji Mukohyama	Inflation and brane cosmology.
Hitoshi Murayama	Leptogenesis. Models of inflation.
Seong Chan Park	Two different types of inflation models, the orbifold GUT inflation and the theory with $f(\phi)R$ term, so called the nonminimal coupling term. The (p) reheating of the inflation theory with the non-minimal coupling term.
Brian Powell	Inflationary phenomenology, parameter estimation, and model building. Understanding inflation as a phenomenon arising from string theory and other extensions of the standard model of particle physics.
Naoshi Sugiyama	Setting constraints on the inflation models and early universe phenomena such as big bang nucleosynthesis by using observational data.
Fuminobu Takahashi	Mechanism of inflation and subsequent reheating processes. Origin of density perturbations and non-Gaussianity. Baryogenesis. Big Bang nucleosynthesis.
Jun'ichi Yokoyama	Inflation models. Generation of fluctuations. Stochastic inflation.

mathematics and physics has been in full flow.

Gauge theory, quantum field theory, general relativity, superstring theory and the theory of integrable systems in physics have provided major influences in the development of mathematics such as algebraic geometry, differential geometry, topology, representation theory, algebraic analysis and number theory. A large scale development has been newly emerging.

This close collaboration between mathematics and physics is particularly important for advancing the study of the concept of space and universe that have been developed by scientists such as Kepler, Newton, Gauss, Riemann, Maxwell, Einstein and many others.

For the past twenty years, methods of quantum field theory have had a major influence on mathematics. Since quantum field theory treats the differential and integral calculus of an infinite number of degrees of freedom, the rigorous development of quantum field theory in mathematics has yet to be established. Nevertheless, in these twenty years, a lot of concepts arising from quantum field theory such as quantum groups have had a major influence on modern mathematics and physics.

Mathematicians at IPMU are working to develop modern mathematics by closely working with physicists. The following are the fields of mathematics studied at IPMU.

Geometry:

Geometry studies various objects. In Euclidean geometry, beginning 2000 years ago, we treat triangles, lengths and angles. Since then the geometric objects we study have been widely

■ Table 8: Mathematics Group (Geometry)

Member	Main Interest
Shushi Harashita	Stratifications and foliations on the moduli space of polarized abelian varieties in positive characteristic and more generally Shimura varieties. Our researches are expected to contribute to establishing the Langlands correspondence, which is one of the main problems in number theory and arithmetic algebraic geometry.
Kentaro Hori	Mirror symmetry as a bridge between symplectic geometry and complex geometry, real algebraic geometry, homological algebra, and their application to string theory.
Shinobu Hosono	Mirror symmetry of Calabi-Yau manifolds, and its applications to Gromov-Witten theory.
Toshitake Kohno	Construction of topological invariants for braids, knots and 3 dimensional manifold based on quantum groups and conformal field theory. Algebraic structures of the homology of the loop spaces of configuration spaces.
Hiroshi Ooguri	Application of new mathematical techniques emerging at the interface of string theory and geometry to solve mysteries of quantum gravity.
Susanne Reffert	Calabi-Yau geometries in the framework of String compactifications.
Kyoji Saito	Construction of primitive forms and associated period maps by use of infinite dimensional Lie algebras (e.g. elliptic algebras and cuspidal algebras) and their representation theory. Partition functions of Ising models on (non-commutative) discrete groups and monoids.
Yoshihisa Saito	Representation theory of quantum groups and infinite dimensional Lie algebras, and related topics.
Yuji Sano	Canonical Kaehler metrics (especially Kaehler-Einstein metrics) and stability of manifolds in the sense of Geometric Invariant Theory.
Ken Shackleton	Large-scale geometry of groups (eg. mapping class groups), in the sense of Gromov combinatorial rigidity in families of groups hyperbolic and relatively hyperbolic groups.
Yukinobu Toda	Derived categories of coherent sheaves on algebraic varieties and the theory of stability conditions on them. It is motivated by several backgrounds, such as minimal model theory or homological mirror symmetry. Construction of generalized Donaldson-Thomas type invariants, counting semistable objects in the derived category.
Mikael Pichot	Nonpositively curved geometry and geometric group theory (especially CAT(0) and hyperbolic). Foliation theory and topological dynamical systems.
Akihiro Tsuchiya	Conformal field theory based on representation theory of infinite dimensional algebra and the theory of D-modules.

developed. In modern geometry, the most important geometric objects are the moduli spaces, the set of figures (manifolds) with some properties on which we put some new structures.

By using the new concepts of moduli, we can study new geometric objects such as black holes in general relativity and strings and branes in superstring theory.

There are many branches in geometry such as algebraic geometry, analytic geometry, differential geometry, symplectic geometry, algebraic topology, named according to the objects and methods for treating them. Recently, however, these various branches of geometries are deeply connected and influence each other, and individual researchers study them from many perspectives.

Quite recently the method of category arising from homological method in algebraic topology is developing strong interactions between mirror symmetry and duality theory arising from superstring theory. Furthermore the theory of quantum invariants of low dimensional manifolds has begun with the study of quantum theory such as integrable systems, soliton equations and the conformal field theory. These quantum invariants turn out to have a deep

connection with other quantum invariants such as Gromov-Witten-Thomas invariants arising from gauge theory in modern physics.

Algebra:

Algebra studies the system of numbers such as integers and polynomials. There are a number of branches of algebras that are divided by the objects and methods they treat. They are commutative algebra, number theory, non-commutative algebra and representation theory of various kinds of algebras.

Commutative algebra is important as a language and method to study algebraic geometry and number theory. Number theory has a long history as a study of properties of integers and prime numbers. The most important objects here are Galois groups. They are studied by using representations of Galois groups, realized as various cohomology groups on manifolds studied in arithmetic geometry. The famous conjecture due to Fermat was solved in the mid-1990s by using a relationship between zeta functions from representation theory of Galois groups and the distribution of prime numbers.

The zeta function in number theory resembles closely various kinds of partition functions that express energy distribution of physical systems. This is the origin of a deep interaction between mathematics and physics in arithmetic.

Representation theory studies non-commutative algebras by realizing them as linear operators on some infinite dimensional vector space. Quite recently, under physical influences, the representation theory of infinite dimensional algebra, such as Affine Lie algebras, Kac-Moody Lie algebras, Virasoro algebras, vertex operator algebras and various kinds of quantum groups has been developed. Another kind of representation theory as linear differential operators on some kinds of infinite dimensional homogenous spaces has been developed.

These connect analyses on various kinds of manifolds and the geometry of these manifolds quite deeply. The methods used are highly abstract and depend on various kinds of homological algebras. These are also related to superstring theory as a concept and method of analysis of infinite degrees of freedom.

■ Table 9: Mathematics Group (Algebra)

Member	Main Interest
Shushi Harashita	Stratifications and foliations on the moduli space of polarized abelian varieties in positive characteristic, and more generally Shimura varieties.
Satoshi Kondo	Arithmetic geometry. Use of tools from algebraic geometry to study problems in number theory.
Mikael Pichot	Bruhat-Tits buildings. Group theory and group algebras. K-theory, the Baum-Connes conjecture and the property of rapid decay. Noncommutative geometry.
Kyoji Saito	Construction of primitive forms and associated period maps by use of infinite dimensional Lie algebras (e.g. elliptic algebras and cuspidal algebras) and their representation theory. Partition functions of Ising models on (non-commutative) discrete groups and monoids.
Akihiro Tsuchiya	Conformal field theory based on representation theory of infinite dimensional algebra and the theory of D-modules.

Analysis:

Analysis studies differential and integral calculus. It is the most fundamental subject in mathematics.

The theory of a module over the ring of differential operators has been developed by Mikio Sato as a theory of D-modules. The theory of D-modules has a deep influence on the various areas of mathematics. For example, these theories have a deep influence on the theory of soliton equations such as K-dV equations arising from non-linear equations in physics.

Now the theory of D-modules and soliton equations has entered into the mainstream of modern mathematics and physics. In addition, this theory has developed with integrable systems such as 1-dimensional quantum many-body problems, 2-dimensional solvable lattice modules and conformal field theory. These theories give basic languages and methods to realize non-perturbative approaches of the superstring theory.

■ Table 10: Mathematics Group (Analysis)

Member	Main Interest
Michio Jimbo	Quantum integrable systems. Algebraic description of correlation functions of integrable 1D spin chains such as the XXZ chain.
Kentaro Hori	(2,2) and (0,2) superconformal field theories and conformally invariant boundary conditions.
Hiroshi Ooguri	Conformal field theories in diverse dimensions that are relevant to dynamics of strings and branes in superstring theory. Application of conformal field theory techniques to study the landscape of string vacua.
Domenico Orlando	Spin chains (XXZ model and related two-dimensional lattices) in connection to dimer models and topological strings.
Susanne Reffert	(Quantum) dimer models. (Quantum) crystal melting and spin chains.
Yoshihisa Saito	Representation theory of quantum groups and infinite dimensional Lie algebras and related topics.
Kenneth J. Shackleton	Geometric group theory. Hyperbolic and relatively hyperbolic groups. Low-dimensional topology. Teichmüller theory and mapping class groups. Curve complexes, pants complexes.
Tadashi Takayanagi	Solvable conformal field theories in their applications to the descriptions of tachyon condensation in string theory. Solvable matrix models and their application to non-perturbative formulations of quantum gravity.
Mikael Pichot	Measured dynamical systems. Representation theory. Functional analysis, operator algebras (C^* -algebras and von Neumann algebras)
Akihiro Tsuchiya	Conformal field theory based on representation theory of infinite dimensional algebra and the theory of D-modules.

Models beyond the Standard Model

After k_B , c and \hbar are set to unity, $[\text{length}] = [\text{energy}]^{-1}$ is the only dimension left in physics. The fundamental law of physics in nature has been probed down to the length scale of order $10^{-3} \text{ fm} = 10^{-8} \text{ \AA}$, which is equivalent to the energy scale of order $10^2 \text{ GeV} = 10^{11} \text{ eV}$. Nothing is known for sure yet, however, what is happening at even shorter distance scales.

Up to now, we have seen that a quantum field theory with quarks, leptons and vector bosons for three different forces describes reasonably well all the experimental data available so far. Among the vector bosons, however, those corresponding to the weak force (which is responsible for the β -decay of nucleons) are known to have masses. There are three such vector bosons, and they are called W^+ , W^- and Z bosons, or weak bosons, as a whole. From the consistency of quantum field theories, it is known that something must be behind the non-zero masses of these vector bosons. It has not been confirmed experimentally yet how these masses are generated.

What is called the Standard Model provides a simple theoretical idea how the weak bosons acquire masses. According to the Standard Model, the masses originate from condensation of quanta of a new scalar boson, called Higgs boson. The Higgs boson is the last missing piece of the Standard Model, and will be discovered in experiments in near future, if the weak bosons have masses through the mechanism predicted by the Standard Model.

Is that the end of the story? Maybe ..., but maybe not. Let us think about the following questions.

- The Higgs boson is the only scalar field in the Standard Model; all other dynamical degrees of freedom in the Standard Model are either fermions or vector fields. Why does the Standard Model has one scalar field, and just one? Why does its condensation develop?
- The Newton constant $G_N \simeq 6.7 \times 10^{-11} \text{m}^3 \text{kg/s}^2$ corresponds to an energy scale $1/\sqrt{G_N \hbar / c^3} \sim 10^{19} \text{ GeV}$. Why is there a huge hierarchy of order 10^{17} between this energy scale and the weak boson masses of order 10^2 GeV , and how can the weak boson masses remain so small under quantum corrections?

In order to solve these questions theoretically, various models beyond the Standard Model have been constructed so far, and we still continue to do so in quest of a better solution to these problems. Once we have concrete models, we can examine whether such models are really consistent with all the available experimental data, predict what kind of signals can be expected in future experiments, and even propose experiments to confirm such models.

The origin of the masses of the weak bosons is not the only puzzle of the Standard Model. It is known that huge fraction of the universe consists of dark matter and dark energy. It is very unlikely that dark matter is actually the ordinary matter particles in the Standard Model. This is where we find another motivation to extend the Standard Model. Our universe may have become so large because of an inflationary process in the early universe, and quantum fluctuations of a scalar field may become the fluctuations of density in the early universe, which eventually become galaxies and clusters of galaxies. So, here is another motivation to introduce a new degree of freedom and extend the Standard Model. Such cosmological issues as inflation, primordial density perturbations and dark matter motivate extensions of the Standard Model, and models in quantum field theories are *the* appropriate framework in order to work on these issues.

Recent reports of excess in high-energy cosmic ray fluxes, deviation from the Standard-

Model prediction of the anomalous magnetic moment of muon, and some other reports of deviations from the Standard Model predictions may also be indications of some physics beyond the Standard Model. We therefore seek for theoretical models that account for these phenomena.

We also address the following problems. The Standard Model is described by a quantum field theory with about 30 parameters, and the values of these parameters can be determined only by measuring them experimentally. Would it be possible to determine them theoretically, by considering theoretical frameworks that contain the Standard Model?

The thermal history of early universe is described very well by the Standard Model at least back to the era with the temperature of order MeV, but it is only with several input parameter values of initial condition of the universe. Those initial condition parameters include baryon asymmetry, normalization of density contrast and the amount of dark energy. How are these initial condition parameters set? Once again, it is impossible to think about such problems without a model that extends the Standard Model.

■ Table 11: Models Beyond the Standard Model Group

Member	Main Interest
Chuan-Ren Chen	Collider phenomenology of the Standard Model and models beyond the Standard Model, including SUSY and Little Higgs models. Examining the interplay between the LHC phenomenology and cosmology.
Damien Easson	Physics beyond the standard model to explain the origin of the dark components of the Universe.
Koichi Hamaguchi	SUSY models and their LHC phenomenology and application to cosmology (baryogenesis, BBN constraints, dark matter and its signatures).
Junji Hisano	Supersymmetric models. Search for clues in accelerator and non-accelerator physics. Construction of realistic models at TeV and at GUT scales.
Ken-iti Izawa	Gauge/gravity-mediated supersymmetry breaking. Supersymmetric inflation. United models.
William Klemm	Signatures from various beyond the standard models. Distinguishing from one another at a collider. Determination of spins of new particles.
Sourav Mandal	Addressing questions in particle phenomenology. Dark matter candidates and their experimental signatures.
Hitoshi Murayama	Supersymmetry breaking models and phenomenology.
Hiroshi Ooguri	General constraints on low energy effective theories that arise from superstring theory or any other consistent theory of quantum gravity. Supersymmetry breaking mechanisms in gauge theories and superstring theory.
Seong Chan Park	Various ideas of the BSM: warped extra dimension, model of EWSB in the context of Gauge-Higgs unification, orbifold GUT, little Higgs etc.
Vikram Rantala	Spin determination using quantum interference at the LHC.
Jing Shu	Warped extra dimension models. Strongly coupled theory.
Fuminobu Takahashi	Supersymmetry. Link between supersymmetric models and cosmology, such as SUSY breaking, dark matter, and SUSY inflation models.
Kai Wang	Model building of BSM physics, particular SUSY models as well as neutrino models. Their collider tests at the CERN LHC.
Taizan Watari	Model building and phenomenology beyond the Standard Model in general. SUSY breaking and mediation, flavor pattern, GUT, inflation, Peccei-Quinn axion, quintessence, landscapes.
Tsutomu Yanagida	PAMELA and ATIC data searching for a convincing model that explains the observed anomalies.

Neutrino Physics

What are the building blocks of nature? Most people have heard of electrons, which are indeed (as far as we can tell) fundamental particles, as well as protons and neutrons, which are themselves composite objects composed of much smaller fundamental particles called quarks. But there are much more unusual fundamental particles, too, and perhaps the most mysterious of these are the neutrinos.

The Standard Model of particle physics contains three generations of fundamental particles. In each of these generations, or families, there are two quarks and two much less massive particles called leptons. In the first family one such lepton is the electron, which carries an electric charge, and the other first-generation lepton is called the electron neutrino, which is electrically neutral. The second generation contains two more types of quarks, a charged lepton called the muon, and the muon neutrino, while the third family contains a final pair of quarks, a charged lepton called the tau, and a tau neutrino.

The three types of neutrinos, the electron neutrino, the muon neutrino, and the tau neutrino, are exceedingly challenging to study, because they hardly interact with matter at all. That means neutrino detectors need to be very big, very sensitive, or both. At IPMU we have teams of researchers working on some of the best and most famous neutrino detectors in the world.

The Super-Kamiokande [Super-K] detector is a 50,000 ton tank of water buried deep under the Japanese Alps. By studying neutrinos generated by cosmic ray interactions in the Earth's atmosphere, in 1998 Super-K made the stunning discovery that different types of neutrinos can spontaneously transform from one type to another, a process known as neutrino oscillation. This also implied that at least two of the three neutrinos have a small, but non-zero mass, something not predicted by the Standard Model. This was the first time since its inception that the Standard Model needed to be revised based on solid experimental data. In 2001 Super-K made a crucial contribution to the solution of the solar neutrino problem by indicating that solar neutrinos produced by the Boron-8 reaction in the Sun could change their flavor while in flight, and uniquely selected the large mixing angle solution to the problem. IPMU members are now working on GADZOOKS!, an initiative to enrich the ultrapure water inside Super-Kamiokande with the element gadolinium. This will greatly reduce backgrounds and, among many other physics benefits, should allow the first-ever detection of a constant stream of neutrinos from distant supernovas.

The KamLAND neutrino detector is located in the same ancient zinc mine as Super-Kamiokande, but instead of water it is filled with 1,000 tons of liquid scintillator. This makes it very sensitive, especially to low energy neutrinos from nuclear reactors and those generated by radioactive decays within the Earth itself. In 2002 KamLAND was the first experiment to observe disappearance of reactor neutrinos, which matched other experiments' solar neutrino data in spectacular fashion. After lowering the energy threshold at which their data could be analyzed, in 2005 KamLAND was the first experiment to detect geoneutrinos, ushering in an entirely new way to study the Earth's interior. Also in 2005, KamLAND saw evidence of spectral distortions in the reactor neutrino signal; clear proof of neutrino oscillations. IPMU members are currently working on modifying KamLAND to detect very low energy solar neutrinos produced

by the Beryllium-7 reaction in the Sun, as well as transforming the KamLAND detector into a huge neutrinoless double beta decay experiment via the addition of Xenon-136 to the detector volume.

As we continue to understand the mysterious neutrinos, as well as the varied processes which produce them within the Earth, upon the Earth, above the Earth, within the Sun, and inside exploding stars, IPMU researchers are using these tiniest of particles to probe the most inaccessible places and farthest reaches of the universe itself.

■ Table 12: Neutrino Physics Group

Member	Main Interest
Kunio Inoue	Neutrino oscillation. Neutrino geophysics. Neutrino astrophysics. Neutrinoless double beta decay. Directional measurement of anti-neutrinos.
Takaaki Kajita	Atmospheric neutrino. Long baseline experiments. Neutrino oscillations.
Kai Martens	Super-Kamiokande experiment for detecting neutrinos from galactic supernova (type II) explosion.
Hitoshi Murayama	Neutrino oscillation phenomenology. KamLand.
Masayuki Nakahata	Boron-8 solar neutrino measurement by Super-Kamiokande detector. Precise measurement of the energy spectrum for the confirmation of matter effect of the neutrino oscillation.
Jan Schuemann	Improving the Super-Kamiokande detector by introducing Gadolinium. Detection of neutrinos from distant supernovae.
Henry W. Sobel	Super-Kamiokande and T2K experiments. Neutrino physics. Supernova. Proton decay.
Yasuo Takeuchi	Low-energy neutrino observations in Super-Kamiokande.
Mark Vagins	Measurements of neutrinos and antineutrinos from supernovae, the sun, and nuclear power reactors. T2K experiment. GADZOOKS experiment.

