

Workshop on “Analytic Representation Theory of Lie Groups”

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The workshop “Analytic Representation Theory of Lie Groups” was held at the Kavli IPMU for four days from July 1, 2015 (Organizer: Professor Toshiyuki Kobayashi, PI at the Kavli IPMU). Four professors including Vershik were invited from Europe and 13 researchers gave 20 hours of talks in total. In the workshop the central subject was on the following two programs advocated by Kobayashi.

- A: “Discover new phenomena in global analysis by using representation theory as a hint.”
- B: “The study of branching laws of infinite-dimensional representations.”

Lie groups are a classic object that arose as continuous transformation groups and since then the theory of Lie groups has been developed, interacting with various fields in mathematics and physics. One can often find symmetries behind classical analysis such as Fourier analysis and special functions and they are described in terms of Lie groups.

Conversely, based on the extensive development of the representation theory, the programs have aroused a new trend in which studies aim to discover new phenomena in global

analysis by using representation theory as a hint.

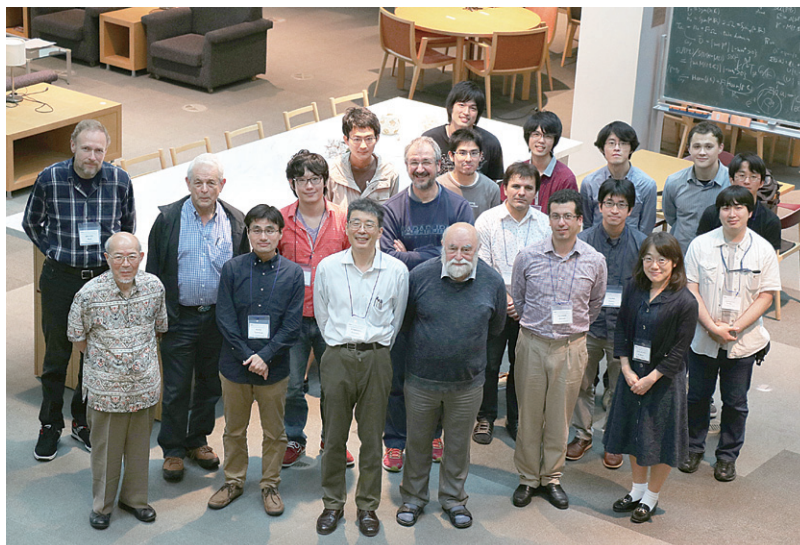
From this point of view, Orsted explained Kobayashi-Mano’s deformation theory and Ben Said-Kobayashi-Orsted’s deformation theory which includes the Fourier transform and the Dunkl transform. Kobayashi asked whether geometric quantizations and limits commute and then suggested a geometric idea for constructions of minimal representations.

Symmetry breaking operators, which control information of restrictions of representations, often came up in our discussion. This can be seen in Pevzner’s talk on the study of differential symmetry breaking operators via the F-method introduced by Kobayashi, Ochiai’s talk on an application of symmetry breaking

operators to automorphic forms, and a talk by the author on branching rules of unitary representations by using symmetry breaking operators.

Vershik constructed representations of certain infinite-dimensional groups, called current groups, using complementary series representations. His talk showed the participants a new aspect of representation theory. Bianchi discussed new results on the covariogram problem which have been obtained by applying relations between geometric invariants and the asymptotic distribution of the zero set of the Fourier transform.

By focusing analytic aspects on representation theory, we found that these programs expand in many directions and the workshop was very fruitful and successful.



Tokyo-Berkeley Summer School “Geometry and Mathematical Physics”

Toshitake Kohno

Kavli IPMU Principal Investigator

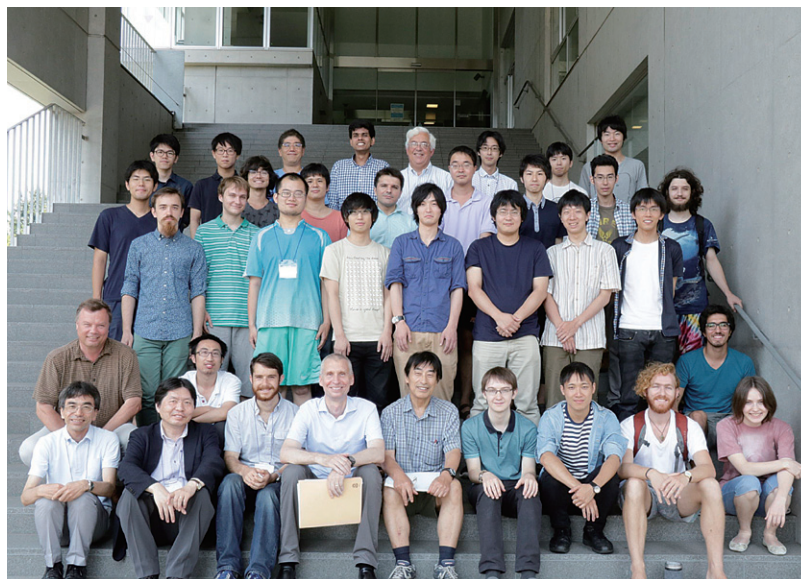
This school was held in the framework of the program for Strategic Partnership between the University of Tokyo and the University of California, Berkeley. We invited five students from the University of California, Berkeley, five students from the National Research University Higher School of Economics and one student from Yau Mathematical Sciences Center, Tsinghua University. Moreover, many Japanese students from both fields of mathematics and physics attended the school and the total number of participants was about 80. To support students, we used the funding of the Leading Graduate Course for Frontiers of Mathematical Sciences and Physics (FMSP) and Japan Student Services Organization (JASSO).

