This fall the Simons Center for Geometry and Physics hosted three programs, bringing together mathematicians and physicists alike in a series of conferences, weekly seminars and collaborative research. The first of these 3 programs, which ran from August 26th – September 27th, was entitled ‘Mock Modular Forms, Moonshine and String Theory’ and was organized by Miranda Cheng, Matthias Gaberdiel and Terry Gannon. The program addressed various topics connected to Mathieu Moonshine; the possible relation of Mathieu Moonshine to the geometry of K3 surfaces, interesting string theoretic connections, and the current status of Monstrous Moonshine, the natural precursor of Mathieu Moonshine. Additionally there were formal math related talks on topics that are of relevance for understanding the conceptual reasons behind Mathieu Moonshine, such as mock modular forms and Maas forms, as well as multiplicative moonshine.

Overall, the program was successful in establishing contacts between different communities, and in stimulating many discussions, some of which have lead to new collaborations.

Math inspired sculpture attracted many to the SCGP art gallery this fall, with professor George Hart’s innovative exhibition, ‘Euclid’s Kiss’. Utilizing every day objects, such as pencils, playing cards, and faux animal fur; Hart displayed his 3D geometric sculptures, which are designed by the use of computer technology and fabricated using laser-cutting or 3D-printing technologies.
The ‘Quiver Varieties’ program ran from September 30 – November 8, and was organized by Ludmila Kamenova, Alexander Kirillov, Jr., Nikita Nekrasov, and Olivier Schiffmann. Through an intensive schedule of weekly seminars, each divided among three separate concentration periods, the program covered some of the most important applications of quiver varieties. Some topics explored were the application of quivers to gauge theories, as well as an overview of recent work on the relation between quiver representations and AGT conjecture in physics. A talk by Hiraku Nakajima shed new light on the geometric properties of supergravity theories. From an algebraic point of view: moduli spaces of slope-semistable sheaves, symplectic eightfolds, hyper-Kähler Lagrangian fibrations, and recent progress on the Core Conjecture. Overall, the Quiver Varieties program succeeded in providing a common forum for researchers in different areas of math and physics (such as gauge theory, representation theory, knot invariants, algebraic geometry) to all collaborate on topics related to quivers and quiver varieties. Additional topics covered by the seminars included the algebraic geometry of loop grassmanians and Uhlenbeck spaces, wall crossing formula, and representation theory of Cherednik algebras. There were also a number of talks exploring quivers from an algebraic point of view: moduli spaces of slope-semistable sheaves, symplectic eightfolds, hyper-Kähler Lagrangian fibrations, and recent progress on the Core Conjecture.

The Physics and Mathematics of Scattering Amplitude’ program ran from August 26 through Dec 20, 2013 and was organized by Zvi Bern, Lance Dixon, Michael Douglas, Sasha Goncharov and Lionel Mason. The program addressed the many recent advances in the study of scattering amplitudes, with the intent of bringing together mathematicians and physicists. Topics included physics-related developments such as perturbative approaches, generalized unitarity, recursion relations, scattering equations, twistor variables and topological string theory, integrability methods and the OPE, color-kinematics duality and double-copy properties of supergravity theories. From the mathematics perspective, topics included the (positive) Grassmannian and polytopes, (motivic) multiple zeta values, single-valued multiple (harmonic) polylogarithms, and the symbol of an iterated integral. The program was finished by an intense workshop summarizing the recent progress pointing to future directions that should have a lasting impact on the field. About mid-way through the program, the news was broadcast that two of the organizers, Zvi Bern (UCLA) and Lance Dixon (SLAC/Stanford), along with David Kosower (IPHT, Saclay) were awarded the American Physical Society’s 2014 J.J. Sakurai prize. The "amplitudes" program itself was natural outgrowth of their decades-long project of computing quantum corrections in the Standard Model of fundamental forces, which has both transformed physicists' ability to make predictions for the Large Hadron Collider and created a vibrant area of shared interest for physics and mathematicians. The Sakurai prize is one of the world’s most prestigious recognitions in theoretical physics, and its award -- for work directly related to the Scattering Amplitudes program and workshop -- provided an extra grace note of recognition to the Center’s fall activities. A serendipitous schedule brought all three prize-winners together at the Center for the first and second weeks of December. In recognition of this signal event, colleagues from the neighboring C. N. Yang Institute for Theoretical Physics, with the support and consultation of Center director John Morgan, organized a symposium on December 6, titled ‘From Trees and Loops to Precision QCD, a Symposium Inspired by the 2014 Sakurai Prize’. The session was attended by three former Sakurai Prize winners; YITP director George Sterman, who introduced the event, Columbia’s Enrico Fermi Chair of Physics, Alfred H. Mueller, who served as session chair, and Brookhaven National Laboratory’s William Marciano. "Inspiration" was the tone of the afternoon event, with luminous talks by Lance Dixon, elucidating the history and development of the ideas, as well as collaborator Stephan Hohen, who described the application of these developments to experiments at the Large Hadron Collider. Nima Arkani-Hamed concluded the event presenting a visionary extension of Bern, Dixon and Kosower’s ideas, and a warm appreciation for their groundbreaking advances.

