Université de Montréal

Faculté des arts et des sciences
Département de mathématiques
et de statistique

SMS 2011: Director's report.

This was indeed an exceptional edition of the *Séminaire des Mathématiques Supérieures* !

First and foremost, the scientific and educational value of the meeting was superb. The quality of the talks was excellent, the preparation and level of the students was superior and this was complemented by a stimulating and intense mathematical atmosphere. The organizers, **Galia Dafni, Robert McCann and Alina Stancu** have done an excellent job not only in what concerns the scientific program but also in operating a rigourous selection of the student participants as well as in managing the day-to-day organizational issues.

I thank all three of them for their hard work as well as **Ms. Sakina Benhima** from the CRM who assisted them and me with the administrative matters required in running this activity.

Secondly, this edition of the SMS was the 50th in the history of this venerable institution but it also was the first in the new, re-configured series. This edition was only possible with the co-operation of our main partners the **CRM**, **Fields Institute**, **PIMS** and **MSRI** as well as with support from the **ISM**, the **Universities of Montreal** and **Concordia** as well as support from the **Canadian Mathematical Society**.

I thank all these insitutions for their contributions and I also thank the board of directors of the SMS for their work and support.

It is clear that this cooperative formula is hugely successful: even if this was the very first school with the new structure, there were essentially no hiccups and the whole process was considerably more stable and streamlined compared with past years which made it easier to focus on scientific matters as opposed to administrative ones. The greater emphasis on scientific aspects also made the selection of students much more competitive than in previous editions. Indeed, the only lingering regret is that we could not provide support to a somewhat larger number of students.

In the following you will find a detailed scientific, organizational and budgetary report. I thank again the organizers for taking the time to prepare such a thorough document.

Yours Sincerely,

O. Cornea

Octav Cornea
Director SMS

Montreal, August 21, 2011.

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Séminaire de Mathématiques Supérieures (SMS) 2011
Metric measure spaces: geometric and analytic aspects
June 27 - July 8, 2011

Organizers: G. Dafni (Concordia University), R. McCann (University of Toronto),
A. Stancu (Concordia University)

1. **Scientific Report.**

In recent decades, metric-measure spaces have emerged as a fruitful source of mathematical questions in their own right, and as indispensable tools for addressing classical problems in geometry, topology, dynamical systems, and partial differential equations. Our 2011 summer school was designed to lead young scientists to the research frontier concerning the analysis and geometry of metric-measure spaces, by exposing them to a series of minicourses featuring leading researchers who highlighted both the state-of-the-art and some of the exciting challenges which remain.

The mini-courses could be grouped into three broad categories: (i) analytical aspects of metric spaces, (ii) functional and metric geometry, and (iii) techniques from optimal transportation — which has emerged as an important collection of ideas build useful links between (i) and (ii). They were all of an exceptionally high quality. It was clear that the speakers had spent a lot of time and effort preparing the material and this was very much appreciated by the audience. Moreover, many of the speakers attended the other mini-courses and this generated interesting interactions. A couple of senior participants — Nicola Gigli (Université de Nice), a co-author of several of the speakers, and Frank Morgan (Williams College) — were present, for all or part of the school, and actively involved in the discussions. After each lecture there was time for questions from the students, which ranged from elementary to very knowledgeable. Often students and lecturers continued the discussions between the talks and during the lunch breaks.

The mini-courses came under the themes outlined above, with certain talks providing links between them. The third and most prevalent was the use of ideas from optimal transportation to define geometric notions on metric measure spaces, in particular the notion of lower curvature bounds. Yann Ollivier began the school by introducing a definition of discrete Ricci curvature on metric spaces, based on the idea of comparing the (average transportation) distance between balls to the distance between their centers. Ollivier's talks were complemented on the one hand by Vitali Kapovitch's lectures, emphasizing the Riemannian geometry point of view, and on the other by Robert McCann's lectures on optimal transportation. Kapovitch described the consequences of curvature bounds on Riemannian manifolds, comparing in particular Ricci curvature versus sectional curvature, and metric analogs in Aleksandrov spaces. McCann's mini-course provided students with insight into the techniques and applications of optimal transportation starting with the classical transportation problem of Monge and Kantorovich and leading to the recent theorems concerning smoothness of optimal

maps by Ma, Trudinger, Wang and Loeper. Along the way there were excursions into two-player zero sum games, convex duality and linear programming, fully nonlinear partial differential equations, the economics of optimal pricing, and connections with minimal Lagrangian submanifolds in semi-Riemannian geometry.