The school's subjects covered various topics coming from interaction between mathematics and physics such as the theory of period integrals, Gromov-Witten invariants, mirror symmetry and Donaldson-Thomas invariants. In the first week, there were three introductory lectures. First, Kyoji Saito gave an introduction to the theory of period integrals starting from the classical theory of elliptic integrals. He explained how such classical theory leads to the construction of the flat Frobenius

structure and the theory of primitive forms. Todor Milanov described a relationship between Gromov-Witten invariants and integrable systems. Then, Akishi Ikeda gave an introduction on a derived category of coherent sheaves on algebraic varieties and Bridgeland stability conditions. On the last day of the first week there was a student session and 14 students gave presentations on their research interests. The program of the second week consisted of mini-courses and 90-minute lectures. The lecturers of the mini-courses were Mikhail Kapranov, David Morrison, Nicolai Reshetikhin and Yukinobu Toda. Mikhail Kapranov described a combinatorial approach to Fukaya categories of surfaces and the concept of Fukaya categories with coefficients. David Morrison started with the

origin of mirror symmetry in string theory and discussed variations of this theme. Nicolai Reshetikhin explained a method of Batalin-Vilkovisky quantization. Yukinobu Toda talked about moduli of Bridgeland semistable objects on 3-folds and Donaldson-Thomas invariants. There were lectures by Kentaro Hori and Masahito Yamazaki. Kentaro Hori talked about the partition function on the hemisphere of two-dimensional supersymmetric sigma models and Masahito Yamazaki gave an introduction to cluster algebras and their applications.

The school was extremely lively, and there were many stimulating discussions among the participants including students. We hope to continue holding this kind of school in the future.



“Kavli IPMU-Durham-KIAS Workshop: New Particle Searches Confronting the First LHC Run-2 Data”

Michihisa Takeuchi

Kavli IPMU Postdoctoral Fellow

The international workshop was held at the Kavli IPMU on September 7 - 11, 2015. This workshop was co-organized by the Kavli-IPMU, Durham University, and KIAS. The organizing committee consists of Michihisa Takeuchi, Shigeki Matsumoto, Mihoko Nojiri, Kai Schmits, Pyungwon Ko, and Michael Spannowsky.

The aim of the workshop was to discuss new physics discoveries at the LHC just after the first LHC Run 2 results became public at the end of August (where the collision energy had been upgraded from 8 TeV to 13 TeV). There were several anomalies and divergences from the Standard Model predictions reported during Run 1; they are to be re-examined during Run 2. It was very timely to hold this workshop at this moment.

The workshop mainly consisted of 2 invited talk sessions in the morning and an invited talk and short talk sessions in the afternoon. In total, we had 10 speakers invited from abroad, 2 speakers invited from the Kavli IPMU, and 26 short talks. There were 67 participants from 11 countries (33 of the participants were from Japan).

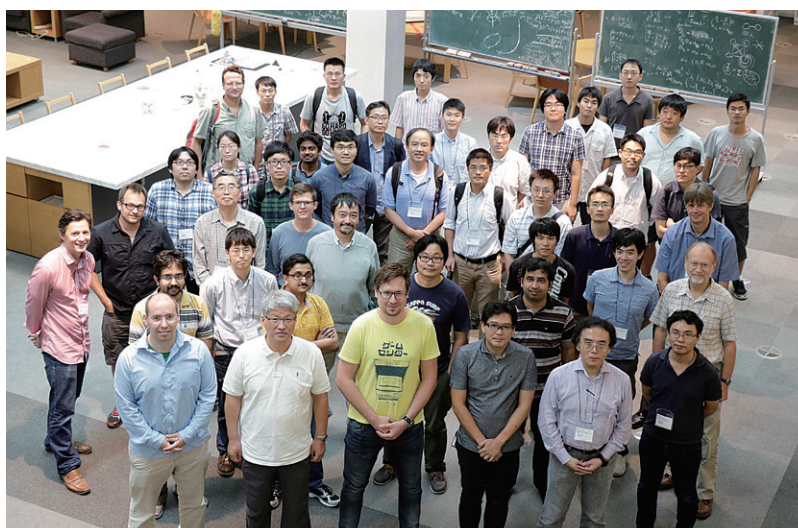
Mihoko Nojiri launched the workshop with an overview for Run 2 and Bryan Webber gave two

