SwissMAP
The Mathematics of Physics
National Centre of Competence in Research

SwissMAP Perspectives

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Special Edition:

Equal Opportunities

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Simplify your life by going LARGE

In theoretical physics, our best tool to calculate observable quantities is perturbation theory. We know very little about strongly coupled systems. Any new tool to access the strongly coupled regime is therefore most welcome. We found that working in sectors of large charge is way of compensating the effects of strong coupling.

I am a string theorist by training and in the course of my career I have gone through what resembles a random walk in the space of problems in formal theoretical physics. I started out in string phenomenology at a time when flux compactifications were a hot topic. I was most attracted by their most formal aspect, namely the algebraic geometry of the compactification manifolds. Motivated primarily by my interest in the (much more formal) field of topological string theory, I went to Amsterdam to work with Robbert Dijkgraaf for my first postdoc. While I never actively worked on this topic, it lead me to become interested in the connections between integrable systems and supersymmetric gauge theories. Realizing such deformed gauge theories appearing in these correspondence within string theory came next. This topic, and brane realizations of supersymmetric gauge theories in general kept me busy for quite a while through my moves to Japan and then to CERN.

To my own surprise, I ended up adding a quite different line of research to my collection. This happened in spring 2015, just after having started my new job at the University of Bern. I was in Japan, visiting my long-time collaborator Simeon Hellerman together with my collaborator (and husband) Domenico Orlando. For me, every new project tends to be a journey into the unknown, not just in the obvious sense that we don't know the end result of a research project when we start it, but also in the sense that it often involves physics I previously knew only little about. This topic was no exception. It is centered on the study of special sectors of three- and four-dimensional conformal field theories (CFTs). The most surprising part was that the problem had nothing to do with string theory or even supersymmetry (even though it is possible to consider superconformal field theories (SCFTs)).

Conformal field theories are, as the name suggests, invariant under conformal transformations. This gives rise to special features. If we know the operator dimension and spin of each local operator, conformal symmetry fixes the two-point functions up to normalization. If we furthermore know the 3-point function coefficients, we can solve the theory completely, in the sense that we can write down all higher correlation functions.

CFTs play an important role in theoretical physics, as they show up in a variety of contexts, such as critical points characterizing second order phase transitions, fixed points in renormalization group flows, and even quantum gravity via the AdS/CFT correspondence. CFTs are scale-free, meaning they contain no characteristic length or energy scale. This means also that we have no dimensionful small parameter in which to perform a perturbative expansion. The dimensionless couplings in a CFT are generically of order one. While in two dimensions the special nature of the conformal group allows us to use a host of analytic techniques, in higher-dimensional CFTs things are much more tricky. Of course, we have some methods at our disposal, such as large-N expansions, (small) epsilon expansions and the conformal bootstrap. And it is possible to run Monte-Carlo simulations on the lattice at strong coupling. But analytic results are still few and far between and any new approach that can help us get a handle on strongly coupled problems is important progress.

The approach we follow is quite a time-honored one in theoretical physics, namely making use of the symmetries of the problem and considering special subsectors of the full theory in which simplifications occur. In our case, we consider CFTs with a global symmetry. Such a symmetry has by Noether's theorem an associated conserved charge, which can be used to slice the Hilbert space of states of the theory into sectors labeled by their charge. We concentrate on a subsector of fixed charge, where we take the charge to be very large. It turns out that it is possible to write a low-energy effective theory in which the inverse of the large charge acts as a controlling parameter, bringing us back to a perturbative regime. Wilson's notion of the effective action in which any term compatible with the symmetries of the problem must appear is conceptually very compelling. If we don't have a way of truncating the effective theory, it is however of very limited practical use. Working at fixed charge allows us to do exactly that. In addition to using the constraints due to symmetry, we also use the fixed-charge scaling to discard those terms which are highly suppressed by inverse powers of the charge. In the problems we have studied so far, we were generally left with only a very small number of contributions which are not suppressed. In other words, working at large charge allows us to make the step from an effective action with infinitely many terms to an expansion which captures the low-energy physics in a handful of terms.

Susanne Reffert discussing large charge with Luis Alvarez-Gaume and Domenico Orlando at the Simons Center for Geometry and Physics. Photo by Jean-François Dars.

I am a string theorist by training and in the course of my career I have gone through what resembles a random walk in the space of problems in formal theoretical physics.

We approach the problem semiclassically, solving the classical equations of motion at fixed charge and minimizing in order to find the lowest-energy state at fixed charge. This ground state has the special feature of being time-dependent. Working at fixed charge breaks both the global and the spacetime symmetries. Part of this breaking is explicit and due to fixing the charge, part of it is spontaneous and due to the ground state itself. Spontaneous symmetry breaking gives rise to massless Goldstone degrees of freedom. They represent the quantum fluctuations around the classical ground state and encode the low-energy physics in the effective action. If the global symmetry we started from was just a U(1), then things are simple and we are left with a single (relativistic) Goldstone boson in terms of which we write a non-linear sigma model. The action contains all the terms compatible with conformal symmetry which are not suppressed by the large charge. If we start from a larger, non-Abelian global symmetry group, we need to first determine the symmetry-breaking pattern. Since the ground state breaks Lorentz invariance, we are generally left with both relativistic and non-relativistic Goldstone bosons, which are distinguished by their dispersion relations (linear versus quadratic in the momentum). Once we have written down the

effective action in the form of a large-charge expansion, we can start calculating the conformal data, namely operator dimensions and three-point coefficients, from which the general n-point functions can be determined. The energy of the ground state at fixed and large charge Q in particular gives via the state-operator correspondence of CFT directly the conformal dimension of the lowest-lying state of charge Q. The biggest contribution to the ground-state energy comes from the classical ground state, while the vacuum energy of the relativistic Goldstones gives a subleading contribution.

Working on CFTs at large charge has been an extremely interesting and enriching experience for me, both scientifically and personally.

One way of using the large-charge method is to apply it to known CFTs, such as for example the Wilson-Fisher fixed point in the infrared of the O(N) vector model in three dimensions. Another stance one could take is to simply assume that a certain CFT exists and apply the large-charge method to it. We have worked with models motivated from both condensed matter physics and particle physics. The large-charge expansion even works for non-relativistic systems with Schrödinger symmetry (as opposed to conformal symmetry). An example is the unitary Fermi gas which can be experimentally realized in the laboratory via cold atoms in a trap. Connecting back to more formal theory topics, the large-charge expansion can be applied also to superconformal field theories at large R-charge. Here, we found in particular that cases with a moduli space of vacua behave very differently from theories with one discrete vacuum I described above.

There is in general little known about the strongly-coupled models we are studying at large charge, so we have few results to compare our predictions to. But whenever there are results to compare to, be it on the lattice or from supersymmetric localization in the case of SCFTs, the confirmation of our predictions has been strikingly strong. When comparing with numerical results from lattice calculations, we found that our formulae derived at large charge even work down to very small values of the charge, which is highly unexpected (see Figure 1). The largest charge used on the lattice was 12, which is by no means a very large charge, but the agreement remains excellent even down to charge one. This has taken us very much by surprise, as it is far from the regime in which our effective theory is valid.
In the case of N=2 SQCD with 4 flavors, we could compare to a supersymmetric localization calculation which has again shown an amazing agreement and even allowed us to estimate the exponential corrections to the large charge expansion (see Figure 2).

Working on CFTs at large charge has been an extremely interesting and enriching experience for me, both scientifically and personally. On the one hand, this is the closest to "real-world" physics I have ever come, and I am really enjoying it. On the other hand, the problem has appealed to quite a varied group of people, getting me into contact with subfields I had known relatively little about before. Working on large charge not only got me talking to new people but has even lead to very interesting new collaborations outside my usual string theory community, such as the one with two lattice theorists, who recently verified our prediction for the O(4) vector model to high precision.