This theme was taken up in the second week by Karl-Theodor Sturm, who spoke about the celebrated curvature-dimension condition for metric measure spaces, originating in his work and that of Lott-Villani (with ideas tracing back to the work of McCann). He introduced a variant of this condition, the so-called "reduced curvature-dimension condition", which has the local-to-global property. The mini-course concluded with a detailed exposition of the relevant notions and results in the setting of Finsler spaces.

The discussion of optimal transportation started by McCann continued with a series of talks by Young-Heon Kim on Ma-Trudinger-Wang curvature and regularity of optimal transport. In this theory, the non-negativity of certain sectional curvatures of a metric induced by the transportation cost turns out to be necessary and sufficient for the smoothness of optimal maps. Focusing his talks in the Riemannian setting, Kim outlined the state-of-the art through a series of examples and counterexamples, building up to his recent joint work on Hölder continuity of optimal maps between not-necessarily-smooth distributions of mass. The course by Felix Otto illustrated further uses of notions coming from optimal transportation, in particular the Wasserstein distance, in partial differential equations from applied mathematics modeling dissipative mixing of immiscible fluids. Here he revisited his classical bound on the nonlinear mixing rate. This appears uncontrolled in the linearized regime due to the Rayleigh-Taylor instability, which predicts that thin fingers of fluid grow faster, with the thinnest fingers growing arbitrarily fast. More than a decade ago, Otto coarse-grained the dynamics, to show that the average fluid density as a function of its height obeys a Burger's type equation which predicts mixing at a bounded rate. In a recent preprint with Gigli, he showed that this dynamics actually represents a gradient flow in a metric space setting, which picks out the unique entropy solution to the scalar conservation law, as explained in his lectures.

The second theme of the summer school, roughly coming under the "analytic aspects" of metric spaces, concerned notions of differentiability on metric measure spaces and the corresponding function spaces. This theme started in the first week with the parallel series of lectures by Piotr Hajłasz and Pekka Koskela. Without relying on much background from the audience, Hajłasz succeeded in introducing students to the fascinating and sometimes surprising world of Sobolev mappings between manifolds, from manifolds into metric spaces and between metric spaces, in which basic facts such as approximation by smooth or Lipschitz functions cannot be taken for granted, and may depend on topological properties involving homotopy groups (in the case of manifolds). Koskela's dynamic lectures exposed the audience to questions from the theory of quasi-conformal mappings in the context of (Ahlfors regular) metric-measure spaces, covering in detail the regularity of QC maps, the notion of quasi-symmetry, and the function spaces preserved under these maps. In addition to Sobolev spaces (using the definition given by Hajłasz), recent work by Koskela, Yang and Zhou

was described, showing that certain appropriately defined Besov and Triebel-Lizorkin spaces are preserved.

The two themes described above came together in the mini-course by Luigi Ambrosio in the school's second week. Ambrosio reviewed and compared various notions of weak gradients and Sobolev spaces in metric measure spaces, such as upper gradients (due to Heinonen and Koskela), absolute continuity on lines (a definition by Levi extended to metric measure spaces by Shanmugalingam), and Cheeger's energy, and showed the identification of weak gradients using optimal transportation techniques, without relying on doubling or Poincaré assumptions. These exciting results (joint work of Ambrosio with Gigli and Savaré) used a gradient flow based on the Wasserstein distance and the curvature-dimension conditions of Lott-Sturm-Villani.

