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Produced and Written by Maria Shtilmark
Edited by Elyce Winters
The SCGP Welcomes Luis Álvarez-Gaumé

The Simons Center for Geometry and Physics is delighted to announce that Luis Álvarez-Gaumé will be joining the Center as its Director effective September 1st 2016. Dr. Álvarez-Gaumé did his undergraduate work at the Autonoma University in Madrid, and his graduate work at Stony Brook University and MIT. He received his Ph.D. from Stony Brook University in 1981. After positions at Harvard and Boston University he joined the Theory Division at CERN as a Senior Member where he has been ever since. He has been the Deputy Head and the Head of the Theory Group for a number of years. His position at CERN has brought him in contact with a large part of the theoretical and experimental high energy community.

Dr. Álvarez-Gaumé’s work has centered mostly upon string theory, quantum field theory and also on cosmology. He is better known for his work on supersymmetric field theories, the study of anomalies, the use of Witten’s index to study the Atiyah-Singer index theorem, and lately he is interested in the study of cosmology, black hole physics and string theory. He has written introductory lectures on Quantum Field Theory and reviewed many aspects of string theory and field theory. Since 2003 he has been a corresponding member of the Spanish Royal Academy of Sciences.

The Center will benefit from Dr. Álvarez-Gaumé’s knowledge and expertise, and everyone associated with the Center is excited to have him join us.

Read the interview with the new Director Luis Álvarez-Gaumé in the upcoming Fall 2016 issue.  sc

PROGRAMS:

The program on GEOMETRIC REPRESENTATION THEORY (January 4-29) organized by David Ben-Zvi, Roman Bezrukavnikov, and Alexander Braverman was an intense gathering of experts aspiring to discuss the exciting recent developments in this field. The official program consisted of 16 seminar lectures over a 4-week period aimed at program participants, as well as two mini-lecture series by Dima Arinkin and Geordie Williamson on recent breakthroughs in the geometric Langlands program and the modular representation theory of algebraic groups, respectively. There were also three colloquium-style weekly talks aimed at a broader local audience, by Valerio Toledano Laredo, Roman Bezrukavnikov and Hiraku Nakajima. The program featured a continuous array of informal discussions and exchange of ideas, with the excellent facilities of SCGP being put to constant use. It also saw the development of ongoing collaborations and beginning of new ones, e.g., Dima Arinkin with Roman Travkin, and David Ben-Zvi with David Jordan and Tom Nevins.

The program on STATISTICAL MECHANICS AND COMBINATORICS (February 15-April 15) organized by Pavel Bleher, Vladimir Korepin, and Bernard Nienhuis aimed to connect re-
cent exciting developments and open problems in the field. The program included 2-3 WEEKLY SEMINARS AND A SIX-VERTEX MODELS, DIMERS, SHAPES, AND ALL THAT workshop (March 14-18), focused on the interplay between algebraic and analytic theories in statistical mechanics and combinatorics. The major topics of the program were vertex and loop models and their relations to supersymmetric Yang-Mills theories and spin chains, random tilings, dimer models and the Arctic circle phenomenon, KPZ universality, quantum groups and algebras associated with integrable systems of statistical mechanics, random matrices, double scaling limits and Painlevé transcendent.

COMPLEX, P-ADIC, AND LOGARITHMIC HODGE THEORY AND THEIR APPLICATIONS program (March 6-April 29), organized by Mark Andrea de Cataldo, Radu Laza, and Christian Schnell drew about forty participants, with a good balance of junior, mid-career and senior people. Many of the leading experts in the field, including Patrick Brosnan, Helene Esnault, Phillip Griffiths, Matt Kerr, Dave Morrison, Burt Totaro, and Sampei Usui, participated. The backbone of the program consisted of daily lectures and of four lecture series: mixed Hodge modules (Claude Sabbah and Schnell), Hitchin systems (Ron Donagi and Tony Pantev), logarithmic Hodge theory (Martin Olsson), and p-adic Hodge theory (Bhargav Bhatt). Additionally, 2-4 research seminars each week were focused on the latest developments in Hodge theory.

The program on GEOMETRY OF QUANTUM HALL STATES (April 18-June 17), organized by Sasha Abanov, Tankut Can, Anton Kapustin, and Paul Wiegmann, focused on the quantum Hall effect (QHE), one of the most fascinating phenomena in condensed matter physics. Since its experimental discovery in the 1980’s QHE continues to fuel work in experimental physics, metrology, fundamental theoretical physics and mathematics. The distinguishing feature of QHE is the quantization of transport coefficients, most notably the Hall conductance. This quantization occurs with a precision matched only in nuclear and atomic physics, and in materials, which are not precisely characterized. (Transport coefficients are Chern numbers, and thus topological characteristics of the quantum state). As such, they can not change continuously under continuous change of parameters of electronic systems. Despite a great effort to find other materials with topological characteristics, QHE remains the case study for topological effects in condensed matter physics.

In addition to the topological characterization, a crucial role is played by the geometric properties of quantum states. Traditionally, electronic systems were tested by electromagnetic probes. Recent work in the field has elucidated the subtle properties of quantum states that are encoded in the response of the state to variations of spatial geometry, as probed by a metric or the shape of boundaries. This observation has led to a geometric description of quantum Hall states, which linked its physics to problems of modern geometry (Kahler geometry), and to the theory of random geometry and quantum gravity. The synthesis of subjects and intriguing links to modern mathematics give the QHE a very special status.

The program brought together physicists and mathematicians working in geometry and its applications to quantum physics, providing a stage for the exchange of ideas and collective effort in developing a geometric approach to quantum Hall states and, more broadly, quantum states with topological characterization. The program started with GEOMETRY OF QUANTUM STATES IN CONDENSED MATTER PHYSICS workshop (April 18-22), encouraging a broader discussion of the role of geometry in quantum states of condensed matter systems.

INDEPENDENT WORKSHOPS:

FLAT HOLOGRAPHY (April 4-8). Organized by Arjun Bagchi, Glenn Barnich, Stephane Detournay, Daniel Grumiller, and Joan Simon. Topical, short and intense, it provided an excellent selection of talks on flat space, on
The Simons Center for Geometry and Physics congratulates Nigel Hitchin, Savilian Professor of Geometry, University of Oxford and SCGP Trustee, for winning the 2016 Shaw Prize in Mathematical Sciences, “for his far reaching contributions to geometry, representation theory and theoretical physics. The fundamental and elegant concepts and techniques that he has introduced have had wide impact and are of lasting importance”.

The Shaw Prize, widely regarded as the Asian Nobel Prize, is an international award, established under the auspices of Mr. Run Run Shaw, annually bestowed upon individuals who have achieved “significant breakthrough in academic and scientific research or applications, and whose work has resulted in a positive and profound impact on mankind.” It honors scientists working in the fields of astronomy, life sciences and medicine, and mathematical sciences. The presentation ceremony will be held on September 27, 2016 in Hong Kong.

Congratulations to Nigel for his many contributions to mathematical physics and to our Center!

Generalized Geometry & T-Dualities (May 9-13). Organized by Marco Gualtieri, Nigel Hitchin, Ctirad Klimcik, Yolanda Lozano, Eoin Ó Colgáin, Martin Rocek, Konstantinos Sfetsos, and Daniel Thompson.

String theory provides for a rich interplay between ideas in physics and mathematics. The phenomenon of T-duality, in which apparently different spacetime geometries are seen to be equivalent in string theory, has encouraged physicists to embrace the mathematics of generalized geometry. This workshop brought together a truly global field of ~50 leading experts, with participants from Japan, Australia, Europe and the US, including those who did foundation work in both the mathematics and its physical applications, to share and extend this synergy.

Key topics included: the incorporation of M-theory U-dualities into generalized geometry where exceptional Lie groups appear as the structure groups of extended tangent bundles; the close interplay of a class of integrable two-dimensional quantum field theories, non-Abelian and generalized T-dualities based on Poisson-Lie symmetries and classical solutions of the Yang-Baxter equation; the geometry of sigma-models with extended supersymmetry and proposals to encapsulate ‘non-geometric’ effects in string theory dubbed Double/Exceptional Field Theory.


See page 13, Conversation with Martin Hairer.

Between Dynamics and Spectral Theory (June 6-10). Organized by William Yessen and Zhenghe Zhang. A successful gathering of senior and young experts from both dynamical systems and mathematical physics, it focused on applications of methods from dynamical systems to spectral analysis of the ergodic Schödinger operators, which arises naturally in solid matter physics to model the motion of quantum particles in a disordered medium. This field has made striking progress in...
the past twenty years, culminating in Artur Avila’s work on global theory of one-frequency quasi-periodic Schrödinger operators, which partly led to the Fields medal he was awarded in 2014. The main emphasis of this workshop were topics like the role of the Lyapunov exponent played in the spectral analysis of Schrödinger operators, the application of KAM theory to reducibility of Schrödinger cocycles, the analysis of quantum transport in quasicrystalline environments, and applications of inverse spectral theory to the KdV equations and Toda lattice. It provided very good opportunities for young experts to expose to and learn from senior ones. It featured a continuous array of informal discussions and exchange of ideas. It also saw the development of ongoing collaborations, for instance, David Damanik with Anton Gorodetski and Milivoje Lukic with Tom VandenBoom, and possible beginning of new ones, e.g. Silvius Klein with Zhenghe Zhang.

NEW PERSPECTIVES ON HIGGS BUNDLES, BRANES AND QUANTIZATIONS (June 13-17).
Organized by Lara B. Anderson, David Baraglia, Laura P. Schaposnik, and Vivek Shende. During the weekend of 11-12 June the SCGP hosted a workshop on “Current Trends in Spectral Data II” organized by Lara B. Anderson and Laura P. Schaposnik. It served to open a longer, one-week program. Both meetings aimed at providing a friendly and informal setting for young and senior researchers to meet and collaborate; in words of a young researcher, the meetings were a great opportunity, “providing a format in which it is easy for people to make connections.” Special attention was put to balance both attendees and speakers in terms of gender and age. Both meetings aimed at highlighting the work of younger speakers with a wide range of backgrounds in geometry and mathematical physics, inter-relating their talks with ones of more senior researchers. The effort to create a stimulating environment and foster new directions of investigation and collaboration seems to have been very well received. Indeed, a big proportion of the participants (in all stages of their careers) have by now contacted the organizers to thank them for such opportunities, remarking on how unique and fruitful the setting had been. Finally, it should be noted that both meetings were organized in collaboration with the Association of Women in Mathematics, and featured more than 50 participants (of whom approximately 30% were women). The attempt of encouraging researchers from both genders to continue with the aim of recruiting more women into the field was well received, and many participants provided feedback after the workshops about the success in this direction. SC
While I will remain at the Center as a faculty member for the next two years, at the end of August I am stepping down as the Director. It is my great pleasure to welcome Luis Álvarez-Gaumé as the Center’s next Director. Luis brings to the Center his infectious enthusiasm and his vast knowledge of physics and mathematics and of the community of scholars that study these subjects. He will be an exceptional leader for the Center as it moves forward.