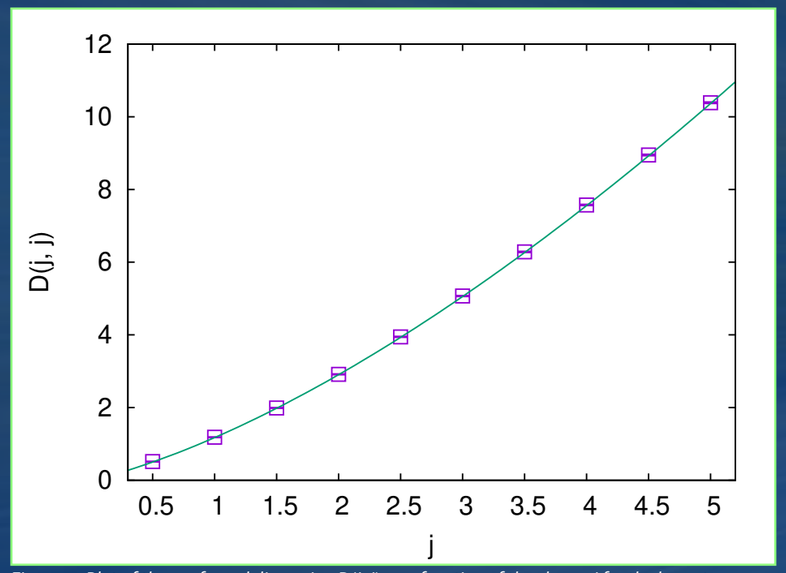


Figure 1 - Plot of the conformal dimension D(j, j) as a function of the charge j for the lowest operator of given charge in the O(4) vector model in three dimensions. The squares represent the data obtained using Monte-Carlo calculations on the lattice. The solid line is the large-charge prediction. Source: "Conformal dimensions in the large charge sectors at the O(4) Wilson-Fisher fixed point", D.Banerjee, Sh.Chandrasekharan, D.Orlando, S.Reffert, arXiv:1902.09542

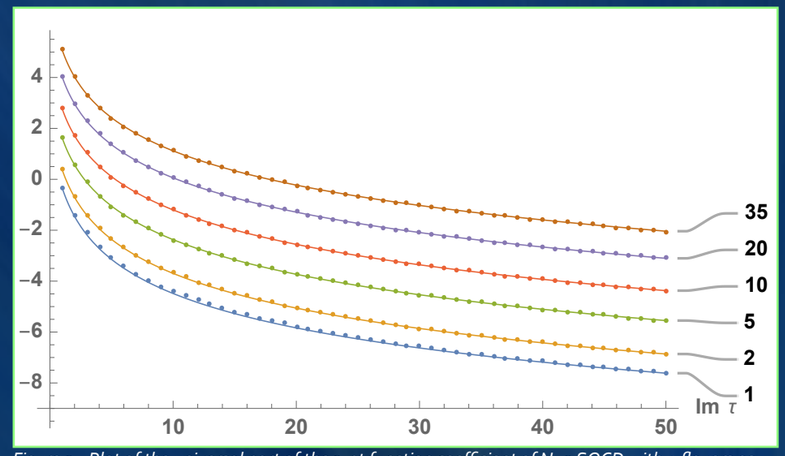


Figure 2 - Plot of the universal part of the 3-pt function coefficient of N=2 SQCD with 4 flavors as function of the gauge coupling for different values of the R-charge. The dotted lines represent the exact numerical results from the localization computation, the solid lines are our large-charge predictions, the numbers on the right side give the value of the fixed charge.
Source: unpublished, based on results from "Universal correlation functions in rank 1 SCFTs", S.Hellerman, Sh.Maeda, D.Orlando, S. Reffert, M.Watanabe, arXiv:1804.01535

Since our original paper in 2015, Simeon Hellerman and his (now former) student Masataka Watanabe, Domenico and I have continued to push the large-charge expansion forward in varying configurations of new and old collaborators. But it's been especially great to see that the topic has attracted a number of independent groups around the globe. In late summer of this year, I am co-organizing (together with Domenico, Simeon and Luis Alvarez-Gaume) a 1-month workshop at the Simons Center for Geometry and Physics, where we are hoping to bring together a varied set of people interested in systems at large quantum number and related topics in order to explore new approaches, connections and applications.

I believe that we've only scratched the surface of the power of the large-charge expansion and that the method can be widely applied and developed in several new directions. Since we are in the unique position of having a good theoretical handle on strongly coupled systems, the large-charge approach might for example allow us to explicitly check conjectured (strong/weak) dualities.

When we first started working on large charge four years ago, at least I had no idea what I was getting into. It's been quite a ride and I've learned so much! The large-charge expansion has exceeded our boldest hopes when we started on the project. I am excited both to be part of and to watch its development and hope that it holds many more exciting surprises for us. Who knows where it will lead me next on my path of theoretical physics research?

There is in general little known about the strongly-coupled models we are studying at large charge, so we have few results to compare our predictions to. But whenever there are results to compare to, the confirmation of our predictions has been strikingly strong.

Author: Susanne Reffert
Professor, UNIBE

A Conversation with
Anna Beliakova

Anna Beliakova is a full professor of mathematics at the University of Zurich. She was born in Minsk (Belarus) and completed her doctorate in 1994 under Professor Robert Schrader at the Free University in Berlin.

Her areas of expertise are topology, in particular knot theory, as well as quantum invariants and their categorization.

In 2011 Prof. Beliakova developed a unified theory of quantum invariants for the 3-dimensional homology spheres in collaboration with Le and Bühler. Later, she introduced horizontal tracks in bi-categories, which she used in 2016 for the construction of the Khovanov-Homology in rings.

In 2007, Anna Beliakova founded the Junior Euler Society at the University of Zurich, which promotes students' interest in mathematics. Since 2018 she is co-chair of the SwissMAP Equal Opportunities Committee.

- Could you say some words about your career? What were the decisive points and/or difficult choices?

The first very important point, perhaps not only in my career but in my whole life, was the fall of the Berlin Wall. At that time, in 1989, I was visiting a friend in eastern Germany, and suddenly the wall that we all thought would be forever, fell down. I went to the other side and asked a professor at the Free University Berlin for a PhD position. Actually, at that point my English was not good enough to fully understand his answer, but I understood that it was rather positive than negative. That is how I obtained my PhD position in Berlin, and had this great opportunity to continue my studies. So this was a major event that determined both my personal and professional lives.

The second turning point happened when I was around 30 years old, with my 3rd postdoc and two small children. I was living in Basel and my husband moved to the region of Zurich because he found a job there. During the weeks, I was alone with two small kids, and with very unclear career chances. At that point I decided to reduce my position in Basel to 20% and join my husband in Zurich. We put our kids in childcare in the canton Schwyz, which was completely unusual in those times. I had to take an additional teaching job at the Technical School in Rapperswil to pay for the childcare. Looking back, this was the right decision. It allowed me to work on my habilitation from home, and after a while I got the SNF professorship and finally my current job at UZH.

> A very important point, not only in my career but in my whole life, was the fall of the Berlin Wall.

- Could you tell us about your field? What are the exciting things happening there at the moment?

I am a quantum topologist. This is an interdisciplinary domain, where we are using ideas from mathematical physics to produce topological invariants of braids, links or 3-dimensional manifolds. At the beginning of the century these invariants were categorized. This means we could lift polynomial invariants to chain complexes. The most exciting feature is that the surfaces connecting knots in 4D induce maps between these chain complexes, so we gain insides into 4-dimensional phenomena through categorization. My dream is to categorize 3-manifold invariants.

> It is our job to show how important it is to further develop mathematics in order to have a leading position in technology and to be competitive with other countries.

- What were your most exciting or rewarding research experiences?

For me the latest one is always the most exciting. After I've understood the problem, I am usually not as interested as I was at the beginning. So for the moment I am really excited about my current project: find a description of 3-manifold invariants that admits a categorization.

- What is, in your view, the right balance between creativity and hard work in mathematics?

I think this depends a lot on the person. There are people who can just be sitting in a chair, thinking about something and get a great idea. For me that doesn't work. I need to work hard in order to get ideas. And then selecting the right one from all these ideas is again hard work. Sometimes, you write a paper without years of working just because you profit from the thoughts you had before. But I would not say that ideas come for free.

As an anecdote, I heard about a mathematician for whom the environment was very important. Once he got a great idea standing on a specific mountain in the Swiss Alps. And apparently, you can meet him there every day because he's still waiting for the next great idea that will change his life. So people work in different ways.

What I really appreciate a lot in mathematics are collaborations, where we exchange ideas and motivate each other. I do much better in collaboration, speaking with people, than when sitting alone in my office. And this is where I have a lot of fun in my job. For me personally, collaboration is the best way to produce new mathematics.

- Many people in the general public have little or no idea about what mathematicians do. What, in your view, can we do to sell our subject better?