The final theme could be described as functional and geometric inequalities. The mini-course of Ollivier concluded with results on concentration of measure and the Brunn-Minkowski inequality for the discrete hypercube (the latter joint work with Villani), part of the body of work for which he was awarded the 2011 CNRS bronze medal. The course of Emanuel Milman, spanning the two weeks, described the relations between isoperimetric inequalities, concentration of measure, and functional inequalities such as Poincaré, Sobolev and log-Sobolev. While isoperimetric inequalities imply Sobolev type inequalities, and it is known from work of Gromov-V. Milman that, in any metric space, the Poincaré inequality implies exponential concentration, the reverse implications do not, generally, hold. It was thus an impressive result that in the case of a Riemannian manifold with density having lower bounds on the Bakry-Émery tensor, E. Milman showed that concentration inequalities imply isoperimetric inequalities. A main ingredient of his proof is a result of Frank Morgan, well known in geometric measure theory. The latter topic was featured in the lectures by Guy David. Starting with the famous Plateau problem in higher dimensions (not yet solved) as an illustration, David's course discussed the structure of minimizers to functionals on currents with a given lower dimensional rectifiable current as boundary. The focus was now on the lack of smoothness, and minimizers in the sense of Almgren, concluding with the proof of Jean Taylor's theorem which characterizes them. His nice manner of exposition was punctuated by exercises in which David engaged the audience.

The relations between various inequalities was also the subject of the course by Thierry Coulhon in the second week. Again working in the Riemannian context, but this time on a non-compact manifold with volume doubling, Coulhon discussed the implications of various heat kernel estimates to L^p boundedness of Riesz transforms, a important question which relates back to the second theme since it concerns the compatibility of various definitions of weak derivatives (i.e. the weak gradient and the square-root of the Laplacian) and the corresponding Sobolev spaces. An example was given of a fractal-like manifold where local and global bounds differ. Heat kernel estimates, and in particular this type of different local and global behaviour, also played a prominent role in the lectures by Martin Barlow, where Gaussian bounds were shown to be equivalent to a parabolic Harnack inequality on the one hand, and doubling and Poincaré on the other. These inequalities (or their failure) were discussed in detail for the Sierpinski

carpet. The high quality of the lectures by Barlow, Ambrosio and Kim during the last days of the school guaranteed a full audience up to the last minute.

2. **Organization and Administration.**

We received 135 applications from which we selected to fund 40 participants other than speakers. Approximately 20 more participants attended without our support, mostly local graduate students, a few local faculty, and a few funded by their home institutions and/or research supervisors.

About 82% of the funding for participants went to graduate students, of which we tried to select those who were already advanced in their studies and working in areas closely related to the topic of the school, and the remaining funding was directed to young PhD's (no earlier than 2008). There were a few exceptions such as the graduate students selected by MSRI based on other criteria, and a very advanced undergraduate student from UBC who was about to enter graduate school. In the selection process, we gave priority to the applicants for whom the school could make a significant impact. In this regard, a letter from the advisor explaining the relevance of the school for the student's program of studies was often a decisive factor. About 20% from the total number of participants, with or without funding, were female.

With the exception of the two CMS scholarships, and the 8 graduate students funded through MSRI's contribution (covering both local and travel expenses), the majority received a somewhat basic local support: 2 weeks in the student residences of the Université de Montreal and a small supplement for daily expenses. To make up for such a small *per diem*, we provided a breakfast every day of the school, as well as coffee breaks. The CRM's administrative assistant was essential in the planning and the organization of the latter. For a small number of participants who requested it, we added a flat CDN$250 aid for travel. In today's travel costs, this is a very small amount. On this basis alone, several other potential participants which we invited to the school declined to attend.

In what regards the CMS scholarships, they were awarded to two exceptionally qualified students enrolled in Canadian PhD programs. Both recipients actively engaged in the Q&A and discussions following the lectures. The MSRI funded students, supported at a higher rate than the average participant, were a bit more difficult to select due to the institute's internal policy which had to be met, and two of the confirmed participants cancelled at the last minute. It is expected that experience will help simplify this selection process in the future.

If additional funding would have been available, we would have probably increased by about 10 the number of participants with financial support, but mostly we would have used the funds to provide more support toward living expenses and travel.

3. **Outline of the Expenditures.**

Speakers: housing at the Terrace Royale hotel near the Université de Montreal, reimbursement of travel expenses and per diem meals.

SMS funded participants: 2 weeks at the dormitories (CDN$440, non-refundable), CDN$210 per diem meals, and a few CDN$250 supplements for travel expenses.