talks on event generations and jet substructures. In the afternoon, Yang Bai talked about non-relativistic particle production at the LHC. On the second day, 8 TeV results and 13 TeV perspectives at ATLAS and CMS were presented by Paul de Jong and Teruki Kamon, respectively, and Valentin V. Khoze talked about the Higgs Portal. On the third day, Tsutomu Yanagida gave a talk on Quarks and Leptons as Quasi-Nambu-Goldstone Fermions. On the fourth day, Seung Joon Lee talked about spin 1/2 composite particles, James B. Dent talked about the general framework of the effective field theory regarding dark matter at the LHC, and Graham Kribs talked about stealth dark matter. On

the final day, Matthew McCullough talked about the Relaxion and Lian-Tao Wang closed the workshop with a talk on spin 1 composite particles.

There were also short talks on new discovery strategies, kinematical variables at the LHC, a model to explain the diboson anomaly, lepton flavor violation, two-Higgs-doublet models, and dark matter searches at the LHC.

The workshop successfully closed with an announcement by Michael Spannowsky regarding a plan to have the next workshop at Durham University next year. It was a very good opportunity for lots of discussions with broad range of topics.



MEXT Scientific Research on Innovative Area Inauguration Symposium “Why Does the Universe Accelerate? – Exhaustive Study and Challenges for the Future – ”

Masahiro Takada

Kavli IPMU Professor

The MEXT Scientific Research on Innovative Area “Why does the Universe accelerate? – Exhaustive study and challenges for the future –” (PI: Hitoshi Murayama) is newly launched in FY2015. During Sep 20 – 21, we had the inauguration symposium at Lecture Hall of the Kavli IPMU. We had over 100 participants even in the middle of Silver Week holidays.

There is observational evidence for two periods of accelerated cosmic expansion: at the very beginning, known as inflation; and the present. Since Newton’s and Einstein’s gravity is known as an attractive force, gravity can only “pull” the expansion to slow it down. Hence cosmic acceleration is the biggest mystery in cosmology. What is “pushing” the Universe to speed it up? We often invoke “inflation” and “Einstein’s cosmological constant” as theories, but they have many unnatural features and are far from being satisfying explanations. The purpose of this research area is to understand the origin of the accelerated cosmic expansion, as well as its interplay with dark matter that competes with the

acceleration to build galaxies and clusters of galaxies. To address this problem never encountered before, we propose to conduct research based on a comprehensive approach: theory units ranging from cosmic acceleration due to inflation (A01: Misao Sasaki, Kyoto U.), decelerated expansion phase due to dark matter (A02: Fuminobu Takahashi, Tohoku U.), and the late-time cosmic acceleration due to dark energy (A03: Naoshi Sugiyama, Nagoya U.); observational units based on CMB experiments (B01: Masashi Hazumi, KEK), galaxy imaging surveys (B02: Satoshi Miyazaki, NAOJ), galaxy redshift surveys (B03: Masahiro Takada, IPMU), and the Thirty-Meter Telescope (B04: Tomonori Usuda, NAOJ); then ultimate units developing tools of combining different cosmological datasets to extract cosmological information (D01: Eiichiro Komatsu, MPA/IPMU) and seeking an ultimate theory of cosmic acceleration from super-string theory with a top-down perspective (C01: Hiroshi Ooguri,

Caltech/IPMU). This research program will be carried out over five-year duration (FY2015 - FY2019).

Representatives from each research group gave talks at the meeting introducing the background, scientific objectives, and planned research programs during the period. We also had contributed talks mainly by young researchers, stimulating various discussions. At the launch of this research program, there were many expectations and a lot of enthusiasm and excitement, and the research teams were able to re-realize responsibility for ensuring the success of the proposed research. The symposium was highly successful and moved the momentum forward.

The symposium was successfully run by other local organizers: Teppei Okumura, Kiyoto Yabe, Yuki Moritani, Hiroko Niikura, Ryoma Murata and Kazuyuki Akitsu. We also thank the Kavli IPMU administrative office members, especially Shoko Ichikawa for their dedicated support.

Workshop