Observational Cosmology

Understanding the nature and origin of large-scale structure in the Universe is one of most compelling issues in observational cosmology. The currently most conventional scenario is given by the cold dark matter (CDM) dominated model, where gravitational instability mainly driven by spatial inhomogeneities of CDM distribution amplifies the seed density perturbations to form the present-day hierarchical structures. Therefore revealing distribution and amount of CDM is crucial to understanding the formation of large-scale structure. In addition the presence of dark energy drives the accelerating cosmic expansion, and therefore affects the growth of structure formation. The dark matter distribution and the nature of dark energy can be explored from massive galaxy surveys. We have worked on measurements from current surveys and are actively involved in the planning and design of the future survey with Subaru Telescope, 8.2 meter optical-infrared telescope at the summit of Mauna Kea (4,200m), Hawaii.

Weak gravitational lensing:

The path of light ray emitted by a distant galaxy is bent by gravitational force of intervening large-scale structure during the propagation, causing the image to be distorted - the so-called weak lensing shear. Conversely, measuring the coherent shear signals between

galaxy images allows us to reconstruct the distribution of invisible dark matter. Moreover, since the weak lensing shear deals with the light propagation on cosmological distance scales, the lensing strengths depend on the cosmic expansion history that is sensitive to the nature of dark energy. Thus weak lensing based observables offer a powerful way for studying the nature of invisible components, dark matter and dark energy. We are carrying out observational and theoretical studies of weak lensing phenomena using our own Subaru data sets as well as simulations of large-scale structure.

Hyper Suprime Camera (HSC):

The HSC, currently under construction, is the project to replace the prime focus camera of Subaru Telescope with a new camera that has wider field-of-view than the current one by a factor of 10. Fully utilizing the unique capabilities of HSC, its survey speed and excellent image quality, we are planning and designing a massive galaxy survey that covers an area of a few thousands square degrees and reaches to the depth to probe the Universe up to redshifts of a few. In fact these data sets will provide us an ideal data sets for exploring the nature of dark matter and dark energy via measurements of cosmological observables available from the data, weak lensing and galaxy clustering statistics. We, IPMU members, are actively involved in this HSC project, and working on the designing and planning of HSC galaxy survey and development of data analysis pipeline.

■ Table 13: Observational Cosmology Group

Member	Main Interest
Yen-Ting Lin	Formation and evolution of galaxies. Roles of galactic mergers and feedback from supermassive blackholes on the formation of giant galaxies. Data analysis of BOSS survey and radio surveys to elucidate the phenomenon of radio-loud active galactic nuclei. Evolutionary connections between galaxies at $z=0$ and $z=1$ using future HSC data.
Issha Kayo	Extraction of cosmological information from the large-scale structure of the Universe, particularly using the actual data taken by the Sloan Digital Sky Survey and virtual data generated by N-body simulations. Construction of a homogeneous catalog of gravitationally lensed quasars to constrain the dark energy.
Keiichi Maeda	Supernova cosmology, especially in the evaluation of applicability of Type Ia supernovae as cosmological distance indicators.
Takaya Nozawa	Evolution of dust throughout the cosmic history. Evaluation of the impacts of dust on the observational cosmology using Type Ia supernovae as a standard candle.
Jan Schuemann	Study of neutrino fluxes and their origin using Super-Kamiokande. Improving the Super-Kamiokande by adding Gadolinium.
Naoshi Sugiyama	Investigation of the Cosmic Microwave Background. Testing of dark energy models using observational data such as the baryon acoustic oscillation and gravitational lensing.
Masahiro Takada	Observational and theoretical studies of gravitational lensing caused by hierarchical structures of the universe. Nature of dark side of the universe, dark matter and dark energy, with the gravitational lensing observables. Future Subaru Weak Lensing Survey.
Jun'ichi Yokoyama	Analysis of CMB anisotropy.
Naoki Yoshida	Large galaxy surveys and weak lensing observations. Computer simulations to generate a large number of mock catalogues for future observational programs.

Sloan Digital Sky Survey III:

Over the next six years (2008-2014), the SDSSIII will exploit the unique wide-field spectroscopic capability of the Apache Point Observatory's 2.5-meter telescope, extending the previous SDSS surveys to a deeper universe with the improved spectrograph. We, IPMU members, are involved in SDSSIII and can freely access to the data sets before the public data release. In particular, one of the planned surveys, the Baryon Oscillation Spectroscopic Survey (BOSS) will map the spatial distribution of luminous galaxies and quasars to detect the characteristic scale imprinted by baryon acoustic oscillations in the early universe. Using the acoustic scale as a standard ruler, we can infer the angular diameter distance to the galaxy redshift, thereby enabling to test the models of dark energy. We are planning to develop an optimal method for measuring properties of galaxy clustering in order to obtain unbiased estimates on the acoustic scale as well as on cosmological parameters.

Proton Decay

The stability of the proton represents one of the greatest theoretical and experimental challenges in particle physics today. In most grand unified theories, particularly those with a TeV intermediate mass scale, the proton "wants" to decay. Experimentally, however, the proton seems determined to outlive us all. Beginning with the first large-scale searches in the 1980s, one promising theory after another has floundered on the shoals of nucleon decay. To date, no hint of a nucleon decay signal has emerged.

In spite of this, the study of nucleon decay provides one of the few approaches to the problem of confronting grand unified theories with experimental data, and any progress toward this goal has unique value for the future development of physics. This program has already been a success. The simplest unification model, minimal SU(5), has been ruled out by the experimental results. Every subsequent grand unification theory will remain only a mathematical construct if further experimental information is not available.

The search for nucleon decay requires massive detectors. A search with a sensitivity of 10^{33} years, for example, requires a detector with approximately 10^{33} nucleons. Since there are 6×10^{29} nucleons per ton of material, this implies detectors of multi-kiloton scale.

The "classical" proton decay mode, $p \rightarrow e^+ \pi^0$, can be efficiently detected with low background. At present, the best limit on this mode ($\tau / \beta > 8.2 \times 10^{33}$ yr, 90% CL) comes from a 141 kton-yr exposure of Super-Kamiokande. The detection efficiency of 44% is dominated by final-state π^0 absorption or charge-exchange in the nucleus, and the expected background is 2 events/Mton-yr.

Supersymmetric theories favor the mode $p \rightarrow \nu K^+$, which is experimentally more difficult due to the unobservable neutrino. The present limit from Super-Kamiokande is the result of combining several channels, the most sensitive of which is $K^+ \rightarrow \mu^+ \nu$ accompanied by a de-excitation signature from the remnant ^{15}N nucleus. Monte Carlo studies suggest that this mode should remain background free for the foreseeable future. The present limit on this mode is $\tau / \beta > 2.3 \times 10^{33}$ yr (90% CL).

Recent theoretical work suggests that if super-symmetric SO(10) provides the framework

for grand-unification, the proton lifetime (into the favored νK^+ decay mode) must lie within about one order of magnitude of present limits. Similarly, SO(10) theories suggest $\tau/\beta(e\pi^0)\approx 10^{35}$ years - about a factor of ten beyond the present limit. Thus, continued progress in the search for nucleon decay inevitably requires larger detectors.

Moreover, the enormous mass and exposure required to improve significantly on existing limits (and the unknowable prospects for positive detection) underline the importance of any future experiment's ability to address other important physics questions while waiting for the proton to decay. Proton decay experiments have made fundamental contributions to neutrino physics and particle astrophysics in the past, and any future experiment must be prepared to do the same.

■ Table 14: Proton Decay Group

Member	Main Interest
Takaaki Kajita	Updated searches for proton decays.
Jan Schuemann	Updated proton lifetime measurement using Gadolinium-enriched Super-Kamiokande.
Henry W. Sobel	Updated measurement of proton decay.
Mark Vagins	Improving the proton decay measurement in water-based detectors via detection of free neutrons significantly suppressing atmospheric neutrino-induced proton decay backgrounds. Development of next-generation, megaton-scale experiments for proton decay.

String Theory

In the past few hundred years, scientists have searched for fundamental laws of nature by exploring phenomena at shorter and shorter distances. Does this progression continue indefinitely? Surprisingly, there are reasons to think that the hierarchical structure of nature will terminate at 10^{35} meter, the so-called Planck length. Let us perform a thought-experiment to explain why this might be the case. Physicists build particle colliders to probe short distances. The more energy we use to collide particles, the shorter distances we can explore. This has been the case so far. One may then ask: can we build a collider with energy so high that it can probe distances shorter than the Planck length? The answer is no. When we collide particles with such high energy, a black hole will form and its event horizon will conceal the entire interaction area. Stated in another way, the measurement at this energy would perturb the geometry so much that the fabric of space and time would be torn apart. This would prevent physicists from ever seeing what is happening at distances shorter than the Planck length. This is a new kind of uncertainty principle. The Planck length is truly fundamental since it is the distance where the hierarchical structure of nature will terminate.

Space and time do not exist beyond the Planck scale, and they should emerge from a more fundamental structure. Superstring theory is a leading candidate for a mathematical framework to describe physics at the Planck scale since it contains all the ingredients necessary to unify general relativity and quantum mechanics and to deduce the Standard Model of particle physics. Superstring theory has helped us solve various mysteries of quantum gravity

such as the information paradox of black holes posed by Stephen Hawking. The theory has given us insights into early universe cosmology and models beyond the Standard Model of particle physics. It provides powerful tools study many difficult problems in theoretical physics - often involving strongly interacting systems - such as QCD (theory of quark interactions), quantum liquid and quantum phase transitions. It has also inspired many important developments in mathematics. All of these aspects of string theory are vigorously investigated at IPMU.

■ Table 15: String Theory Group

Member	Main Interest
Damien Easson	Building models of inflation from string theory. Time dependent solutions in string theory. Brane Gas model of string cosmology.
Dongfeng Gao	Mathematical aspects of string theory.
Simeon Hellerman	String theory and its connections to quantum gravity, cosmology, condensed matter, particle physics and mathematics. Development of tools to understand and apply string theory in generic environments.
Kentaro Hori	4d N=1 string compactifications in various frameworks, especially, worldsheet approaches to Type II orientifolds with D-branes and fluxes, M-theory on G_2 holonomy manifolds, worldsheet approaches to heterotic strings. Topological strings as well as supersymmetric gauge theories in various dimensions.
Shinobu Hosono	Mirror symmetry of Calabi-Yau manifolds and its applications to Gromov-Witten theory.
Toshiya Imoto	Holographic QCD.
Wei Li	Black holes. Gauge/Gravity correspondence. 3D quantum gravity.
Shinji Mukohyama	String cosmology.
Hiroshi Ooguri	Development of theoretical tools to apply string theory to questions relevant to high energy physics, astrophysics, and cosmology.
Domenico Orlando	Exact CFT solutions. Topological strings. Effective descriptions for M-theory.
Susanne Reffert	String compactifications. Topological string theory.
Ken Shackleton	Connection between string theory and the completion of the Weil-Petersson metric on Teichmueller space.
Shigeki Sugimoto	Conjectured duality between string theory and gauge theory, and its application to QCD and hadron physics.
Tadashi Takayanagi	String theory as quantum gravity especially from the viewpoint of holography such as AdS/CFT duality. Relation between the entanglement entropy and the gravitational entropy such as the black hole entropy.
Taizan Watari	String phenomenology. Inflation (in the past). GUT and F-theory compactification.

Structure Formation

There are rich structures in the present-day universe, such as stars, galaxies, and large-scale structure. We study how these objects are formed using large computer simulations and sophisticated theoretical models.

The standard Big Bang model posits that the universe was nearly homogeneous and very hot when it was born. Tiny "ripples" in the distribution of matter are generated through a rapid expansion phase called inflation in the very early universe. These primeval density fluctuations grow by the action of gravity, eventually forming luminous objects such as galaxies.

The energy content of the universe and basic statistic that describe the condition of the early universe have been determined with great accuracy from recent observations of cosmic microwave background radiation, large-scale galaxy distribution and distant supernovae. Cosmology is now at a stage where theory can make solid predictions, whereas a broad class of observations can be directly used to verify them.

Our primary interests are in primordial star formation in the early universe, the formation and evolution of galaxies, and the formation of large-scale structure. Results from these studies will be used for making good plans and proposals for next generation large observational programs such as Subaru-HSC dark energy survey.

■ Table 16: Structure Formation Group

Member	Main Interest
Issha Kayo	Extraction of cosmological information from the large-scale structure of the Universe, particularly using the actual data taken by the Sloan Digital Sky Survey and virtual data generated by N-body simulations. Construction of a homogeneous catalog of gravitationally lensed quasars to constrain the dark energy.
Naoshi Sugiyama	Investigation of linear evolution of structure in the universe and effect of magnetic fields.
Masahiro Takada	Observational and theoretical studies of gravitational lensing caused by hierarchical structures of the universe. Nature of dark side of the universe, dark matter and dark energy, with the gravitational lensing observables. Future Subaru Weak Lensing Survey.
Naoki Yoshida	Formation of stars, galaxies and the large-scale structure of the universe using supercomputer simulations.
Yen-Ting Lin	Atacama Cosmology Telescope (ACT) project, a large cluster survey that detects clusters via the Sunyaev-Zel'dovich effect (SZE). Analyses of the data from ACT, SDSS, and Subaru, to study the evolution of galaxies within clusters, as well as to use the statistical properties of clusters (such as clustering and abundance) to constrain cosmology.

Supernova

Supernovae are explosions of stars at the end of their lives. Core-collapse supernovae (Type II, Ib, and Ic) are the outcome of the gravitational collapse of massive stars (i.e., more than ten times as massive as the Sun), followed by formation of a neutron star or a black hole, announced by a huge amount of neutrinos. Thermonuclear supernovae (Type Ia) are explosions driven by nuclear reactions within a white-dwarf star.

Supernovae provide natural laboratories for a range of physical processes, such as neutrino physics, some of which can not be addressed by experiments on the Earth. Furthermore, they are the main contributors of heavy elements in the Universe; without them, baryons in the Universe would be only hydrogen, helium and some minor elements, although in reality the Universe is filled with about a hundred different sorts of elements. Their energy produced at the explosions is huge, and supernova explosions could play important roles even in formation and evolution of galaxies. Finally, importance of understanding their natures is highlighted by their use as cosmological distance indicators, leading to the discovery of the Dark Energy.

Our understanding of the above issues is still far from satisfying, with various issues still under investigation. At IPMU, we cover most of the topics related to supernovae; Evolution of stars toward supernovae (K. Nomoto), theory of core-collapse and explosion (K. Sato), theory of neutrinos from supernovae (K. Sato) and attempt to detect these neutrinos at Kamioka (M. Vagins), theory of thermonuclear explosion (K. Nomoto), nucleosynthesis of elements up to iron (K. Maeda) and beyond (S. Wanajo), formation of dust grains (T. Nozawa), theory of optical emission from supernovae and evaluation of their use as cosmological distance indicators (K. Nomoto, K. Maeda), and observations using the Subaru telescope (K. Maeda). By unifying these attempts, we aim to comprehensively understand supernovae and their influences on the evolution of the Universe.

■ Table 17: Supernova Group

Member	Main Interest
Keiichi Maeda	Theory of nucleosynthesis and radiation transfer. Observations of individual supernovae.
Masayuki Nakahata	Search for supernova neutrinos using Super-Kamiokande detector. It covers both supernova burst neutrinos and supernova relic neutrinos.
Ken'ichi Nomoto	Type Ia supernova cosmology to provide precision constraints on cosmic acceleration and the equation of state of dark energy by clarifying the progenitors and explosion mechanism. Evolution and nucleosynthesis of first stars to study cosmic chemical evolution. Gamma-ray bursts and hypernovae to clarify the production mechanisms of huge explosion energy from black holes and neutron stars.
Takaya Nozawa	Evolution of dust at high redshifts, considering the formation of dust in supernovae and destruction of dust in the shock driven by supernovae.
Jan Schuemann	Gadolinium-upgrade for Super-Kamiokande for observing neutrinos from supernova formations, past and present.
Henry W. Sobel	Super-Kamiokande and T2K for studying neutrino physics, supernova, and proton decay.
Yasuo Takeuchi	Real-time neutrino burst search in Super-Kamiokande.
Shinya Wanajo	Origin of elements that are synthesized in supernovae. Nucleosynthesis of r-process species (e.g., gold, platinum, uranium, etc.) in core-collapse supernovae.
Mark Vagins	Detection of the diffuse neutrino background produced by distant supernovae. Improvement of Super-Kamiokande experiment's response to the arrival of a burst of neutrinos from a supernova within our galaxy.

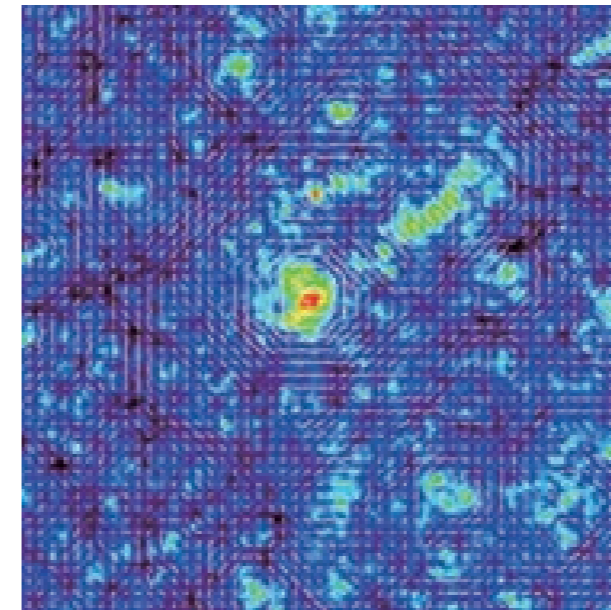
6. Research Highlight

Measuring dark matter distribution in a galaxy cluster region with gravitational lensing

Gravitational lensing is one of the most important predictions of Albert Einstein's gravity theory, General Relativity. When matter or energy (the two are equivalent in General Relativity) exists, the surrounding space-time is curved, and the strength of gravity is described by the curvature of space-time. When a light ray propagates through such a curved space-time, the light cannot travel straight and is bent, which is the so-called gravitational lensing. Conversely measuring the gravitational lensing allows us to recover the distribution of total matter whatever the matter is visible or not. Thus gravitational lensing thus opens up a window for unveiling the invisible matter in the universe, thereby allowing us to explore the nature of invisible mysterious components of the universe, dark matter and dark energy.

A cluster of galaxies containing from hundreds to thousands of galaxies within a region of a few Mpc scales in radius is the most massive, gravitationally bound objects in the universe. Thus galaxy clusters display most striking lensing phenomena. One of such examples is demonstrated in a simulated image of Figure 8, showing how galaxy images behind a cluster are affected by the gravitational lensing effect of a cluster. The gravitational lensing diffraction is slightly different for neighboring light rays on the sky due to the gradient of the gravitational field such that a light ray closer to the cluster center is more deflected by lensing and vice versa. As a result, the shape of distant galaxy image is slightly deformed or sheared by the lensing, which is the so-called weak lensing shear.

For each galaxy image, we cannot discriminate lensing distortion signal from its intrinsic shape as the galaxy shape is not circular and has various intrinsic shapes. However, as demonstrated in Figure 8, this gravitational shearing effect causes a coherent distortion pattern of background galaxy images. Galaxy images are preferentially deformed tangentially with respect to the cluster center, and this coherent signal can be discriminated in a statistical sense.