CMS scholarships: 2 at CDN$1000 a piece.

MSRI funded participants: 8 covering housing, meals and travel expenses, plus additional dormitory charges for the two students who cancelled at the last minute, for a total of US$10,000.

Social activities:

Daily breakfast and coffee breaks.

Two wine-and-cheese receptions for the students and speakers (covered by the CDN $20 fee charged to each participant).

Two dinners for the speakers at local restaurants (one per week due to some speakers not staying for the whole two weeks).

4. **Acknowledgements.**

The organizers wish to acknowledge the generous support of the sponsors of the SMS 2011: the CRM, Fields Institute, PIMS, MSRI, ISM, Unversité de Montréal, Concordia University and the CMS. We also recognize the hard work of the SMS Director, Octav Cornea, and Sakina Benhima, the SMS administrator at the CRM, and thank those who assisted her with the social activities.

5. **Speakers.**

- L. Ambrosio (Scuola Normale Superiore, Pisa)
  Title: *Calculus in metric measure spaces with Ricci curvature bounded from below*
- M. Barlow (University of British Columbia)
  Title: *Heat equation on some fractal metric spaces*
- T. Coulhon (Université de Cergy-Pontoise)
  Title: *Heat kernel estimates, Sobolev type inequalities and Riesz transform on non-compact Riemannian manifolds*
- G. David (Université de Paris-Sud, Orsay)
  Title: *Regularity results for minimal sets*
- P. Hajlasz (University of Pittsburgh)
  Title: *Sobolev mappings into metric spaces*
- V. Kapovitch (University of Toronto)
  Title: *Fundamental groups of manifolds with lower Ricci curvature bounds*
- Y.-H. Kim (University of British Columbia)
  Title: *Ma-Trudinger-Wang curvature and regularity of optimal transport*
- P. Koskela (University of Jyväskylä)
  Title: *Quasiconformal mappings and function spaces*
- R. McCann (University of Toronto)
  Title: *Optimal transportation*
- E. Milman (Technion, Haifa)
  Title: *Isoperimetric, functional and concentration inequalities*
- Y. Ollivier (CNRS, Université Paris-Sud, Orsay)
  Title: *Discrete Ricci curvature with applications*
- F. Otto (Max Planck Institute for Mathematics in Sciences, Leipzig)
  Title: *Burger's equation as a gradient flow on two-phase Wasserstein space*
- K.T. Sturm (University of Bonn)
  Title: *Ricci bounds for metric measure spaces and geometric analysis*

6. **Participants.**

- Tayeb Aïssiou, *Concordia University, Canada*
- Suliman Albandik, *Mathematisches Institut Gottingen Universität, Germany*
- Sebastien Andres, *University of British Columbia, Canada*
- Alex Austin, *University of Illinois at Chicago, USA*
- Jorge Basilio, *CUNY, USA*
- Mohammad Bavarian, *University of British Columbia, Canada*
- Ryan Benty, *Concordia University, Canada*
- Raquel Cabral, *Concordia University, Canada*
- Li Chen, *Université de Paris Sud, Orsay, France*
- Shibing Chen, *University of Toronto, Canada*
- Jong Keun Choi, *Yonsei University, South Korea*
- Guy David, *UCLA, USA*
- Qintao Deng, *Huazhong Normal University, China*
- Jian Duan, *University of Arkansas, USA*
- Tullia Dymarz, *Université de Paris Sud, Orsay, France*
- Nathaniel Eldredge, *Cornell University, USA*
- Andrew Fenwick, *Concordia University, Canada*
- Richard Fournier, *Université de Montréal, Canada*
- Paul M. Gauthier, *Université de Montréal, Canada*
- Saman Gharib, *University of British Columbia, Canada*
- Nicola Gigli, *Université de Nice, France*
- Dorian Goldman, *Université Pierre Marie Curie - Paris 6, France*
- Jasun Gong, *University of Pittsburgh, USA*
- Heather Griffin, *University of Arkansas, USA*
- Metin Alpen Gur, *Indiana University, USA*
- John Harvey, *University of Notre-Dame, USA*
- Erwan Hillion, *Université de Neuchâtel, Switzerland*
- Xueping Huang, *Bielefeld University, Germany*
- François Huard, *Bishop's University, Canada*
- Lionel Jassioneesse, *Université de Bourgogne, Dijon, France*
- Chanyoung Jun, *University of Illinois at Urbana-Champaign, USA*
- Ehsan Kamalinejad, *University of Toronto, Canada*
- Kyle Kinnenberg, *UCLA, USA*