Scientific Leadership of the Center. The permanent members comprise the most important component of the Center’s scientific life. Kenji Fukaya joined the Center as a permanent member in April 2013; Nikita Nekrasov became a permanent member in September 2013; and Simon Donaldson joined the Center as a permanent member in January 2014. Also, in 2014 Samson Shatashvili became a long-term half-time visiting professor. Together with the Director and Deputy Director these senior scientists provide the academic vision for the Center and oversee all of its scientific activities. They are the mentors for the Center’s postdoctoral fellows, who are at the Center for three years. They are actively involved in many of the Center’s programs and workshops. Many visitors come expressly to have scientific interactions with our senior scientists.

Our Deputy Director, Alexander (Sasha) Abanov, has been an indispensable partner to me in leading the Center these last four years. Working with the external Scientific Advisory Committee, he oversees the choices of programs and workshops held at the Center. He works directly with the organizers of these activities to fashion the scientific content, to set the overall budgets for and timing of the activities. His scientific judgment, his ease in dealing with people, and his dedication to the Center have contributed significantly to the Center’s success, and they have made my job as Director much easier.

Michael Douglas was the first permanent member of the Center. His hiring signaled to the math and physics communities the quality of scientist that our permanent member would be. From the time of my arrival as Director, he was a thoughtful and insightful partner as we built the Center, developed its policies and methods of operation, set its scientific direction, and sought to hire other permanent members. Three years ago Mike left us to join Renaissance Technologies. I thank Mike for all his contributions, both scientific and administrative, to the Center.

The Center’s Administrative Staff. Another important component of the Center is its staff. They are responsible for making the Center run smoothly and for informing the outside world about the wide range of activities taking place here. They make sure our visitors are housed and are reimbursed for their expenses. Just as importantly, they make the visitors feel welcome and help to resolve any problems that arise in connection with their visits. We have an exceptional staff and they have created for us a reputation as a place that is very easy to visit, as well as a place that is intellectually stimulating. The staff is led by Elyce Winters, who is responsible for the Center’s operations and for hiring and overseeing the administrative, IT and AV staff. She has assembled a professional, smoothly functioning staff.

The administrative staff includes Janell Rodgers, programs and workshops coordinator, who handles invitations and schedules visits, Teresa DePace, assistant to the Director, who also handles reimbursements, Melissa Wessler, housing coordinator, and Nora Donaldson, editorial assistant. Maria Shhtilmark is responsible for the Center’s newsletters. The IT staff consists of Tim Young, who is also building manager, and Jason May, who created our custom database and video portal. Josh Klein is our AV manager and is in charge of recording all the talks in the Center. The Center’s art program and exhibition space are the responsibility of Dr. Lorraine Walsh, our Art Program Director, who is also the Curator of the Simons Center Gallery. She has brought amazing shows to the Center and helped make it a resource for the entire Stony Brook Campus and the wider Three Village area.
How did you become the Director of the SCGP?

I was quite happy being a math professor at Columbia. I had heard about the Simons Center, mainly as Mike Douglas was ‘on the market’ and, together with the Physics department at Columbia, we made him an offer. It looked like we were going to get him. Then at the last minute he accepted the offer from the Simons Foundation to be a permanent member of the Center. That was their first permanent member. I was disappointed, but I thought: “They are off to a good start” and didn’t really pay much more mind. Then I got a phone call from a committee working on how to set up the Simons Center and hire a Director. They knew that I had experience with various institutes, and I’d been on the board of MSRI, so they asked me to come and share my experiences and thoughts with them. So I did. I went home afterwards and I said to my wife, Ellen: “That was the strangest meeting I’ve ever been in. It was half a ‘pick-your-brain’ half a job interview.” Which, in fact, was exactly what it was. They were interviewing some people to pick their brain, and some people they were interviewing to pick their brain and also thinking they could be possible candidates to be the director. Couple of weeks went by and nothing happened, and I said to Ellen: “Well, if it was the job interview I didn’t get the job.” About a week later Jim called and said: “I want to meet you. I am willing to come half-way. You’re at Columbia, I’m over at East side, let’s meet at a restaurant, in the 80s on the West side, “Isabella’s.” He offered me the job of Director at the Simons Center. I said: “Jim, I am flattered but I am not looking for another job.” We talked about it. I went home that night and said to Ellen that I was not really interested. But I described the position to her and she said: “You’re taking this job!” My, she was right. I accepted the job. I spent the summer of 2008 here getting to know people and getting the sense of the landscape. I went off to Stanford for a sabbatical year that had already been arranged. I came back in the summer of 2009 and started the job. We were over at the Math Tower back then. In early 2010 I hired Elyce Winters, Tim Young and Jason May. We started hiring administrative staff. The building was under construction and we were quite involved in that process. I made some changes in the internal layout: more small offices, fewer large (and shared) offices; the expansion of the café from a “coffee and snacks” operation to a full service kitchen serving hot lunches, which necessitated expanding the lunch-room area. The quality of the blackboards was an important issue to which I paid a lot of attention. And believe it or not, I spent an enormous amount of time thinking about keys, eventually deciding on the key-card system we have now.

These were the practical details. Important as they are, they pale in comparison to the decisions about permanent members and other senior scientists, which was the most important aspect of the job that I was assuming. Even during my sabbatical at Stanford I was thinking about hiring permanent members. I approached people—some to pick their brains about whom we should hire and some to
convince them to consider coming to the Center. Once I got to Stony Brook, the pace of these conversations and overtures increased significantly. I knew that it would take time to get permanent members on board so to provide senior leadership for the Center, in the interim, I began by bringing senior people for visits: Gang Tian came for each of the first three years for two months. Paul Seidel and Peter Ozsvath were a year-long visitors. Nick Read, Zvi Bern, and Yakov Eliashberg were semester-long visitors. Sasha Zamolodchikov visited for three months a year for several years.

In searching for permanent members and other long-term senior visitors I was very fortunate to have the aid and support of an excellent Board of Trustees. Their extensive knowledge and acute judgment informed the many lengthy conversations and eventual decisions as we moved forward in the hiring process.

**Were you always interested in math or did you oscillate between it and some other science?**

I’d been a mathematician before I knew there was such a thing. Like many mathematicians, I’ve always had an interest in physics. By the time I was a sophomore in college I was doing graduate work in math, so that didn’t leave much time to do other things. I did take 2 years of physics where Feynman’s lectures were used as a textbook. I essentially just did math after that. I did have to take a psychology course one summer to meet distribution requirement and a Middle Eastern history course, which I hated. All I wanted to do was math.

**You’ve been living in New York City since 1976 — has it been a blessing or a curse, and what are your favorite places?**

When I got to New York City in 1976 I felt “Oh, this is home. This feels natural to me.” I toyed with the idea of staying in Paris when I was at IHES. But even though I loved Paris, I decided to move to New York. As for my favorite places in the city, I used to go to the Sculpture Garden at the Museum of Modern Art, and I used to go to the Frick. They had a place you could sit and read, and I would go there and work. In Paris I would sit in cafes, I love that combination of working and watching the humanity go by. But I’ve never been able to replicate that in New York, it’s too noisy. Instead of cafes I use the parks: Riverside Park, Central Park and, more recently, Madison Square Park, which I like a lot.

In a documentary about Perelman, that you were part of, Mikhail Gromov mentioned that for him a joke can often trigger scientific inspiration. **What sparks it for you?**

I interpret Gromov to mean that change in perspective or attention and a release of tension can cause things that have been ‘percolating’ subconsciously to suddenly come together in unexpected ways. New connections are made, patterns are seen in a new light and we experience the ‘Ah ha’ moment.

Many times over my career I have awakened with the solution to a problem, a problem that I had been stuck on the night before. Somehow turning off the conscience moderator that enforces attention directly on the problem under consideration allows the mind to think more intuitively and the solution arrives from left field. I am reminded of an experience of looking at one of the pictures of thousands of closely-spaced dots. When you first look at it you see no pattern, but then after a few seconds the picture resolves and you see a three-dimensional shape emerging out of the dots. What is the mind doing during those few seconds? Certainly, whatever it is, it is not conscious. It is the subconscious searching desperately for patterns.

I was very struck by a vignette Henri Poincaré recounts in Science and Hypothesis. When he was writing about mental gymnastics or the psychology of doing mathematics, he talked about how for two weeks he worked very hard on a problem and was stuck. So he decided to take a vacation, and as he was stepping onto a bus to take a tour the solution just appeared to him. This seems to me to be a description of the same phenomenon: namely, change of attention away from the problem allows the solution to appear spontaneously from the subconscious.

The ‘Ah ha’ moment when things click is for me extremely satisfying. **Wanting to have more, to have more insights of understanding, is one of the main driving forces in my intellectual life.**
What makes you interested in a mathematical problem?

Several things come to mind: questions that are natural and whose answers (hopefully) reveal a crucial, important feature of the structure; a special case that seems at odds with a general understanding of the way things are; a question that is important because of its connections to other areas. Of course, all these in the end involve aesthetic considerations: natural, counter-intuitive, important.

Mathematics is filled with these types of problems, some of them quite old and quite famous. The questions that I work on are ones where I feel my approach and my mathematical knowledge give me a chance to see things in a different light and make some progress. Also, I work on problems that I feel are susceptible to resolution with my ‘style’ of mathematics.

How do you work?