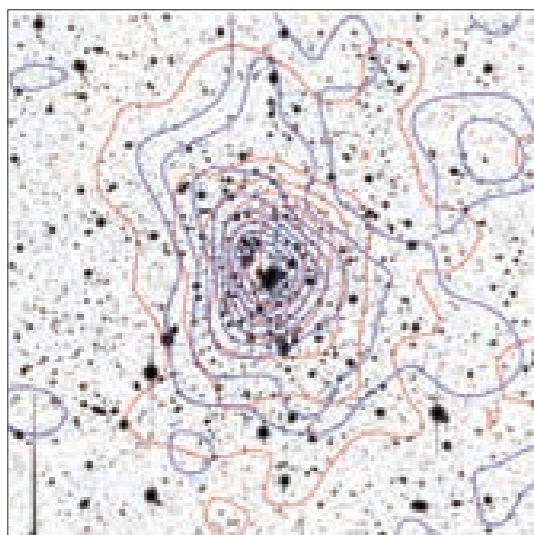
■ Figure 8: A simulation image of gravitational lensing in a cluster region (about 1 degree on a side). The color scales show the mass density field projected between galaxies of redshift 1 and an observer; the redder color region shows the region with higher mass density. This simulated region has a very massive cluster at the middle. The small rods at each position demonstrate that a background galaxy image is deformed along the rod. The size of rod corresponds to the strength of lensing distortion. It is clear that, around a massive cluster, background galaxy images are preferentially tangentially deformed with respect to the cluster center, thus causing characteristic coherent pattern of galaxy images. (Credit: T. Hamana, NAOJ)

Inversely, by measuring this coherent pattern of background galaxy images, we can recover the mass distribution in the cluster region in a model-independent way, which includes the contribution of dark matter.

This lensing signal is weak, but extends out to the whole region of a cluster, thereby providing a unique means of measuring the total matter distribution in the entire cluster region. To measure these weak lensing distortion signals, we need (1) to use as many galaxies as possible in order to extract the coherent shearing pattern of the images and (2) to measure the shapes of galaxy images with high precision. In these senses, the Subaru Telescope with 8.2m primary mirror in diameter and at the summit of 4,200m Mt. Mauna in Hawaii is the best instrument for measuring the weak lensing signals of galaxy clusters, thanks to its excellent image quality and photon collecting power (i.e. delivering deep images or many galaxies to be analyzed).

Masahiro Takada, together with a team of collaborators, has been carrying out a systematic study of cluster lensing by using the Subaru data. Figure 9 shows one example of our study, showing the mass distribution reconstructed from the measurement of weak gravitational lensing effects on background galaxies for the cluster A1689. The color image shows the Subaru imaging data, while the blue (thick) contours show the two-dimensional mass density field reconstructed from the lensing measurement. Note that each contour is stepped by the 1σ measurement error. It is clear that the mass density gets denser as one is approaching to the cluster center, and indeed peaks near to the cluster center (the center is inferred from the position of the brightest galaxy member).

The shape of mass distribution is not spherical and has an elongated structure, usually more elongated compared to the shape inferred from intracluster hot gas distribution observed via the X-ray and Sunyaev-Zel'dovich effect (radio) measurements. On the other hand, the red contours depict the distribution of member galaxies. The galaxy distribution appears to well follow the mass distribution. This agreement is much expected, because the member galaxies, once formed, interact with other components only via gravity and behave like collision-less particles like dark matter. Also the detailed analysis shows that the amount of total matter



■ Figure 9: The weak lensing measurement result for the cluster A1689. The gray image shows the Subaru imaging data of A1689, while the blue contours show the mass density field reconstructed from the measurement of weak lensing shearing effect on background galaxy images. The mass density field indeed gets higher towards the cluster center, and the properties of mass distribution is found to be in good agreement with the cold dark matter model predictions. On the other hand, the red contours show the distribution of member galaxies, which well follows the mass distribution as expected.

inferred from the lensing signal is much (by a factor 10) greater than the sum of member galaxies and intracluster hot gas, strongly suggesting the existence of invisible matter, i.e. dark matter on cluster scales.

These properties of mass distribution are found to be in good agreement with the predictions from cold dark matter dominated structure formation scenario. The model predictions are derived based on several critical assumptions: dark matter is cold (negligible intrinsic velocity dispersion) and interacts with other particles only via gravity. Therefore a detailed comparison of the reconstructed mass distribution with the theoretical predictions can be used to test the cold dark matter paradigm as well as to derive constraints on the nature of dark matter, which is the goal of our lensing study. The team is now collecting Subaru data of homogenous cluster sample (about 40 clusters as of May 2009) and will hopefully report the derived constraints on cold dark matter model in the near future.

Further reading: arXiv:0903.1103 (submitted to PASJ)

Protostar Formation in the Early Universe

Large modern-day telescopes have revealed distant astronomical objects that were in place when the universe was less than 1 billion years old. Nature of the universe during the period of a few hundred million year prior to that, however, remains largely unknown. It is generally thought that the universe soon after the Big Bang had only simple elements such as hydrogen and helium as a form of gas with no luminous stars. This period is sometimes referred to as "the cosmic dark age". How the first stars formed from the cosmic primordial gas has been a burning question for years. Knowing the answers to these questions is so important because their formations and eventual explosions provided the seeds for subsequent stars to come into being.

Naoki Yoshida, together with Kazuyuki Omukai of National Astronomical observatory of Japan and Lars Hernquist of Harvard-Smithsonian Center for Astrophysics, conducted a state-of-the-art computer simulation to study the formation of a proto-star which would eventually shine its light into this darkness.

Their simulations use the initial condition determined cosmologically and by now well established constituting the standard model of the universe. All other important basic physics such as gravitation, hydrodynamics, and atomic and molecular processes in a hydrogen-helium gas are well understood. The simulation follows these processes rigorously. Other complications that plague investigations of star formation in the local universe, such as the presence of strong magnetic fields or heavy elements, can be neglected at these early times. The simulation covers a dynamic range of 10^{13} , from a fraction of solar radius (10^{10} cm) to cosmological volume of hundreds of kiloparsecs (10^{23} cm). According to the standard model of the universe, the energy density is dominated by dark energy and cold dark matter. The simulation follows the gravitational collapse of dark matter.

They followed the evolution of dark matter and gas in a cube 200 comoving kiloparsecs on a side. A gravitationally bound dark-matter halo that formed in the volume at an epoch when the cosmological redshift was $z = 14$ is shown in Figure 10.

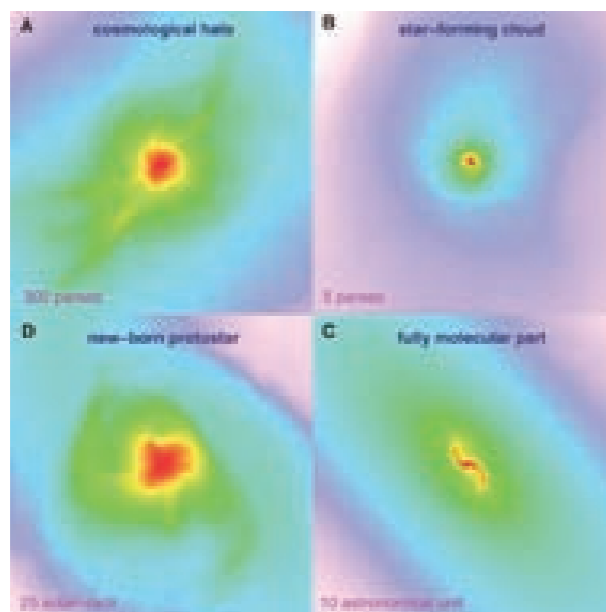
The mass of this halo (500,000 solar masses, M) and the physical conditions within it are particularly conducive for it to host a primordial star. The gas within this halo had a temperature of 1000 K, and a small mass of hydrogen molecules ($\sim 10^{-4}$ in number fraction) had already formed, enabling efficient radiation cooling. Through the action of radiative cooling, a star-forming gas cloud collected in the host dark halo. The subsequent thermal and chemical evolution of the primordial gas cloud were followed for more than 20 decades in density up to the epoch of protostar formation.

The structure in and around the newly formed protostar was rather complex (Fig.10D). At this time, there were substantial variations in density and temperature even in the innermost (10 solar radii) region. Clearly, the primordial protostar was not simply a sphere surrounded by a single accretion shock.

Within a mass of 0.1 M, two spiral arms rotated rapidly; the outer part (0.05 to 0.1 M) appeared nearly centrifugally supported, whereas the central part had gravitationally collapsed. The central core lost part of its angular momentum via gravitational torques exerted by nonaxisymmetric perturbations. The newly born protostar was supported by both thermal pressure and rotation. The overall velocity structure was characteristic of a collapsing gas with an initially slow rotation.

The results show a complete picture of how a primordial protostar with a mass 1% that of the Sun may have formed from tiny cosmological density fluctuations. If the gas surrounding the protostar accreted efficiently, the protostar would quickly grow to be as massive as 10 M within 1000 years. A detailed protostellar calculation for a similarly large accretion rate predicts that the mass of the star when it lands on the main sequence will be 100 M. The model provides a viable scenario for the early chemical enrichment in the universe by massive primordial stars, which is necessary for the formation of later populations of ordinary stars.

Further reading: Science 1 August 2008: Vol 321. no. 5889, pp. 669-671



■ Figure 10: Projected gas distribution around the protostar. (A) The large-scale gas distribution around the cosmological halo (300 pc on a side). (B) A self-gravitating, star-forming cloud (5 pc on a side). (C) The central part of the fully molecular core (10 astronomical units on a side). (D) The final protostar (25 solar radii on a side). The color scale from light purple to dark red corresponds to logarithmically scaled hydrogen number densities from 0.01 to 10^3cm^{-3} (A), from 10 to 10^6cm^{-3} (B), and from 10^{14} to 10^{19}cm^{-3} (C). The color scale for (D) shows the density-weighted mean temperature, which scales from 3000 to 12,000 K.

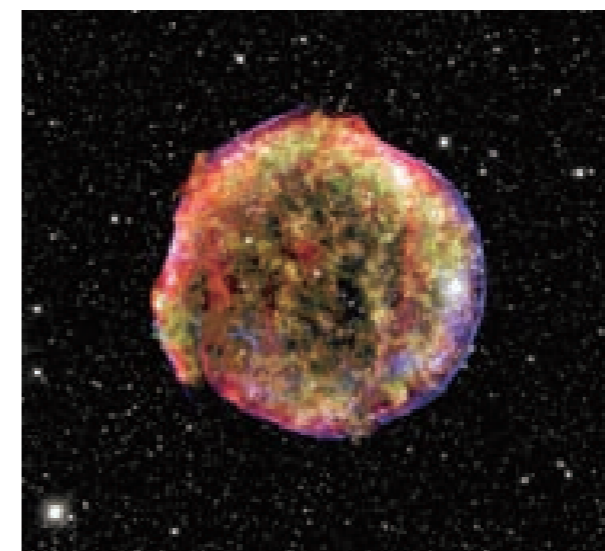
Light Echos of the 1572 Supernova

Astronomers at the Subaru Telescope went back in time and observed light from a “new star” that originally was seen on 11 November 1572 by astronomer Tycho Brahe and others. What Brahe observed as a bright star in the constellation Cassiopeia, outshining even Venus, was actually a rare supernova event where the violent death of a star sends out an extremely bright outburst of energy. He studied the brightness and color of the “new star” until March 1574 when it faded from view. The remains of this milestone event are seen today as Tycho’s supernova remnant (Figure 11).

On 24 September 2008, using the Faint Object Camera and Spectrograph(FOCAS) instrument at Subaru, the light echoes (Figure 12) were broken apart into the signatures of atoms (spectra) present when Supernova 1572 exploded, bearing all the information about the nature of the original blast. The results showed clear absorption of once-ionized silicon and absence of the hydrogen H-alpha emission. The findings were very typical of a Type Ia supernova (Figure 13).

During the study, the astronomers tested theories of the explosion mechanism and the nature of the supernova progenitor. For Type Ia supernovae, a white dwarf star in a close binary system is the typical source, and as the gas of the companion star accumulates onto the white dwarf, the white dwarf is progressively compressed, and eventually sets off a runaway nuclear reaction inside that eventually leads to a cataclysmic supernova outburst. However, as Type Ia supernovae with luminosity brighter/fainter than standard ones have been reported recently, the understanding of the supernova outburst mechanism has come under debate. In order to explain the diversity of the Type Ia supernovae, the team studied the outburst mechanisms in detail.

The comparisons with template spectra of Type Ia supernovae found outside our Galaxy shows that Tycho’s supernova belongs to the majority class of Normal Type Ia, and, as such, is thought to be one of the best candidates for Type Ia in our galaxy. This finding is significant because Type Ia supernovae are the primary source of heavy elements in the Universe, and



■ Figure 11: Image of Tycho’s Supernova Remnant: a color composite of various data. The remnant is approximately 25 light-year in diameter.

play an important role as cosmological distance indicators, serving as standard candles because of constant luminosity at the peak of their light curve. In addition, the team discovered that Supernova 1572 shows a hint of an aspherical/nonsymmetrical explosion, which, in turn, could put limits on explosion models for future studies.

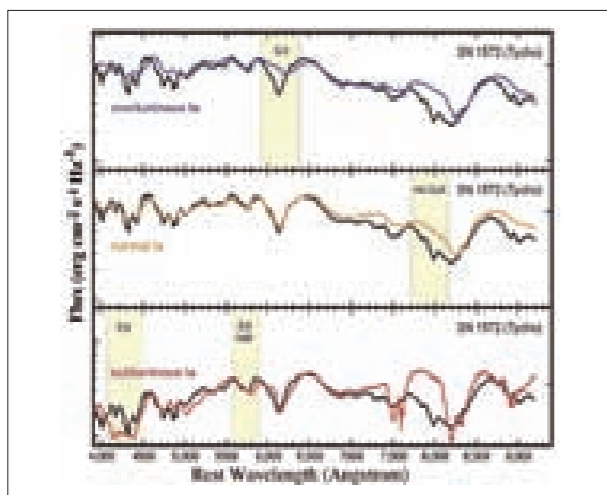
This observational study at Subaru established how light echoes can be used in a spectroscopic manner to study supernovae outburst that occurred hundreds of years ago. The light echoes, when observed at different position angles from the source, enabled the team to look at the supernova in a three dimensional view. For the future, this 3D aspect will accelerate the study of the outburst mechanism of supernova based on their spatial structure, which, to date, has been impossible with distant supernovae in galaxies outside the Milky Way.

The research was conducted by the team of IPMU (lead by Ken'ichi Nomoto), NAOJ and Max-Planck Institute.

Further reading: Nature 4 December: Vol. 456. pp. 617-619



■ Figure 12: The light echoes from Tycho's supernova. The optical light (blue) arrived at Earth in 1572. Optical light (yellow) was scattered by dust cloud around the supernova and arrived at Earth in 2008. Since the emitting regions were apparently shifted from 23 August 2008 to September 24, the optical lights (yellow) were confirmed as light echoes.



■ Figure 13: The spectrum of Tycho's supernova (the horizontal axis is the rest wavelength and vertical axis is flux). Black solid lines show the spectrum of Tycho's SN1572. Comparison with templates of subluminous, normal and overluminous type Ia supernova (upper: overluminous (blue), middle: normal (orange), bottom: subluminous (red)). The agreement between the black and orange lines indicates that the Tycho's supernova belongs to the majority class of normal Type Ia.

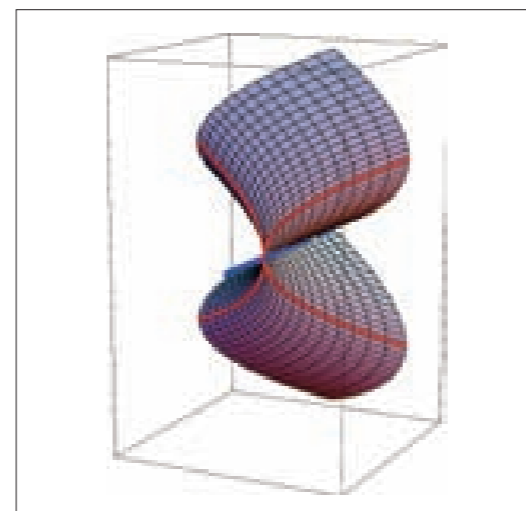
Heterotic F-Theory

Interactions of all elementary particles are known to be described by the Standard Model, which is a model of quantum field theory written in terms of various fields (such as quarks and leptons) and about 30 parameters. Values of these parameters control strength of forces and masses of various particles. Quantum field theories in general as a theoretical framework, however, does not tell anything about what the values of those parameters should be. Superstring theory, however, is a quantum theory that accommodates both gravity and field theories of elementary particles, and may have more theoretical predictive powers than quantum field theories in general.

Superstring theory is not fully understood yet, and is under intense investigation by scientists all over the world. Various formulations of superstring theory have been proposed, and "F-theory" is one of them. In F-theory, all the dynamical degrees of freedom (fields such as quarks and leptons) originate from fluctuations of geometry, and it is crucial to understand the precise relation between geometry and the degrees of freedom observed in physics, in order to derive theoretical predictions of the parameters of the Standard Model. An algebraic geometer Yukinobu Toda and a particle physicist Taizan Watari at IPMU cooperated to tackle this problem, in collaboration with Hirotaka Hayashi (U. Tokyo), Radu Tatar (U. Liverpool) and Masahito Yamazaki (U. Tokyo). They employed a string duality to study F-theory, examined structure of mathematical objects called "sheaves", and succeeded in determining the precise relation between geometric structures and various fields of the supersymmetric Standard Model (Fig.14) for the first time in the world. This study opened a new way to calculate values of the parameters of the Standard Model.

The string duality employed in this study is called Heterotic-F theory duality. It implies an equivalence between a quantum mechanical moduli space of a certain gauge theory and that of a certain geometry. The duality itself is not yet understood very well, and was also a subject of investigation. The joint collaboration of a mathematician and physicists also clarified various aspects of this duality, which is also interesting from mathematical point of view.

Further reading: Nuclear Physics B806 (2009) 224



■ Figure 14: Geometry of F-theory compactification is translated to differential equations that determine massless-mode wavefunctions in the internal space. The wavefunctions are used to calculate Yukawa couplings of quarks and leptons. The differential equation contains a potential term, and the potential varying over the internal space is determined from the original geometry. This figure shows behavior of the potential for the Higgs field (in the vertical axis) varying over the coordinates of the internal space (in the two horizontal directions) near a point where a D_5 singularity of the original geometry is enhanced to D_7 . Practical calculation of the massless-mode wavefunctions is made much easier by reducing this problem to an easy problem in algebraic geometry, which is to find holomorphic sections on a complex curve (blue in the figure). There, we only need to use the information that there are two red curves intersecting the blue curve at the pinch-point singularity.



■ Figure 15: The American Mathematics Society awarded the inaugural Leonard Eisenbud Prize to Hiroshi Ooguri (IPMU/Caltech), Andrew Strominger and Cumrun Vafa (Harvard) in January 2008. The AMS Eisenbud Prize was established in 2008 to honor works that strengthen the connection between mathematics and physics, once in every three years. Ooguri, Strominger, and Vafa used string theory and the forefront of high-dimensional geometry to study properties of small blackholes that are beyond the reach of Hawking's theory. Ooguri was also a recipient of the 2008 Humboldt Research Award for his work in developing a mathematical method in quantum field theory and string theory.



■ Figure 16: Shigeki Sugimoto was a co-recipients of the 2008 Toshiei Kimura theoretical physics Prize of Yukawa Foundation. It was shared with Tadakatsu Sakai of Ibaraki University. They developed an analysis technique "holographic quantum chromodynamics model based on gauge superstring theory/gravity correspondence" of strong interaction using superstring theory. This prize is given to those who made significant contribution in the area of gravity/space-time theory, field theory and related area in fundamental theoretical research, and are expected to continue to take leading role in the fields.