- Jun Kitagawa, *Princeton University, USA*
- Slawomir Kolasinski, *University of Warsaw, Poland*
- Jonathan Korman, *University of Toronto, Canada*
- Artem Kozhevnikov, *École Normale Supérieure, Paris, France*
- Eric Larson, *Washington State University, USA*
- Hanjin Lee, *McGill University, Canada*
- Woon Yin (Paul) Lee, *University of California, Berkeley, USA*
- Stephen Lewis, *University of Washington, USA*
- Xiangyu Liang, *Université de Paris Sud, Orsay, France*
- Janna Lierl, *Cornell University, USA*
- Shiping Liu, *Max Planck Institute for Mathematics in Sciences, Leipzig, Germany*
- Wolfgang Loehr, *University Duisburg-Essen, Germany*
- Charly Makitu Kivuvu, *University of South Africa (UNISA), South Africa*
- Frank Morgan, *Williams College, USA*
- Michael Munn, *CUNY-City Tech, USA*
- Mohammad Najafi Ivaki, *Concordia University, Canada*
- Vincent Nolot, *Université de Bourgogne, Dijon, France*
- Melanie Pivarski, *Roosevelt University, Chicago, USA*
- Mohammad Rostami, *University of Waterloo, Canada*
- Boutayeb Salahaddine, *Université de Cergy-Pontoise, France*
- Christian Seis, *Max Planck Institute for Mathematics in Sciences, Leipzig, Germany*
- Shichang Song, *University of Illinois at Urbana-Champaign, USA*
- Benjamin Steinhurst, *Cornell University, USA*
- Daniele Valtorta, *Università degli Studi di Milano, Italy*
- Eduardo Santillan Zeron, *Cinvestav-IPN (Institut Polytechnic National), Mexico*
- Xiangwen Zhang, *McGill University, Canada*
- Yongsheng Zhang, *Stony Brook University, USA*

Appendix 1 : Program

Centre de recherches mathématiques
Université de Montréal

École d'été SMS 2011 (50e édition) "Espaces métriques mesurés : aspects géométriques et analytiques"
Du 27 juin au 8 juillet 2011

SMS 2011 Summer School (50th Edition) "Metric Measure Spaces: Geometric and Analytic Aspects"
June 27 - July 8, 2011

HORAIRE / *PROGRAM*

Conférences : salle Z-330 (Pavillon Claire-McNicoll)
Pauses-café : salle 1221 (Pavillon André-Aisenstadt)
Réception (29 juin) : Salon Maurice-L'Abbé (Pavillon André-Aisenstadt)

Lectures: Room Z-330 (Pavillon Claire-McNicoll)
Coffee Breaks: Room 1221 (Pavillon André-Aisenstadt)
Reception (June 29): Salon Maurice-L'Abbé (Pavillon André-Aisenstadt)

Le lundi 27 juin 2011 / *Monday, June 27, 2011*

09:00 - 09:45 Inscription et café croissants (Hall d'entrée Pav. Aisenstadt) / *Registration and Coffee & Croissants (Hall d'entrée Pav. Aisenstadt)*

09:45 - 10:00 Mot de bienvenue / *Opening Remarks*

10:00 - 11:00 **Yann Ollivier** (Université Paris Sud)
"Discrete Ricci curvature with applications - I"

11:15 - 12:15 **Guy David** (Université Paris Sud)
"Regularity results for minimal sets - I"

12:15 - 14:00 Pause-déjeuner / *Lunch break*

14:00 - 15:00 **Vitali Kapovitch** (University of Toronto)
"Fundamental groups of manifolds with lower Ricci curvature bounds - I"

15:00 - 15:30 Pause-café / *Coffee break*
(Salle / *Room* 1221)

15:30 - 17:00 **Robert McCann** (University of Toronto)
"Optimal Transportation: Geometry, Regularity and Applications - I"