Search
Organized by Patrick Meade, Michele Papucci, and Raman Sundrum. Sponsored by the C.N. Yang Institute for Theoretical Physics and the Simons Center for Geometry and Physics.
AUGUST 20 - 22, 2013
Mock Modular Forms, Moonshine, and String Theory
Organized by Miranda Cheng, Matthias Gaberdiel, and Terry Gannon
AUGUST 26 - SEPTEMBER 27, 2013
Quiver Varieties
Organized by Nikita Nekrasov, Alexander Kirillov, Olivier Schiffmann, and Ludmila Kamenova
OCTOBER 14 - 18, 2013
Graduate Workshop on Geometry of Hilbert Schemes
Organized by Mark de Cataldo, Alexander Kirillov, Jr., and Robert Lazarsfeld.
NOVEMBER 18 - 22, 2013
The Geometry and Physics of Scattering Amplitudes
Organized by Zvi Bern, Lance Dixon, Michael Douglas, Alexander Goncharov, and Lionel Mason
DECEMBER 9 - 13, 2013
For video recordings of workshop talks please visit http://scgp.stonybrook.edu/multimedia/videos

The SCGP welcomes unique proposals for semester long programs and shorter workshops.
Visit http://scgp.stonybrook.edu/scientific/call-for-proposals for guidelines and funding opportunities.
INTERVIEW WITH PERMANENT MEMBER KENJI FUKAYA

KENJI FUKAYA

1. What prompted you to start studying mathematics? One main reason I started studying mathematics was that I enjoyed being able to do something that was completely original. In mathematics one does not need to be popular or to follow the crowd. A mathematician can just work in a way he or she believes to be good. Whether we are right or not will eventually become clear by the correctness or importance of the things we obtain. When I was an undergraduate I liked to stay at home and think. Mathematics, I found, is a very good form of communication for me.

2. What did you first study and how did your research interests evolve to include symplectic topology? I started studying topology when I was in graduate school in Tokyo. The first subject I studied was metric Riemannian geometry, which I studied for about 7-8 years. When I visited the Max Planck Institute in Bonn, I had plenty of time, so I took that opportunity to learn something new.

I learned various things in the mathematics of Gauge theory. Metric Riemannian geometry and Gauge theory are connected to various other mathematics. But the part of mathematics to which they are related is rather different. Metric Riemannian geometry is related to the field of real analysis infinite groups etc. Mathematics of Gauge theory is related to the field of algebraic geometry and elementary particle physics etc. This interaction with different fields was interesting to me. When I was an undergraduate I spent much time studying symplectic geometry and Physics, both of which were my favorite subjects. Then a few years later I started to write a few papers on Gauge theory. The mathematics of Gauge theory is actually closely related to certain areas of symplectic geometry. So from there I began doing research in symplectic geometry.

3. How did you develop the geometric structure of Fukaya categories? I began studying the Gauge theory Floer homology of 3 manifolds with boundary. Gauge theory Floer homology associates a group to a 4-manifold. I had a conference at the University of Warwick in 1992, Simon Donaldson explained an idea that certain category associated to a 2 manifold is a possible framework to extend Floer homology to 3 manifolds with boundary. The object of the category Donaldson suggested is a Lagrangian submanifold of the space of representations of the fundamental group of a 3 manifolds. His proposal is that to a 3 manifold with boundary one associates an object of this category, which is Lagrangian submanifold of symplectization of the space of representation of the fundamental group of the boundary. Based on a certain result of mine (the behavior of gauge theory Floer homology under certain operations on manifolds) I thought that the correct object to be associated to a 3 manifold with boundary is not a Lagrangian submanifold itself, but rather a functor from this category of Lagrangian submanifolds to an algebraic category. I then started to work out this project. The first step is to actually rigorously establish the process to associate an appropriate algebraic category (built from the Lagrangian submanifolds) to a symplectic manifold. This took me more than 10 years. In 1993 I explained this project at a conference in Japan called Katada, (one of Taniguchi conferences). Maxim Kontsevitch was there. Soon after that he found that the category I proposed could be the symplectic geometry part of the categorical formulation of Mirror symmetry. Inspired by Kontsevich’s insight, my focus changed. Rather than focusing on the application of this structure associated to a Lagrangian submanifold to Gauge theory, I began to focus on its application to Mirror symmetry and symplectic topology.