I walk a lot when I think. I walk around the Stony Brook campus. For a long time I lived near Columbia University, so I would walk back to my apartment, take long walks in Riverside Park. I do need a blackboard, so after walking and thinking, I will return to the board to see if the details work out. Somebody quoted Gromov saying that when he smoked a blackboard appeared in his head and he could do math, but when he stopped smoking, the blackboard disappeared. Well, I am not Gromov. I never had a blackboard in my head. I need a real one. Another way I work is with the computer. I start preparing manuscript very early in the process and I spend 90% of the time doing what you might call working out the details at the computer. It may be that this is not the most efficient way, but that’s the way I do it.

As a mathematician, interested in poetry of W.B. Yeats, have you ever come across math in literature?

Off of the top of my head, I can think of an example of very mathematical-type passages. It is “Infinite Jest” by David Foster Wallace. There is a scene that takes place at a tennis camp. The kids make up a game about territories, countries represented by different parts of the tennis courts. Tennis balls are kiloton bombs. Kids are grouped into teams (countries) with territory to defend and bombs to launch to attack other countries. At some point, because he is angry at one of his opponents, one of the players breaks out of the game, and instead of lobbing tennis balls as bombs to destroy territory he fires a shot and hits a person on an opposing team in the head with a ball. The moderators of the game begin arguing about the difference between the actual things: people, tennis courts, tennis balls and what they represent generals, countries, bombs. Are the strikes against what is represented, say a general in charge of the war, or against the person representing the general, another kid against whom you have grudge? It is similar to an analysis a semiotician or a logician would give. Anyway, the game degenerates into mayhem and full-blown mob violence ensues. It’s hilariously funny.

There are authors who, while not directly invoking mathematics, have a style that appeals to a mathematical sensibility. James Joyce immediately comes to mind as a prime example of this.

What has been the most exciting thing you’ve ever come across in math?

Transversality. It’s very powerful. A friend of mine who’s given to aphorisms once said that transversality unlocks the secret of a manifold. That was back in the days when we were trying to understand manifolds using surgery theory.

One thing that fascinates me today is what is the source of some of these symmetries that physics is predicting in mathematics. I am not sure I will live to see mirror symmetry fully understood, but it is a tantalizing mystery. And of course, more generally along these lines, what’s the most appropriate mathematical formulation of Quantum Field Theory? The math community is slowly making progress understanding mirror symmetry, more
pieces of it are falling into place. There are theorems and conjectures; you can measure the progress. You can’t measure progress towards making Quantum Field Theory more rigorous. Clearly, there is something fundamental there that we don’t understand. We don’t even understand the outlines of what it might look like. And that’s great. When you understand everything it’s boring. When you don’t understand, life is interesting.

You were elected member of the National Academy of Sciences and fellow of the American Mathematical Society. What do these honors mean to you?

It is an honor to be in the first class of AMS Fellows. Surely, there will be many, many excellent mathematicians who are or will become AMS fellows, and I am happy to be considered one of them. As far as the National Academy, I was quite pleased to be elected. It’s one of these societies that only exist to elect other people, or not. It does do some policy studies, so hopefully it plays an important role in society, but basically it is an honorific society. I looked around the other day at the membership and thought I am not sure I belong here, but I’m happy the other members think I do.

Originally physicists and mathematicians were both called natural philosophers, with no difference between the two. In a sense, is the mission of the Simons Center bringing physics and math back to their roots in an attempt to re-converge?

One of the Center’s stated goals to bring the disciplines and their practitioners closer together by having activities that draw from both worlds. But I do not believe that we are ever going to re-combine the disciplines into one. Physicists and mathematicians have very different views on what questions are important, what one considers an acceptable or an excellent answer. So, the fundamental raisons d’être of mathematics and physics are just different, and they are never going to be brought back together. But I do believe that each discipline can benefit from understanding what the other knows, what issues it confronts, and how its practitioners think. Still, while understanding each other will not make them think and react in the same way, it will make their lives richer and more interesting. SC

I JUST LIKE PINK FLOYD

Conversation with Martin Hairer, Regius Professor of Mathematics at the Mathematics Department of the University of Warwick

Pleasure to welcome you at the Simons Center. You were able to not only come to the Center, but to be a sole organizer of the workshop on Stochastic Partial Differential Equations. What were the workshop’s highlights? We naturally focused on recent developments. I tried to invite participants from different directions, who didn’t necessarily know each other before, to enable people to hear new things. A few years ago several works came out in relatively quick succession, developing different theories that now allow us to deal with classes of stochastic PDEs that nobody knew how to tackle before. I developed one of these theories, and more or less at the same time Massimiliano Gubinelli and coauthors developed a different approach that solves very similar problems. These led to an explosion of new results in various directions. There are many brilliant young people who got attracted to the field, so partly the point of the workshop was to get them to meet the older crowd of the stochastic PDE community.

Your lecture “Random Loops”, given within the Simons Center Weekly Talks framework, received many accolades among members of the Stony Brook math community. For our readers, what were its central geometric, algebraic, or analytical points? The central point was more on the algebraic, rather than the geometric side. There is a whole theory of renormalization developed for the last 70 years or so in order to get rid of infinities, or divergent quantities, that arise in Quantum Field Theory. These were fairly well understood at the intuitive, or physical level some time ago and, at the mathematical level, their algebraic structure was fairly well understood 15 years ago due in particular to works by Alain Connes and Dirk Kreimer. The nice feature of the problem I presented is that one is naturally lead to two of these mathematical structures, acting in concert. One of them gets rid of the divergent quantities at very small scales, which
is what one usually sees in quantum field theories – infinities showing up in the equations, and a mathematical structure acting on the problem, creating just the right cancellations for these infinities to go away. Simultaneously, part of the technique is to describe what happens at some much larger intermediate scale. When viewed from the perspective of these intermediate scales, one also sees divergences appearing at large scales. So there is another, formally very similar mathematical structure, appearing in the problem with the effect of removing these large-scale divergences. The way in which these structures appear and interplay is something people haven’t looked at before.

**Which direction is your field, stochastic PDEs, developing?** One direction in which it is going now is to try to understand in a more systematic way how stochastic PDEs arise from classical models of statistical mechanics. What one is often interested in is to take some discrete microscopic model (spin model, particle model, etc.), put some dynamic on it, and then try to understand what happens at very large scales. Typically, at very large scales, some form of the law of large numbers kicks in, leading to an effective description of the system by a PDE. In some typical situations, the system furthermore depends on a parameter like the temperature, external magnetic field, etc., such that, when one tunes this parameter there will be a critical value at which something happens, there is a change of large-scale behavior. When you then look at what happens to the large scale behavior at these critical values, one typically sees something random. So the small random fluctuations of the microscopic system build up to give a macroscopic random effect. In some cases, one can describe explicitly what happens at these large scales, how one has to rescale things in order to see a non-trivial limit. But in many cases one doesn’t know – one maybe knows it for some special situations and then one has a guess that because a given system “looks like” some other system for which one can describe the large-scale behavior, it should behave in the same way. Unfortunately, there are very few rigorous results that go beyond certain special situations. For example, the two dimensional case is very special because of its very rich symmetry group of conformal transformations. Some systems have nice integrability properties, which allow one to compute certain observables explicitly and then take limits on these explicit formulas. What is much easier, at least to some extent, is to figure out what happens with systems that have some additional parameter that one can play with, allowing to tune the behavior between one where one understands the large-scale behavior, typically via a central limit theorem yielding Gaussian behavior, and one where one doesn’t really understand the large scale behavior. When the parameter is tuned to be close to the critical value, one can observe a “crossover” regime at some intermediate scale. The behavior in this regime is typically described by classically ill-posed stochastic PDEs. One direction in which this field is going is trying to justify mathematically the story I just told you. One knows how to justify it for certain models and these are very nice results. But there isn’t yet a
clean general machinery that would unify these proofs, they are still very much ad hoc.

**You have been in your area for 10 years. When and why, if ever, would you like to change the field?** I worked on stochastic PDEs during my Ph.D., then moved away to do more work on finite-dimensional systems and recently moved back. I suppose it really depends on whether there are still enough interesting questions around… one just never really knows these things in advance. You work on a problem and might find an interesting question in a different area, which might drag you away from the problem that you started with in the first place. You just have to keep an open mind and be willing to explore where your explorations might take you.

**Once asked about HairerSoft, the name under which you distribute Amadeus, sound editing software, you mentioned your interest in Pink Floyd. Did their music have any influence on your becoming a mathematician?** No, I just like Pink Floyd. (Laughs). My interest in sound came from the point of view of the physical phenomena of sound. I was in high school, and became interested in what sound is, how we perceive it, what does it mean to play a certain note or tune, how could you recognize these things, etc. That’s how my work on the Amadeus software started. In the very beginning, the plan was to write not a sound editor, but a program to which you could just feed a recording, and it would spit out the musical score. But I was 17, and that was beyond my programming abilities. (Laughs). The first step was to get the recording into the computer, so I started to write the sound editor that could do the recording and actually allow me to then mess around with sound. That’s how I started out.

**Do you have an answer to a question most interviewers have why the sound of one’s own voice is so terrible?** I am not a biologist, but if you take a recording of your voice and play it back you only hear through your ears, whereas if you speak yourself you also get it directly through the bones and your body, this is why it doesn’t sound the same.

**Is it true that when you were 12 your father gave you a calculator that could execute 26-variable programs, and that triggered your interest in math?** I don’t think it was triggered by it—I got that calculator because I asked for it, so my interest in maths was there already. But my interest in programming was certainly triggered by it.

**In the 2014 Fields Medal Simons Foundation video you demonstrate some serious scone baking skills—do you have advice for our chefs, or a recipe for our readers?** I think your chefs are very good! At home we tend to do very simple cooking. We think that the most important thing is good ingredients, and we tend to keep their preparation very simple. My wife is Chinese, so we tend to mix things up a bit—Chinese spices with whatever vegetables we get. And relatively simple preparations, like steamed fish, or pan-fried tuna steak. We eat meat, but Xue-Mei isn’t terribly keen on it, so we eat more fish.