■ Figure 17: Masahiro Takada received the Astronomical Society of Japan Young Astronomer Award for his work on the dark matter. He has developed a theoretical method to probe dark matter using the gravitational lensing phenomenon predicted by Einstein's general theory of relativity. Takada has also led observations using the Hubble Space Telescope and the Subaru Telescope, and has successfully identified the distribution of the dark matter.



■ Figure 18: Naoki Yoshida received the International Union of Pure and Applied Physics (IUPAP) Young Scientist Prize in Computational Physics for his state-of-the-art computer simulation study on the large-scale structure of the universe.



■ Figure 19: Masayuki Nakahata received the 25th Inoue Prize for Science for his contribution on "Observation of solar neutrinos and their oscillations". He has been a senior member of the Kamiokande and Super-Kamiokande experiments.



■ Figure 20: Kunio Inoue received the 2008 JSPS Prize for his contribution on "Precision Measurement of Reactor Neutrino Oscillations". He has been a leader of KamLand project for detecting anti-neutrinos generated from the power reactors, successfully leading to the world highest precision determination of the mass difference between different types of neutrinos. Inoue has also been pioneering the research for detecting neutrinos from inside the earth.

7. Seminars

JFY2007

Oct 15, Shinobu Hosono, Univ. Tokyo
"Topics on string theory, mirror symmetry, and Gromov-Witten invariants"

Oct 29, Hiroshige Kajiura, RIMS Kyoto Univ.
"Some examples of triangulated and/or A_∞ -categories related to homological mirror symmetry"

Oct 30, Shigeki Sugimoto, IPMU
"String theory and QCD"

Dec 10, Dmitry Kaledin, Steklov Math Inst/Univ. Tokyo
"Deligne conjecture and the Drinfeld double"

Jan 8, Takada Masahito, Tohoku Univ.
"Gravitational lensing and dark matter and dark energy"

Jan 9, Naoki Yoshida, Nagoya Univ.
"Structure Formation in the Early Universe"

Jan 10, Tadashi Takayanagi, Kyoto Univ.
"Holography and Entanglement Entropy"

Jan 16, Matthew Buckley, Berkeley/IPMU
"Discriminating spin through quantum interference"

Jan 28, Jim Gunn, Princeton
"BOSS"

Feb 1, Jenny Greene, Princeton Univ.
"The Mass Function of Local Active Black Holes"

Feb 1, Mariska Kriek, Princeton Univ.
"AGNs and suppressed star formation in massive galaxies at $z \sim 2.5$ "

Feb 6, Hiroyuki Abe, YITP
"Moduli stabilization, F-term uplifting and sequestering in supergravity models"

Feb 12, Katrin Wendland, Augsburg Univ.
"How to lift a construction by Hiroshi Inose to conformal field theory"

Feb 13, Koichi Hamaguchi, Univ. Tokyo
"Ultralight Gravitino at the LHC"

Feb 14, Yuki Shimizu, Waseda Univ.
"Direct and Indirect Dark Matter Search Experiment"

Feb 19, Mark Vagins, UC Irvine
"GADZOOKS! A Potential Super-Kamiokande Upgrade"

Feb 20, Mohab Abou Zeid, KEK
"Gauge Theory, Gravity and Twistor String Scattering Amplitudes"

Feb 21, David Poland, UC Berkeley
"More visible effects of the hidden sector"

Feb 22, Werner Porod, Wuerzburg Univ.
"Testing supersymmetric neutrino mass models at future collider experiments"

Feb 27, Masaki Tsukamoto, Kyoto Univ.
"Deformation of Brody curves and mean dimension"

Feb 28, Alexandre Kozlov, Tohoku Univ.
"Neutrino physics program at KamLand"

Mar 5, Keiichi Maeda, IPMU
"Hunting for the Geometry of Supernova Explosions by Optical/NIR Observations"

Mar 10, Shing-Tung Yau, Harvard Univ.
"Geometric analysis and their applications in mathematics and theoretical physics"

Mar 14, Damien A. Easson, Univ. Durham
"Cosmology from spinning branes"

JFY2008

Apr 4, Yen-Ting Lin, Princeton Univ.
"Ensemble properties of cluster galaxies and their redshift evolution"

Apr 8, 15, 22, May 13, Akihiro Tsuchiya, IPMU
"Lecture: Homotopy theory (before 1970)"

Apr 9, Simeon Hellerman, IAS
"Cosmological Unification of String Theories"

Apr 11, Shin'ichiro Ando, Caltech
"Astrophysical Probe of New Physics: Cosmological Dark Matter and Anisotropy"

Apr 16, Jose M Figueroa-O'Farrill, Univ. Edinburgh
"Killing superalgebras in supergravity"

Apr 23, Motohico Mulase, UC Davis
"Integrable systems and intersection theory on moduli spaces of Riemann surfaces"

Apr 23, Chuan-Ren Chen, IPMU
"Direct and Indirect search for signals of the Littlest Higgs model with T-parity at Colliders"

Apr 24, Motohico Mulase, UC Davis
"Recursion relations in intersection theory on the moduli spaces of Riemann surfaces"

Apr 30, Kentaro Hori, Univ. Toronto
"Phases of N=2 theories in 1+1 dimensions with boundary"

May 8, Yukinobu Toda, IPMU
"Limit stable objects on Calabi-Yau 3-folds"

May 12, Kai Martens, Univ. Utah
"Cosmogenic Neutrinos and the HiRes experiment"

May 12, Jean-Michel Bismut, Univ. Paris-Sud, Orsay
"The hypoelliptic Laplacian"

May 14, Alexey Bondal, Univ. Aberdeen
"Derived categories in Noncommutative Geometry"

May 19, Jean-Michel Bismut, Univ. Paris-Sud, Orsay
"A survey of Quillen metrics"

May 21, Kazushi Ueda, Osaka Univ.
"Toric degenerations of Gelfand-Cetlin systems and potential functions"

May 28, Yasuaki Hikida, KEK
"H3+ Liouville relation and its applications"

May 29, Nobuchika Okada, KEK
"Higgs boson mass bounds in the Standard Model with seesaw-induced neutrino masses"

May 29, Masahito Yamazaki, Univ. Tokyo
"Quivers, brane tilings and toric Calabi-Yau/Sasaki-Einstein geometry"

Jun 2, Shinobu Hikami, Univ. Tokyo
"Intersection theory from duality and replica"

Jun 4, Yukiko Konishi, Kyoto Univ.
"On solutions to Walcher's extended holomorphic anomaly equation"

Jun 5, Kentaro Hori, Univ. Toronto
"Phases of N=2 theories in 1+1 dimensions with boundary Part II"

Jun 9, Alejandro Ibarra, DESY
"Indirect Signatures of Gravitino Dark Matter"

Jun 9, Michael Douglas, Rutgers Univ.
"String compactification and the landscape"

Jun 10, Michael Douglas, Rutgers Univ.
"Balanced Kahler metrics and physics"

Jun 11, Eiichiro Komatsu, Univ. Texas
"The 5-Year Wilkinson Microwave Anisotropy Probe (WMAP) Observations: Cosmological Interpretation"

Jun 12, Shushi Harashita, IPMU
"Generic Newton polygons of Ekedahl-Oort strata in the moduli space of abelian varieties"

Jun 13, Eiichiro Komatsu, Univ. Texas
"Hunting for Primordial Non-Gaussianity"

Jun 18, Andy Neitzke, Princeton Univ.
"Crossing the wall: overcoming an Obstruction in Quantum Field Theory and String Theory"

Jun 19, Andy Neitzke, Princeton Univ.
"BPS Wall-crossing and Hyperkahler Geometry"

Jun 19, Sakura Schafer-Nameki, Caltech
"Planar Ads/CFT: wrapping it up"

Jun 20, H. Murayama, IPMU
"IPMU, Mathematics, Physics, and me"

Jun 24, Massimo Passera, INFN
"The muon g-2 and the bounds on the Higgs boson mass"

Jun 25, J. Manuel Garcia-Islas, Mexico
"Spin foam models of quantum gravity"

Jun 25, Andrei Mikhailov, Caltech
"String theory and Maillet formalism"

Jun 26, Shigeki Matsumoto, Toyama Univ.
"Weak Scale Gravitino Dark Matter"

Jun 26, Andrei Mikhailov, Caltech
"String theory and Maillet formalism"

Jun 30, J. Manuel Garcia-Islas, Mexico
"Quantum topological invariants and black hole entropy"

Jul 2, Kentaro Nagamine, Univ. Nevada
"Galaxy Formation through Cosmic Time using Cosmological Hydrodynamic Simulations: successes and current issues"

Jul 3, Yuji Sano, IPMU
"On multiplier ideal sheaves on toric Fano manifolds"

Jul 10, Shiou Kawagoe, Univ. Tokyo
"Neutrino oscillations in non-spherical supernova"

Jul 14, Jie Xiao, Fan Xu, Tsinghua Univ.
"Drived Hall algebra I"

Jul 16, Kazuhiro Sakai, Keio Univ.
"AdS/CFT correspondence and Integrable systems"

Jul 17, Kenji Kadota, Univ. Minnesota
"Cosmology in warped extra dimensions"

Jul 17, Kyoji Saito, IPMU
"Partition functions for non-commutative lattices"

Jul 18, Jie Xiao, Fan Xu, Tsinghua Univ.
"Drived Hall algebra II"

Jul 21, Jie Xiao, Fan Xu, Tsinghua Univ.
"Drived Hall algebra III"

Jul 22, Latham Boyle, Canadian Inst Theo Astr (CITA)
"Testing inflation: gravitational waves, consistency conditions, and bootstrap relations"

Jul 23, Latham Boyle, CITA
"Binary black hole merger: symmetry and the spin expansion"

Jul 24, Jie Xiao, Fan Xu, Tsinghua Univ.
"Lie Algebras Associated with Derived Categories I"

Jul 24, Michael Strauss, Princeton Univ.
"Quasars from z=0 to z=6: Demographics and Clustering as Clues to their Physical Nature"

Jul 28, Jie Xiao, Fan Xu, Tsinghua Univ.
"Lie Algebras Associated with Derived Categories II"

Jul 28, Lin Weng, Kyushu Univ.
"Symmetries and the Riemann Hypothesis"

Jul 29, Jie Xiao, Fan Xu, Tsinghua Univ.
"Lie Algebras Associated with Derived Categories III"

Jul 30, Satoshi Kondo, IPMU
"On a Drinfeld modular analogue of Beilinson's conjecture"

Jul 31, Akihiro Tsuchiya, IPMU
"Vertex Operator Algebra with C2-finite conditions and Logarithmic Conformal Field Theory"

Aug 4, Kentaro Nagao, Kyoto Univ.
"Counting invariants of perverse coherent systems on CY 3-folds and their wall-crossings"

Aug 11, Shushi Harashita, IPMU
"Introduction to Deligen-Lusztig theory"

Aug 13, Michael Kiermaier, MIT
"One-Loop Riemann Surfaces in Schnabl Gauge"

Aug 18, Hisanori Furusawa, NAOJ
"Applications of wide and deep multi-waveband imaging in the extragalactic astronomy: Suprime-Cam to HSC"

Aug 21, David M. Goldberg, Drexel U
"Where is the Information in Cluster Lenses?"

Aug 22, Yeong-Gyun Kim, KAIST
"Mass and Spin at LHC"

Aug 28, Andrei Frolov, Simon Fraser U
"A Singularity Problem with f(R) Dark Energy"

Sep 3, Yasuaki Hikida, KEK
"The FZZ-Duality Conjecture - A Proof"

Sep 9, Mitsuru Kakizaki, Bonn U
"Abundance of Thermal Relics in Non-standard Cosmological Scenarios"

Sep 10, Atish Dabholkar, U Pari 6
"Black Hole Entropy in String Theory - A Window into the quantum Structure of Spacetime -"

Sep 10, Kai Wang, IPMU
"Testing origin of neutrino mass at the LHC"

Sep 17, Jing Shu, IPMU
"Topological Interactions at the LHC and Generalized Landau-Yang Theorem"

Sep 18, Brian Powell, IPMU
"What we know (and may ever know) about inflation"

Sep 18, Shunji Matsuura, U Tokyo/Perimeter Inst
"Holographic non-local operators"

Sep 19, Shin Nakamura, CQUnST, Sogang U
"A Holographic Dual of Bjorken Flow"

Sep 22, Antonio Enea Romano, YITP
"Effects of particle production during inflation"

Sep 24, Simon Dedeo, U Chicago
"The Phenomenology of Gravity"

Sep 25, Simon Dedeo, U Chicago
"The View from U Chicago"

Oct 01, Cosimo Bambi, IPMU
"A possible observational signature of the weight of vacuum energy"

Oct 02, Sven Bjarke Gudnason, U Pisa
"SO and U_{Sp} Kähler and HyperKähler Quotients and Lumps"

Oct 02, George Hou, NTU
"CP Violation for the Heaven and the Earth"

Oct 07, Doron Lemze, Tel Aviv
"Combining Lensing, X-ray, and galaxy dynamic Measurements in Clusters"

Oct 08, Takaya Nozawa, IPMU
"Formation of dust in primordial supernovae and its survival within the supernova remnants"

Oct 09, Shima Shimizu, ZEUS
"Results on the proton structure from HERA"

Oct 10, Tom Broadhurst, Tel Aviv
"Testing Λ CDM with Subaru Observations of Cluster Mass Profiles"

Oct 14, Akihiro Tsuchiya, IPMU
"Conformal field theory and vertex operator algebras"

Oct 14, Johan Alwall, SLAC
"Matching QCD radiation in gluino and squark production at the LHC"

Oct 14, Maxim Kontsevich, IHES
"Wall Crossing"

Oct 15, Kaoru Hagiwara, KEK
"Jet angular correlation in vector-boson fusion processes at hadron colliders"

Oct 16, Domenico Orland, IPMU
"Quantum Crystals and Topological Strings"

Oct 22, Thierry Foglizzo, Service d'Astrophysique/Waseda
"From the whistle of a kettle to the asymmetric explosion of supernovae"

Oct 22, David Berenstein, U California, Santa Barbara
"A new dimension for the AdS/CFT correspondence"

Oct 23, Alex Kusenko, UCLA
"Echoes of supersymmetry from the early universe: baryons, dark matter, and gravitational waves"

Oct 27, Michael Semenov-Tian-Shansk, U Bourgogne
"Poisson groups and differential Galois theory of Schroedinger equation on the circle"

Oct 27, Anatoli Kirillov, RIMS Kyoto
"Dunkl operators and quadratic algebras"

Oct 29, Shigeki Sugimoto, IPMU
"Properties of Baryons in Holographic QCD"

Oct 30, Hiromitsu Takahashi, GLAST
"The Fermi Gamma-ray Space Telescope"

Nov 5, Sergey Gorchinskiy, Steklov Math Inst
"Conjectures on motives: case of simple threefolds"

Nov 5, Lawrence Hall, UC Berkeley
"Predictions from the Multiverse"

Nov 6, Chun-Lin Shan, Seoul N U
"Identifying Weakly Interacting Massive Particles from Direct Dark Matter Detection Data"

Nov 6, Simeon Hellerman, IPMU
"Cosmological unification of string theories"

Nov 10, Shirley Ho, Princeton
"What can you do with Cosmic Microwave Background as a Backlight?"

Nov 10, Kazuya Koyama, Portsmouth
"Modified gravity as an alternative to dark energy"

Nov 17, David Morrison, UCSB
"Open strings and noncommutative algebraic geometry"

Nov 19, Pisin Chen, NTU/Stanford
"The Dark Energy Puzzle"

Nov 20, Joe Conlon, Oxford
"Hierarchy Problems in String Theory: An Overview of the LARGE Volume Scenario"

Nov 20, Nicolai Reshetikhin, UC Berkeley/Amsterdam
"Quantum groups at roots of unity and invariants of links"

Nov 27, Seiji Terashima, YITP
"Toward a Proof of Montonen-Olive Duality via Multiple M2-branes"

Nov 28, Mikael Pichot, IPMU
"Groups of intermediate rank"

Dec 1, Kentaro Hori, U Toronto/IPMU
"A pair of non-birational but derived equivalent Calabi-Yau manifolds from non-Abelian gauge theories"

Dec 3, Yuji Okawa, U Tokyo
"The boundary state from open string fields"

Dec 11, Manabu Akaho, Tokyo Met U
"Immersed Lagrangian Floer theory"

Dec 15, Hiro Tajima, SLAC
"Science and Instrumentation of ASTRO-H Mission: Next Generation X-ray/Gamma-ray Satellite Mission"

Dec 16, Alexie Leauthaud, LBL
"Halo properties of Groups and Clusters via Weak Gravitational Lensing in COSMOS"

Dec 16, Kevin Bundy, UC Berkeley
"The Mass-Dependent Role of Mergers in Galaxy Evolution"

Dec 18, Kazunori Kohri, Lancaster
"Big-Bang nucleosynthesis and a hint to solve problems in astrophysics, cosmology and particle physics"

Dec 18, Nakwoo Kim, Kyung Hee U
"On the geometry of supersymmetric AdS solutions"

Dec 24, Yuji Tachikawa, IAS
"New Developments in $d=4$, $N=2$ Superconformal Field Theories"

Dec 24, Amihay Hanany, Imperial College
"Brane Tilings and M2 branes"

Jan 5, Seiji Kawamura, NAOJ
"Journey Toward Gravitational Wave Astronomy"

Jan 7, Henk Hoekstra, Leiden
"Weak Lensing by large scale structure"

Jan 8, Kiwoon Choi, KAIST
"M₁₂-assisted on-shell reconstruction of missing momenta and application to spin measurement at the LHC"

Jan 8, Yu Nakayama, UC Berkeley
"An Index for Non-relativistic Superconformal Field Theories"

Jan 9, Dmitry Kaledin, Steklov Math Inst
"Fedosov quantization in algebraic and holomorphic setting"

Jan 15, Haibo Yu, UC Irvine
"Hidden Charged Dark Matter and Its Relics"

Jan 15, Jan Zaanen, Leiden
"Planckian dissipation"

Jan 16, Kenneth Shackleton, IPMU
"On Harvey's curve complex"

Jan 22, Masamune Oguri, Stanford
"The SDSS Quasar Lens Search and its use as a dark energy probe"

Jan 22, Ryo Ookawa, Titech
"Moduli of Bridgeland semistable objects on the projective plane"

Jan 23, Amaya Moro-Martin, Princeton
"Debris Disks"

Jan 27, Andrea Ferrara, Scuola Normale Superiore, Pisa
"The First Billion Years"

Jan 29, Tatsuma Nishioka, Kyoto U
"CFT Duals for Extreme Black Holes"

Feb 4, Robert Emparan, ICREA & Barcelona
"Black Holes and Blackfolds in Higher Dimensions"

Feb 5, Jiayu Tang, IPMU
"Complementarity of Future Dark Energy Probes"

Feb 5, Daniel Sternheimer, Keio U
"The deformation philosophy of quantization, singleton physics and noncommutative analogues of space-time structures"

Feb 9, Hideki Maeda, Centro de Estudios Cientificos
"Self-similar growth of black holes in the Friedmann universe"

Feb 9, Robert Brandenberger, McGill
"String Theory and the Very Early Universe"

Feb 11, Masahiro Ibe, SLAC
"R-axion: A new physics signature involving muon pairs"

Feb 12, Yifang Wang, IHEP
"Reactor neutrino experiments and future prospects"

Feb 16, Sergei Blinnikov, ITEP
"Supernova light"

Feb 18, Frank Daniel Steffen, Max Planck Inst
"Supersymmetric Dark Matter in Cosmology and at Colliders"

Feb 19, Shouhei Ma, U Tokyo
"0-dimensional cusps of the Kahler moduli of a K3 surface"

Feb 24, A.G. de Bruyn, ASTRON, Dwingeloo and Kapteyn Institute, Groningen
"LOFAR - a major new low frequency observatory: science drivers, challenges and some pilot facility results"

Feb 24, Saleem Zaroubi, Kapteyn Astronomical Institute, Groningen
"Probing the End of the Universe's Dark Ages with LOFAR"

Feb 25, Ashley J. Ruitter, New Mexico State U
"Double Compact Object Binaries"

Feb 26, Federico Urban, UBC
"The cosmological constant as a manifestation of the conformal anomaly"

Feb 26, Wei Li, IPMU
"Three Stringy Realizations of Fractional Quantum Hall Effect"

Feb 27, Niayesh Afshordi, Perimeter Inst
"The end of the cosmological constant problem!"