4. What has it been like for you and your family to move across the world from Japan and now live in the US? For me, to come to the US is to do something different, and I’ve always loved trying new things. At my age (60s) it is getting harder and harder to do something which I never done before. So I am glad to have this opportunity to change my life significantly by coming here. (Of course the Simons Center is also an ideal place for me to do research.)

I am not sure how much my family has enjoyed coming here. They’ve agreed to do so and I thank them very much for that. On the other hand, I believe it is good for them, as well as me, to have a different experience from the life they had in Japan. My children are in school in the US and I hope this kind of experience will have a positive impact on their education, and broaden their horizons.

5. Tell us a little about your program for the spring semester, Moduli Spaces of Pseudo-holomorphic curves and their applications to Symplectic Topology. Several groups of people, including myself, developed this so called the virtual technique in the late 1980s and early 1990s. It greatly expands the way we can apply the most important method in global symplectic geometry, which is the method of pseudo-holomorphic curves. On the other hand, it is based on a certain idea, which is novel to many people working in the area and requires them to change their way of thinking about the basics of the theory from the very beginning. These ideas have been around for 15 years, but still there are not too many people who fully understand this method and use it systematically. I want to change this situation, since this method is powerful and actually easy to use, and I believe will be essential for many advances to come in the subject. One reason that it is easy to use is that, unlike many other techniques in this subject, the final result itself can be applied without too many restrictive hypotheses.

To clarify the current state of knowledge about this technique and to inform a wider community of symplectic topologists and geometers about this technique and its possible uses, these are the main purposes of this program.

PERMANENT MEMBER UPDATES

Dr. António Kapustin will join the SCGP in the Summer of 2014 as the Center’s newest Permanent Member, bringing his expertise in quantum field theory, with applications to particle physics and condensed matter physics and his newest interests in non-perturbative dualities in field theory and string theory, supersymmetry, and Topological Quantum Field Theory to the Center’s collaborative research activities.

Dr. Michael Douglas has stepped down from his role as Permanent Member of the Center to pursue opportunities with Renaissance Technology. Dr. Douglas remains an Affiliate Faculty Member of the Center and will continue to advise students in Stony Brook University’s Department of Physics and the CN Yang Institute for Theoretical Physics.

CYRIL CLOSSERT received his Ph.D. in Physics from the Université Libre de Bruxelles under the tutelage of Riccardo Argurio. He has since held a postdoc position at the Weizmann Institute of Sciences. Cyril’s recent research interests focus on rigid supersymmetry on curved manifolds, in various dimensions with the goal that exact results such as the computation of the exact partition function of field theories on very general compact manifolds (without topological twist) will likely lead to a deeper understanding of field theory dualities and uncover new relations between field theory observables in various dimensions.

MOHAMMAD FARAZJADEH TEHRANI received his Ph.D. in Mathematics in 2012 from Princeton University, under his adviser Gang Tian, and published his thesis on the “Gromov space of real curves in symplectic geometry”. He was a Visiting Assistant Professor at Cornell University in 2012-2013. Mohammad’s current research includes work to properly formulate the “Gromov-Witten sum formulas in symplectic geometry” as well as extending the definition of real invariants to higher genus. His other research interests include geometry, anywhere from differential to algebraic geometry.

VIJAY KUMAR received his Bachelor’s degree in Electrical Engineering from the Indian Institute of Technology in Madras in 2007, his Ph.D. in Physics in 2013. His thesis, written under the supervision of Washington Taylor, was on the landscape of six-dimensional supergravity theories and its relation to six-dimensional strings. Vijay’s research is focused on probing geometry from the point of view of string theory, working on problems that arise in the context of F-theory, topological string theory and supersymmetric gauge theories.

BEN WARD received his Ph.D. in Mathematics from the University of Oxford in 2013. His current research is focused on probing geometry from the point of view of string theory, working on problems that arise in the context of F-theory, topological string theory and supersymmetric gauge theories.

MAX LIPYANSKIY received his Ph.D. in Mathematics from MIT, and joined the Simons Center in September 2013. His research interests are in gauge theory and symplectic geometry. More recently he has worked on an analytic framework that unifies the compactness theorems of Mikhail Gromov and Karen Uhlenbeck.

DANIEL SUNG-JOON PARK has been a Research Assistant Professor at the Simons Center for Geometry and Physics since 2012. His thesis, written under the supervision of Washington Taylor, was on the landscape of six-dimensional supergravity theories and its relation to six-dimensional strings. His current research is focused on probing geometry from the point of view of string theory, working on problems that arise in the context of F-theory, topological string theory and supersymmetric gauge theories.