**For Martin Hairer’s family recipe go to page 28!**

You've referred to yourself as an “ambassador of mathematics.” In this capacity, is there a question you wish you were asked, and you are not? There is one thing that I would certainly like to change for mathematics, particularly in the UK, and it is to do with how the funding agencies work. There seems to be more of this tendency towards handing out big grants, singling out a few stars, handing them loads of money, and then that’s it! Many people would be very happy to get modest travel grants, I think that in the U.S. the Simons Foundation does that, and for most mathematicians that’s fantastic—just a few thousand dollars per year to be able to go to a few conferences and to stay connected to the community. This is something that the funding agencies in the UK don’t seem to be interested in. For them, it is of course easier to administrate one large grant, rather than many disparate small pots of money. But it would certainly create a much healthier atmosphere and not divide the community into haves and have-nots. Right now, some people find it very easy to travel around to present their results and to meet new people, and some people are stuck. That’s something I would really like to see change, but unfortunately it seems to be going precisely in the wrong direction. SC
If we have four objects—say $A, B, C, D$—there are just three ways of dividing them into pairs

$$(AB)(CD) \ (AC)(BD) \ (AD)(BC).$$

The salient property is that 3 is less than 4. This simple fact expresses something special about the number 4. For example if we take 6 objects there are 10 ways to divide them into triples; there are 35 ways to divide 8 objects into quadruples, 126 ways to divide 10 objects into quintuples and so on. We will discuss two famous applications of this special property of 4: one going back five centuries and one underlying important concepts in contemporary differential geometry and physics.

### The Quartic Equation

We are all familiar with the quadratic formula. The solutions of an equation $at^2 + bt + c = 0$ are

$$t = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}.$$  

The solution of quadratic equations (but not in such algebraic notation) goes back many millenia. The ancient Greeks studied conic curves, the curves obtained by intersecting a plane with a cone or cylinder. These are ellipses, hyperbolae and parabolas, with some exceptional, “singular” cases when we get one or two straight lines. Algebraically, in terms of co-ordinates $(x, y)$ on the plane, a conic is given by an equation $Q(x, y) = 0$ where

$$Q(x, y) = Ax^2 + Bxy + Cy^2 + Dx + Ey + F,$$

for constants $A, \ldots, F$. The problem of finding the intersection of a conic with a given line becomes a quadratic equation in a single variable $t$, which is solved by the quadratic formula.

What about equations of higher degree, involving higher powers of $t$: can we find formulae for the solutions? We move on to the beginning of the modern era in mathematics and the successful solution of cubic equations in 16th century Bologna. For our purposes here, let us just say that there is a formula to solve any cubic equation (that is, involving at most the power $t^3$). Adjusting $t$ by the addition of a constant, one can reduce to the case of an equation $t^3 - pt - q = 0$ and the formula is

$$t = \sqrt[3]{q/2 + \sqrt{q^2/4 + p^3/27}} - \sqrt[3]{q/2 - \sqrt{q^2/4 + p^3/27}}.$$  

We want to focus on the next case: quartic equations, involving $t^4$. Remarkably, the solution of quartic equations came hard on the heels of the cubics. (The solutions were both published in a book Ars Magna by Cardano, in 1545, the quartic case being due to Ludovico Ferrari.) This came about because the quartic equation can be reduced to the cubic case. In general, an equation of degree $n$ has $n$ solutions or “roots” (some of which may coincide). To understand this properly one needs to use complex numbers but we do not need to go into that, so we just assume that the roots exist as some kind of numbers and write the four
roots of a quartic as \(t_1, t_2, t_3, t_4\). Then we can form three expressions by dividing these four roots into pairs

\[
\begin{align*}
\lambda_1 &= (t_1 + t_2)(t_3 + t_4) \\
\lambda_2 &= (t_1 + t_3)(t_2 + t_4) \\
\lambda_3 &= (t_1 + t_4)(t_2 + t_3).
\end{align*}
\]

The key point now is that \(\lambda_1, \lambda_2, \lambda_3\) are the roots of a cubic equation, with co-efficients that can be written down in terms of those of the quartic. We first solve this cubic equation to find the \(\lambda_i\) and then we can recover the roots \(t_1, \ldots, t_4\) from those.

This can all be expressed more geometrically by setting up our quartic equation as the problem of finding the intersection of two conics. Suppose that our quartic equation is

\[
at^4 + bt^3 + ct^2 + dt + e = 0
\]

Divide by \(t^2\), so the equation is

\[
at^2 + bt + c + dt^{-1} + et^{-2} = 0.
\]

Now let \(Q_0(x, y) = xy - 1\) so the conic \(Q_0(x, y) = 0\) is a hyperbola, which we can parametrise by a variable \(t\) as \(x = t, y = t^{-1}\).

Take another conic \(Q_1(x, y) = 0\) where

\[
Q_1(x, y) = ax^2 + bx + c + dy + ey^2.
\]

Then the roots of our quartic equation yield the intersection points of these two conics. Now for any fixed number \(\lambda\) the conic with equation \(Q_0 + \lambda Q_1\) also passes through these same four intersection points: we have what is called in algebraic geometry a “pencil of conics” through the four points. In this pencil there are three singular conics: if the four intersection points are divided into pairs then we get two lines, one for each pair and these two lines form a singular conic. Algebraically, the condition for the conic defined by the equation \((Q_0 + \lambda Q_1) = 0\) to be singular is the vanishing of the determinant of a \(3 \times 3\) matrix and this yields a cubic equation in \(\lambda\) with the three roots \(\lambda_1, \lambda_2, \lambda_3\). So the procedure is to first find a root of this cubic; identify the lines making up the resulting singular conic, and finally get the solutions of the original problem as the intersections of the lines with the hyperbola.

One might have hoped to go on to find more and more complicated formulae solving equations of arbitrarily high degree, but that turns out to be impossible. (By this we mean formulae involving only the ordinary arithmetic operations and taking roots \(\sqrt{-}\).) This is nowadays understood as a part of Galois Theory, initiated by Évariste Galois before his death in a duel in 1832. There is a profound connection between the solubility of equations and the symmetries between the different roots. For each \(n\) the permutation group \(\Sigma_n\) is the group of one-to-one mappings from a set of \(n\) elements to itself. Galois tells us that the solubility of a general equation of degree \(n\) is expressed in terms of the permutation groups \(\Sigma_n\). The solubility of an equation of degree \(n\) is equivalent to a special property of \(\Sigma_n\), and this fails for \(n \geq 5\), so there is no formula. From this point of view the solution of quartic equations \((n = 4)\) hinges on the existence of a group homomorphism from \(\Sigma_4\) onto \(\Sigma_3\). This just expresses the fact that if we permute the four objects \(A, B, C, D\) we permute the three decompositions into pairs. For \(n > 4\) there is no similar homomorphism (all one can do is to map the group \(\Sigma_n\) to the group of order two by the “sign” of a permutation).

### 4-DIMENSIONAL SPACE

We change direction and consider spaces of dimension \(n\) rather than finite sets. Take \(n = 2\) so we have the plane \(\mathbb{R}^2\). The rotations of the plane (fixing the origin) form a group \(SO(2)\) which can be identified with a circle.
(the angle of rotation). Similarly, the rotations of 3-dimensional space $\mathbb{R}^3$ are a group $SO(3)$ which is much more complicated. The rotations themselves form a 3-dimensional object, since we have to specify an axis of rotation (2 parameters) and an angle (1 parameter). In general for each dimension $n$ we have a group $SO(n)$ of rotations of $\mathbb{R}^n$. The special fact about dimension 4 is that there is a homomorphism from $SO(4)$ to $SO(3)$—roughly analogous to the homomorphism $\Sigma_4 \to \Sigma_3$ of finite permutation groups that we discussed above. In fact there are two such homomorphisms (interchanged by changing the orientation of $\mathbb{R}^4$) which we can put together to make a map

$$\rho : SO(4) \to SO(3) \times SO(3),$$

and this is very close to being a 1-1 correspondence: it only fails to be so because for any $R \in SO(4)$ the negative $-R$ is also a rotation, and these map to the same pair in $SO(3) \times SO(3)$. So up to this small ambiguity of sign we could say that rotations of 4-space decompose into “right handed” and “left-handed” parts, each of which is a rotation of a 3-dimensional space.

This is a very special property of 4-dimensions: nothing like it happens in other dimensions. If we were 4-dimensional beings it would be wired into our brains—perhaps pure right (or left) handed rotation would be a prized achievement in 4-dimensional gymnastic competitions. (Of course, you might say that we are 4-dimensional beings because we live in 4-dimensional space-time. That involves Lorentzian, rather than Euclidean, geometry and works out differently—the special feature is that the Lorentz group in $3 + 1$ dimensions can be described by $2 \times 2$ matrices with complex numbers as entries. But we will not go into that here.)

One way to see the map $\rho$ is by considering the space of 2-dimensional planes through the origin in $\mathbb{R}^4$, clearly analogous to the pairs in a set of four objects. More precisely we want to take 2-dimensional planes with a given orientation. The set of these planes forms what is called the Grassmann manifold $\text{Gr}_2(\mathbb{R}^4)$ and it is not hard to see that it is a 4-dimensional object. There is nothing special about 2 and 4 here—we can just as well consider $k$-dimensional subspaces of $\mathbb{R}^n$ for any $k, n$. What is special is that $\text{Gr}_2(\mathbb{R}^4)$ is a product of two-dimensional spheres $S^2 \times S^2$. Now $SO(4)$ acts on $\text{Gr}_2(\mathbb{R}^4)$—a rotation of the 4-dimensional space moves one plane to another one—and this action is just given by ordinary rotations of the two copies of $S^2$. So, if one accepts these assertions, one gets the map $\rho$. Pure left-handed rotations of $\mathbb{R}^4$ fix one copy of $S^2$ and pure right-handed rotations the other.