8. Conferences

Feb 27, Ghazal Geshnizjani, Perimeter Inst
"Observational Evidence for Cosmological-Scale Extra Dimensions"

Mar 2, Stavros Katsanevas, Paris
"A roadmap to the stars: towards a global strategy for astroparticle"

Mar 4, Simon Glover, Heidelberg U
"The stellar initial mass function in low metallicity gas"

Mar 5, C.P. Yuan, Michigan State U
"Precision Measurements at Hadron Colliders"

Mar 5, Tetsuji Kimura, YITP
"AdS Vacua, Attractor Mechanism and Generalized Geometries"

Mar 12, Andreas Karch, Washington U
"A holographic perspective on non-relativistic defects"

Mar 16, Kouichi Hirotani, Nat'l Tsing Hua U, Taiwan
"Pulsars: excellent systems for testing particle acceleration theories"

Mar 18, Pierre-Simon Maugeard, CPPM, Marseille
"In situ commissioning of the ATLAS electromagnetic calorimeter and early Z' to ee discovery potential"

Mar 19, Hiroyuki Nakaoka, U Tokyo
"Introduction to the 2-categorical homological algebra"

Mar 24, Geoffrey Schrank, U Utah
"Dynamics of Hyperpolarized ^{129}Xe Production"

Mar 24, Jing Liu, Max Planck Inst
"Development of segmented germanium detectors for neutrinoless double beta decay experiments"

Mar 25, Seong Chan Park, PMU
"Splitting Kaluza-Klein spectrum and its phenomenology"

Mar 26, Neil Turok, Perimeter Inst
"Quantum Resolution of Cosmological Singularities"

Mar 26, Simeon Hellerman, IPMU
"The Strong Gravity Theorem"

JFY2007

Dec 17 - 21, 2007
Focus week: LHC Phenomenology

Mar 11 - 12, 2008
IPMU Opening Symposium

Mar 17 - 21
Focus Week: Neutrino Mass

Mar 20 - 22
Asian mathematicians and theoretical physicists

JFY2008

May 22 - 24
Moonshiney Conference in Kashiwa

June 23-27
Focus Week: LHC physics

September 12-16
Focus Week: Quantum Black Holes

September 16-18
A Workshop on Micro-local analysis on symplectic manifolds

November 17-21
Focus Week: Messengers of Supernova Explosions

January 4-9, 2009
Supersymmetry in Complex Geometry

March 16-20
Focus Week: Determination of Masses and Spins of New Particles at the LHC



Figure 21: John Conway (right) and John McKay (left) on the occasion of the Moonshiney Workshop at IPMU.

9. Conference Talks

JFY2007

East Asian Conference on Algebraic Topology
(2007.11.05, SNU, Seoul, Korea)
Toshitake Kohno
"Loop spaces of configuration spaces and link homotopy invariants"

Progress of Quantum Field Theory and String Theory
(2007.12.07 - 10, Osaka City U, Osaka, Japan)
Hirosi Ooguri
"Meta-stable vacua in perturbed Seiberg-Witten theory, revisited"

ICRR Theory Group Workshop
(2007.12.10 - 11, ICRR, Japan)
Fuminobu Takahashi
"Inflaton decay in supergravity and the new gravitino problem"

Workshop on Early Universe Thermometers
(2008.2.06 - 08, Padova, Italy)
Hitoshi Murayama
"Models of Dark Matter"

Joint Asian Committee for Future Accelerators Physics and Detector Workshop and Global Design Effort meeting on International Linear Collider (TILC08)
(2008.03.03 - 06, Sendai, Japan)
Hitoshi Murayama
"ILC, Future Particle Physics and Cosmology"

The 4th International Workshop on Nuclear and Particle Physics at J-PARC (NP08)
(2008.03.05 - 07, Mito, Japan)
Hitoshi Murayama
"Prospects for Particle Physics"

Focus week on neutrino mass
(2008.03.17 - 20, IPMU, Kashiwa, Japan)
Hitoshi Murayama
"Neutrino Oscillation Phenomenology"

KEK Cosmo Group Inaugural Conference: Accelerators in the Universe
(2008.03.12 - 14, KEK, Japan)
Fuminobu Takahashi
"Gravitino and Inflation"

30 Years of Mathematical Methods in High Energy Physics
(2008.03.17 - 19, YITP, Kyoto U, Japan)
Hirosi Ooguri
"New Anomalies in Topological String Theory"

JFY2008

The 6th DECIGO Workshop
(2008.04.16, NAOJ, Japan)
Fuminobu Takahashi
"Gravity waves as a probe of the gravitino mass"

Korean Physics Society Meeting
(2008.04.17, Daejeon, Korea)
Masahiro Takada
"Gravitational Lensing and Dark Matter and Dark Energy"

UC Riverside Physics Colloquium
(2008.05.01, Riverside, USA)
Hitoshi Murayama
"Big World of Little Neutrinos"

RIKEN Nishina Center Physics Colloquium
(2008.05.13, Wako, Japan)
Hitoshi Murayama
"The Next Twenty Years in Particle Physics"

Japan-France Joint Workshop on Cosmology of the Early Universe
(2008.05.14, Nikko, Japan)
Shinji Mukohyama
"Brane inflation in string cosmology"
Fuminobu Takahashi
"The Anthropic Solution to the Strong CP problem"

University of Tokyo Colloquium
(2008.05.16, Tokyo, Japan)
Hitoshi Murayama
"Quantum Universe"

Continuous Advances in QCD (CAQCD08)
(2008.05.15 - 18, U Minnesota, Minneapolis, USA)
Shigeki Sugimoto
"Properties of Baryons from D-branes and Instantons"

Caltech Annual Seminar Day
(2008.05.17, Pasadena, USA)
Hirosi Ooguri
"Black Holes and the Fate of Determinism"

Cosmology Near and Far: Science with WFMOS
(2008.05.19 - 21, Kona, Hawaii, USA)
Masahiro Takada
"Cosmological limits on neutrino mass"

QUARKS 2008
(2008.05.23 - 29, Sergiev Posad, Russia)
Alexandre Kozlov
"KamLAND results and prospects"
Shinji Mukohyama
"Brane inflation in string cosmology"

32nd Johns Hopkins Workshop "Perspectives in String Theory"
(2008.05.28 - 31, SNU, Seoul, Korea)
Shigeki Sugimoto
"Perspectives in Holographic QCD"

String Phenomenology 2008
(2008.05.29, U Penn, Philadelphia, USA)
Taizan Watari
"Heterotic-F Theory Duality Revisited"

PASCOS-08
(2008.06.02 - 06, Perimeter Inst, Canada)
Fuminobu Takahashi
"The Anthropic Solution to the Strong CP problem"

Kavli Institute for Theoretical Physics Conference
"Anticipating Physics at the LHC"
(2008.06.02 - 06, Santa Barbara, USA)
Hitoshi Murayama
"Deciphering New Physics Through Spin Measurement Using Quantum Interference"

Melbourne Neutrino Theory Workshop
(2008.06.02 - 04, Melbourne, Australia)
Hitoshi Murayama
"Can we experimentally test seesaw and leptogenesis?"

Non-Perturbative Methods in Strongly Coupled Gauge Theories
(2008.06.09 - 27, Florence, Italy)
Shigeki Sugimoto
"Static Properties and Form Factors of Baryons in Holographic QCD"

Braids, Knots and Applications
(2008.06.10, Univ. de Montpellier, France)
Toshitake Kohno
"Braids, Drinfel'd associator and rational homotopy"

SUSY08 Pre-school Lectures at Korean Institute for Advanced Study
(2008.06.12 - 14, Seoul, Korea)
Hitoshi Murayama
"Supersymmetry"

The 16th International Conference on Supersymmetry and the Unification of Fundamental Interactions (SUSY08)
(2008.06.16 - 21, Seoul, Korea)
Hitoshi Murayama
"Gauge Mediation Made Viable and Generic"
Fuminobu Takahashi
"Non-Gaussianity from Symmetry"

Takagi Lectures, Mathematical Society of Japan
(2008.06.21, Kyoto, Japan)
Hirosi Ooguri
"Geometry as seen by String Theory"

The 10th Anniversary Symposium of Research Center for Neutrino Science
(2008.06.21, Sendai, Japan)
Hitoshi Murayama
"Impact of the KamLAND Experiment"

Modified Gravity on Cosmological Scales
(2008.06.23, ICG, Portsmouth, UK)
Shinji Mukohyama
"Gravity in Higgs phase"

Eurostrings 2008
(2008.06.30 - 07.04, Amsterdam, Holland)
Hirosi Ooguri
"Current Correlators for General Gauge Mediation"

The 10th International Workshop on Neutrino Factories, Superbeams and Betabeams (NuFact08)
(2008.06.30 - 07.05, Valencia, Spain)
Hitoshi Murayama
"Neutrinos in the Standard Model and Beyond"

Aspen Center for Physics, Center Colloquium
(2008.07.17, Aspen, USA)
Hirosi Ooguri
"Searching for the Language of Quantum Gravity: Black Holes, Molten Crystals and Topological Twist"

The 13th Advanced Accelerator Concepts Workshop
(2008.07.27 - 08.02, USA)
Hitoshi Murayama
"The Physics beyond the LHC"

Cosmology with the CMB and LSS
(2008.07.21 - 08.31, Inter University Centre for Astronomy and Astrophysics (IUCAA), Pune, India)
Masahiro Takada
"Neutrinos and Cosmology (lecture)"

The 10th Asia-Pacific International Astronomical Union Regional Meeting
(2008.08.03 - 07, Kunming, China)
Masahiro Takada
"Gravitational Lensing and Observational Cosmology"

Summer Institute 2008
(2008.08.06, Fuji-Yoshida, Japan)
Shinji Mukohyama
"Dynamical Black hole as a holographic dual of Bjorken Flow"

Summer Institute in Phenomenology of Particle Physics
(2008.08.10-17, Chi-Tou, Taiwan)
Hitoshi Murayama
"From Colliders to the Universe"

Summer School of Young Nuclear and Particle Physicist Group of Japan
(2008.08.19, Tokyo, Japan)
Hitoshi Murayama
"Quantum Universe"

Strings 2008
(2008.08.18 - 23, CERN, Switzerland)
Hirosi Ooguri
"Summary Talk"

Conference in Honour of Peter Orlik
(2008.08.21, Toronto, Canada)
Toshitake Kohno
"Bar Complex of Orlik-Solomon algebra and rational universal holonomy maps"

Summer Institute "Theories de jauge, gravite et theories de cordes"
(2008.08.25 - 09.05, Ecole Normale Superieure, Paris, France)
Shigeki Sugimoto
"Baryons in Holographic QCD"

Cosmo08
(2008.08.25 - 29, Madison, USA)
Hitoshi Murayama
"Reconciling supersymmetry and leptogenesis"

Cosmic Dust - Near & Far
(2008.09.08 - 12, Heidelberg, Germany)
Takaya Nozawa
"Origin and Nature of Dust in the Early Universe"

International Workshop on Next Nucleon decay and Neutrino detectors (NNN08)
(2008.09.11 - 13, Paris, France)
Alexandre Kozlov
"KamLAND general talk"
Mark Vagins
"GADZOOKS!"

Hitoshi Murayama
"Neutrino and proton decay: What can we learn for fundamental physics and cosmology"

Focus Week on Quantum Black Holes
(2008.09.12 - 16, IPMU, Japan)
Tadashi Takayanagi
"Fuzzy Ring from M2-brane Giant Torus"

Maria Laach Summer school
(2008.09.08 - 13, Maria Laach, Germany)
Hitoshi Murayama
"Particle Physics"

Neutrino Physics and Astrophysics
(2008.09.17 - 21, Beijing, China)
Hitoshi Murayama
"Theoretical overview of neutrino physics"

Recent Developments in String/M Theory
(2008.09.22 - 26, KIAS, Korea)
Tadashi Takayanagi
"Entanglement Entropy and Phase Transition in AdS/CFT Correspondence"

European Priorities in Astroparticle Physics
(2008.09.29 - 30, Brussels, Belgium)
Hitoshi Murayama
"Japanese priorities"

Intelligence of Low Dimensional Topology 2008
(2008.10.08, Osaka City U, Japan)
Toshitake Kohno
"Braids, local system homology and KZ connection"

New Vision 400
(2008.10.12, Beijing, China)
Naoki Yoshida
"The First Stars"

Workshop on Underground Detectors Investigating Grand Unification (UDiG)
(2008.10.16 - 17, Brookhaven National Laboratory, New York, USA)
Hitoshi Murayama
"Studying the Universe Underground"

APS Division of Nuclear Physics Annual Meeting
(2008.10.19 - 20, Oakland, USA)
Hitoshi Murayama
"Studying the Universe Underground"

Going Beyond the SM, Marching into the LHC era
(2008.10.20 - 24, Kavli Inst Beijing, China)
Kai Wang
"Testing Origin of Neutrino Mass at the LHC"

Von Neumann Algebras and Ergodic Theory of Group Actions
(2008.10.26 - 11.01, Oberwolfach, Germany)
Mikael Pichot
"Groups of intermediate rank"

Cosmology and Structure Formation
(2008.10.26 - 28, Seoul, Korea)
Masahiro Takada
"The impact of finite-mass neutrinos on nonlinear matter power spectrum"
Naoki Yoshida
"Formation of Primordial Stars"

The 9th International Committee for Future Accelerators
(2008.10.28 - 31, SLAC, Stanford, USA)
Hitoshi Murayama
"Physics highlights & perspectives"

ASIAA Colloquium
(2008.11.18, Inst Astr and Astrophy, Taiwan)
Masahiro Takada
"Neutrino Mass and Cosmology"

University of Hawaii Colloquium
(2008.11.25, Honolulu, Hawaii, USA)
Naoki Yoshida
"The First Stars"

Particle Physics, Astrophysics and Quantum Field Theory: 75 Years since Solvay
(2008.11.27 - 29, Nanyang, Singapore)
Hitoshi Murayama
"Supersymmetry Breaking and Cosmology"

10. Visitors

Excellence Cluster Science Week
(2008.12.01 - 04, Max-Planck Institute, Garching,
Germany)
Fuminobu Takahashi
"Cosmic-ray positrons from decaying dark matter"

Colloquium at Carnegie Observatory
(2008.12.02, Pasadena, USA)
Masahiro Takada
"Subaru Weak Lensing Study of Galaxy Clusters"

University of Michigan Physics Colloquium
(2008.11.03, Ann Arbor, USA)
Hitoshi Murayama
"The Big World of Little Neutrinos"

Indian Strings Meeting 2008
(2008.12.06 - 13, Pondicherry, India)
Shigeki Sugimoto
"Properties of Baryons in holographic QCD"

ICRR Theory Workshop
(2008.12.08 - 09, ICRR, Japan)
Fuminobu Takahashi
"Cosmic rays from dark matter"

ITC Colloquium, Harvard University
(2008.12.16, Boston, USA)
Naoki Yoshida
"Formation of Primordial Stars"

Cosmic-Ray Electron and Positron Workshop
(2008.12.24, Waseda U, Tokyo, Japan)
Fuminobu Takahashi
**"Decaying hidden gauge boson and the PAMELA
and ATIC/PPB-BETS anomaly"**

Workshop on QCD Phase Structure
(2008.12.25 - 26, Kyushu U, Fukuoka, Japan)
Shigeki Sugimoto
"AdS/CFT and its application"

2008 Subaru Users' Meeting
(2009.01.14 - 16, NAOJ, Tokyo, Japan)
Masahiro Takada
"Cosmology with WFMOS Survey"

Workshop on Early Structure Formation
(2009.1.15, Tsukuba, Japan)
Naoki Yoshida
"Formation of Primordial Stars and Blackholes"

New Horizons for Modern Cosmology
(2009.01.19 - 03.13, Arcetri, Florence, Italy)
Cosimo Bambi
**"Strange stars: a laboratory to investigate the
problem of the cosmological constant"**

VIPAC meeting
(2009.01.27, Heidelberg, Germany)
Taizan Watari
"GUT Symmetry Breaking Revisited"

Northwestern University Colloquia
(2009.01.30, Chicago, USA)
Hitoshi Murayama
"The Big World of Little Neutrinos"

GUTs in Strings
(2009.02.03, DESY, Hamburg, Germany)
Taizan Watari
"Yukawa Couplings in F-theory"

Fundamental Aspects of Superstring Theory
(2009.02.12, Santa Barbara, USA)
Hiroshi Ooguri
"Crystal Melting and Quantum Calabi-Yau"

Progress in Particle Physics 2008
(2009.02.16 - 19, YKIS, Kyoto, Japan)
Damien Easson
**"The eta problem and inflation with Hubble mass
inflaton"**

Supercomputing in Solid State Physics
(2009.2.16, Kashiwa, Japan)
Naoki Yoshida
**"Supercomputer Simulations of Cosmic Structure
Formation"**

International Workshop on Noncommutative
Geometry and Physics
(2009.02.18 - 21, Keio U, Tokyo, Japan)
Tadashi Takayanagi
"AdS/CFT and Chern-Simons Gauge Theory"

String-Cosmology Workshop
(2009.02.18 - 20, Kinoshita, Japan)
Fuminobu Takahashi
**"Cosmology based on supergravity and related
topics"**

Lecture Series at YITP
(2009.02.23 - 24, Kyoto, Japan)
Shinji Mukohyama
"Higgs phase of gravity"

KEK Annual Theory Meeting on Particle Physics
Phenomenology (KEKPH09)
(2009.03.03 - 06, KEK, Japan)
Fuminobu Takahashi
"Non-Gaussianity as a probe of the early Universe"

16th YKIS symposium
(2009.03.09, YITP, Kyoto, Japan)
Taizan Watari
**"From recent developments in F-theory
compactification"**

Beatrice M. Tinsley Memorial Lecture
(2009.3.23, Austin, USA)
Naoki Yoshida
"Formation of primordial stars and blackholes"