This is clearly a challenge because the problems we are working on are usually not simple to describe. But on the

other hand, it is impressive how little the public knows about mathematics. If I tell someone I'm a mathematician, the first reaction is usually, "Oh, you should be very good in multiplying big numbers!" If I say that I am doing research they ask, "Are there any open problems in mathematics?" So we definitely need to change this view on mathematics.

Another typical question that even students of mathematics ask is, why use something in dimension N when our real world is three-dimensional? Here I usually explain that when you wake up in the morning in a good or a bad mood, it might depend on your last conversation with your relatives, the well-being of your friend, what you ate yesterday, and so on and so on. You could easily come up with a list of 10 parameters just to explain how you feel today. And of course, a mathematical model that could predict how you feel tomorrow will not only depend on just 3 parameters. Cambridge analysts for example, represented a person as a point in a seven-dimensional space. And apparently, this is a quite good approximation of how we function by elections.

What we should make clear to people is that a lot of things around us are based on mathematical models. And they work, because the mathematics was well understood and even simplified down to clear and fast algorithms. We are profiting from this

try. All these things exist and work because the mathematics behind them is completely understood.

This is probably our job to stress this point and to show how important it is to further develop mathematics in order to have a leading position in technology and to be competitive with other countries. It's really a key point.

It is important for us to make an effort and to speak with people from neighbouring fields. In SwissMAP we have this possibility.

every day. Like Siri which is nothing more than an artificial intelligence which is again a good algorithm that works. We see this everywhere be it money transfer or the medical indus-

- What did SwissMAP change in your research life?

SwissMAP is great. I was never supported as much as during the years since SwissMAP was created. We have unique possibilities to organise conferences, invite colleagues, hire postdocs and even organise some special activities for female mathematicians that help them to develop their careers. This is an amazing opportunity, and it has enriched my research quite significantly.

- What in your opinion could promote or encourage cross-project collaborations within SwissMAP?

This is not just a SwissMAP problem, but one we see everywhere in science. For example, people in algebra and geometry would usually not collaborate. The way mathematics was developed in the past was by dividing fields and isolating problems to be able to solve them. We are used to dig deeper and deeper holes, to become more and more specialized to produce new results. This is a successful strategy. But even deeper results may come from a broader perspective; therefore it is important for us to make an effort and to speak with people from neighbouring fields. In SwissMAP we have this possibility by organizing conferences that border on different domains and by meeting colleagues from physics.

I have learnt a lot since the beginning of SwissMAP. For example, on a conference organised by Grigory Mikhalkin in Tessin last summer, I heard lectures on enumerative geometry and tropical knots and then used their methods in my research. I also learned about theoretical physicists view on the categorization of 3-manifold invariants in one of the SwissMAP conferences.

I think just making people talk to each other is already a lot. In order for this cooperation to go further, we probably need a few more years where we continue to talk to each other and organise more of such interdisciplinary activities. It is probably too optimistic to expect an immediate result here.

Speaking to the public is quite similar as speaking to colleagues from neighbouring fields. This effort should be valued and appreciated more. For example, I have just read the book "Love & Math" by Edward Frenkel. I really see this book as a serious effort to popularise a certain mathematical program. The author reached a broad mathematical audience and in so doing, contributed to the success of this program. This definitively deserves some recognition.

- As co-chair of the Equal Opportunities Committee in SwissMAP, what plans do you have to encourage female researchers and young families in science?

We've already had a few very good things implemented, like the program that encourages professors to hire women PhD's and postdocs, by paying 50% of their salary through SwissMAP. We are reimbursing childcare costs during conferences for SwissMAP participants, etc.

In 2019 we launched a new mentoring program. The idea is to fix the "leaky pipeline", i.e. to encourage talented young people especially women to continue their research career. On the SwissMAP website, we collect short CV's of the mentors, showing each other's experiences and areas of expertise as well as explain where they can help especially well. In this way our young researchers may choose mentors that best suit their needs and profit from their experience. I'm really looking forward to this program.

Corinna Ulcigrai is also organising a women lunch in Zurich, where female mathematicians can chat, exchange experiences and also help each other.

Finally, we are currently implementing a new hiring policy in SwissMAP aiming to reduce bias in the hiring process.

Conversation with
Anna Beliakova
December 2018, Zurich

Interviewed by Maria Kondratieva
On behalf of the NCCR SwissMAP

Presenting the

NCCR SwissMAP Mentoring Program for women PhD and Postdocs

"It can be difficult to talk about what is on your mind - but it is most definitely worth it. Talking to someone who has had similar experiences can be very motivating and beneficial. I felt that after the discussion with my mentor, I was able to think much more clearly."

Ulrike Riess, SwissMAP

Problematic supervision impacting research?

Striking a balance between one's scientific career and personal life is a problem every young researcher faces. This is especially true for young women, many of whom might decide against entering the field because of the difficult choices one needs to make in order to become a scientist.

As part of the ongoing effort of SwissMAP to address the gender gap in our field, the Equal Opportunities Committee has recently launched the SwissMAP Mentoring Program for Women PhD and Postdoc members.

PhD students and Postdocs often face daunting challenges. Researchers are often reluctant to seek help, believing that they should be able to resolve their problems on their own. It is not an easy decision to speak to someone, however, it is precisely in these situations, talking to the right person, who may have had similar experiences, can make the difference in finding solutions. Effective mentorship can play a critical role in a researcher's future career trajectory.

The mentoring program offers all SwissMAP women PhDs and Postdocs impartial, confidential support at all stages of their careers. Mentees can seek advice from more senior SwissMAP participants, who have volunteered as mentors and can thus benefit from their knowledge, skills and expertise.

Too much to do and little time to do it?

As our Postdoc member Ulrike Riess (ETH Zurich) explained "*At that time our first child had just been born and things were getting somewhat difficult… During the talk I had with Anna Beliakova, I received some very good advice on how to organize childcare.*"

The idea behind the program is that all PhD and Postdoc SwissMAP women freely choose a mentor, who does not necessarily work in the same institution or field. Participants have access to the list of mentors and their profiles, in which each one of the eight mentors (four women and four men) has briefly introduced themselves, described their career path as well as their hobbies and interests. Participants then contact the mentor of their choice directly to organize a first meeting. After this first meeting, they decide whether or not to continue with the program.

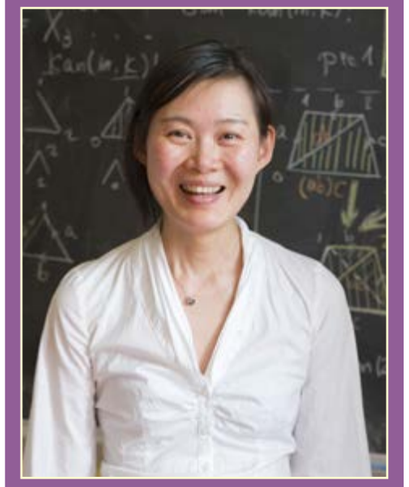
The SwissMAP mentoring program is an important step towards creating a more encouraging environment for women researchers and providing with support in their careers. The program is certain to have a positive impact on the professional and personal lives of female PhD and Postdocs within SwissMAP.

Can't decide between an academic path and the industry?

Author: Sophie Schmidhuber
On behalf of the NCCR SwissMAP

Balancing Yin and Yang in the field of Mathematics:

Interview with Prof. Chenchang Zhu



Chenchang Zhu received her PhD in mathematics from the University of California at Berkeley in 2004 under prof. Alan Weinstein. She was an assistant professor at the Fourier Institute, Grenoble as of 2006. She got tenured in at the Mathematics Institute of the Georg-August-Universität Göttingen since 2013.
Her research interests include: Poisson geometry, Symplectic geometry, higher structures in differential geometry, such as higher stacks, gerbes, Lie algebroids, higher Lie groupoids and simplicial manifolds.

Following our *Women at the Intersection of Mathematics and High Energy Physics* conference that took place in April 2019, we met with SwissMAP scholar Prof. Chenchang Zhu, to talk with her about her experiences as a woman mathematician and about the impact of the conference.

- Going back to your school days, what or who drew you initially to mathematics?

I would say when I changed elementary schools. I was around 10 years old, I remember I was not such a popular kid, I ranked around the middle of the class. Then, there was a math's test and somehow I got a perfect score, I don't know how! A woman teacher then came up to me and explained that she held a small class specially for the kids who had very high scores and invited me to join the class. In those classes we did some exercises together, I found those small classes and the people very nice, they were very intelligent. I was certainly very happy to attend this class, especially as it was a new school for me. That was how this whole thing started and then I began to participate in the Mathematical Olympiad in this small group.