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The Simons Center Welcomes Our New Research Assistant Professors

From top: Cyril Closett, Mohammad Farazjadeh Tehrani, Vijay Kumar, Max Lipiansky, Daniel Park, Ben Ward and Peng Zhao
The Simons Center for Geometry and Physics Art and Science Program is a cultural outreach program connecting scientists and artists, as well as University members and the local community. During the summer months of 2013, the program presented ‘Synergy: Dance, Data and Sculpture’, an exhibition that consisted of multiple lectures by mathematicians and artists, weekly interactive workshops by artist-in-residence Bill Duffy, and a classical summer concert series, featuring pianist Leon Livshin. Events of the SCGP Art and Science program are free and open to the public, with the goal of enhancing the intellectual life of the Center and the greater community.

The fall semester kicked off with an innovative exhibit titled ‘Food Physics’, which featured a multitude of still life paintings by artist Mia Brownell. Mia, born to a sculptor and a biophysicist, fuses vibrant compositions that reference 17th century European still lifes, with an exploration of the science and sociology of food. Special lectures by Professors Nancy Goroff and Jeff Lipton further enhanced the exhibit’s theme of “food science” by exploring topics such as the chemistry of everyday food, as well as holiday sugar cookies created from a 3D printing process.

This autumn was harvest season at the SCGP Café, and Chef Paolo and his staff shared the bounty with their guests. From festive pumpkin centerpieces on the tables, to seasonal root vegetables grown in our very own garden, signs of autumn’s harvest were hard to miss at the SCGP Café. Following his farm-to-table philosophy, Chef Paolo served up seasonal dishes such as quinoa stuffed acorn squash, pumpkin soups, and locally caught striped bass.

In keeping with this same tradition to actively engage in our local community, Chef Paolo showed off his culinary skills at the Harvest East End food festival in September, bringing home an honorable mention for his innovative (and delicious) spin on crème-brulée; served in it’s original duck egg shell, and infused with vanilla bean, then topped with a sprinkle of maple bacon crumble. Visitors and guests of the Simons Center Café watched the leaves change colors and fall, as the Café transitioned from autumn inspired fare, to winter dishes to warm the soul. Hearty stews, sweet potato fondant, and scratch made desserts such as panettone and holiday pies were just a few of the seasonal favorites.

Starting in November and running through December, Chef Paolo was featured in our ‘Food Physics’ art exhibition, with a series of molecular gastronomy cooking demonstrations. Molecular gastronomy blends scientific lab techniques with local ingredients to transform foods’ look, texture and flavor, appealing to both science fans and foodies. With demonstrations of “texturization” and “gelification”, Chef Paolo created culinary treats such as instantly frozen ice cream, and translucent pasta made from a liquid base, using ingredients like liquid nitrogen and equipment rivaling that usually only found in chemistry labs.

Like the SCGP Cafe on Facebook or visit their website to see their ever changing daily menu and find out what Chef Paolo has in store for the spring! scgp.stonybrook.edu/cafe
COMING SPRING 2014
PROGRAMS & WORKSHOPS

PROGRAMS | SPRING 2014

MODULI SPACES OF PSEUDO-HOLOMORPHIC CURVES AND THEIR APPLICATIONS TO SYMPLECTIC TOPOLOGY
Organized by Kenji Fukaya, Dusa McDuff, and John Morgan
JANUARY 2 – JUNE 30, 2014

QUANTUM ANOMALIES, TOPOLOGY, & HYDRODYNAMICS
Organized by Alexander Abanov, Dmitri Kharzeev, Boris Khesin, Dam Son, and Paul Wiegmann
FEBRUARY 17-JUNE 13, 2014

WORKSHOPS

ASPECTS OF SUPERGRAVITY
JANUARY 6-10

QUANTUM ANOMALIES AND HYDRODYNAMICS
FEBRUARY 17-21

STRONGLY COUPLED SYSTEMS AWAY FROM EQUILIBRIUM
FEBRUARY 24-28

WORKSHOPS CONT.

WORKSHOP ON MODULI SPACES OF PSEUDO-HOLOMORPHIC CURVES I
MARCH 17-21

EQUIVARIANT GROMOV-WITTLER THEORY AND APPLICATIONS
MAY 12-16

GEOMETRICAL ASPECTS OF HYDRODYNAMICS
MAY 19 - 23

WORKSHOP ON MODULI SPACES OF PSEUDO-HOLOMORPHIC CURVES II
JUNE 2 - 6

SIMONS SUMMER WORKSHOP
JULY 21 – AUGUST 15

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Back Row (from left to right): Tim Young, Joshua Klein, Jason May
Front Row (from left to right): Kim Keary, Elyce Winters, Vanessa Mieczkowski, Teresa DePace, Maria Froehlich