TRAM

Training, Research and Motion network

1 Overview

Since its beginning Mathematics strived to be a global enterprise. Free flow of ideas and exchange of information shared between traveling practitioners has been a defining element of the mathematical culture since the Plato's Academy, creation of the Library of Alexandria and then later reproduced in the great scientific centers of medieval Europe.

This ancient model in its modern reincarnation has reached its peak at the beginning of the XXth century in Europe and brought with itself arguably one of the best if not the best generation of mathematicians. Knowledge was shared through publication of treatises and articles in journals (the oldest mathematical journal still in publication is Journal für die reine und angewandte Mathematik which dates back to 1824), training of graduate students, who would often during and after completion of their PhD's travel between scientific centers (Oxford, Cambridge, Gottingen, Paris), spending a year at each place to work with best minds of the time. Among that generation there were several Princeton mathematicians who exemplify this tradition. Salomon Bochner received his PhD at Berlin and subsequently spent a year each in Copenhagen with Bohr, Oxford with Hardy and in Cambridge with Littlewood. James Wedderburn had his PhD in Edinburgh then moving to Leipzig to study with Frobenius and to Berlin to work with Schur for a year.

This model had been eventually transplanted on the American soil with Princeton University playing a leadership role. Princeton established the first research professorship in mathematics in the United States, the Henri Burchard Fine Professorship. In 1928 under the direction of Dean Fine Princeton created the Scientific Research Fund, which made possible a stream of distinguished visiting mathematicians. In particular P. Alexandroff's (Moscow) and H. Hopf's (Gottingen) visit to Princeton and their subsequent collaboration with Princeton faculty - S. Lefschetz, O. Veblen and J. Alexander, made a lasting impact on the field of Topology.

After World War II global connections have been restored and expanded to include new centers of excellence, e.g. in Japan. Today, with an aid of modern technology and in the absence of some of the political barriers of the past, we live in a fully connected global society, in which a paper written by a Chinese mathematician can be discussed at lunch at Princeton the same afternoon it is posted in Beijing. An explosion of the electronic word however has also resulted in weakening of the social ties. Passive learning now often replaces active individual exchange of information and ideas thus skewing the balance between transmission of knowledge via written word and a more rewarding and productive act of mentoring and personal interaction towards the former. This specifically affects students who often fall in the trap provided by an easy access to online or printed sources but also forgo voluntarily or involuntarily, due to the lack of available programs or resources, invaluable scientific experience achieved from being personally exposed to different global mathematical cultures.

We firmly believe in the scientific tradition that supports and encourages a free flow of ideas and people, transcends geographical borders and physically connects individuals and institutions. Like a root system supporting a tree we envision reemergence of new global mathematical centers.
physically interconnected in a single network promoting, sustaining and reinvigorating mathematical culture.

We believe that the statute and continuing vitality of the Mathematics Department at Princeton provides it with a unique position to play a leadership role in the creation of such network. We propose the creation of a flexible structure connecting and interconnecting five international centers of mathematical excellence based in Beijing (China), Bonn (Germany), Cambridge (England), Jerusalem-Beer-Sheva-Tel Aviv (Israel) and Moscow (Russia) with Princeton.

The partnership will build upon existing research collaborations and will strive to expand and open new ways of mathematical inquiry and mentoring.

The hubs of the proposed Network occupy dominant strategic positions in the current fabric of mathematical culture.

In China our partner will be the new Beijing international Center for Mathematical Research, which is an independent research center in Peking University. Its primary purpose is to promote mathematical research in China and around the world and train new generation of young mathematicians. The Center is closely connected with the School of Mathematical Sciences at Peking University, which is the top Mathematics Department in China.

In Continental Europe our Network will be represented by the Hausdorff Center for Mathematics in Bonn, which leadership position in German mathematical life in the last 40 years has been recognized by the German government by awarding it a status of the Cluster of Excellence. It is the only Cluster of Excellence in Mathematics among the 37 clusters, which are being funded for five years each within the German government's Excellence Initiative.

In the UK the Network hub will be the Mathematics Department at the University of Cambridge, which together with Oxford are the historical and current leaders of mathematical activity in the UK.

The new "Israeli Cluster of Excellence in Mathematics" formed by the three top departments of mathematics in Israel at The Hebrew University of Jerusalem, The Weizmann Institute of Science and Tel-Aviv University will be the fourth Network node.

In Russia we will partner with the Independent University of Moscow -an elite university for research mathematicians, created in 1991 by a group of Russian mathematicians that included V. Arnold, S. Novikov, Y. Sinai (PU) and P. Deligne and R. McPherson (IAS, Princeton) to continue the eminent tradition of Russian mathematical thought.