To get to the bottom of things we need some algebraic machinery. We will use “exterior” or “Grassmann” algebras introduced by the mathematician Hermann Grassmann in 1844. (Another route to the same end would be to
discuss a different kind of algebra, the “quaternions” discovered by Hamilton about the same time.) Work in \( \mathbf{R}^n \) with co-ordinates \( x_1, \ldots, x_n \). Then we have the algebra of polynomials (just as we considered in Section 1 for the case \( n = 2 \)) which can be thought of as formal expressions generated by the \( x_i \) subject to the commutative condition \( x_i x_j = x_j x_i \). For the exterior algebra we do the same but impose anti-commutativity. The product is denoted by the symbol \( \wedge \) and we impose \( x_i \wedge x_j = -x_j \wedge x_i \). Just as a polynomial can be written as a sum of terms of different degrees, so also for the elements of the exterior algebra: for each \( k \) we have a space \( \Lambda^k \mathbf{R}^n \) of “exterior forms of degree \( k \)". The elements of \( \Lambda^k(\mathbf{R}^n) \) can be expressed as linear combinations of a standard basis

\[
x_{i_1} \wedge x_{i_2} \wedge \ldots \wedge x_{i_k},
\]
corresponding to subsets \( \{i_1, \ldots, i_k\} \) of size \( k \) of \( \{1, \ldots, n\} \). So the dimension of \( \Lambda^k(\mathbf{R}^n) \) is the binomial co-efficient

\[
\frac{n \times (n - 1) \ldots \times (n - k + 1)}{k \times (k - 1) \ldots \times 1},
\]

the number of ways of choosing \( k \) objects out of \( n \).

This exterior algebra is tailored to study the geometry of subspaces. Let \( P \) be a \( k \)-dimensional subspace of \( \mathbf{R}^n \) and choose an orthonormal basis of vectors \( v_1, \ldots, v_k \) for \( P \). Then the wedge product \( v_1 \wedge \ldots v_k \) lies in \( \Lambda^k \mathbf{R}^n \) and the algebra is designed so that changing the choice of basis changes this at most by a sign. The choice of an orientation of \( P \) fixes this sign ambiguity. The upshot is that we map the Grassmann manifold \( \text{Gr}_k(\mathbf{R}^n) \) into \( \Lambda^k \mathbf{R}^n \).

If we have a \( k \)-dimensional subspace \( P \subset \mathbf{R}^n \) the orthogonal complement of \( P \) is an \( (n - k) \)-dimensional subspace. The corresponding construction in exterior algebra is a map

\[
*: \Lambda^k \mathbf{R}^n \to \Lambda^{n-k} \mathbf{R}^n.
\]

Up to a sign this takes a basis element \( x_{i_1} \wedge \ldots x_{i_k} \) to \( x_{j_1} \wedge \ldots x_{j_{n-k}} \) where \( \{j_1, \ldots, j_{n-k}\} \) is the complement of \( \{i_1, \ldots, i_k\} \) in \( \{1, \ldots, n\} \). Now we are almost done. If we take \( n = 4 \) and \( k = 2 \) the map \( * \) takes \( \Lambda^2 \mathbf{R}^4 \) to itself and the reader can check that \( ** \) is the identity. This means that \( \Lambda^2 \mathbf{R}^4 \) is the sum of two pieces, called the self-dual and anti self-dual pieces, on which \( * \) is \( \pm 1 \) respectively

\[
\Lambda^2 \mathbf{R}^4 = \Lambda^2_+ \oplus \Lambda^2_-.
\]

These two pieces are each 3-dimensional. Explicitly, a basis of \( \Lambda^2_+ \) is given by

\[
x_1 \wedge x_2 + x_3 \wedge x_4 , \quad x_1 \wedge x_3 + x_4 \wedge x_2 , \quad x_1 \wedge x_4 + x_2 \wedge x_3,
\]

and of \( \Lambda^2_- \) by

\[
x_1 \wedge x_2 - x_3 \wedge x_4 , \quad x_1 \wedge x_3 - x_4 \wedge x_2 , \quad x_1 \wedge x_4 - x_2 \wedge x_3;
\]

these corresponding to the three ways of dividing \( \{1, 2, 3, 4\} \) into pairs. Now we see the map \( \rho \) it is given by the action of a rotation of \( \mathbf{R}^4 \) on these two 3-dimensional spaces \( \Lambda^2 \pm \).
If we write an element $\omega \in \Lambda^2 \mathbb{R}^4$ as a sum of self-dual and anti-self-dual pieces $\omega = \omega_+ + \omega_-$ then one finds that the image of the Grassmann manifold is given by the condition that these two pieces have length 1

$$|\omega_+| = |\omega_-| = 1,$$

which exhibits $\text{Gr}_2(\mathbb{R}^4)$ as a product of a pair of 2-spheres.

This decomposition of the exterior 2-forms is important in differential geometry and mathematical physics. If we single out one “time direction” $x_4 = t$ in $\mathbb{R}^4$ then an exterior 2-form can be written in terms of a pair of vectors $\mathbf{E}, \mathbf{B}$ in 3-space as

$$B_1(x_2 \wedge x_3) + B_2(x_3 \wedge x_1) + B_3(x_1 \wedge x_2) + E_1(t \wedge x_1) + E_2(t \wedge x_2) + E_3(t \wedge x_3).$$

In a relativistic treatment of electromagnetism, the electromagnetic field at each point is an exterior 2-form on space-time. Then when a time direction is singled out the vectors $\mathbf{E}, \mathbf{B}$ are the usual electric and magnetic fields. The $*$-operation interchanges $\mathbf{E}, \mathbf{B}$ and can be seen as a symmetry between electricity and magnetism, particular to 4 dimensions. This is not precisely a symmetry on Lorentzian space-time; it does not exactly preserve Maxwell’s equations because some signs change. But in the Euclidean version of Maxwell’s theory the symmetry becomes exact. The same holds for the generalisations of Maxwell’s equations to the Yang-Mills equations of modern particle physics. One can define special “instanton” solutions of the Yang-Mills equations which exploit this particular feature of dimension 4, and various relatives such as the Seiberg-Witten equations.

Another mathematical area where dimension 4 stands out is topology, more precisely the differential topology of 4-dimensional manifolds. There are many fundamental questions one can pose about $n$-dimensional manifolds which are broadly understood for $n$ not equal to 4 but are completely out of reach in this special dimension. But many surprising phenomena have been detected—for example infinite families of inequivalent manifolds which look identical from the point of view of classical topological tools. These manifolds are distinguished by certain topologically-invariant properties of the instanton solutions to the Yang-Mills or Seiberg-Witten equations defined on them. In some mysterious way, which we only have glimpses of, the special geometry of the rotations in four dimensions, of the 2-planes and exterior forms is bound up with these topological phenomena. sc
Was the farewell tea party a true farewell?

It was a mock farewell, as I am staying on for three more years as a John S. Toll Professor. This fall I’ll be running the Graduate Student Practicum, which involves all graduate students who are teaching for the first time. We do classroom exercises; I visit their classes and we “debrief” afterwards; another class gets taped and we review the tape together.

The main thing I am going to miss about teaching is contact with young people. Stony Brook has always had an impressive mix of undergraduates: some very well-prepared ones who barely need any guidance, and some, often the first in their families to attempt college, for whom Stony Brook is a first big step on the way to a successful life. Stony Brook students are a very good bunch and I’ve liked them all along. The graduate students are excellent, of course. Over the years I’ve been lucky to work with some very talented individuals. (SC: And may we add, some very good professors.)

Jim Simons (quoted at the farewell tea by Dennis Sullivan): “Tony and I arrived at the same time at Stony Brook, and at the same age. Almost. Tony expressed relief at learning that he was a month or so younger than I was, because we both felt the chairman should be older. Tony was a great help building the department in those days, always up for entertaining visiting candidates, parties, etc. When Tony came back from Russia and told us about Gromov, it was more or less: “Don’t ask questions, just bring him”…

Tony Phillips: We have a great faculty, and that’s another plus. Dennis Sullivan told me once that one of the privileges of being a mathematician is being in contact with really extraordinary people, and if Dennis, who himself is quite extraordinary, thinks of it that way… We’ve worked with people like Thurston, Gromov, Milnor—and these luminaries, extraordinary human beings, were our friends!
Jeff Cheeger (quoted by Dennis Sullivan): “It’s somewhat hard to recreate the atmosphere of those crazy times with Jim as the ringleader. There was a new wild party every week” (at Jim’s house, or Tony’s house, or Jeff’s house) and Jeff remembers staying up until the early hours of the morning with Tony and everyone, dancing, and Tony being responsible for bringing Gromov to Stony Brook, after Tony had met him in Russia. “Tony recounted how Vladimir Rokhlin, Gromov’s advisor, had told him that Misha was the kind of person who would have been exceptional, no matter what he had chosen to do. After a moment’s thought, Tony added, “Well maybe not as a sports announcer.”

Tony Phillips: We were a small department of 20–25 people, and we were young: fifteen of us were in our 20s and early 30s—you can’t recreate that! Jim Simons was the chair, tasked with building up a world-class Mathematics department. The University was expanding, and expanding into mathematics. John Toll, the Stony Brook President, trusted Jim to make high quality hires. Jim and I arrived here in 1968; until then it had been mostly a service department, but there was a graduate program in place, and Bill Barcus and his colleagues had maintained rigorous standards. So Jim had a solid foundation to build on.

The transition from the old to the new was quite smooth, and Jim was very good at this. It was almost like an industry here, hiring mathematicians. We had dinners and parties here almost every week; it was a lot of fun. Many up-and-coming mathematicians came through, and some of them stayed. Jim ran up an incredible bill at the restaurant—he kept charging meals, but it turned out there was no account to charge them to; Ron Douglas, the next chair, for the first couple of years had to work through the accumulated local debt Jim had run up... It wasn’t lavish spending, just nice dinners at the “Elks” in Port Jefferson. (An old-fashioned American restaurant, good fish. Where the Starbucks is now). That was the adolescence of the department. Happy times, and a lot of important work got done: when Cheeger and Gromoll proved their wonderful theorem, that every positively curved complete Riemannian manifold is fibered over an embedded “soul,” we started calling them “The Soul Brothers.” It was an exciting time.

The Stony Brook department has kept this quality of openness and lack of pretention since those days. Many of us have worked at maintaining that spirit, and I think—I hope—it’s now in the DNA of the department. If you ask people what it’s like at Stony Brook, they’ll probably tell you it’s a very friendly department, very open, no prima donnas. I am very grateful for that.