Afterwards, it was kind of by chance. When I was in high school my favourite rock singer Wong Ka Kui died in Hong Kong, I think he died June 30th 1993. I was really sad and at that time you couldn't go to Hong Kong from the mainland but I knew that the International Mathematical Olympiad was going to take place in Hong Kong in 1994 and I was determined to go there. I've never worked so hard in my life. I remember it was around 40 degrees outside and I would still get up at 8:00 am and work until 10:00 pm. I actually managed to finish all the high school math textbooks in one summer break!

Although in these small classes there were mostly boys, I was not affected by this. The boys were quite nice to the few girls in the class. Also, I feel that compared to other peers who say that when they were younger they sometimes felt a gender bias coming from boys and even from the teachers, in my case it was different. It is probably because in China, at least in my generation, the one child policy meant that in my family I was like "the little princess", and I never felt second best. I would say that for that generation of girls in China, we felt very much equal to boys. I did not care so much about this.

- Did you have any women role models who inspired your career?

I went to the WAM (Women And Mathematics) in IAS Princeton. It is very similar to the recent SwisssMAP women's conference, only it was more aimed at students. It was hosted by Karen Uhlenbeck, who by the way, recently became the first woman to receive the Abel Prize in Mathematics!

I would say that it was Karen who inspired me during this conference. She really awakened this thing inside of me. Before that, I was just enjoying life and I didn't think too much about my future, then Karen really made me think seriously about what I wanted to do in the future. I could see Karen, this amazing woman professor who was there, who organized panel discussions and other very good women professors, women postdocs, who shared honestly their life, both professional and personal, with us. There were difficulties, but they were manageable and these women all seemed to enjoy what they did! I thought to myself, yes, it is possible to become a woman professor! In fact, I returned to WAM again the following year and I was really thankful to Karen.

- Can you speak about your experience as a woman mathematician, particularly at different stages of your life?

I guess the period of graduate school was a beautiful time for me: to learn to live in a new culture and explore life. There was a lot of going on for me, and I was at the moment when I had to figure out what to do in life for the future. Then, the period of being a postdoc, I spent 2 years at ETH Zurich and then another 2 years as a young assistant professor maître de conférences in Grenoble. That time for me was mostly a period when I became independent from my PhD advisor and I began to work with many new collaborators. It was amazing how during that period there was much criticism! I would say it was firstly, due to the fact that I was no longer under the protection of my advisor and secondly, because I was not yet fully established. Now I realised that my advisor Alan Weinstein, at the same time, being an outstanding mathematician, has also a very gentle and supportive character. He is incredibly fair towards his students with regards to gender. So, I didn't feel at all being different among his students. Today, I realised that it is not the case in general. I was really lucky to have Alan as my advisor!

> As a young woman professor, I have had to work extra to earn respect and trust in my ability, my proofs, and my insight.

- Do you think the criticism was accentuated by the fact you were a woman or, does everybody experience this on the road to professorship?

At that time I didn't think it was particularly because I was a woman. However, now when I look back I think it was half and half. I feel math's society tends to have more "male culture" compared to other areas, such as art or biology.

- … and as a young woman professor what challenges have you had to face? Do you feel more pressure or expectations?

As a young woman professor, I have had to defend hard make a sound, to work extra to earn respect and trust in my ability, my proofs, and my insight. With time and patience, I'm happy that some are convinced, but or take my words, even comparing to male colleagues with the same age.

> I believe that the greatest pressure and challenge I face is the balance between career and family. I also feel this applies to most women professors.

I'm still continuing on this path.

I believe that the greatest pressure and challenge I face is the balance between career and the family. I also I feel this applies to most women professors.

- Do women need to be much better than men to get to the same place?

When I entered the job market the pro-women movement, as well as the presence of the equal opportunities officers in committees, were already very established. I actually I felt it was quite more balanced compared to the previous generation of women mathematicians. I think it was much tougher for them. On the other hand, as I mentioned above, I do feel, as a woman, sometimes, I need to work extra to convince people to trust me

- Did you ever benefit from mentoring or are there any specific moments when you believe it could have been helpful?

I benefited much from mentoring from Karen Uhlenbeck. During my graduate school years it was unforgettable how Karen encouraged so many women mathematicians. She served as a role model to us. We could see there were women pro-

fessors and how they could also be speakers at ICM, and how they work their path over there concretely!

We also discussed about all the problems we could face and how we could go about them. How to manage family life and a career. I found WAM extremely successful and helpful. They gave advice and we all shared experiences.

- You attended the recent SwissMAP Women at the Intersection of Mathematics and High Energy Physics conference. Could you tell us about the benefits of attending?

In terms of content structure, mathematically speaking, I benefited a lot. It was a rich mixture of a variety of topics. I've never learnt so much. Each section was followed by a half hour topic discussion lead by a top figure in the area, where we were free to ask questions.

Somehow the energy amongst participants was different. For example, when someone is too prominent or aggressive, you don't dare to ask questions, but if someone is more low key and calm then your brain is stimulated to ask questions. You do not feel intimidated or, afraid to ask questions is inappropriate or not welcomed. In my opinion during this conference people discussed with an opened mind. It was different to attending other types of high profile conferences.

Credit: © Noel Tovia Matoff

I think it is important not to let mathematics change us. We need to stand up for ourselves and bring something new to the mathematics culture, to have more of a balance.

As I said in the panel discussion during the conference, you need to have the balance of Yin and Yang. Yin is something to support and grow something on top of it and Yang is this constructive prominent energy also in the direction of competitiveness. Even the male participants in the conference felt much more open to ask questions - it changed the energy field.

On the networking side of the conference and in terms of giving women visibility and recognition, I think before this conference I did not know most of the participants and now I've met women from both mathematics and physics and we had deep discussions. The atmosphere invited you to exchange ideas.

- The panel discussions were very rich in content and it was great to see participants of different backgrounds interacting. Could you briefly tell us something about the gender equality issues which were raised and were you surprised to learn about any of them?

I think one of the panel discussions was about candidate profile reading in a committee. I remember someone said "if a profile contains a lot of activities, interactions and collaborations, if it's a man, people tend to think, he's very active and if it's a women they tend to think she's very sociable." This is so true! I was just going through some profiles and I noticed that even I was unconsciously doing so. After noticing this, I went back and restarted, avoiding reading the applicant's name and only reading the profiles. I had to re-educate myself.

- Are there any challenges and possible solutions specifically related to the field of mathematics with regards to gender equality?

I think mathematics is a very classical subject created at a time of a male dominated society. I think the first women mathematicians known to the general public date back to around 100 years ago, whereas the first man goes back to 2000 years ago. So, because of this the challenge is that it has already a lot of Yang energy inside. What is definition of being smart and intelligent in mathematics? What is the definition of being valuable and deep in mathematics? What is definition of a talent and a star in mathematics? Its all, already 99% or 99.9% male based opinions.

If you take biology for example, a more recent science, more women are present. The subject was there at a moment when the ratio of men and women in education matched more evenly. That I find specific to mathematics, because of this somehow all the definitions of smartness… and also missing early women role models… that is why it is great that Karen won the prize, I was really happy when I found out.

- … and specifically on the subject of recruitment?

As I've said, maths has a lot of Yang energy in it. Firstly, we need more women, who will automatically bring some other kind of culture. Secondly, we certainly need to have more of these women conferences, like the SwissMAP conference or what Karen had in the US, and also summer schools for young women mathematicians. I also think it is important not to let mathematics change us, but precisely we need to stand up for ourselves and bring something new to the mathematics culture, to have more of a balance. I think that it is good to have a balance of both energies. When you have energy balance you can progress more efficiently.

- What advice would you give young women considering a career as researchers in mathematics?

I think first one would need to make sure it's something that you really like. Follow your heart but that is probably advice for both men and women. Secondly, to be persistent, to stick to it. I would say before you become established you will meet a lot of criticism and you need to be aware that you are likely to encounter it. Women sometimes tend to leave if they think "I am not so good with this" and how do we judge if we are good at this? Often through feedback from outside. This outside feedback plays a major role - that's unavoidable.