Our proposed partners enthusiastically support this initiative and are in the process of formalizing their participation at the highest level of administration of the respective institutions. Beijing, Bonn and Israeli nodes had already made a promise to provide parallel funds to support local Network activities.

In the future we see a gradual expansion of the Network, linking Princeton with other global focal points of mathematical research and training. Our plans include partnerships with centers in Paris and in Japan.

The Network will extend the international aspects of the academic and research environment at Princeton and help to secure and expand its current position of global leadership. It will enable
Princeton to influence developments in the scientific landscape in other countries and will provide Princeton with a competitive edge to attract the best faculty and students throughout the world.

2 Network Flows

2.1 The Student Flow

In mathematical culture personal interaction remains the most effective mechanism for sharing and imparting knowledge. This is particularly important at the early stages of a scientific development. As a consequence one of the main goals of the proposed Network will be to facilitate a student flow moving smoothly between the nodes of the Network. The flow will be modeled on the semester or year-long exchanges of graduate students and undergraduate student’s participation in special programs. It will allow students to take advantage of very distinct mathematical cultures, focused in the nodes of the Network, and of being mentored by top mathematical minds spread among these Centers of Excellence. With this initiative Princeton Mathematics Department will be able to further cement its role in influencing formation of future global leaders of mathematical science.

We should note that whereas broadly similar networks in Europe allow students to benefit from the strengths of a larger scientific community, a similar infrastructure is not available to our graduate students. As a result they tend to remain at Princeton for the duration of their undergraduate and graduate studies and miss an invaluable experience.

A vigorous exchange will allow our students to interact and learn from the global leaders in any given area, while simultaneously giving our faculty and students the benefits of working and interacting with the brightest young researchers visiting us from around the world.

We intend to create a Graduate Mathematical Travel program which will include hosting 3 visiting students at any given time at Princeton and sending several of our graduate students to other Network nodes. We will also expand a graduate gap year initiative, which have been successfully tried by a few of our best graduate students. It will give several of our undergraduate and graduate students the opportunity to engage in a year-long intensive study before starting their graduate program. Cambridge has a long tradition of having students spending a gap year there to complete Certificate of Advanced Study in Mathematics (Part III of the Mathematical Tripos). Bonn will begin offering a comparable program within their master program (taught in English). The Independent University of Moscow offers the "Math in Moscow" program - a 15 week of intensive study at the advanced undergraduate level.

2.2 The Expert Flow

For the success of the Network, equally important to the mentorship flow involving undergraduate and graduate students is a free exchange of ideas between the senior mathematicians of the Network. Our history tells us that mathematical breakthroughs often result from sudden and unexpected connections between seemingly disparate subjects, realized at someone's lecture or in direct contact.

\(^1\) Already the preparation of this proposal initiated several activities within the partnering centers of excellence.
\(^2\) For example the Erasmus Exchange Program or scientific networks of the European Union
In today's specialized and insulated culture such accidental contacts are rarer: successful models of longer scientific visits have been replaced by shorter 1-2 day colloquia trips thus narrowing the window of scientific opportunities.

To encourage collaboration and exchange of ideas within the Network we will establish special *Alexandroff Visiting Professorships*. Alexandroff Visiting Professors will be invited to come to Princeton for periods of two weeks up to one month. They will participate in the life of the Princeton mathematics department and interact with faculty and students through mini-courses and special seminars. The Visiting Professors will bring vital new mathematical cultures and traditions from abroad to our department and into our classrooms. In addition, this visiting program will lead to new research collaborations and strengthen the ties between Princeton and our partnering centers of excellence. This program will be also supported locally at the other nodes of the Network.

### 3 Focal Points

The Network flows of individuals will be complemented by focused activities involving larger groups of researchers at the participating institutions.

#### 3.1 Net-Working Groups

Global unity of mathematical culture is reflected in a large number of overlapping interests and themes, albeit with a specific local flavor, pursued by the faculty members of the Network institutions.

One of the goals of the Network will be to link different groups with common mutual interests. Seeds for some of these links have already been planted whether in the form of existing small collaborations or recruitment of former students.

We plan to expand the existing and create new scientific links between the nodes of the Network by forming faculty driven working groups, unified by a common research theme, exchanging ideas and holding regular meetings and workshops. The choice of subjects will be determined by the interested faculty members. Currently, the mathematical research themes that attracted high amount of interest among the members of the proposed Network include:

- Algebraic and Symplectic Geometry
- Applied Mathematics
- Lie groups and Representations
- Probability and Mathematical Physics

Whereas most scientific collaborations in mathematics are carried out on an individual basis, *Net-Working groups* will explore the possibility of exchanging ideas and collaborating as a research group. Such interactions are common in many experimental sciences, yet they are rare in the mathematical research culture. Thus, the working groups will complement the dominant culture in the mathematics department of traditional one-on-one student-advisor, postdoc-mentor or collaborator relationships. In particular, the working groups will involve junior faculty and graduate

---

3 Named after a distinguished Russian mathematician P. Alexandroff, whose 1928 visit to Princeton resulted in a long lasting impact both in Princeton and in Russia.
students, who often do not participate in individual research collaborations, providing them with first-hand experience of collaborative research in mathematics.