The other thing that was very important to me was the contact between the Mathematics and the Physics departments, which goes way back. There is the celebrated encounter between C. N. Yang and Jim Simons, which led to the discovery that what physicists called “gauge field,” was in fact identical to something mathematicians had been studying for 40 years, under the name of “connection in a principal
fibre bundle." The insight led to an enormous development in modern physics and also, very significantly, in modern mathematics. In 1978 Jim commissioned me to write a propaganda piece for "Research," a SUNY Central publication, about the differential geometry group at Stony Brook. He said: "Of course, you will have to talk about the Aharonov-Bohm effect." I’d never heard of it, but I read up and realized it was an example of really non-trivial topology and geometry manifesting itself in a physics experiment. I also remembered Yang coming down to tea one afternoon, very excited, exclaiming “Fibre bundles exist!”—he was talking about a neutron-precession experiment that had just been performed. I wrote about both these experiments (with my friend Herb Bern-stein) in Scientific American, and ended up working in that field for 5 or 6 years; that public-relations assignment from Jim turned out to be very valuable for me.

Mikhail Lyubich: Just to elaborate on how Tony brought Gromov to Stony Brook I would like to quote some very nice recollections by Tony Phillips: When I was in Russia on the Inter-Academy exchange program in 1969, my advisor Sergei Novikov told me I had to go to Leningrad to meet this young mathematician Gromov. He arranged my trip; I gave a talk, and spoke with everybody: Yasha Eliashberg, who was a student then, V.A. Rokhlin, the great topologist and Misha’s advisor. I’d studied some Russian, but it was even feebler than it is now. I couldn’t converse, but everyone knew some other language: Eliashberg knew French, Rokhlin knew German, and Misha knew some kind of English. In the evening I was invited to Misha’s apartment, where of course there was vodka. At one point I didn’t know
what language I was speaking, and that's the only time this has ever happened to me! (They say that Russians like to get foreigners drunk just to see what they are really like).

**Blaine Lawson, Jr.** Tony made a huge difference in my life. I met him in 1971 when I came here to visit for the spring. We were both doing foliations at that time, and we went to a conference over at Oberwolfach. We were standing around at some point and a fellow came over to me and asked: “Where is this guy from? He speaks French perfectly but I can’t figure out the accent.” I said: “New York City.”

**John Morgan:** Upper East Side!

**Tell us about your role as Mathematics executive officer at the Simons Center.** In the very beginning of the Simons Center I had that title and was on the board. I was involved in all discussions about what was the best way to have a research center, about the layout of the building, volume of public and private spaces, should there be a cafeteria or not (I was against the cafeteria, as a matter of fact—I thought it would be a distraction; of course I love it now). It was really interesting to work with the architects as they were planning it. For example, the idea of having the ground plan slightly curved came in about halfway through the project. Initially it was going to be rectangular. We all could see right away that it made the whole building so much more interesting. I am proud we have such a fantastic place on campus. I really appreciate good architecture and every time I walk through the Center I think: This place is so beautiful! It’s so well designed and so pleasant to be in!

**SC:** We are certainly with you there!

**Jeff Cheeger** (quoted by Dennis Sullivan): “When Tony’s tenure was being decided Milnor’s letter made the positive decision clear, which Jim paraphrased as “Quality and Taste.” These attributes served Tony well as Chairman of the Art Committee for the Simons Center.”

**Tony Phillips:** Personally, I am proud of my work with Nina Douglas and Christian White on the **Iconic Wall** (and the brochure for the wall, which was a big deal and a lot of work) and I’m proud of the Penrose pavement. The wall wasn’t my idea, but the pavement was. Initially I wanted it for the ground floor, but the architects suggested putting it in the outdoor area where it is now. It worked out extremely well. Carmen Menocal, one of the architects, really went with the idea and adapted it brilliantly, getting the pattern to match the shape of the courtyard and even finding a way to put the trees in conforming to the pattern—it’s perfect, I’m very, very happy with it! I’ve also been very pleased to watch the development of the Simons Center Arts Program. Recently, for example, there was a great show of work by Manfred Mohr, “Pioneer of Algorithmic Art.” Some of his creations were done on analog printers at Brookhaven, before there was such a thing as computer graphics. I was very grateful to get acquainted with this guy.

**Mikhail Lyubich:** We are standing in Tony’s Gallery, as half of these posters in Math Common Room were produced by Tony!

**Tony Phillips:** I made some of them, I made the Milnor poster. Here is a sketch for it, made with a primitive color copier in 1991.

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2 Tony Phillips’s talk on theorem selection: scgp.stonybrook.edu/video_portal/video.php?id=1889
In the cultural mathematics section of the list of your works the words “labyrinths and mazes” are mentioned at least 6 times. My interest in labyrinths came about through serendipity. I had a friend Jean-Louis Bourgeois, Louise Bourgeois’s son. Jean-Louis styled himself a labyrinthologist. He taught me about a traditional labyrinth kids draw as a game in India, which we know as the Cretan maze. Later, visiting friends in Tucson, I noticed that a basket they had on the wall, woven by the local Indians, had the same maze pattern that Jean-Pierre had told me about. How did this thing get from Crete to Arizona? The next year at my parents’, I was going through a Sotheby’s catalog (my father was working for them then). It was a sale of Judaica. There was a picture from a medieval manuscript, a Sefer Haftorot, representing the 7 walls of Jericho as labyrinth. It was very much like the Cretan, but different! Being a mathematician, I said to myself: one can be one, but if there are two, there’s got to be a lot! I started looking at their mathematical properties and figured out how you could generate hundreds of them. Each of these labyrinths has a depth, say N, and the question naturally arises, how many different labyrinths are there of depth N? Let’s call it that number M(N). There is no way to compute this number from N: you have to construct them all and count how many you have. But M(N) increases exponentially with N. I programmed a computer to calculate it up to M(22) = 73 424 650. The next even number would have taken me 16 times longer, etc. But it turned out that the same function had just come up in theoretical physics, counting something called rainbow diagrams; physicists used better methods to push the calculation up to M(48) = 794 337 831 754 564 188 184. This was a nice example of mathematics in the air, how it crystallizes and these amazing coincidences happen (there was a third simultaneous calculation of M(N) in a still different context, in Warren Smith’s Princeton thesis). It’s like a Möbius strip – if you see a picture of one you know it has to be late 19th century, or more recent. Nobody thought of a Möbius strip before, in some sense it didn’t exist; the idea sort of blossomed.

The main reference on labyrinths is the 1988 book by Hermann Kern. It’s encyclopedic, except that he...
didn’t know about the stone labyrinths on islands of the Solovki Archipelago in the White Sea. There is an obvious continuity between that ancient tradition and similar constructions in Finland and Sweden (on the other side of the peninsula), with some unexplained differences. Now that I am retired maybe I can get out there to check.

Marie-Louise Michelsohn: “Tony is my best friend in this department and outside of it! I met Tony in 1977 at IHES. It was a wonderful year, and Tony recruited Blaine and me, and we are very grateful. I am very grateful for all the interactions!”

Your co-authorship with Moira Chas resulted in 3 papers, one, bearing an intriguing title, Counting almost simple curves on the “pair of pants”, in preparation. It’s been something new for me, and hard, but a lot of fun. Moira has been studying curves on surfaces (the “pair of pants” is a nickname for the thrice-punctured sphere) and has used the computer to discover very interesting patterns in the relation between length and self-intersection number; we have been trying to figure out Why? In a way it’s easier than some kind of mathematics, where the level of abstraction can be very high. Here everything is totally concrete, but the patterns are mysterious. For example, we can prove that a certain phenomenon cuts in for sufficiently long curves, but the computer data give an exact starting point. Trying to improve our result leads to more and more complications. It’s amazingly intricate, but we’re getting there.

Jack Milnor: I’ve probably known Tony longer than anyone, and it’s been a great pleasure all these years. Congratulations to endurance – lasting 50 years at Stony Brook!

In a recent interview Martin Hairer spoke about his interest in sound, and his love for Pink Floyd. In your case it is Bach and bird songs. Martin wrote an excellent sound-processing software package called Amadeus, which I’ve been using for the last 15 years; when I read that Martin Hairer had won the Fields Medal I thought this must be the son of the person who wrote the software, as it was so long ago—but it was the same guy; he did it when he was in high school! I use his software to edit bird song recordings. It makes beautiful sonograms and is all-around perfect for the job. It was a great pleasure to meet him at his Simons Center workshop.

I believe that the connection between math and sound hasn’t been as well explored as the visual connections. Take M.C. Escher, and all the energy that has gone into making intricate mathematical graphic designs, especially with fractals. It’s like candy – you can’t stop eating it and yet… I recently came across a website with a “Mandelbrot zoom” — you start looking, and you watch it unfold further and further; it keeps going, and going, and going… This incredible structure is there, but what does it mean?

One place where I found “sonification” to be useful is in thinking about tides. Before I moved out here I hadn’t thought about them all. But living on Strong’s Neck I would drive past Little Bay every morning around the same time; some days it was full, and some days it was empty. I discovered tide tables, and started wondering how they were generated. They turn out to be the product of wonderful 19th century physics and mathematics, much of it due to Kelvin. The tides are driven by gravity, and depend on the relative position of the Sun, the Moon and the Earth, and on the rotation of the Earth, so all the forces are completely understood. But at any given port, the exact pattern depends on the local undersea topography, and the way the water there is connected to other bodies of water, in a totally mathematically un-analyzable way. Also, because the various astronomical periods involved (year, month, day, etc.) are not rationally related, the pattern never repeats exactly. But Kelvin and company figured out how to take a month’s worth of tide readings at a port, and use Fourier analysis with small integer combinations of the astronomical frequencies to predict the height of that tide at that port at any time in the future. They even built amazing machines to sum up the Fourier series and produce the data for the tide tables. (Part of the joy of being a mathematician is in coming across these amazing mathematical patterns). So sonification: the sequence of high and low tide points can be interpreted as a 4-part musical score; each port has its own distinctive tune. For a conference in Venice I recently commissioned Levi Lorenzo, one of our Music graduate students, to score a couple of ports: Venice (marimba) and Ancona (wind quartet). He did a beautiful job.

Dennis Sullivan: Quality, culture, and taste! A true gentleman. Now, what’s a true gentleman? There is an essay by Cardinal Newman by which a gentleman is someone “who reduces conflict without reducing content.” True gentleman, Tony Phillips!