JFY2007

H. Kajiura, RIMS Kyoto (Japan), 07/10/29 - 10/29
Y.G. Kim, KAIST (Korea), 07/12/6 - 12/21
D. Kaledin, Steklov Inst (Russia), 07/12/10 - 12/10
G. Polesello, INFN Pavia (Italy), 07/12/15 - 12/22
S.H. Zhou, Peking (China), 07/12/16 - 12/21
T. Lari, INFN Milano (Italy), 07/12/16 - 12/22
Q. Li, Karlsruhe (Germany), 07/12/16 - 12/21
C.P. Yuan, Michigan State (US), 07/12/17 - 12/23
S. Schumann, Edinburgh (UK), 07/12/17 - 12/19
Y. Sumino, Tohoku (Japan), 07/12/17 - 12/19
T. Kamon, Texas A&M (US), 07/12/17 - 12/20
K. Mawatari, KIAS (Korea), 07/12/17 - 12/20
P. Mieda, Harvard (US), 07/12/17 - 12/20
S. Okada, Kobe (Japan), 07/12/17 - 12/20
S.C. Park, Seoul (Korea), 07/12/17 - 12/20
M. Perelstein, Cornell (US), 07/12/17 - 12/20
E. Turner, Princeton (US), 08/1/26 - 2/5
V. Rentala, UC Berkeley (US), 08/1/26 - 4/16
J. Gunn, Princeton (US), 08/1/27 - 08/2/2
M. Vagins, UC Irvine (US), 08/2/18 - 2/20
Y. Nomura, UC Berkeley (US), 08/2/18 - 2/23
D. Poland, UC Berkeley (US), 08/2/18 - 2/23
W. Porod, Wuerzburg (Germany), 08/2/19 - 2/24
A. Ruitter, New Mexico (US), 08/2/23 - 2/25
C. Belzyski, New Mexico (US), 08/2/23 - 2/23
F. Urban, UBC (Canada), 08/2/23 - 3/1
A. Slosar, LBNL (US), 08/3/1 - 3/20
A.B. McDonald, Queens (Canada), 08/3/4 - 3/14
S. Katsanevas, Paris (France), 08/3/8 - 3/12
K. Jacobs, Freiburg (Germany), 08/3/8 - 3/14
T. Dimofte, Caltech (US), 08/3/8 - 3/16
S.T. Yau, Harvard (US), 08/3/9 - 3/13
G.F. Giudice, CERN (Switzerland), 08/3/9 - 3/14
S.D.M. White, Max Planck (Germany), 08/3/9 - 3/14
D.J. Gross, UCSB (US), 08/3/9 - 3/15
J. Siegrist, LBNL (US), 08/3/9 - 3/12
M. Dilworth, NSF Tokyo Office (Japan), 08/3/10 - 3/10
H. Goto, KEK (Japan), 08/3/10 - 3/10
S. Hamamoto, Toyama (Japan), 08/3/10 - 3/10
T. Kawano, Tokyo (Japan), 08/3/10 - 3/10
K. Matsumoto, KEK (Japan), 08/3/10 - 3/10
S. Miyoki, ICRR Tokyo (Japan), 08/3/10 - 3/10
S. Nagataki, YITP Kyoto (Japan), 08/3/10 - 3/10
E. Nakamura, Tokyo (Japan), 08/3/10 - 3/10
K. Nakamura, Soukandai NAOJ (Japan), 08/3/10 - 3/10
D. Perret-gallix, FJPL/IN2P3/CNRS (France), 08/3/10 - 3/10
F. Scardigi, YITP Kyoto (Japan), 08/3/10 - 3/10
N. Tominaga, NAOJ (Japan), 08/3/10 - 3/10
K. Uzawa, Kwansai Gakuin (Japan), 08/3/10 - 3/10
M. Yamashita, ICRR Tokyo (Japan), 08/3/10 - 3/10
Y.K. Kim, Chicago/Fermilab (US), 08/3/10 - 3/12
R.J. Gaitskell, Brown (US), 08/3/10 - 3/15
J. Ellis, CERN (Switzerland), 08/3/10 - 3/12
D. Easson, Durham (UK), 08/3/10 - 3/12
Y. Abe, Cereja Tech Co. (Japan), 08/3/11 - 3/11
M. Abou, KEK (Japan), 08/3/11 - 3/11
M. Bando, Aichi (Japan), 08/3/11 - 3/11
J. Daniel, Kobe (Japan), 08/3/11 - 3/11
T. Deguchi, Ochanomizu (Japan), 08/3/11 - 3/11
M. Fujii, Kyoto (Japan), 08/3/11 - 3/11

K. Fukaya, Kyoto (Japan), 08/3/11 - 3/11
A. Gerard, Cheng Kung (Taiwan), 08/3/11 - 3/11
R. Goto, Osaka (Japan), 08/3/11 - 3/11
K. Hasegawa, Tohoku (Japan), 08/3/11 - 3/11
H. Hata, Ochanomizu (Japan), 08/3/11 - 3/11
M. Hayashi, NAOJ (Japan), 08/3/11 - 3/11
T. Hirayama, Nat'l Ctr Theo Sci (Taiwan), 08/3/11 - 3/11
J. Hisano, ICRR Tokyo (Japan), 08/3/11 - 3/11
K. Ichikawa, ICRR Tokyo (Japan), 08/3/11 - 3/11
S. Ichinose, Shizuoka (Japan), 08/3/11 - 3/11
N. Ikeda, Ritsumeikan (Japan), 08/3/11 - 3/11
M. Ishida, Meisei (Japan), 08/3/11 - 3/11
S. Iso, KEK (Japan), 08/3/11 - 3/11
K. Ito, Titech (Japan), 08/3/11 - 3/11
K. Iwasaki, Titech (Japan), 08/3/11 - 3/11
F. Kajino, Konan (Japan), 08/3/11 - 3/11
T. Kalman, Tokyo Komaba (Japan), 08/3/11 - 3/11
S. Kasuya, Kanagawa (Japan), 08/3/11 - 3/11
Y. Kawahigashi, Tokyo Komaba (Japan), 08/3/11 - 3/11
Y. Kikukawa, Tokyo (Japan), 08/3/11 - 3/11
Y. Kitazawa, KEK (Japan), 08/3/11 - 3/11
K. Kiyohara, Okayama (Japan), 08/3/11 - 3/11
C. Kobayashi, NAOJ (Japan), 08/3/11 - 3/11
K. Konichi Kohki, Tokyo (Japan), 08/3/11 - 3/11
M. Kotani, Tohoku (Japan), 08/3/11 - 3/11
T. Kugo, YITP Kyoto (Japan), 08/3/11 - 3/11
C. Matsui, Tokyo (Japan), 08/3/11 - 3/11
T. Matsuki, Tokyo Kasei (Japan), 08/3/11 - 3/11
T. Miwa, Titech (Japan), 08/3/11 - 3/11
K. Mizutani, Saitama (Japan), 08/3/11 - 3/11
S. Morita, Tokyo Komaba (Japan), 08/3/11 - 3/11
J. Murakami, Waseda (Japan), 08/3/11 - 3/11
M. Nagai, ICRR Tokyo (Japan), 08/3/11 - 3/11
K. Nagano, KEK (Japan), 08/3/11 - 3/11
S. Nakamura, Tohoku (Japan), 08/3/11 - 3/11
N. Yoshida, Nagoya (Japan), 08/3/11 - 3/11
H. Naruse, Okayama (Japan), 08/3/11 - 3/11
G. Novichikov, Keio (Japan), 08/3/11 - 3/11
K. Okamura, Tokyo (Japan), 08/3/11 - 3/11
Y. Okochi, Caltech (US), 08/3/11 - 3/11
H. Omori, Tokyo (Japan), 08/3/11 - 3/11
K. Sakai, Tokyo Komaba (Japan), 08/3/11 - 3/11
H. Sato, Hyogo U of Edu (Japan), 08/3/11 - 3/11
H. Sekiya, ICRR Tokyo (Japan), 08/3/11 - 3/11
M. Seta, Tsukuba (Japan), 08/3/11 - 3/11
K. Shackleton, Titech (Japan), 08/3/11 - 3/11
D. Sternhaimer, Bourgogne (France), 08/3/11 - 3/11
S. Sugimoto, Nagoya (Japan), 08/3/11 - 3/11
M. Tada, SEIKO EG & G Co. (Japan), 08/3/11 - 3/11
K. Takemura, Yokohama City U (Japan), 08/3/11 - 3/11
K. Takenaga, Tohoku (Japan), 08/3/11 - 3/11
Y. Takeuchi, ICRR Tokyo (Japan), 08/3/11 - 3/11
R. Tanaka, Okayama (Japan), 08/3/11 - 3/11
D. Tarama, Kyoto (Japan), 08/3/11 - 3/11
T. Tsuboi, Tokyo Komaba (Japan), 08/3/11 - 3/11
T. Uematsu, Kyoto (Japan), 08/3/11 - 3/11
K. Usui, Tokyo (Japan), 08/3/11 - 3/11
T. Watari, Tokyo (Japan), 08/3/11 - 3/11
Y. Yabu, Kyoto (Japan), 08/3/11 - 3/11
M. Yamanaka, Saitama (Japan), 08/3/11 - 3/11
M. Yamaguchi, Tohoku (Japan), 08/3/11 - 3/11
M. Yamazaki, Tokyo (Japan), 08/3/11 - 3/11

K. Yonekura, Tokyo (Japan), 08/3/11 - 3/11
 S. Petcov, SISSA (Italy), 08/3/12 - 4/18
 R. Peccei, UCLA (US), 08/3/12 - 3/14
 N. Reshetikhin, UC Berkeley (US), 08/3/12 - 3/14
 D.R. Morrison, UCSB (US), 08/3/12 - 3/15
 A. Kusenko, UCLA (US), 2008/3/14 - 3/25
 H. Robertson, Washington (US), 08/3/15 - 3/21
 E. Pierpaoli, U Southern Cal (US), 08/3/15 - 3/23
 A. Giuliani, INFN Milano (Italy), 08/3/16 - 3/21
 G.G. Raffelt, Max Planck (Germany), 08/3/16 - 3/22
 V. Rodin, Tuebingen (Germany), 08/3/16 - 3/22
 P. Di Bari, INFN Padova (Italy), 08/3/17 - 3/20
 B. Kim, KIAS (Korea), 08/3/19 - 3/22
 Y.G. Oh, Wisconsin (US), 08/3/19 - 3/22
 K. Hori, Toronto (Canada), 08/3/19 - 3/23
 A. Dhar, TIFR (India), 08/3/20 - 3/22
 K. Liu, UCLA (US), 08/3/20 - 3/22
 A. Sen, Harish-Chandra Inst (India), 08/3/20 - 3/22
 P.J. Yi, KIAS (Korea), 08/3/20 - 3/22
 S.J. Rey, Seoul (Korea), 08/3/20 - 3/23

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Y.T. Lin, Princeton (US), 08/4/3 - 4/6
 S. Ando, Caltech (US), 08/4/11 - 4/11
 J. Figueroa-O'Farrill, Edinburgh (UK), 08/4/16 - 4/16
 M. Mulase, UC Davis (US), 08/4/23 - 4/24
 K. Hori, Toronto (Canada), 08/4/24 - 5/6
 K. Martens, Utah (US), 08/5/11 - 5/16
 J.M. Bismut, Paris-Sud Orsay (France), 08/5/12 - 5/12
 A. Bondal, Aberdeen (UK), 08/5/14 - 5/16
 J. McKay, Concordia (Canada), 08/5/18 - 5/24
 J.M. Bismut, Paris-Sud Orsay (France), 08/5/19 - 5/19
 K. Ueda, Osaka (Japan), 08/5/21 - 5/21
 J. Conway, Princeton (US), 08/5/21 - 5/24
 R.L. Griess, Michigan (US), 08/5/21 - 5/24
 C.H. Lam, Taiwan (Taiwan), 08/5/21 - 5/24
 T. Basak, Chicago (US), 08/5/21 - 5/25
 J.F. Duncan, Harvard (US), 08/5/21 - 5/26
 H. Yamauchi, Aichi U of Edu (Japan), 08/5/21 - 5/24
 H. Shimakura, Aichi U of Edu (Japan), 08/5/21 - 5/24
 K. Maehata, Image Mission Co. (Japan), 08/5/22 - 5/22
 M. Fujii, Kyoto (Japan), 08/5/22 - 5/24
 K. Harada, Ohio State (US), 08/5/22 - 5/24
 K. Ishihara, Saitama (Japan), 08/5/22 - 5/24
 Y. Kawahigashi, Tokyo Komaba (Japan), 08/5/22 - 5/24
 M. Kitazume, Chiba (Japan), 08/5/22 - 5/24
 S. Kondo, Nagoya (Japan), 08/5/22 - 5/24
 A. Matsuo, Tokyo Komaba (Japan), 08/5/22 - 5/24
 A. Munemasa, Tohoku (Japan), 08/5/22 - 5/24
 I. Nakamura, Hokkaido (Japan), 08/5/22 - 5/24
 K. Naoi, Tokyo Komaba (Japan), 08/5/22 - 5/24
 S. Robert, free writer (Canada), 08/5/22 - 5/24
 T. Takebe, Ochanomizu (Japan), 08/5/22 - 5/24
 H. Yamada, Hitotsubashi (Japan), 08/5/22 - 5/25
 E.L. Turner, Princeton (US), 08/5/28 - 6/12
 N. Okada, KEK (Japan), 08/5/29 - 5/29
 K. Hori, Toronto (Canada), 08/5/29 - 6/8
 C.S. Park, Caltech (US), 08/6/6 - 6/26
 J.W. Song, Caltech (US), 08/6/6 - 6/26
 M. Douglas, Rutgers (US), 08/6/7 - 6/11
 A. Ibarra, DESY (Germany), 08/6/9 - 6/9

E. Komatsu, Texas (US), 08/6/9 - 6/20
 M. Yamazaki, Tokyo (Japan), 08/6/9 - 6/27
 A. Neitzke, Princeton (US), 08/6/12 - 6/25
 K. Hori, Toronto (Canada), 08/6/14 - 6/17
 K. Nagamine, Nevada (US), 08/6/16 - 8/15
 Y. Watanabe, Texas (US), 08/6/16 - 6/20
 A. Mikhailov, Caltech (US), 08/6/17 - 7/1
 S. Schfer-Nameki, Caltech (US), 08/6/17 - 7/3
 D. Nitta, Tohoku (Japan), 08/6/17 - 6/19
 S. Hellerman, Princeton (US), 08/6/21 - 6/24
 T. Moroi, Tohoku (Japan), 08/6/22 - 6/27
 K. Takahashi, KEK (Japan), 08/6/22 - 6/27
 D. Auston, Kavli Foundation (US), 08/6/23 - 6/23
 M. Chun, Kavli Foundation (US), 08/6/23 - 6/23
 R. Cavanaugh, Florida (US), 08/6/23 - 6/27
 H.C. Cheng, UC Davis (US), 08/6/23 - 6/27
 S.P. Das, Bonn (Germany), 08/6/23 - 6/27
 P. Fox, Fermilab (US), 08/6/23 - 6/27
 R. Frederix, Louvain (Belgium), 08/6/23 - 08/6/27
 I.W. Kim, Seoul (Korea), 08/6/23 - 6/27
 Y.G. Kim, KAIST (Korea), 08/6/23 - 6/27
 R. Kitano, Los Alamos (US), 08/6/23 - 6/27
 T. Lari, INFN Milano (Italy), 08/6/23 - 6/27
 C. Lester, Cambridge (UK), 08/6/23 - 6/27
 T. Okui, J Hopkins (US), 08/6/23 - 6/27
 E.K. Park, Florida (US), 08/6/23 - 6/27
 J.G. Wacker, SLAC (US), 08/6/23 - 6/27
 S. Bornhauser, Bonn (Germany), 08/6/23 - 6/27
 S. Dutta, Delhi (India), 08/6/23 - 6/26
 A. Akeroyd, Chen Kung (Taiwan), 08/6/23 - 6/27
 M. Asano, ICRR Tokyo (Japan), 08/6/23 - 6/27
 B. Gong, Chinese Acad Sci (China), 08/6/23 - 6/27
 K. Hiramatsu, Soukendai (Japan), 08/6/23 - 6/27
 J. Hisano, ICRR Tokyo (Japan), 08/6/23 - 6/27
 K. Igi, RIKEN (Japan), 08/6/23 - 6/27
 B. Jager, KEK (Japan), 08/6/23 - 6/27
 S. Matsumoto, Toyama (Japan), 08/6/23 - 6/27
 M. Nagai, KEK (Japan), 08/6/23 - 6/27
 E. Nakamura, Tokyo (Japan), 08/6/23 - 6/27
 K. Nakamura, ICRR Tokyo (Japan), 08/6/23 - 6/27
 T. Okada, ICRR Tokyo (Japan), 08/6/23 - 6/27
 F. Rikkert, Louvain (Belgium), 08/6/23 - 6/27
 K. Sakurai, Nagoya (Japan), 08/6/23 - 6/27
 T. Sekiguchi, ICRR Tokyo (Japan), 08/6/23 - 6/27
 T. Shimada, Meiji (Japan), 08/6/23 - 6/27
 W. Sreethawong, KEK (Japan), 08/6/23 - 6/27
 T. Takayama, ICRR Tokyo (Japan), 08/6/23 - 6/27
 M. Takeuchi, Kyoto & KEK (Japan), 08/6/23 - 6/27
 Y. Yonekura, Tokyo (Japan), 08/6/23 - 6/27
 M. Passera, INFN (Italy), 08/6/24 - 6/24
 J.M. Garcia-Islas, Nat'l Auton (Mexico), 08/6/25 - 6/25
 J. Xiao, Tsinghua (China), 08/7/5 - 8/4
 F. Xu, Tsinghua (China), 08/7/5 - 8/4
 M. Kiermaier, MIT (US), 08/7/7 - 7/14
 S. Kawagoe, Tokyo (Japan), 08/7/10 - 7/10
 K. Sakai, Keio (Japan), 08/7/16 - 7/16
 K. Kadota, Minnesota (US), 08/7/16 - 7/18
 M. Kiermaier, MIT (US), 08/7/20 - 8/14
 Y. Okawa, Tokyo (Japan), 08/7/21 - 7/22
 L. Boyle, Toronto (Canada), 08/7/21 - 7/28
 R. Lupton, Princeton (US), 08/7/22 - 7/26
 M. Strauss, Princeton (US), 08/7/22 - 7/26

S. Bickerton, Princeton (US), 08/7/22 - 7/28
 C. Loomis, Princeton (US), 08/7/22 - 7/28
 F. Mullally, Princeton (US), 08/7/22 - 7/28
 K. Izumi, Kyoto (Japan), 08/7/23 - 7/23
 K. Oda, Osaka (Japan), 08/7/23 - 7/23
 H. Sugiyama, SISSA (Italy), 08/7/25 - 8/10
 W. Lin, Kyushu (Japan), 08/7/28 - 7/28
 K. Hori, Toronto (Canada), 08/7/29 - 10/31
 A. Bondal, Aberdeen (UK), 08/8/4 - 11/30
 I. Zhdanovskiy, Moscow (Russia), 08/8/4 - 8/31
 D.F. Gao, Tronto (Canada), 08/8/6 - 11/30
 D. Goldberg, Drexel (US), 08/8/15 - 8/31
 B.K. Fujikawa, LBNL (US), 08/8/17 - 9/21
 H. Furusawa, NAOJ (Japan Hawaii), 08/8/18 - 8/20
 Y.G. Kim, KAIST (Korea), 08/8/22 - 8/22
 E. Kearns, Boston (US), 08/8/24 - 8/31
 A. Frolov, Simon Fraser (Canada), 08/8/28 - 8/28
 C. Walter, Duke (US), 08/8/28 - 9/16
 M. Verbitsky, Moscow (Russia), 08/9/1 - 09/2/28
 H. Kajiuira, Chiba (Japan), 08/9/1 - 9/5
 B. Kim, KIAS (Korea), 08/9/1 - 9/5
 K. Altmann, Berlin (Germany), 08/9/1 - 9/6
 S. Galkin, Steklov Math Inst (Russia), 08/9/1 - 9/6
 M. Perling, Bochum (Germany), 08/9/1 - 9/6
 V. Przyjalkowski, Steklov Math Inst (Russia), 08/9/1 - 9/7
 A. Takahashi, Osaka (Japan), 08/9/1 - 9/5
 M. Kobayashi, Tokyo Met (Japan), 08/9/1 - 9/5
 R. Okawa, Titech (Japan), 08/9/1 - 9/5
 S. Okuhara Saki, Tokyo Met (Japan), 08/9/1 - 9/5
 M. Sakurai, Tokyo (Japan), 08/9/1 - 9/5
 H. Uehara, Tokyo Met (Japan), 08/9/1 - 9/5
 K. Yoshioka, Kobe (Japan), 08/9/1 - 9/5
 S. Freedman, UC Berkeley (US), 08/9/2 - 9/16
 Y. Hikida, KEK (Japan), 08/9/3 - 9/3
 A. Kuznetsov, Steklov Math Inst (Russia), 08/9/3 - 9/11
 N. Iizuka, UCSB (US), 08/9/7 - 9/20
 M. Yamazaki, Tokyo (Japan), 08/9/8 - 9/16
 M. Kakizaki, Bonn (Germany), 08/9/9 - 9/9
 W.D. Ruan, KAIST (Korea), 08/9/10 - 9/17
 S. Moriyama, Nagoya (Japan), 08/9/11 - 9/16
 S. Mukhi, TIFR (India), 08/9/11 - 9/16
 A. Dabholkar, Paris (France), 08/9/11 - 9/17
 V. Hubeny, Durham (UK), 08/9/11 - 9/17
 F.L. Lin, Taiwan (Taiwan), 08/9/11 - 9/17
 G. Mandal, TIFR (India), 08/9/11 - 9/17
 M. Rangamani, Durham (UK), 08/9/11 - 9/17
 A. Rosly, ITEP (Russia), 08/9/11 - 10/22
 H. Goto, KEK (Japan), 08/9/11 - 9/16
 K. Hotta, Hokkaido (Japan), 08/9/11 - 9/16
 Y. Efremenko, Tennessee (US), 08/9/11 - 10/2
 P. Decowski, LBNL (US), 08/9/11 - 9/15
 Y. Hikida, KEK (Japan), 08/9/11 - 9/17
 S. Nakamura, Hanyang (Korea), 08/9/11 - 9/19
 K. Hashimoto, RIKEN (Japan), 08/9/12 - 9/17
 Y. Hyakutake, Osaka (Japan), 08/9/12 - 9/17
 T. Ishii, Osaka (Japan), 08/9/12 - 9/17
 S. Iso, KEK (Japan), 08/9/12 - 9/17
 D. Kabat, Columbia (US), 08/9/12 - 9/17
 Y. Michishita, Kagoshima (Japan), 08/9/12 - 9/17
 M. Nakashima, Tokyo (Japan), 08/9/12 - 9/17
 M. Natsuume, KEK (Japan), 08/9/12 - 9/17
 J. Nishimura, KEK (Japan), 08/9/12 - 9/17