3.2 Networkshops

Each year one of the Net-working groups will hold a "Networkshops", which will be a focal point for the network wide activities.

Each Networkshop will bring together about 30 researchers and graduate students from the partner institutions for a study a preselected hot research topic. The Networkshops will be the place for the most intense mathematical discussions within the network. They will provide a unique opportunity for graduate students and younger researchers to meet with their peers from other Centers for Mathematical Excellence and to create long lasting scientific friendships and collaborations. The Networkshops will be held in peaceful and quiet locations, amply present in and utilized by our European partners, ideally suited for periods of concentrated work and study. They will be equally funded by our partners.

3.3 Distinguished Lecture Series

As another focal point the Network will establish a joint Distinguished Lecture Series rotating between participating Institutions. A distinguished mathematician will deliver a series of three lectures. Several senior mathematicians and students from every Network node will be invited to the event. The lectures will be recorded and broadcasted ensuring the highest level of global accessibility and participation. The Distinguished Lecture Series will be a biannual event, one of which will always be hosted at Princeton.

4 The Participating Institutions

4.1 Beijing International Center for Mathematical Research

Peking University is recognized as the preeminent Chinese university in the sciences and humanities. Its Mathematics program is the best in China by a significant margin. A consequence of a unique combination of academic excellence and strategic direction is that other universities in China look to Peking University for leadership. Among Chinese universities, Peking is distinguished by a free and lively academic environment, and it is the origin of many of the economic and social reforms in China.

Our partnering institution is the new Beijing international Center for Mathematical Research, Peking University (abbreviation: BICMR) which is an independent research center in Peking University. Its primary purpose is to promote mathematical research in China and around the world and to train new generation of young mathematicians. It promotes and supports scientific exchanges, conferences and workshops for in mathematical science. BICMR has very close relationship with the School of Mathematical Sciences at Peking University.

Peking University and Princeton University have developed a close working relationship in both pure and applied mathematics, mostly through the efforts of Professors Gang Tian and Weinan E. Professor Tian is a geometer of great distinction who was a graduate student at Peking University and maintains strong institutional ties at all levels. Professor E is the leader within the US of a multiscale mathematics community that is developing a new kind of applied mathematics inspired by
the challenge of new materials. He created the applied mathematics program at Peking University, and the result is the beginning of a common curriculum with Princeton. In the recent years some of the best students from Peking University have gone to Princeton for their graduate study. There also have been scientific exchanges between the two universities. In particular, A. Wiles, S. Klainerman and I. Daubechies visited Peking University to deliver series of lectures.

We believe this partnership can be the foundation for a broader strategic partnership between Princeton University and Peking University and further contribute to the expanding role and visibility of Princeton University in China.

Our collaboration with BICMR will be coordinated by the principal investigators Profs. G. Tian (Princeton) and W. E (Princeton). On the Chinese side, the partnership will be managed by Prof. H. Fan, who is a distinguished researcher working in the areas of Theoretical Physics, Geometric Analysis and Symplectic Geometry. BICMR is prepared to commit 85,000US to support the activities of the Network held in China.

4.2 Hausdorff Center for Mathematics, Bonn

In the last 40 years Bonn established its position as the leading Mathematical Center in Germany. This has been recently recognized by the German government, which awarded the Bonn "Hausdorff Center for Mathematics" a status of the "Cluster of Excellence". It is the only Cluster of Excellence in Mathematics among the 37 clusters, which are funded for five years each within the German government's Excellence Initiative. The center involves the four Mathematics Institutes in Bonn, the Max Planck Institute for Mathematics, and the Institute for Economic Sciences. The involved faculty consists of about 50 professors in Pure Mathematics, Applied Mathematics, and Theoretical Economics. The Hausdorff Center of Mathematics offers a master program (in English) as well as a PhD program which are overseen by the "Bonn International Graduate School in Mathematics". The Hausdorff Institute for Mathematics offers special trimester programs with visiting scientists within the Hausdorff Center.

In addition to the general Network activities describe above and to offer more students the opportunity to interact with scientists at the Hausdorff Center, small groups of graduate students from Princeton will be invited to participate in various mathematical activities in Bonn, e.g. the annual poster exhibition of the Bonn International Graduate School in Mathematics, the distinguished Felix Klein and Lipschitz lectures series in Pure and Applied Mathematics.