I would say to women mathematicians and young women especially, that one needs to stick at it a bit more. It's totally normal for someone to receive criticism early in their career - especially when you are a woman. Try to digest this criticism and don't give up because of it. Be more sure about yourself and try to find support within the community.

Credit: Mayra Lirot

Conversation with Chenchang Zhu
April 2019, Geneva

Interviewed by Mayra Lirot
NCCR SwissMAP

UNIVERSAL OPTIMALITY OF E_8 AND LEECH LATTICES

1. Introduction

The E_8 lattice and the Leech lattice are among the most famous mathematical objects. These exceptional structures emerge in dierent areas of mathematics and physics, here are only a few to name: number theory, classication of finite groups, theory of Lie groups, automorphic forms, coding theory, extremal graph theory, string theory and statistical physics. What is the reason for their "celebrity" status in nature? We cannot give a complete answer to this question. However, jointly with H. Cohn, A. Kumar, S. D. Miller, and D. Radchenko, we have recently found that these lattices have the following rare property – they are *universally optimal* [4].

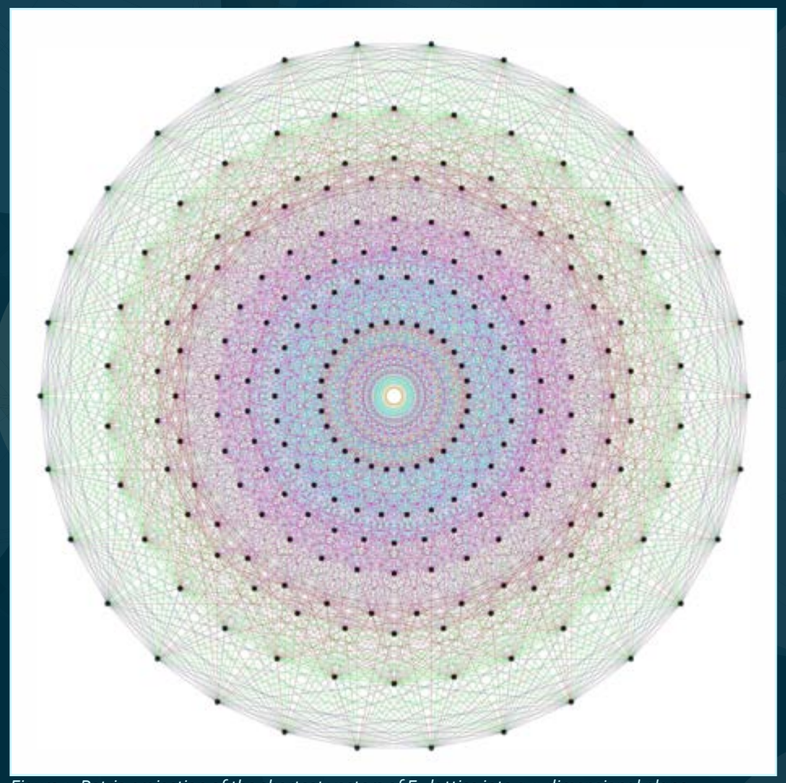


Figure 1. Petrie projection of the shortest vectors of E_8-lattice into a 2-dimensional plane. Source: Wikipedia

2. E_8 and Leech lattices

Let us introduce the two lattices in question a little closer. Both E_8 and Leech lattice belong to the "family" of *even unimodular lattices*. We recall that a *lattice* in the Euclidean space is a discrete full rank abelian subgroups, *unimodular* lattices are the lattices containing on average 1 point per unit of volume, and the term *even* means that the length squared of each lattice vector in an even integer number. Lattices with these both properties can exist only in dimensions dividible by 8, they are rare in small dimensions and come in huge numbers in dimensions bigger then 24. The E_8-lattice is the unique even unimodular lattice in dimension 8, while the Leech lattice is one of 24 possible such lattices in dimension 24 and the only one among them having no vectors of the smallest possible non-zero length \sqrt{2}. Both E_8 and the Leech lattice enjoy the number of symmetries and extremal properties. For example, the shortest vectors of each of these lattices are the unique solutions to the sphere kissing problem in dimensions 8 and 24. Also these lattices are solutions to the sphere packing problem in their respective dimensions. We have found that the E_8 and the Leech lattices are extremal for a much bigger family of optimization problems.

3. Universal optimality

Universal optimality is a property of a point conguration to be a simultaneous solution to a "universum" of optimization problems. This notion was introduced by H. Cohn and A. Kumar [2] and applied to point configurations in homogeneous spaces such as the Euclidean space, hypersphere, or hyperbolic space subject to the minimization of the energy of pairwise point interactions. We can think of points in the conguration as particles of some kind.

Energy minimization generalizes the sphere packing problem in $\boldsymbol{R}^d$, in which we wish to maximize the minimal distance between neighboring particles while fixing the particle density. In the energy minimization problem we fix the particle density *delta>0* and assume that the energy of interaction between a pair of particles depends only on distance *r* between them. Suppose that this dependence is given by a function *p(r)*. Then the *p-energy* of a conguration is the average interaction energy per particle. An energy minimization problem asks for a point conguration of density *delta* with the smallest possible value of *p-energy*. If exists, such a configuration is also called a *ground state*.

We will concentrate on energy potentials of a particular shape: we will consider repelling interactions such that the repulsion increases as particles get closer. Here is a more formal mathematical description. Recall that a function *g: (0;Infinity) -> **R*** is *completely monotonic* if it is infinitely differentiable and satisfies the inequalities $(-1)^k g^{(k)} >= 0$ for all $k >= 0$. 1. In other words, *g* is nonnegative, weakly decreasing, convex, and so on. For example, inverse power laws are completely monotonic, as are decreasing exponential functions. By Bernstein's theorem the completely monotonic functions of squared distance are the cone spanned by the Gaussians and the constant function 2. It follows that if a periodic configuration is a ground state for every Gaussian, then the same is true for every completely monotonic function of squared distance (by monotone convergence, because the potential is an increasing limit of weighted sums of finitely many Gaussians).

Following Cohn and Kumar, we call such a conguration universally optimal: Let *C* be a point configuration in $\boldsymbol{R}^d$ with density *rho*, where *rho>0*. We say *C* is *universally optimal* if WWit minimizes *p*-energy whenever *p: (0;infinity) -> **R*** is a completely monotonic function of squared distance.

Computations show that the universally optimal configurations are rare. A putative list of universally optimal configurations on hyperspheres is given here [2]. Examples of universally optimal configurations are also known in other metric spaces.

4. Universal optimality in Euclidean spaces

Currently, only three universally optimal configurations at the Euclidean spaces are known: the lattice of integer numbers in $\boldsymbol{R}^1$ [2], the E_8-lattice in $\boldsymbol{R}^8$, and the Leech lattice in $\boldsymbol{R}^{24}$ [4]. The hexagonal "honeycomb" lattice in dimension 2 is also conjectured to be universally optimal. A classical result is that the hexagonal lattice solves the sphere packing problem [7], however its optimality for potential energy minimization still remains open. On the other hand, the computations suggest that there is no universally optimal configuration in the 3-dimensional Euclidean space and the ground states depend on the energy profile [5], [6]. A similar situation has been detected in other small dimensions. This leads to an assumption that the existence of a universally optimal configuration in Euclidean space is an exceptional coincidence and raises a question whether it occurs only in dimensions 1, 2, 8 and 24.

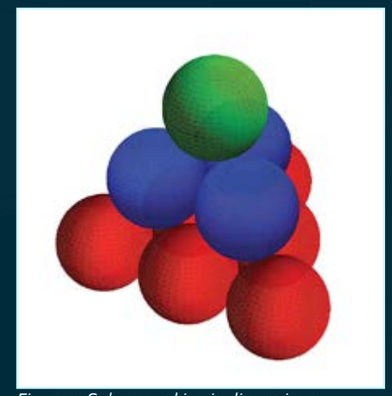


Figure 2. Sphere packing in dimension 3

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Author: Maryna Viazovska
Professor, EPFL

The importance of organizing a women workshop:

Interview with Eva Miranda

The Women in Geometry and Topology Workshop this year will be taking place in Barcelona, 25th - 27th September and is organized by GEOMVAP. Our Deputy Director and Co-Chair of our Equal Opportunities Committee Anton Alekseev (UNIGE) is part of the Organizing Committee.

In this short interview, Eva Miranda (UPC) also part of the organization committee, tells us about the importance of organizing a women workshop and what she hopes it will achieve.