Y. Okawa, Tokyo (Japan), 08/9/12 - 9/17
 S. Pilansky, Komaba Tokyo (Japan), 08/9/12 - 9/17
 Y. Sekino, Okayama Inst Quantum Phys (Japan), 08/9/12 - 9/17
 N. Shiiki, Tokyo (Japan), 08/9/12 - 9/17
 K. Shirokawa, Academia Sinica Taiwan (Taiwan), 08/9/12 - 9/17
 T. Azuma, Setsunan (Japan), 08/9/12 - 9/16
 M. Fujita, Kyoto (Japan), 08/9/12 - 9/16
 K. Hasebe, Takuma-ct (Japan), 08/9/12 - 9/16
 S. Hikami, Tokyo (Japan), 08/9/12 - 9/16
 M. Honda, Soukendai (Japan), 08/9/12 - 9/16
 A. Hosoya, Titech (Japan), 08/9/12 - 9/16
 T. Kikuchi, Kyoto (Japan), 08/9/12 - 9/16
 Y. Kitazawa, KEK (Japan), 08/9/12 - 9/16
 N. Manabe, Soukendai (Japan), 08/9/12 - 9/16
 K. Matsumoto, KEK (Japan), 08/9/12 - 9/16
 T. Matsuo, Tsukuba (Japan), 08/9/12 - 9/16
 T. Sugawa, Osaka city (Japan), 08/9/12 - 9/16
 Y. Sumitomo, KEK (Japan), 08/9/12 - 9/16
 H. Tanaka, Tokyo (Japan), 08/9/12 - 9/16
 Y. Tsuchiya, Tokyo (Japan), 08/9/12 - 9/16
 K. Umetsu, Nihon (Japan), 08/9/12 - 9/16
 N. Yamamoto, Tokyo (Japan), 08/9/12 - 9/16
 S. Yokoyama, Tokyo (Japan), 08/9/12 - 9/16
 M. Yoshimatsu, Tokyo (Japan), 08/9/12 - 9/16
 Y. Akamatsu, Tokyo (Japan), 08/9/12 - 9/17
 T. Azevanagi, Kyoto (Japan), 08/9/12 - 9/17
 S. Matsuura, Tokyo (Japan), 08/9/12 - 9/17
 T.S. Tai, Riken (Japan), 08/9/12 - 9/18
 B. Leclerc, Caen (France), 08/9/13 - 9/20
 T. Nishioka, Kyoto (Japan), 08/9/13 - 9/16
 R. Koder, Tokyo (Japan), 08/9/16 - 9/18
 T. Kuwabara, RIMS Kyoto (Japan), 08/9/16 - 9/18
 S. Ariki, RIMS Kyoto (Japan), 08/9/16 - 9/18
 N. Enomoto, RIMS Kyoto (Japan), 08/9/16 - 9/18
 S. Kito, RIMS Kyoto (Japan), 08/9/16 - 9/18
 K. Nagao, Kyoto (Japan), 08/9/16 - 9/18
 S. Naito, Tsukuba (Japan), 08/9/16 - 9/18
 R. Ohkura, Titech (Japan), 08/9/16 - 9/18
 Y. Saito, Tokyo (Japan), 08/9/16 - 9/18
 N. Sawada, Tsukuba (Japan), 08/9/16 - 9/18
 D. Sternhaimer, Bourgogne (France), 08/9/16 - 9/18
 S. Tsuchiura, RIMS Kyoto (Japan), 08/9/16 - 9/18
 Y. Voglaine, Louvain (Belgium), 08/9/16 - 9/18
 S. Dedeo, Chicago (US), 08/9/19 - 10/10
 A.E. Romano, YITP Kyoto (Japan), 08/9/22 - 9/22
 E.L. Turner, Princeton (US), 08/9/27 - 10/12
 T. Broadhurst, Tel Aviv (Israel), 08/9/28 - 10/15
 D. Lemze, Tel Aviv (Israel), 08/9/28 - 10/15
 S.B. Gudnason, Pisa (Italy), 08/10/2 - 10/2
 W.S. Hou, Taiwan (Taiwan), 08/10/2 - 10/2
 S. Gorchinskiy, Steklov Math Inst (Russia), 08/10/6 - 11/7
 S. Shimizu, DESY (Germany), 08/10/9 - 10/9
 J. Alwall, Stanford (US), 08/10/13 - 12/19
 Y.K. Kim, Chicago/Fermilab (US), 08/10/14 - 10/14
 M. Kontsevich, IHES (France), 08/10/14 - 10/14
 A. Kusenko, UCLA (US), 08/10/16 - 12/13
 D. Bernstein, UCSB (US), 08/10/22 - 10/22
 H. Foglizzo, Service d'Astro Phys (France), 08/10/22 - 10/22
 A. Kirillov, RIMS Kyoto (Japan), 08/10/26 - 10/27
 M. Semenov-Tian-Shansky, Bourgogne (France), 08/10/26 - 10/27
 H. Takahashi, Hiroshima (Japan), 08/10/30 - 10/30
 J. Conlon, Cambridge (UK), 08/11/1 - 11/15

S. Blinnikov, ITEP (Russia), 08/11/1 - 09/4/30
 L. Hall, UC Berkeley (US), 08/11/3 - 11/12
 T. Takeuchi, Virginia Tech (US), 08/11/3 - 11/28
 E. Kearns, Boston (US), 08/11/6 - 11/11
 C.L. Shan, Seoul (Korea), 08/11/6 - 11/6
 S. Ho, Princeton (US), 08/11/7 - 11/16
 K. Koyama, Portsmouth (UK), 08/11/10 - 11/10
 M. Limongi, INAF (Italy), 08/11/16 - 11/18
 D.R. Morrison, UCSB (US), 08/11/16 - 11/18
 L.F. Wang, Texas A&M (US), 08/11/16 - 11/18
 R. Peccei, UCLA (US), 08/11/17 - 11/18
 C. Fryer, Los Alamos (US), 08/11/17 - 11/21
 G. Fuller, UCSD (US), 08/11/17 - 11/21
 C. Gerardy, Florida State (US), 08/11/17 - 11/21
 M. Hamuy, Chille (Chille), 08/11/17 - 11/21
 J. Hidaka, UCSD (US), 08/11/17 - 08/11/21
 Y. Ihara, Tokyo (Japan), 08/11/17 - 11/21
 N. Iwamoto, JAEA (Japan), 08/11/17 - 11/21
 N. Izutani, Tokyo (Japan), 08/11/17 - 11/21
 T. Kajino, NAOJ (Japan), 08/11/17 - 11/21
 Y. Kamiya, Tokyo (Japan), 08/11/17 - 11/21
 K. Konichi, ICRR Tokyo (Japan), 08/11/17 - 11/21
 M. Kutsuna, RESCEU Tokyo (Japan), 08/11/17 - 11/21
 A. Mizuta, Chiba (Japan), 08/11/17 - 08/11/21
 T. Moriya, Tokyo (Japan), 08/11/17 - 11/21
 P. Nugent, LBNL (US), 08/11/17 - 11/21
 G. Pignata, Chille (Chille), 08/11/17 - 11/21
 I. Sakon, Tokyo (Japan), 08/11/17 - 11/21
 T. Sekiguchi, ICRR Tokyo (Japan), 08/11/17 - 11/21
 Y. Suwa, Tokyo (Japan), 08/11/17 - 11/21
 M. Tanaka, Tokyo (Japan), 08/11/17 - 11/21
 H. Tsunemi, Osaka (Japan), 08/11/17 - 11/21
 H. Umeda, Tokyo (Japan), 08/11/17 - 11/21
 N. Yasuda, ICRR Tokyo (Japan), 08/11/17 - 11/21
 T. Yoshida, NAOJ (Japan), 08/11/17 - 11/21
 P. Chen, SLAC (US), 08/11/19 - 11/19
 H.C. Wang, Taiwan (Taiwan), 08/11/19 - 11/19
 R. Nakajima, LBNL (US), 08/11/25 - 11/28
 E. Sorokina, ITEP (Russia), 08/11/30 - 12/30
 D. Nagai, Yale (US), 08/12/1 - 12/1
 J. Peacock, Edinburgh (UK), 08/12/8 - 12/12
 R. Ellis, Caltech (US), 08/12/8 - 12/14
 M. Staudacher, Max Planck (Germany), 08/12/9 - 12/10
 B. Eynard, CEA Saclay (France), 08/12/11 - 12/13
 M. Mulase, UC Davis (US), 08/12/11 - 12/13
 B. Safnuk, Central Michigan (US), 08/12/11 - 12/13
 L. Deccart, Princeton (US), 08/12/14 - 09/1/7
 M. Takeuchi, Kyoto & KEK (Japan), 08/12/17 - 12/20
 S. Bruenn, Florida Atlantic (US), 08/12/17 - 12/21
 A. Hanany, MIT (US), 08/12/18 - 09/1/21
 D. Kaledin, Steklov Math Inst (Russia), 09/1/4 - 1/13
 S. Kawamura, NAOJ (Japan), 09/1/5 - 1/5
 A. Futaki, Titech (Japan), 09/1/5 - 1/5
 H. Hoekstra, Leiden (Netherlands), 09/1/5 - 09/1/12
 L. Ornea, Bucharest (Romania), 09/1/5 - 1/17
 K. Choi, Kaist (Korea), 09/1/5 - 1/18
 G. Cavalcanti, Utrecht (Netherlands), 09/1/5 - 1/8
 A. Fujiki, Osaka (Japan), 09/1/5 - 1/8
 R. Goto, Osaka (Japan), 09/1/5 - 1/8
 A. Tomasiello, Harvard (US), 09/1/5 - 1/8
 U. Lindstrom, Uppsala (Sweden), 09/1/5 - 1/8
 L. Martucci, LMU München (Germany), 09/1/5 - 1/8

M. Rocek, Stony Brook (US), 09/1/5 - 1/8
 C. Albertsson, YITP Kyoto (Japan), 09/1/5 - 1/8
 N. Yotsutani, Nagoya (Japan), 09/1/5 - 1/8
 T. Mabuchi, Osaka (Japan), 09/1/6 - 1/8
 G. Grantcharov, Florida Int'l (US), 09/1/7 - 1/12
 Y. Nakayama, UC Berkeley (US), 09/1/8 - 1/8
 E. Turner, Princeton (US), 09/1/11 - 1/30
 M. Ooguri, Stanford (US), 09/1/12 - 1/25
 U. Maio, Max Planck (Germany), 09/1/15 - 1/15
 J. Zaanen, Leiden (Netherlands), 09/1/15 - 1/15
 H. Yu, UC Irvine (US), 09/1/15 - 1/27
 C. Loomis, Princeton (US), 09/1/21 - 1/21
 M. Mriek, Princeton (US), 09/1/21 - 1/21
 M. Strauss, Princeton (US), 09/1/21 - 1/21
 R. Lupton, Princeton (US), 09/1/21 - 1/22
 R. Brandenberger, McGill (Canada), 09/1/21 - 1/24
 R. Ookawa, Titech (Japan), 09/1/22 - 1/22
 A. Moro-Martin, Princeton (US), 09/1/23 - 1/23
 A. Ferrara, Scuola Normale Superiore Pisa (Italy), 09/1/27 - 1/27
 T. Nishioka, Kyoto (Japan), 09/1/29 - 1/29
 D. Sternheimer, Keio (Japan), 09/2/5 - 2/5
 R. Brandenberger, McGill (Canada), 09/2/9 - 2/9
 H. Maeda, Centro de Estudios Científicos (Chille), 09/2/9 - 2/9
 M. Ibe, SLAC (US), 09/2/12 - 2/12
 Y. Wang, IHEP (China), 09/2/12 - 2/12
 B.K. Fujikawa, LBNL (US), 09/2/15 - 3/2
 S. Ma, Tokyo (Japan), 09/2/19 - 2/19
 F.D. Steffen, Max Planck (Germany), 09/2/19 - 2/19
 A.G. De Bruyn, ASTRON (Netherlands), 09/2/24 - 2/24
 S. Zaroubi, Kapteyn Astr Inst (Netherlands), 09/2/24 - 2/24
 N. Afshordi, Perimeter Inst (Canada), 09/2/24 - 3/1
 G. Ghazal, Perimeter Inst (Canada), 09/2/24 - 3/1
 S. Glover, Heidelberg (Germany), 09/2/28 - 3/15
 I. Nisoli, Pisa (Italy), 09/2/28 - 5/25
 S. Katsanevas, Paris (France), 09/3/2 - 3/2
 S.P. Oh, UCSB (US), 09/3/2 - 3/12
 C.P. Yuan, Michigan (US), 09/3/2 - 3/13
 A. Karch, Washington (US), 09/3/12 - 3/12
 M. Bersten, Chille (Chille), 09/3/13 - 09/4/30
 L. Wang, Princeton (US), 09/3/15 - 3/21
 M. Lisanti, Stanford (US), 09/3/15 - 3/22
 J. Alwall, SLAC (US), 09/3/15 - 3/22
 K. Hirokuni, Tsing Hua (Taiwan), 09/3/16 - 3/16
 B. Allanach, Cambridge (UK), 09/3/16 - 3/20
 A. Barr, Oxford (UK), 09/3/16 - 3/20
 W. Cho, KAIST (Korea), 09/3/16 - 3/20
 K. Choi, KAIST (Korea), 09/3/16 - 3/20
 C. Csaki, Cornell (US), 09/3/16 - 3/20
 C. Duhl, Louvain (Belgium), 09/3/16 - 3/20
 R.M. Godbole, Indian Inst Science (India), 09/3/16 - 3/20
 B. Gripaios, CERN (Switzerland), 09/3/16 - 3/20
 T. Han, Wisconsin-Madison (US), 09/3/16 - 3/20
 K. Hasegawa, DESY (Germany), 09/3/16 - 3/20
 M. Herquet, NIKHEF (Netherlands), 09/3/16 - 3/20
 N. Kersting, Sichuan (China), 09/3/16 - 3/20
 K. Kong, Fermilab (US), 09/3/16 - 3/20
 K. Mawatari, Heidelberg (Germany), 09/3/16 - 3/20
 M. Park, Florida (US), 09/3/16 - 3/20
 M. Peskin, SLAC (US), 09/3/16 - 3/20
 T. Plehn, Heidelberg (Germany), 09/3/16 - 3/20
 G. Polesello, INFN (Italy), 09/3/16 - 3/20
 A.R. Raklev, Cambridge (UK), 09/3/16 - 3/20

A. De Roeck, Antwerpen (Belgium), 09/3/16 - 3/20
 T. Tait, Argonne & Northwestern (US), 09/3/16 - 3/20
 H.C. Tsai, Taiwan (Taiwan), 09/3/16 - 3/20
 B. Webber, Cambridge (UK), 09/3/16 - 3/20
 B. Francesca, CERN (Switzerland), 09/3/16 - 3/20
 J.S. Lee, Nat'l Center for Theor Sci (Taiwan), 09/3/16 - 3/20
 S. Ferrag, Glasgow (UK), 09/3/16 - 3/20
 K. Igi, Riken (Japan), 09/3/16 - 3/20

K. Sakurai, Nagoya (Japan), 09/3/16 - 3/20
 H. Yokoya, Niigata (Japan), 09/3/16 - 3/20
 H. Nakaoka, Tokyo (Japan), 09/3/19 - 3/19
 N. Turok, Perimeter Inst (Canada), 09/3/26 - 3/26
 R. Gregory, Durham (UK), 09/3/27 - 09/4/10
 H. Tye, Cornell (US), 09/3/27 - 09/4/2
 W. Song, Inst Theo Phys (China), 09/3/30 - 09/4/3
 F. Urban, UBC (Canada), 09/3/31 - 09/4/2

11. Publications

JFY2007

Asphericity in Supernova Explosions from Late-Time Spectroscopy,

Keiichi Maeda, Koji Kawabata, Paolo A. Mazzali, Masaomi Tanaka, Stefano Valenti, Ken'ichi Nomoto, Takashi Hattori, Jinsong Deng, Elena Pian, Stefan Taubenberger, Masanori Iye, Thomas Matheson, Alexei V. Filippenko, Kentaro Aoki, George Kosugi, Youichi Ohyama, Toshiyuki Sasaki, Tadafumi Takata, Science 319, 1220 (2008)

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Hidetaka Sonoda, Gentaro Watanabe, Katsuhiko Sato, Kenji Yasuoka, Toshikazu Ebisuzaki, Phys. Rev. C 77, 035806 (2008)

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Yu Nakayama, M. Yamazaki, T. T. Yanagida, Phys. Lett. B 663, 281 (2008)

Affleck Dine leptogenesis via multiple flat directions,

Kohei Kamada, Jun'ichi Yokoyama, Phys. Rev. D 78, 043502 (2008)

Inflation at the GUT scale in a Higgsless universe,

Nemanja Kaloper, Lorenzo Sorbo, Jun'ichi Yokoyama, Phys. Rev. D 78, 043527 (2008)

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Takaya Nozawa, Takashi Kozasa, Nozomu Tominaga, Itsuki Sakon, Masaomi Tanaka, Tomoharu Suzuki, Ken'ichi Nomoto, Keiichi Maeda, Hideyuki Umeda, Marco Limongi, Takashi Onaka, Astrophys J. 684, 1343 (2008)

Probing reheating temperature of the universe with gravitational wave background,

Kazunori Nakayama, Shun Saito, Yudai Suwa, Jun'ichi Yokoyama, JCAP 06, 020 (2008)

Single-field inflation, anomalous enhancement of superhorizon fluctuations, and non-Gaussianity in primordial black hole formation,

Ryo Saito, Jun'ichi Yokoyama, Ryo Nagata, JCAP 06, 024 (2008)

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N. Tominaga, M. Limongi, T. Suzuki, M. Tanaka, K. Nomoto, K. Maeda, A. Chieffi, A. Tornambe, T. Minezaki, Y. Yoshii, I. Sakon, T. Wada, Y. Ohyama, T. Tanabe, H. Kaneda, T. Onaka, T. Nozawa, T. Kozasa, K. S. Kawabata, G. C. Anupama, D.K. Sahu, U.K. Gurugubelli, T.P. Prabhu, and J. Deng, Astrophys. J. 687, 1208 (2008)

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Hirota Hayashi, Radu Tatar, Yukinobu Toda, Taizan Watari, and Masahito Yamazaki, Nucl. Phys. B 806, 224 (2008)

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Subaru and Keck Observations of the Peculiar Type Ia Supernova 2006gz at Late Phases,

Keiichi Maeda, Koji Kawabata, Weidong Li, Masaomi Tanaka, Paolo A. Mazzali, Takashi Hattori, Ken'ichi Nomoto, Alex V. Filippenko, Accepted for publication in Astrophys. J.