Tony Phillips: A toast to Stony Brook! Party on!
The latest exciting edition of the Della Pietra Lecture Series was delivered by Professor Tadashi Tokieda, the Director of Studies in Mathematics at Trinity Hall, Cambridge and the Poincaré Distinguished Visiting Professor in the Department of Mathematics, Stanford.

Along came magic

Prof. Tokieda, who likes applying mathematics to physics, and also applying physics to mathematics, and whose interests include inventing, collecting and studying toys, grew up as a painter in Japan. Later he was educated as a classical philologist in France (in fact, English was the seventh language that he learned), before becoming a mathematician. He is known for using innocent-looking everyday objects to reveal the underlying mathematical surprises. Filled with experimental movies, table-top demos and cartoons, his talks were incredibly engaging, and sometimes even had a little magic in them.

Each edition of the series, bringing world-renowned scientists to the Simons Center, includes a technical talk, a high school lecture and a lecture for the general public. On February 9th the marathon of talks began with Chain Reactions, technical talk looking into phenomena in nature where the reaction seems neither equal in magnitude nor opposite in direction of the action. Kicking off with a chain fountain, the talk included unknown paragraphs from Aristotle, apparently in more and more violation of Newton’s 3rd law, analysis of which suggested that these phenomena are in a sense generic, the keys being shock, singularity in the material property, and supply of “critical geometry.”

The next talk Tadashi gave that same day was titled Science from a Sheet of Paper. By folding, stacking, crumpling, and tearing he explored the rich variety of sciences, from geometry and magic tricks to elasticity and the traditional Japanese art of origami (ori–fold, gami–paper). But there was more in professor’s bag of tricks—during a special tea, Tadashi, who knows too well that one of the most interesting places to be is around scientists when they eat, quickly performed a timely Valentine’s Day present—linked hearts, with a pair of rings next to them.

Magic with a Ribbon, Paperclips, Rubber Bands, a captivating talk given on February 10 to over two hundred high school students, confronted the perception that answering a question ‘What does it mean to calculate?’ involves numbers and formulas. Using a ribbon, paper-clips and rubber bands, he explored a sequence of magic tricks, and before they knew it, students found themselves doing sophisticated ‘calculations’ on objects, that aren’t numbers or formulas at all.

There was indeed something magical in how Tadashi’s hands, projected on the screen, showed

With a ruler and a compass

E. Galois 1811–1832

No : e.g. 60° impossible to trisect.

But YES with paper folding : origami

C. F. Gauss 1777–1855

For which $N$ can you draw a regular polygon of $N$ sides?

$N \equiv 3$ possible . . .

$N$ must look like: a power of $2 \times \{2^m + 1\}$

$= a$ power of $2 \times (3, 5, 17, 257, . . .)$

But with origami, ALL $N$ possible.
fantastic geometry of Miura ori (a self-collapsing map being folded with only 1 degree of freedom). A true wit, with observations like “in biology cells divide by multiplying”, Tadashi filled his talks with jokes. The audience was to look differently at theories of Galois, Gauss, and Poisson, laugh about Landau preaching to his ‘disciples’ with donkey ears, the Amazon River, elephants, and Leonardo Da Vinci, and learn the theory of elasticity in 45 seconds. The magic Tadashi showed is robust, you can later show it off to friends and family. So, “take a sheet of paper…” (Tadashi Tokieda)

To watch the videos, please visit: scgp.stonybrook.edu/archives/17238
Three exhibitions, curated by Art Program Director, Dr. Lorraine Walsh, and held at the Simons Center Gallery this Spring, began with Through a Looking Glass (December 3, 2015-February 18, 2016) featuring the work of internationally acclaimed artists Jeppe Hein, Daniel Rozin, and Alyson Shotz. According to Walsh, “these artists individually explore perception and viewpoint using mirrors as a place for reflection. In their work the viewer is an active participant seeing the world in an illusory space with beauty, humor or surprise.”

Jeppe Hein’s interactive sculptures and installations combine elements of humor with the traditions of minimalism and conceptual art. At first glance his sculptures appear to be uncomplicated, formally simple affairs possibly nodding to 1970s’ conceptual art and minimalism, but they react to human presence when approached. Daniel Rozin, whose talk Creating Digital Interactive Art Using Reflection opened the exhibition, works in interactive digital art, creating sculptures and installations that have the unique ability to change and respond to the presence of a viewer. In some of Rozin’s pieces, the viewer is the subject. In other works, the viewer takes part, actively and creatively, in the performance of his artwork. Even though computers are often used in Rozin’s work, they are seldom visible. Alyson Shotz works with a variety of media, from sculpture to prints to animation. She is known for manipulating synthetic materials to investigate modes of perception, experiential boundaries, and natural and scientific phenomena. Shotz uses mirrors, plastic, glass, steel, and beads to create physical structures that simultaneously comment on the space surrounding the piece, often through the transformative implementation or capture of light. Her talk closed the exhibition. Another talk during the Through a Looking Glass exhibition was given by Dr. Walsh to local high school students, in the Simons Center Gallery.

It didn’t take long for the next exhibition to follow. Titled Form and Line, it was on display from March 3 to April 21 and featured the work of artist Beverly Ress, alongside the nascent products by Virginia Tech Industrial Design students. “Dissimilar in concept and outcome, their paired artwork provides uncanny affinities. Ress’s beautiful inquiry of natural
forms, including universal shapes such as the torus, Klein bottle and Möbius strip, and the student’s exploration of line, volume, and planar analysis, exquisitely discover form and line anew,” says Walsh. Mitzi R. Vernon, former Professor at Virginia Tech and currently Dean of the College of Design at the University of Kentucky, opened the exhibition with the talk Form to Product.

**Spring 2016 Art Crawl**, a bi-annual event that includes guided tours of several art galleries on Stony Brook’s campus, including the Skylight gallery, Earth and Spaces Sciences and the Simons Center gallery, took place on April 21 and finished with the closing reception of the Form and Line exhibition. Also during Spring 2016 the Simons Center became classroom space for Dr. Walsh’s 10-week seminar course for first year students, titled Where Art and Science Meet and dedicated to study of the interplay of art, science and technology.

The **2016 Inaugural Simons Center ArtSci Lecture** featured China Blue’s talk *Art, Science and Algorithmic Aesthetics*. China Blue is an award winning international artist working at the intersection of art, science and technology. She creates customized EEG (electroencephalogram) software to sense the brain’s electrical activity to control the light and sound in interactive sculptures. Over the past two decades she has created sound art that focuses on developing data sonification. Her research includes bioacoustics, ultra and infrasonic sampling devices, brain wave monitoring, and robotic sensory avatars. She is currently the Norman Prince Neurosciences Institute Artist-in-Residence, at Rhode Island Hospital.

**Buckminster Fuller: Inventing for Today** (May 9 – August 25, 2016) opened with Kurt Przybilla’s *Explorations in the Geometry of Thinking* talk. This ongoing exhibition sheds light on Fuller’s legacy as a great inventor that resonates in art, science and industry today. The exhibition features thirteen screenprints of Fuller’s patented inventions,
photos of his architecture classes including working on a geodesic dome with students at Black Mountain College in North Carolina, and Fuller’s unique geometric sculpture *Duo-Tet Star Polyhedras*. Born in 1895, Fuller worked for more than five decades developing experimental solutions that reflected his commitment to the potential of innovative design to create technology that does “more with less.” Throughout the course of his life Fuller held 28 patents, authored over 30 books, and received 47 honorary degrees. While his most well known work, the geodesic dome, has been produced over 300,000 times worldwide, Fuller’s true impact on the world today can be found in his continued influence upon generations of designers, architects, scientists and artists committed to creating a more sustainable and viable planet. Shortly before his death in 1983, Fuller received the Presidential Medal of Freedom, the nation’s highest civilian honor, with a citation acknowledging that his “contributions as a geometrician, educator, and architect-designer are benchmarks of accomplishment in their fields.”

The upcoming exhibition RESOUND, inspired by the recent scientific discovery of gravitational waves in space, will be on view from September 8th to October 28th, 2016. This exhibition also takes place during F_EAT: Fifty Years of Experiments in Art and Technology (E.A.T.), an event series at Stony Brook University proposed by Lorraine Walsh that includes an art exhibition, and a panel discussion that celebrates the continued legacy of E.A.T. This exhibition aims to integrate each artist’s unparalleled dedication to art, science and technology. The participating artists include Memo Akten, Sougwen Chung, Seth Cluett, Yoon Chung Han, Carsten Nicolai and Jess Rowland. An opening talk will be given on September 14 by the MIT LIGO Laboratory Director David Shoemaker, titled Realizing Einstein’s Dream: Observing the Signature of Dynamic Space-Time. sc
The Drunkard and the Policemen: *The Solution*

It is convenient to think about many drunkards starting at random points of the city and the number of drunkards still walking through the city at time $t$. Let us begin with a naive (and incorrect) estimate. Assuming that at time $t$ the drunkards are distributed uniformly, we can easily estimate that their average density is decreasing with the rate $e^{-ct/\tau}$. This would be a reasonable estimate if the policemen were distributed uniformly (e.g., forming a regular array) throughout the city. However, the distribution of policemen is also random and at large time $t$ the distribution of drunkards will be far from uniform. In fact, there are rare fluctuations (tails of distribution) in positions of policemen which will determine the long time fate of the drunkards.

Consider a drunkard who was “lucky” and found himself in the middle of an area of a typical radius $R$ which is free from policemen. The probability of finding such an empty place is proportional to $e^{-c\pi R^2}$ and there will be a lot of such places in an infinite city. The motion of the drunkard in the city without policemen is diffusive and his average deviation from the initial point is $\langle r^2 \rangle = t^2(t/\tau)$. This means that this drunkard is “safe” for a time about $t^* = \frac{R^2}{\pi} \tau$. Assuming that the drunkard will be caught after that time we estimate the fraction of this type of drunkards as $e^{-c\pi R^2-t/t^*} = e^{-\frac{1}{R^2} \frac{\pi}{\pi c \tau} R^2}$. Finding the maximum of this expression over $R$ we find that at time $t$ the drunkards dominating the fraction are the ones for $R = R_t = l \sqrt{\frac{\pi c \tau}{2t}}$, and the fraction itself is $e^{-2l \sqrt{\frac{\pi c \tau}{2t}}}$.