- Can you tell us about your impression of the 2017 Women in Geometry and Topology in Zurich?

I remember that when I was first invited to be a speaker at the 2017 Women in Geometry and Topology Workshop in Zürich, organised by SwissMAP, I must admit that I was initially slightly reluctant about the idea of a workshop highlighting women (or any specific gender) in the title. I was, however, very impressed by the event and its success. I was also particularly surprised by the number of men who attended the talks and actively participated by asking questions. This was indeed unexpected for me.

- You say you were initially reluctant to participate, are you convinced now of the benefits of this type of event?

I believe organising this type of workshop is very important, not only for women in mathematics or, in this case geometry and topology, but in other subjects too. As women, we are used to being invited to conferences and finding ourselves to be the only woman or one of the few women speakers. I think it is very pleasant to bring a lot of women to the surface so that people stop thinking that there are no women in mathematics or in geometry and topology.

People are sometimes a bit hesitant about attending a women's conference, as I was. I would like to change this. I want to bring women from different countries together and give them visibility and I also want men to be present. I take this opportunity to encourage people from all genders to come and to participate!

- How did you get involved in the organization of this year's workshop?

During the 2017 workshop in Zurich, SwissMAP member Anna Beliakova (UZH), suggested I organise the next workshop in Barcelona… Initially I was unsure. I remember then having some very interesting discussions during the conference about how to address the gender gap, how the situation in Switzerland was different from the situation in Spain or Italy and about how every country has a diverse scenario and social ingredients. Notwithstanding, there are also many similarities. Being at the conference and seeing the benefits as well as the different conversations encouraged me to organise this year's workshop. On top of that, in 2018 we were awarded a special research project focused on Geometry and Topology SGR932 from Generalitat (GEOMVAP), where gender balance

is one of the strategic objectives as well as public engagement, and we decided to include this conference in the list of activities addressing the gender gap.

- What are the similarities and new features planned for this year's program?

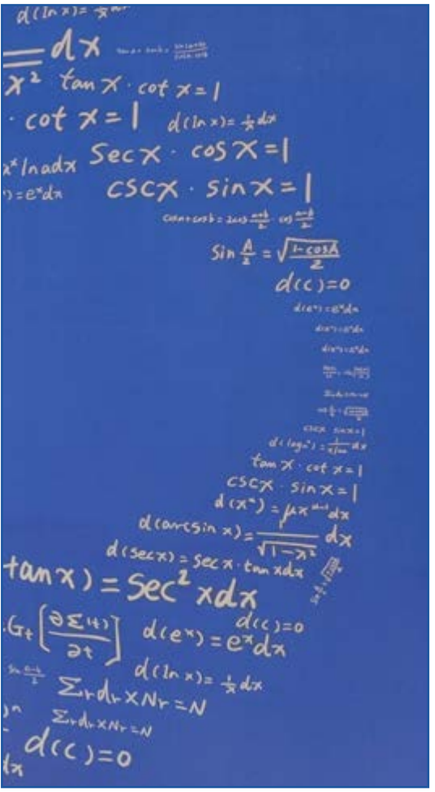
The plenary speakers from the last workshop of Women in geometry and topology covered a range of different topics. We are following the same guidelines this year: we have women who work more in topology, women who work more in symplectic geometry, some in algebraic geometry and also others who work in applications to computer science.

This year one of our public lecture speakers will be Carme Torras (CSIC), who works in computer science. We are very honoured as she is an exceptional researcher and has been awarded many different prizes; she is a real role model! In fact, our goal is to put forward different examples of role models. We believe this that is important, as one of the problems that exists is the visibility of women in mathematics. The more we advance, the fewer there are. Although this has been a constant problem, the situation is now desperate. In the master class I am teaching this year on differential geometry, I have only one woman out of 11 students. I believe we really have to do something about this and organising this workshop is a move in the right direction and I'm hopeful it will contribute to making things change.

Our goal is to put forward different examples of role models on the table. We believe this is important as one of the existing problems is the visibility and number of women in the mathematics.

- Who are you expecting will submit applications for the contributed talks?

One of the new features for this year's workshop is that the call for contributions is also open to all genders. The plenary speakers are female mathematicians but the call for contributions is open to all genders. We want this because we believe that things are going to change but for



of view as this is a common effort. We would like our panels to also be composed of people who are not in mathematics. For example, we recently invited someone with a social studies background to be part of the panel discussions as we want to have a wide perspective on the problems and solutions. One of our panel discussions will be "From inequalities to equalities: how to break the glass ceiling in maths". The moderator of the panel will be Marta Casanellas (UPC).

- The public lectures are an important part of the programme. Can you tell us about the speakers?

These public talks are open to non-experts and are not only for mathematicians. Both speakers are excellent and have very original profiles. One of the talks will be given by Marta Macho (UPV/EHU), recipient of the Ekamunde Equality Prize and also chair of mathematics and gender at the University of Bilbao. The title of her talk will be "Sesgos de género en la academia: cuando las matemáticas no funcionan" (Gender bias in academia: When mathematics doesn't work). Marta gives wonderful talks and I am delighted to have her as a speaker. She has a very different type of approach when she gives talks, I am sure that the participants will not be disappointed with her presentation; she tackles the problems from a different angle and she is very provocative.

We also have a public lecture by Carme Torras, who I mentioned earlier. Her lecture will be entitled "Cloth manipulation in assistive robotics: Research challenges, ethics and fiction" She has a very interesting profile, a mathematician who has reinvented herself. She is now working in robotics with robots to design clothes (ERC Advanced Grant Clothilde) and in this process of designing clothes there is a lot of mathematics. I don't know how she finds the time, but she is also a science fiction writer.

- What would you say are the long term effects of this type of event and what in your opinion is the take home message?

For the people who participate as speakers, I think the visibility for women is very important. I will give an example, it is something that can happen too often when you are a member of a scientific committee and you're asked to name and propose speakers of the field. In an instinctive way the first names that will cross your mind are people whom you've actually seen giving talks. Perhaps if you've never heard of a particular woman giving a talk you would not necessarily think of her. This type of event is also a good way to promote and give women visibility. People will remember them and know which field they are working on.

It is equally important for the next generations. PhD students or Master's students who find themselves the only woman in their course will be glad to participate in this women's workshop and be inspired by the role models.

In summary, I would say that this type of conference firstly provides great visibility for women researchers. Secondly, it provides role models that can inspire younger generations. Finally, it sends out a message to the grant providers and to society. The grant covering most of this event is from Generalitat and it was awarded to us as part of their strategic objective on gender equality. We want to tell the government to keep moving in this direction and that what we are currently doing is not enough.

I would like to add that one of the footprints that we are going to get from this workshop is that we are going to offer the opportunity to participants who have a contributed talk to publish them in a Springer book of the collection Research Perspectives CRM Barcelona, which our research group is editing in 2019. So the conference will leave a trace behind not only in our minds but also a printed trace in a book.

- Can you tell us about where the workshop will be taking place?

The three-day workshop will mostly take place at CRM, which is the main research centre in mathematics in Barcelona. We have decided that the public talks will be held in the centre of Barcelona at the Institute of Catalan Studies because CRM is just outside Barcelona. Our motivation to organise it in the centre of Barcelona was mainly to give more visibility to this part of the programme, which is of general interest not only to mathematicians but also to the general public.

I want to take this opportunity to advertise that Barcelona is a wonderful place to visit and also that we have grants available to cover lodgings and registration. Come and visit us!
The link to the conference is www.crm.cat/2019/Women_GT

> We want to have all genders involved because we believe that things are going to change but for this to happen we need the participation of everybody.

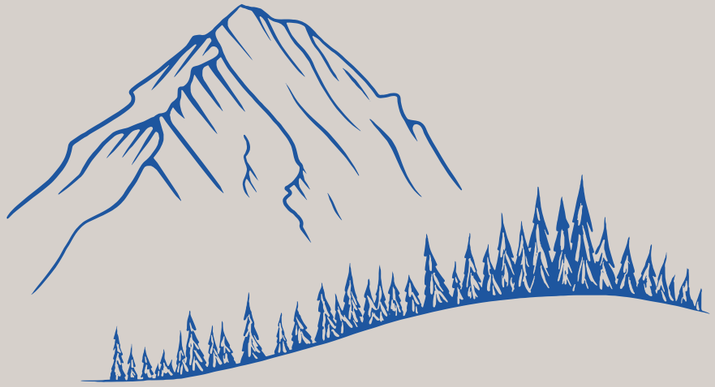
> This type of conference firstly, provides great visibility for women researchers. Secondly, it provides role models that can inspire younger generations. Finally, it sends out a message to the grant providers and to society.

this to happen we need everybody to participate.