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Shinta Kasuya, Masahiro Kawasaki and Fuminobu Takahashi, JCAP 10, 017 (2008)

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Ryo Nagata, Jun'ichi Yokoyama, Phys. Rev. D 78, 123002 (2008)

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Supernova 2008D associated with the Luminous X-ray Transient 080109: An Energetic Explosion of a Massive Helium Star,

Masaomi Tanaka, Nozomu Tominaga, Ken'ichi Nomoto, S. Valenti, D.K. Sahu, T. Minezaki, Y. Yoshii, M. Yoshida, G.C. Anupama, S. Benetti, G. Chincarini, M. Della Valle, P.A. Mazzali, E. Pian,
Accepted for publication in *Astrophys. J.*

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A. Gal-Yam, F. Bufano, T. Barlow, E. Baron, S. Benetti, E. Cappellaro, P.J. Challis, R.S. Ellis, A.V. Filippenko, R.J. Foley, D.B. Fox, R.P. Kirshner, D.C. Leonard, W. Li, D. Maoz, T. Matheson, P.A. Mazzali, M. Modjaz, K. Nomoto, E.O. Ofek, J. Simon, T. Small, G.P. Smith, M. Turatto, S.D. Van Dyk, and L. Zampieri,
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Astrophys. J. 689, 1191 (2008)

The broad line type Ic supernova SN 2007ru:

Adding to the diversity of type Ic supernovae,
D.K. Sahu, Masaomi Tanaka, G.C. Anupama, Uday K. Gurugubelli, and Ken'ichi Nomoto,
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The Delay Time Distribution of Type Ia Supernovae and the Single Degenerate Model,

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Current Correlators for General Gauge Mediation,

Hiroshi Ooguri, Yutaka Ookouchi, Chang-Soon Park, and Jaewon Park,
Accepted for publication in *Nucl. Phys. B*

Solving Cosmological Problems of Supersymmetric Axion Models in Inflationary Universe,

Masahiro Kawasaki, Kazunori Nakayama,
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Upperbound on Squark Masses in Gauge-Mediation Model with Light Gravitino,

Junji Hisano, Minoru Nagai, Shohei Sugiyama, and T. T. Yanagida,
Phys. Lett. B 665, 237 (2008)

Quantum Interference Effects Among Helicities at LEP-II and Tevatron,

Matthew R. Buckley, Beate Heinemann, William Klemm, and Hitoshi Murayama,
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Decaying D-branes and Moving Mirrors,

Tomoyoshi Hirata, Shinji Mukohyama and Tadashi Takayanagi,
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Gravitational Waves as a Probe of the Gravitino Mass,

Fuminobu Takahashi, T.T. Yanagida, and Kazuya Yonekura,
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Test of Anomaly Mediation at the LHC,

Shoji Asai, Takeo Moroi, T.T. Yanagida,
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Inclusive transverse mass analysis for squark and gluino mass determination,

Mihoko M. Nojiri, Yasuhiro Shimizu, Shogo Okada, Kiyotomo Kawagoe,
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Chemical Abundances of the Secondary Star in the Black Hole X-ray Binary XTE J1118+480,

Jonay I. Gonzalez Hernandez, Rafael Rebolo, Garik Israelian, Alexei V. Filippenko, Ryan Chornock, Nozomu Tominaga, Hideyuki Umeda, and Ken'ichi Nomoto,
Astrophys. J. 679, 732 (2008)

The Outermost Ejecta of Type Ia Supernovae,

Masaomi Tanaka, Paolo A. Mazzali, Stefano Benetti, Ken'ichi Nomoto, Nancy Elias-Rosa, Rubina Kotak, Giuliano Pignata, Vallery Stanishev, Stephan Hachinger,
Astrophys. J. 677, 448 (2008)

Electromagnetic Properties of the Early Universe,

Keitaro Takahashi, Kiyotomo Ichiki, Naoshi Sugiyama,
Phys. Rev. D 77, 124028 (2008)

Determining the mass of a ultra-light gravitino at LHC,

K. Hamaguchi, S. Shirai, and T.T. Yanagida,
Phys. Lett. B 663, 86 (2008)

Aspherical Properties of Hydrodynamics and Nucleosynthesis in Jet-induced Supernovae,

Nozomu Tominaga,
Astrophys. J. 690, 526 (2009)

The evolution of the peculiar Type Ia supernova SN 2005hk over 400 days,

D.K. Sahu, Masaomi Tanaka, G.C. Anupama, Koji S. Kawabata, Keiichi Maeda, Nozomu Tominaga, Ken'ichi Nomoto, and Paolo A. Mazzali,
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Young and Massive Binary Progenitors of Type Ia Supernovae and Their Circumstellar Matter,

Izumi Hachisu, Mariko Kato, and Ken'ichi Nomoto,
Astrophys. J. 679, 1390 (2008)

nu-Process Nucleosynthesis in Population III Core-Collapse Supernovae,

Takashi Yoshida, Hideyuki Umeda, and Ken'ichi Nomoto,
Astrophys. J. 672, 1043 (2008)

A hybrid method for determining SUSY particle masses at the LHC with fully identified cascade decays,

Mihoko M. Nojiri, Giacomo Polesello, Daniel R. Tovey,
JHEP 05, 014 (2008)

Metastable Vacua in Perturbed Seiberg-Witten Theories, Part 2: Fayet-Iliopoulos Terms and Kahler Normal Coordinates,

Joseph Marsano, Hiroshi Ooguri, Yutaka Ookouchi, Chang-Soon Park,
Nucl. Phys. B 798, 17 (2008)

Discriminating spin through quantum interference,

Matthew R. Buckley, Hitoshi Murayama, William Klemm, Vikram Raval,
Phys. Rev. D 78, 014028 (2008)

No Evidence for Variability of Intervening Absorption Lines toward GRB 060206: Implications for the Mg II Incidence Problem,

Kentaro Aoki, Tomonori Totani, Takashi Hattori, Kouji Ohta, Koji S. Kawabata, Naoto Kobayashi, Masanori Iye, Ken'ichi Nomoto, and Nobuyuki Kawai,
Accepted for publication in *Publ. Astron. Soc. Japan*

Gauge Mediation with Sequestered Supersymmetry Breaking,

Satoshi Shirai, Fuminobu Takahashi, T. T. Yanagida and Kazuya Yonekura,
Phys. Rev. D 78, 075003 (2008)

Constraints on the time variation of the fine structure constant by the 5-year WMAP data,

Masahiro Nakashima, Ryo Nagata, Jun'ichi Yokoyama,
Prog. Theor. Phys. 120, 1207 (2008)

Properties of newly formed dust by SN2006jc based on near-to-mid infrared observation with AKARI,

I. Sakon, T. Wada, Y. Ohshima, D. Ishihara, T. Tanabe, H. Kaneda, T. Onaka, N. Tominaga, M. Tanaka, T. Suzuki, H. Umeda, K. Nomoto, T. Nozawa, T. Kozasa, T. Minezaki, Y. Yoshii, S. Ohya, F. Usui, H. Matsuhara, T. Nakagawa, and H. Murakami,
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A note on Markov type constants,

Shin-ichi Ohta and Mikael Pichot,
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Holographic Baryons: Static Properties and Form Factors from Gauge/String Duality,

Koji Hashimoto, Tadakatsu Sasaki, and Shigeki Sugimoto,
Prog. Theor. Phys. 120, 1093 (2008)

Observational Characteristics and Possible Asphericity of Over-Luminous Type Ia Supernovae,

Keiichi Maeda and Koichi Iwamoto,
Accepted for publication in *MNRAS*

Growth functions associated with Artin monoids of finite type,

Kyoji Saito,
Proc. Japan Acad. Ser. A (2008)

Bar complex, configuration spaces and finite type invariants for braids,

Toshitake Kohno,
Accepted for publication in *Topology and its Applications*

Tycho Brahe's 1572 Supernova as a standard type Ia explosion revealed from its light echo spectrum,

Oliver Krause, Masaomi Tanaka, Tomonori Usuda, Takashi Hattori, Miwa Goto, Stephan Birkmann, Ken'ichi Nomoto,
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Hajime Takami and Katsuhiko Sato,
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Shunsaku Horiuchi, Yudai Suwa, Hajime Takami, Shin'ichiro Ando and Katsuhiko Sato,
Accepted for publication in *MNRAS*

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Yudai Suwa, Tomoya Takiwaki, Kei Kotake, and Katsuhiko Sato,
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Consistent Anti-de Sitter-Space/Conformal-Field-Theory Dual for a Time-Dependent Finite Temperature System,

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Mitsutoshi Fujita, Yasuaki Hikida, Shinsei Ryu and Tadashi Takayanagi,
JHEP 0812, 065 (2008)

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G. C. Anupama, D. K. Sahu, U. K. Gurugubelli, T. P. Prabhu, N. Tominaga, M. Tanaka, K. Nomoto,
MNRAS 392, 894 (2009)

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Shushi Harashita,
Accepted for publication in the *Asian Journal of Mathematics*

12. Preprints

Simulations of Baryon Acoustic Oscillations I: Growth of Large-Scale Density Fluctuations,
Ryuichi Takahashi, Naoki Yoshida, et al.
MNRAS 389, 1675 (2008)

Nucleosynthesis of ^{56}Ni in wind-driven Supernova Explosions and Constraints on the Central Engine of Gamma-Ray Bursts,
Keiichi Maeda and Nozomu Tominaga,
Accepted for publication in MNRAS

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Lawrence J. Hall, Michael P. Salem and Taizan Watari,
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Shushi Harashita,
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Cosimo Bambi and Katherine Freese,
Phys. Rev. D 79, 043002 (2009)

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Hiroshi Ooguri and Masahito Yamazaki,
Accepted for publication in Communications in Mathematical Physics

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Kiyotomo Ichiki, Masahiro Takada, Tomo Takahashi,
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Chuan-Ren Chen, Fuminobu Takahashi and T. T. Yanagida,
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Chuan-ren Chen, William L. Klemm, Vikram Rantala, Kai Wang,
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The Impact of Non-Gaussian Errors on Weak lensing Surveys,
Masahiro Takada, Bhuvnesh Jain,
Accepted for publication in MNRAS

Conformal Inflation, Modulated Reheating and WMAP5,
Takeshi Kobayashi and Shinji Mukohyama,
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Pavel Fileviez Perez, Hiren Patel, Michael Ramsey-Musolf, Kai Wang,
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Non-Gaussianity from isocurvature perturbations,
Masahiro Kawasaki, Kazunori Nakayama, Toyokazu Sekiguchi, Teruaki Suyama, Fuminobu Takahashi,
JCAP 11, 019 (2008)

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Chuan-Ren Chen, Fuminobu Takahashi, T. T. Yanagida,
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A General Analysis of Non-Gaussianity from Isocurvature Perturbations,
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JCAP 02, 004 (2009)

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JFY2007

IPMU 07-0001
Moduli stabilization in stringy ISS models,
Yu Nakayama, M. Yamazaki, T. T. Yanagida,
arXiv:0710.0001[hep-th], Phys. Lett. B 663, 281 (2008)

IPMU 07-0002
Discriminating spin through quantum interference,
Matthew R. Buckley, Hitoshi Murayama, William Klemm, Vikram Rantala,
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Metastable Vacua in Perturbed Seiberg-Witten Theories, Part 2: Fayet-Iliopoulos Terms and Kahler Normal Coordinates,
Joseph Marsano, Hiroshi Ooguri, Yutaka Ookouchi, Chang-Soon Park,
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Towards Unravelling the Structural Distribution of Ultra-high-energy Cosmic Ray Sources,
Hajime Takami and Katsuhiko Sato,
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Distortion of Ultra-high-energy Sky by Galactic Magnetic Field,
Hajime Takami and Katsuhiko Sato,
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IPMU 07-0006
Phase diagram of nuclear "pasta" and its uncertainties in supernova cores,
Hidetaka Sonoda, Gentaro Watanabe, Katsuhiko Sato, Kenji Yasuoka, Toshikazu Ebisuzaki,
arXiv:0712.0052[nucl-th], Phys. Rev. C 77, 035806 (2008)

IPMU 07-0007
A Problem of the QCD Axion in Supergravity,
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IPMU 07-0008
A hybrid method for determining SUSY particle masses at the LHC with fully identified cascade decays,
Mihoko M. Nojiri, Giacomo Polese, Daniel R. Tovey,
arXiv:0712.2718[hep-ph], JHEP 05, 014 (2008)

IPMU 07-0009
nu-Process Nucleosynthesis in Population III Core-Collapse Supernovae,
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IPMU 07-0010
Young and Massive Binary Progenitors of Type Ia Supernovae and Their Circumstellar Matter,
Izumi Hachisu, Mariko Kato, and Ken'ichi Nomoto,
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IPMU 07-0011
The evolution of the peculiar Type Ia supernova SN 2005hk over 400 days,
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IPMU 07-0012
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I. Sakon, T. Wada, Y. Ohyama, D. Ishihara, T. Tanabe, H. Kaneda, T. Onaka, N. Tominaga, M. Tanaka, T. Suzuki, H. Umeda, K. Nomoto, T. Nozawa, T. Kozasa, T. Minezaki, Y. Yoshii, S. Ohyabu, F. Usui, H. Matsuhara, T. Nakagawa, and H. Murakami,
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IPMU 07-0016
Electromagnetic Properties of the Early Universe,
Keitaro Takahashi, Kiyotomo Ichiki, Naoshi Sugiyama,
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IPMU 07-0017
Cosmic Microwave Background-Weak Lensing Correlation: Analytical and Numerical Study of Non-linearity and Implications for Dark Energy,
Atsushi J. Nishizawa, Eiichiro Komatsu, Naoki Yoshida, Ryuichi, Takahashi, Naoshi Sugiyama,
arXiv:0711.1696[astro-ph]

IPMU 07-0018

The Outermost Ejecta of Type Ia Supernovae,
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Ken'ichi Nomoto, Nancy Elias-Rosa, Rubina Kotak,
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From Primitive Forms to Frobenius Manifolds,
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IPMU09-0018
Triangulated Categories of Matrix Factorizations for Regular Systems of Weights with $\epsilon = -1$,
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IPMU09-0019
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13. Outreach and Public Communications

IPMU09-0020

Runaway Dynamics and Supersymmetry Breaking,
Izawa K.-I., Fuminobu Takahashi, T.T.Yanagida, Kazuya Yonekura

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IPMU09-0023

Dark matter and collider phenomenology of split-UED,
Chuan-Ren Chen, Mihoko Nojiri, Seong Chan Park, Jing Shu, Michihisa Takeuchi

IPMU09-0024

Nambu-Goldstone Dark Matter and Cosmic Ray Electron and Positron Excess,
Masahiro Ibe, Yu Nakayama, Hitoshi Murayama, Tsutomu Yanagida

IPMU09-0025

Emergent Calabi-Yau Geometry,
Hiroshi Ooguri and Masahito Yamazaki

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Stop and Decay of Long-lived Charged Massive Particles at the LHC detectors,
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Decaying Hidden Gaugino as a Source of PAMELA/ATIC Anomalies,
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IPMU09-0031

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Shunichiro Kinoshita and Shinji Mukohyama

IPMU09-0032

ABJM Theory with Flavors and FQHE,
Yasuaki Hikida, Wei Li and Tadashi Takayanagi

IPMU09-0033

Axion braneworld cosmology,
Cosimo Bambi, Masahiro Kawasaki, Federico R. Urban

IPMU09-0034

Growth functions for Artin monoids,
Kyoji Saito

IPMU09-0036

Coset Construction for Duals of Non-relativistic CFTs,
Sakura Schafer-Nameki, Masahito Yamazaki, Kentaroh Yoshida

IPMU09-0037

Neutrinoless Double Beta Decay and $H^{} \rightarrow I^{*}I^{*}$ Decays in the Higgs Triplet Model,**
S.T. Petcov, H. Sugiyama and Y. Takanishi

IPMU09-0038

Improved Predictions for Higgs PT at the Tevatron and the LHC,
Qing-Hong Cao, Chuan-Ren Chen, Carl Schmidt and C.-P. Yuan

We make strong efforts for publicizing our mission and the outcome of IPMU research activities. We also put strong emphasis on outreach program for general public. Not only these are our obligation to tax payers, but more importantly, we like to share our exciting ideas for solving the mystery of the universe and how we are making progress with others.

Public Lectures

Director Murayama gave a lecture "Is There an End to the Universe?" on July 12, 2008 on Kashiwa Campus. Audience of more than 300, mostly from Kashiwa area and ranging from teen agers to their eighties, enthusiastically listened to one hour lecture and participated in subsequent one hour session of questions and answers. Encouraged by the success, we organized another of his public lecture on the same topic on January 24, 2008 at the Yayoi Hall of Hongo Campus. An audience of 300, this time mostly of Tokyo area, attended. Director Murayama gave another public lecture "The Mystery of the Missing Antimatter" on two occasions, once on October 24, 2008 at the Kashiwa Campus Open House and other at Miraikan, Tokyo, during an event called Science Agora 2008 during November 22-24, 2008.



Figure 22: Hitoshi Murayama's public lecture at Kashiwa campus on July 12, 2008. The lecture was followed by a question and answer session.

We organized a series of five public lectures in an informal cafe-style at the Tama Rokuto Science Museum, Tokyo, jointly with the museum. "Science Cafe - Universe" covered the topics of "The Universe: Present, Past, and Future" by N. Sugiyama on February 14, "Birth of the Universe and Inflation Theory" by K. Sato on February 21, "The Universe Explored by Neutrino" by K. Inoue on February 28, "The Mystery of the Missing Antimatter: Kobayashi-Masukawa Theory and its Limitation" by H. Murayama on March 7, "Black Hole and the Crisis of Causality" by H. Ooguri on March 14.

IPMU NEWS

We published "IPMU NEWS" magazine five times, covering a wide range of news at IPMU such as hosted conferences and seminars, research highlight, introduction of new arrivals, and also featuring interested topics.



Video Clips

We started a series of short video clips where an IPMU scientist explained technical scientific terms to general public in just one minute on the website.



■ Figure 23: Susanne Reffert explains about the superstring theory in one minute video clip.

Website

We have been making special effort to construct a website (<http://www.ipmu.jp/>) that provides detailed and practical information for the employees and visitors. Particular emphasis has been placed to help foreign employees to understand Japanese procedures on hiring contract such as salary and tax and benefits, the work-related information such as research grants and travel expenses, as well as living information such as schools and hospitals.



■ Figure 24: The website team lead by Midori Ozawa won the 2008 President's Award for operational improvement.



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