I received this problem as one of my final exam problems in a condensed matter theory course taught by David Khmelnitskii at the Landau Institute for Theoretical Physics. Although I did not solve the problem during the exam David showed me the solution in the end and gave me an “A” nonetheless. I still consider that exam to be the most instructive physics exam I have taken in my life. The solution presented above is semi-heuristic. For more details, see Tale 4 from David Khmelnitskii’s scientific “Fairy Tales” http://www.tcm.phy.cam.ac.uk/~dek12/1. Studies of rare fluctuations in physics were pioneered by I. M. Lifshitz. In mathematics the theory of large deviations was developed by S. S. R. Varadhan, http://www.abelprize.no/c53862/seksjon/vis.html?tid=53870.

— A. Abanov
eing born and raised in New York, I have many food memories. Like many others, my family would gather at my grandparents’ home for Sunday dinner. On our drive in from Long Island to Bensonhurst, I remember my father always double parking in front of our favorite bakery on 18th Avenue to pick up a box of Italian pastries and warm semolina bread. Sometimes, if he had the urge, or as a reward for not rough housing in the backseat, he would get my brothers and me a small box of something special to take home. The special boxes smelled of millie fiore and almonds and contained beautifully hand-decorated fruit-shaped marzipan, and a few of our favorite cookies. My favorites were sometimes called Seven Layers, or Rainbow Cookies. They didn’t have seven layers, and they were only colored red, white, and green.

I never forgot those cookies, and when the SCGP Café first opened in March of 2011, with the help of my talented pastry chef Rachel, we came up with a cookie that lives up to its name.

1. In a stand electric mixer, with the paddle attachment, beat almond paste with a small amount (¼) of egg to soften.

2. When almond and initial addition of egg start to smooth and look like a paste, add butter and sugar. Continue to beat with paddle until it looks like a soft paste. Be sure to stop the mixture and scrape down the sides if mixture rides up the sides of the bowl without being incorporated.

3. While the mixer is still running, add remaining eggs one at a time. Only add additional egg when previous addition completely incorporates into mixture.

4. Stop mixer, remove bowl, and completely scrape down the sides of the bowl, being careful to scrape down to the bowl bottom, incorporating all the butter that might not have mixed into the paste.

5. Add sifted flour, and return to mixer on slowest speed, beat just until everything is incorporated, and mixture is of consistency of smooth paste. DO NOT OVER MIX. Turn off mixer, set aside.
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AUSTRIAN SAUERKRAUT
WITH A FIELDS TWIST
Sauerkraut with “G’selchtem”
by Martin Hairer

This is a recipe I do regularly at home. I learned it by watching my grandma cook it when I was a kid. It should easily serve 4 people, but in any case it tastes great after reheating. (Almost better, actually.)

1. Buy a smoked rolled gammon (1-1.5kg) and put it to boil. It needs to boil for about 2-3 hours, so this has to be done early enough. It shouldn’t be too lean or it will get a bit dry.

2. Take about 1.5kg of Sauerkraut and boil it for about 20 minutes with a small handful of dried juniper berries (you can slightly crush them to release more flavor).

3. While it is boiling, coarsely chop one large white onion and two or three shallots. Cut about 200g of Tyrolean Speck into fine slices. (Pancetta also works fine as a substitute.)

4. In a sufficiently deep pan, heat the speck until the fat has become translucent, then add the onion / shallots and sauté until brown.

5. Strain the Sauerkraut and add it to the pan, turn the heat down to a medium heat.

6. Dissolve a stock cube in about 150ml of boiling water and add it to the Sauerkraut.

7. Cut a few potatoes into small cubes (about half an inch) and mix them into the Sauerkraut. Leave it to simmer for a good half an hour. Make sure that most of the water has evaporated: it shouldn’t be soggy anymore and the Sauerkraut itself should be very slightly browned.

8. Cut the boiled ham into thick slices and serve them with the Sauerkraut. Accompany it with horseradish and strong mustard.

The right kind of smoked gammon might not be easy to find, but it can of course be replaced by other meats, like pork belly, or simply Frankfurters.

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1 Chefs use metric system for baking because of its precision. But measuring eggs in grams may seem tricky! There is a formula for calculating the number of eggs – divide number in grams by 52 (17 eggs).
Math Kangaroo 2016

The Simons Center Auditorium for the third time opened its doors to the annual Math Kangaroo international competition on March 17. It was hosted by SchoolNova, an official center for Math Kangaroo since 2006. SchoolNova is a weekend enrichment program which operates on the SBU campus since 2004 and offers classes in math, physics and foreign languages. The math competition attracted over 100 school children in grades 1 to 12. Math Kangaroo, whose mission is to encourage students to master their mathematical skills, give them confidence in their ability for comprehending mathematics and help them understand how math applies in nature’s laws and human activities, is held every year on the third Thursday of March. Any student qualifies if he or she can work independently reading the questions and marking answers. The competition questions, chosen by the International Math Kangaroo Committee, are age-appropriate, interesting and in the format of word problems. The competition originated in the 1980s Australia (hence the title), and became popular in France in the 1990s. It came to the US in 1998, when only 32 students around the country participated. Over 24,000 students participated in the US this year.

The Simons Center is happy to support SchoolNova and to become a venue where mathematics is celebrated at all ages, and show that mathematical education is significant in every part of the world.

Art Program and Gallery Events

Resound
September 8 - October 28, 2016
Memo Akten, Sougwen Chung, Seth Cluett, Yoon Chung Han, Carsten Nicolai, Jess Rowland

Opening Reception
September 14, 2016
Talk by David H. Shoemaker, Director, MIT LIGO Laboratory; Leader, Advanced LIGO; Senior Research Scientist, MIT Kavli Institute. Realizing Einstein’s Dream: Observing the Signature of Dynamic Space-Time

2016 Fall Art Crawl – Student-led Gallery Tours
September 29 and November 15, 2016

Simons Center ArtSci Speaker Series:
Special Guest Laurie Anderson
September 29, 2016

Opening Reception for F_E.A.T.: Fifty Years of Experiments in Art and Technology Conference
October 13, 2016
Talks by Julie Martin, Director, Experiments in Art and Technology (E.A.T.) and Michael Connor, Artistic Director, Rhizome and Visiting Professor, NYU Tisch School of the Artz

The Oakes Twins
November 15, 2016 – March 30, 2017
Ryan Oakes, Trevor Oakes

Opening Reception Artist Talk
November 15, 2016
Ryan Oakes, Trevor Oakes
From Iterative Form to Concave Perception

Studio Visits with Art Students
November 16, 2016

For Art Program and Gallery Events, please visit: scgp.stonybrook.edu/art
2016-2017 ACADEMIC YEAR PROGRAMS

Automorphic Forms, Mock Modular Forms and String Theory  
*August 29–September 30, 2016*, organized by Terry Gannon, David Ginzburg, Axel Kleinschmidt, Stephen D. Miller, Daniel Persson, and Boris Piolin

Entanglement and Dynamic Systems  
*September 7–December 16, 2016*, organized by Chris Herzog, Vladimir Korepin, and Bruno Nachtergaele

Mathematics of Gauge Fields  
*October 10, 2016–April 28, 2017*, organized by Simon Donaldson, Kenji Fukaya, John Morgan

Turbulent and Laminar Flows in Two Dimensions  
*March 20–April 21, 2017*, organized by Gregory Falkovich and Alexander Zamolodchikov

Mathematics of Topological Phases of Matter  
*May 1–June 23, 2017*, organized by Lukasz Fidkowski, Dan Freed, and Anton Kapustin

2016-2017 ACADEMIC YEAR WORKSHOPS

Automorphic Forms, Mock Modular Forms and String Theory  
*August 29–September 2, 2016*, organized by Terry Gannon, David Ginzburg, Axel Kleinschmidt, Stephen D. Miller, Daniel Persson, and Boris Piolin

Simons Collaboration on Special Holonomy  
*September 6–14, 2016*, organized by Bobby Acharya, Robert Bryant, Simon Donaldson, Mark Haskins, and Dave Morrison

Derived Categories and Chow Groups of Hyperkaehler and Calabi-Yau Varieties  
*September 19–23, 2016*, organized by Daniel Huybrechts, Ljudmila Kamenova, Emanuele Macri, Eyal Markman

Entanglement in Quantum Spin Chains  
*October 3–7, 2016*, organized by Chris Herzog, Vladimir Korepin, and Bruno Nachtergaele

Recent Developments in the Mathematical Study of Gauge Theory  
*October 17–21, 2016*, organized by Simon Donaldson, Kenji Fukaya, John Morgan

Entanglement in Field Theory and Gravity  
*December 5–7, 2016*, organized by Matthew Headrick, Patrick Hayden, and Chris Herzog

The Universe through Gravitational Waves  
*December 12–15, 2016*, organized by Luis Álvarez-Gaumé, Vitor Cardoso

String Theory and Scattering Amplitudes  

Applied Newton-Cartan Geometry  
*March 6–10, 2016*, organized by Eric Bergshoeff, Gary Gibbons, Rob Leigh, Djordje Minic, and Dam Thanh Son

Fluid Flows: from Graphene to Planet Atmospheres  
*March 20–24, 2017*, organized by Gregory Falkovich and Alexander Zamolodchikov

Beyond WIMPs: from Theory to Detection  
*March 27–29, 2017*, organized by Rouven Essig, Jeremy Mardon, Samuel McDermott, Peter Sorensen, Tomer Volansky, and Tien-Tien Yu

Gauge Theory and Low Dimensional Topology  
*April 24–April 28, 2017*, organized by Simon Donaldson, Kenji Fukaya, John Morgan

Quantitative Symplectic Geometry  
*May 8–12, 2017*, organized by Dan Cristofaro-Gardiner, Richard Hind, Michael Hutchings

Strongly Correlated Topological Phases of Matter  
*June 5–9, 2017*, organized by Lukasz Fidkowski, Dan Freed, and Anton Kapustin

Matrix Factorizations in Mathematics and Physics  
*June 12–16, 2017*, organized by David Eisenbud, David Morrison, Irena Peeva

SPECIAL EVENTS

Della Pietra Family Auditorium Dedication  
*November 17, 2016*

For the most up-to-date schedule, please visit: scgp.stonybrook.edu/science