Personally, I'd like to encourage all kinds of profiles for the contributed talks. I don't want an all-women event. I want all genders to be present to see how we can improve the situation by talking to each other and cooperating to improve the situation.

- Have you also considered having male participants in the panel discussions?

We plan to also have men because it is very important to have all points



Conversation with Eva Miranda
June 2019, Geneva

Interviewed by Mayra Lirot
NCCR SwissMAP

SwissMAP member stories:

Olga Chekeres

SwissMAP member stories: Olga Chekeres (UNIGE, A. Alekseev Group)

SwissMAP-funded PhD student, Olga Chekeres, completed her thesis in April 2019, one year earlier than planned. Supervised by Anton Alekseev, she wrote two successful publications: A. Alekseev, O. Chekeres and P. Mnev "Wilson surface observables from equivariant cohomology" and O. Chekeres "Quantum Wilson surfaces and topological interactions".

Olga's plans are to join the University of Connecticut, USA, for the next 3 years as an Assistant Research Professor.

Olga's exceptional career trajectory has been clearly led by remarkable enthusiasm and determination. From a very early age she was fascinated with astronomy and astrophysics and remembers that she was often reading books at the local library about stars and black holes and was very curious as to how it all worked.

However, once she finished school the possibility of continuing her education in either physics or mathematics did not really occur to her at the time. The reason was not lack of encouragement at home, nor gender inequalities. Olga explained that in post-Soviet Russia equality between men and women prevailed. Furthermore, the education she received from her parents strongly encouraged her to study and to have a career. However, in the Russian countryside where she grew up, she had never been exposed to the possibility of research as a career option. Though studying mathematics or physics was strongly recommended to her by her math teacher, at the time she had the impression that the only possibilities this path would offer would be of working at the local school as a teacher.

After finishing school, she decided to study languages and economics, which were considered as fashionable at the time, and completed a Master's degree on each of the subjects. Subsequently, not long after she started her professional career, she became chief accountant at an international company. However, in spite of this promising and successful start to her career, she questioned her choice and what her real interests were and began to explore other possibilities.

Olga remembered the great interest she initially had in astrophysics. Reviving this strong fascination on the subject, she decided to prepare for the entry exam for the Bachelor's in physics at the Moscow Institute of Physics and Technology (MIPT). The entry exam was a requirement for all prospective students.

But fate had other plans, she moved to Geneva with her husband and daughter before she could sit for the MIPT entry exam. Upon arrival to Geneva, determined to continue her project, she was faced with a further challenge, that of learning French to allow her to enter the University of Geneva. She pursued her studies and successfully completed her Bachelor's, Master's and PhD at the University of Geneva in ten years.

Particularly admirable is also the way that Olga managed her personal life in an academic climate, juggling her research and being mother of three children. Her second youngest, now two years old, was born in the middle of her PhD, and her thesis defense took place only two weeks before the birth of her third child. A very important aspect, without which her research could not have been accomplished, was the extremely encouraging and supportive environment she found at Villa Battelle.

Research Area

Early on in her Bachelor's Olga realized that astrophysics was not exactly what she was interested in and decided to orient herself towards theoretical physics. Her research field is now mathematical physics and she particularly enjoys working at the interface between mathematics and physics and believes in the power of mathematics to explain and predict how the physical world functions.

More specifically, her research is focused on surface observables in gauge theories. Gauge theories are at the very heart of our current understanding of the fundamental

Credit: Alexandra Orlova; Taken at Pre-String-Math Summer School, July 2017 in Hamburg

laws of nature. The Standard Model of elementary particles is precisely a non-abelian gauge theory with a gauge group G = U(1) X SU(2) X SU(3). It provides a unified model for 3 out of 4 fundamental interactions - electromagnetic, weak and strong - and is famous for its predictive power. The existence of its last building block – the Higgs boson – was confirmed at CERN in 2012. Even gravity in general relativity, which is not part of the Standard Model, can in some sense be treated as a gauge theory.

Gauge theories are geometric in character. From a physical point of view they describe a particle subject to an independent symmetry transformation at each point of space-time. Geometrically this means that for each point of space-time there is an "attached" space representing the internal structure of the particle. The natural mathematical description for such a construction is the theory of principal bundles, connections and the curvatures of these connections.

A very important example of an observable - that is to say a physical quantity that can be measured - is a Wilson loop. This is a gauge invariant quantity defined on a 1-dimensional line. It was initially introduced in 1974 by Kenneth G. Wilson to solve the problem of confinement of quarks, which however still remains unsolved. In electromagnetism this observable corresponds to a phase shift obtained by a charged particle transported in an electric field along a closed loop, measuring how much the particle 'fails' to be the same on returning to the same point in space.

Olga's work consists in constructing a Wilson surface observable, passing from a gauge invariant quantity defined on a 1-dimensional line to a gauge invariant quantity defined on a 2-dimensional surface. In string theory such an observable would correspond to a phase shift obtained not by a point particle, but by a charged 1-dimensional string transported in electric field along a loop. It can also describe surface defects within some gauge theory. Finally, the construction of a Wilson surface observable allowed to formulate Wilson surface theory as a separate 2-dimensional model, without any gauge theory in the background.

Credit: Serguei Ganjour

Olga's research plans are not restricted to the study of Wilson surfaces. She has several research projects related to Wilson surfaces, which she would like to implement in the near future. Her longer-term research interests are to approach quantum gravity. Currently there exist several candidates for a unifying theory that can incorporate quantum gravity, i.e. string theory, loop quantum gravity, causal dynamical triangulations, causal sets, tensor models, etc. Olga believes that eventually in the correct theory space-time should be discrete, not continuous, in the same way that matter consisting of particles is discrete.

We wish Olga all the best in her future endeavors!

Authors: Olga Chekeres, Mayra Lirot
SwissMAP, UNIGE

Events 2019-20

Past Events: 2018 - 2019
Between 2018 and 2019 SwissMAP held and participated in a number of successful events.
The joint activity of the ETH Institute for Theoretical Studies and SwissMAP resulted in the school *Modular forms, periods and scattering amplitudes*. The annual *Workshop on Statistical Mechanics* was held in Les Diablerets. The conference *Interactions of low-dimensional topology and "higher" representation theory* brought together researchers and students interested in both topics. Along with the Univesity of Geneva, SwissMAP organised the *2018 Mirimanoff Lectures*. Our Club de Maths organised the *UNIGE Olympiades mathématiques* aimed at 11 to 15 year old students. And in December, the *Amsterdam-Brussels-Geneva-Paris Doctoral School* was held on the topic "Quantum Field Theory, Strings and Gravity".

For more detailed information please visit our Website:
http://nccr-swissmap.ch/events

Feb - Apr

18 - 20 February
Women at the Intersection of Mathematics and High Energy Physics
Geneva
The primary goals of the workshop are to promote the visibility of women in fields of research at the threshold of mathematics and theoretical physics.

18 - 21 March
Deformation quantization, Batalin-Vilkovisky formalism and index
Geneva
The aim of the workshop is to compare different approaches to index coming from the deformation quantization, Batalin-Vilkovisky formalism and path integrals.

May - Jul

11 - 22 March
goMATH - Women in Mathematics
Zurich
NCCR SwissMAP will be participating in the goMATH – Women in Mathematics event organized by the ETH Zürich.

22 - 26 July
Young Topologists Meeting 2019
Lausanne
The Young Topologists Meeting is an annual event for graduate students, recent PhDs and other junior researchers in topology (both pure and applied).

16 - 19 July
Swiss Knots 2019
Zurich
Swiss Knots 2019 is part of a series of conferences on knot theory and low-dimensional topology organized in Switzerland.

Aug - Sep

18 - 23 August
New trends in geometry and mathematical physics
Ascona
Anton Alekseev, Damien Calaque, Alexander Veselov and Thomas Willwacher are organising the confernce on the occasion of the 60th birthday of Giovanni Felder.