From the German side, the collaboration with Bonn will be coordinated by Prof. D. Huybrechts, Director of the Bonn International Graduate School in Mathematics. Prof. W. Ballmann, Director of the Max-Planck-Institute for Mathematics and Associate Director of the Hausdorff Institute, and Prof. F. Otto, Director of the Hausdorff Center, will coordinate the research collaboration in the areas of Pure and Applied Mathematics. The Hausdorff Center is prepared to commit 100,000USD a year for the next 3 years to support the activities of the Network.
4.3 Centre for Mathematics Sciences, University of Cambridge

The Faculty of Mathematics at Cambridge consist of two departments (DPMMS and DAMTP) housed together in the Centre for Mathematics Sciences (CMS) and constituting the largest body of research mathematicians in the UK. The strength of CMS is further complemented by the presence of the Isaac Newton Institute a national research institute involved in running six month programs in mathematical and physical sciences, which will be of particular interest to members of the Network.

There are already several ongoing individual collaborations between the members of the proposed Network, including Princeton, and the members of CMS. In addition to occupying a strategic position in the mathematical life in the UK, University of Cambridge will provide an excellent opportunity for our undergraduate and graduate students to spend a year there enrolled in the Part III of the Mathematical Tripos.

From the Cambridge side the collaboration will be coordinated by Prof. J.M.E. Hyland - the Head of the Department of Pure Mathematics and Mathematical Statistics.

4.4 Israeli Cluster of Excellence in Mathematics

In response to our proposed initiative the top three Mathematics Departments at The Hebrew University of Jerusalem (HU), The Weizmann Institute of Science (WIS) and Tel-Aviv University (TAU) formed" The Israeli Cluster of Excellence in Mathematics", which will be our partnering institution for this network.

There has been an ongoing collaboration between Princeton faculty and faculty there for many years. Princeton has recruited several excellent junior and senior faculty members from these institutions. Our ties are particularly strong in the fields of Probability and Mathematical Physics, Lie groups and Representations and Algebraic and Symplectic Geometry, which will be among the research themes of the Network.

The "The Israeli Cluster of Excellence in Mathematics" will be directed by a board of three directors: Prof. D. Kazhdan (HU), Prof. O. Zeitouni (WIS) and Prof. Z. Rudnick (TAU). The board will elect among its members, on a rotational basis, a coordinator who will be the contact person between Israel and Princeton. The Israeli Cluster of Excellence is prepared to commit 60,000USD a year for the next 3 years for the Network activities held in Israel.

4.5 Moscow Independent University

Independent University of Moscow is an elite university for research mathematicians where the best and brightest students from Russia and abroad are immersed into the rich heritage of the great Moscow mathematical school. It was founded in 1991 by a group of Russian mathematicians that included V. Arnold, S. Novikov and Y. Sinai (PU), and P. Deligne and R. MacPherson (IAS, Princeton). It has established itself as a leader in Russian mathematical life and started very successful international collaborations, in particular with Ecole Normale Superieure and Centre National de la Recherche Scientifique.

In addition to the general activities of the Network, we are planning to take advantage of a very successful English-language program ran by IUM for foreign students. It is called "Math in Moscow" and offers 15 weeks of intense immersion into mathematics, as well as a chance to learn about
Russian culture and to form friendships with Russian colleagues. Several students from Princeton, including such star students as A. Negut ’08, participated in this program with excellent results. In the other direction, we are certain that as many friendships will be formed and as much mathematical progress will be made when some IUM graduate students will be given an opportunity to visit Princeton.

From the Russian side, the collaboration will be coordinated by Prof. M. Tsfasman, a renowned expert in arithmetic algebraic geometry and its application, in particular, error-correcting codes. Traditional strengths of IUM, in particular, in Geometry, Lie theory, and Representation theory, fit very well with the proposed network-wide activities.

5 List of Collaborators

5.1 Beijing
X.H. Zhu, Y.G. Shi, B.X. Wang, Ming Jiang, Bin Yu, Pinwen Zhang, Huijun Fan, Wei Wang

5.2 Bonn
D. Huybrechts, W. Ballmann, F. Otto

5.3 Cambridge
M. Dafermos, B. Green, B. Schlein, B. Totaro

5.4 Israel
A. Lubotzky, E. Lapid, J. Solomon, R. Livne from the HU, E. Titi, G. Kozma, V. Rom-Kedar, L Benjamini from WIS, J. Bernstein, L. Polterovich, M. Sodin, N. Alon from TAU.

5.5 Moscow
M. Tsfasman, A. Bufetov, G. Olshanski, M. Finkelberg

5.6 Princeton