08 - 11 September
6th SwissMAP General Meeting
Villars-sur-Ollon
The program will include: the SwissMAP Innovator Prize ceremony, colloquia covering SwissMAP research directions, talks by junior participants etc.

12 - 16 August
Representation Theory and Integrable Systems
Zurich
Pavel Etingof, Giovanni Felder and Evgeny Mukhin are organising the confernce on the occasion of the 60th birthday of Vitaly Tarasov and the 70th birthday of Alexander Varchenko.

Oct - Dec

01 Sep - 30 Jun
Master Class in Mathematical Physics
Geneva
SwissMAP is organizing a year-long master class at the University of Geneva in the academic year 2019/2020 for master and beginning PhD students.

Jan - Feb

02 - 07 Feb 2020
Winter School in Mathematical Physics
Les Diablerets
The annual Winter School in Mathematical Physics will take place at the hotel Les Sources in Les Diablerets in February 2-7, 2020.

29 Jul - 07 Aug 2021
ICMP 2021
Geneva
We are happy to announce that Geneva will be hosting the next International Congress of Mathematical Physics in 2021. The event is expected to attract around 800 participants from around the world.

Awards

Alessio Figalli

Fields Medal 2018

Congratulations to Alessio Figalli, Professor at the ETH Zurich and new NCCR SwissMAP member for winning the Fields Medal at the ICM 2018 in Rio de Janeiro! The Fields Medal is awarded every four years at the ICM to recognize outstanding mathematical achievement for existing work and for the promise of future achievement. Alessio Figalli is awarded for his contributions to the theory of optimal transport and its applications in partial differential equations, metric geometry and probability.

Vincent Tassion

2019 Rollo Davidson Prize

Vincent Tassion received the 2019 Rollo Davidson Prize in recognition of his extensive achievements in disordered systems and percolation. Vincent Tassion has been an assistant professor at the Department of Mathematics at ETH Zurich and a SwissMAP participant since January 2017. His area of research covers phase transitions in statistical physics models, such as percolation or the Ising model. In recent years, Vincent Tassion has grappled with a number of unanswered questions in this area, including for models in three-dimensional space.

Maryna Viazovska

2019 Satter Prize

Congratulations to Prof. Maryna Viazovska (EPFL) who recieved the 2019 Satter Prize for her groundbreaking work in discrete geometry and her spectacular solution to the sphere-packing problem in dimension eight.

Alice Gasparini

CPEP Award - Second place

Congratulations to Alice Gasparini on winning second place of the CPEP Award for her work on General Relativity and Cosmology Activities for high schools.

Nina Holden and Lorenz Eberhardt

2019 SwissMAP Innovator Prize

Nina Holden is awarded for her impressive work on probabilistic topics related to mathematical physics, such as Liouville quantum gravity, random planar maps and their embeddings and scaling limits, random allocations and matchings, and trace reconstruction. Lorenz Eberhardt is awarded for his important insights into string theory on AdS3 and its dual 2d CFT.

Yilin Wang andJunliang Shen

2018 SwissMAP Innovator Prize

Yilin Wang is awarded for her remarkable and original work on the Loewner energy of planar curves and loops. Junliang Shen is awarded for his work on the moduli of sheaves: the construction of virtual cobordism classes and the connection of the enumerative geometry of elliptically fibered Calabi-Yau 3-folds to Jacobi forms.

Grants

Marcos Marino

ERC Synergy Grant 2018

Congratulations to our member Marcos Mariño (UNIGE) who received an ERC Synergy Grant 2018 for the proposal "ReNewQuantum: Recursive and exact new quantum theory". The grant is part of the EU's research and innovation program, Horizon 2020.

Benjamin Schlein

ERC Advanced Grant

Congratulations to our member Benjamin Schlein (UNIZH) for receiving an ERC Advanced Grant titled "Correlations in Large Quantum Systems". He aims at understanding the macroscopic properties of quantum systems, as arising from a microscopic description based on the fundamental laws of nature.

Ghazaleh Asghari

SwissMAP Equal Opportunities Excellence Scholarship

Ghazaleh is a Masters student, she joined Prof. Cattaneo's group at UZH where she will be until 2020.

Beatriz Navarro

SwissMAP Equal Opportunities Mobility Grant

We are glad to announce Beatriz Navarro, from Toronto University, as recipient of our Mobility Grant. Beatriz will be based at UNIGE.

New Collaborators

Corinna Ulcigrai

University of Zurich

Corinna Ulcigrai is an Italian mathematician working on dynamical systems. She obtained her Ph.D. in 2007 from Princeton University with Yakov Sinai as her thesis advisor. She was awarded the European Mathematical Society Prize in 2012, and the Whitehead Prize in 2013. She worked as a professor at the University of Bristol. She is a professor at the University of Zurich. Her research interests include ergodic theory, dynamical systems and Teichmueller dynamics. Especially ergodic, mixing and spectral properties of parabolic dynamical systems.

Alessio Figali

ETH Zurich

Alessio Figalli is a professor at the ETH Zurich since 2016. He earned a joint doctorate in 2007 from the Scuola Normale Superiore di Pisa and the Ecole Normale Supérieure de Lyon. In 2007 he was appointed Chargé de recherche at the CNRS, and in 2008 he went to the Ecole Polytechnique as Professeur Hadamard. In 2009 he moved to the University of Texas at Austin as Associate Professor. Then he became Full Professor in 2011, and R.L.Moore Chair holder in 2013. His research interests calculus of variations and partial differential equations. He recently won the Fields Medal at the ICM 2018 in Rio de Janeiro.

Puzzle Corner

Test your math and logic skills with these puzzles, kindly put together by some of our contributors.

1. On the way home

Every day, Zoe's mother, Wilma, picks her up at the train station when she comes home from school, and then Wilma drives Zoe home. They always return home at 5:00 pm. One day, Zoe left school early and got to the train station an hour early. She then started walking home. Wilma left home at the usual time to pick Zoe up and they met along the route between the train station and their house. Wilma picked Zoe up and then drove home, arriving at 4:48 pm. For how many minutes had Zoe been walking before Wilma picked her up?

From Wearing Gauss's Jersey, Dean Hathout, CRC Press, 2013.

2. Rational Numbers

All the rational numbers in [0, 1] with denominator up to 2019 in lowest terms have been written down in increasing order. The fraction preceding 736/737 has the form $x/(x + 2)$ with $x \in N$.
What is x?

3. Count the zeros

How many zeros are at the end of the number 100! ?

4. Nonnegative Integers

Is it possible to find two subsets A and B of the set of nonnegative integers such that every nonnegative integer x can be written uniquely as a sum $x = a + b$ with $a \in A$, $b \in B$?

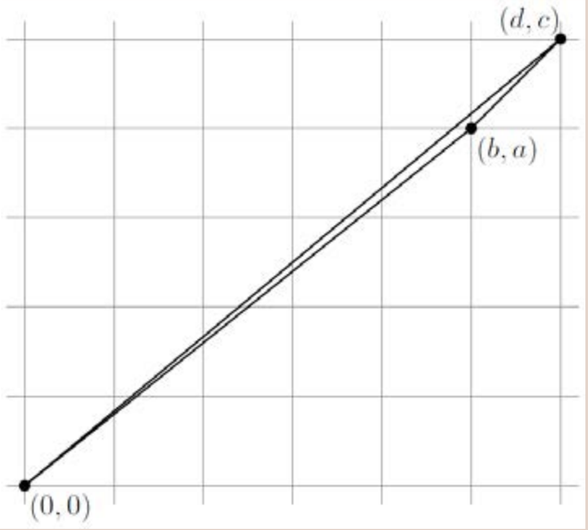
Answers

1. On the way home

Zoe was walking for 54 minutes before she was picked up.

2. Rational Numbers

Consider a grid of unit squares in the plane. If a/b < c/d are consecutive fractions in the sequence, the triangle with vertices (0, 0), (b, a), (d, c) contains no lattice points in its interior and no boundary lattice points besides its vertices.



Pick's formula implies that its area is 1/2. On the other hand, it's area is (bc–ad)/2 by the conventional formula. Therefore, bc–ad = 1. So, we obtain an equation for x; its solution is x = 1471.
The sequence described in the problem is called the Farey sequence corresponding to N = 2019.

3. Count the zeros

There are 24 zeros.

4. Nonnegative Integers

Yes. Let A and B be the sets of all nonnegative integers whose binary expansion contains only 0's at odd (respectively, even) positions, counted from the right.

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