Le mardi 28 juin 2011 / *Tuesday, June 28, 2011*

08:30 - 09:30 Petit-déjeuner (1221) / *Breakfast (1221)*

09:30 - 10:30 **Yann Ollivier** (Université Paris Sud)
"Discrete Ricci curvature with applications - II"

10:45 - 12:15 **Robert McCann** (University of Toronto)
"Optimal Transportation: Geometry, Regularity and Applications - II"

12:15 - 14:00 Pause-déjeuner / *Lunch break*

14:00 - 15:00 **Vitali Kapovitch** (University of Toronto)
"Fundamental groups of manifolds with lower Ricci curvature bounds - II"

15:00 - 15:30 Pause-café / *Coffee break*
(Salle / *Room* 1221)

15:30 - 16:30 **Piotr Hajlasz** (University of Pittsburg)
"Sobolev mappings into metric spaces - I"

16:45 - 17:45 **Pekka Koskela** (University of Jyväskylä)
"Quasiconformal mappings and function spaces - I"

Le mercredi 29 juin 2011 / *Wednesday, June 29, 2011*

08:30 - 09:30 Petit-déjeuner (1221) / *Breakfast (1221)*

09:30 - 10:30 **Yann Ollivier** (Université Paris Sud)
"Discrete Ricci curvature with applications - III"

10:45 - 12:15 **Guy David** (Université Paris Sud)
"Regularity results for minimal sets - II"

12:15 - 14:00 Pause-déjeuner / *Lunch break*

14:00 - 15:00 **Robert McCann** (University of Toronto)
"Optimal Transportation: Geometry, Regularity and Applications - III"

15:00 - 15:30 Pause-café / *Coffee break*
(Salle / *Room* 1221)

15:30 - 16:30 **Piotr Hajlasz** (University of Pittsburg)
"Sobolev mappings into metric spaces - II"

16:45 - 17:45 **Pekka Koskela** (University of Jyväskylä)
"Quasiconformal mappings and function spaces - II"

18:00 Réception vin et fromages (Salon Maurice L'Abbé) / *Wine-and-cheese reception (Salon Maurice L'Abbé)*

Le jeudi 30 juin 2011 / *Thursday, June 30, 2011*

08:30 - 09:30 Petit-déjeuner (1221) / *Breakfast (1221)*

09:30 - 10:30 **Yann Ollivier** (Université Paris Sud)
"Discrete Ricci curvature with applications - IV"

10:45 - 12:15 **Guy David** (Université Paris Sud)
"Regularity results for minimal sets - III"

12:15 - 14:00 Pause-déjeuner / *Lunch break*

14:00 - 15:00 **Vitali Kapovitch** (University of Toronto)
"Fundamental groups of manifolds with lower Ricci curvature bounds - III"

15:00 - 15:30 Pause-café / *Coffee break*
(Salle / *Room* 1221)

15:30 - 16:30 **Piotr Hajlasz** (University of Pittsburg)
"Sobolev mappings into metric spaces - III"

16:45 - 17:45 **Pekka Koskela** (University of Jyväskylä)
"Quasiconformal mappings and function spaces - III"

Le vendredi 1 juillet 2011 / *Friday, July 1, 2011*

08:30 - 09:30 Petit-déjeuner (1221) / *Breakfast (1221)*

09:30 - 10:30 **Vitali Kapovitch** (University of Toronto)
"Fundamental groups of manifolds with lower Ricci curvature bounds - IV"

10:45 - 12:15 **Emanuel Milman** (Technion-Israel Institute of Technology)
"Isoperimetric, Functional and Concentration Inequalities - I"

12:15 - 14:00 Pause-déjeuner / *Lunch break*

14:00 - 15:00 **Piotr Hajlasz** (University of Pittsburg)
"Sobolev mappings into metric spaces - IV"

15:00 - 15:30 Pause-café / *Coffee break*
(Salle / *Room* 1221)

15:30 - 16:30 **Pekka Koskela** (University of Jyväskylä)
"Quasiconformal mappings and function spaces - IV"

Le lundi 4 juillet 2011 / *Monday, July 4, 2011*

08:30 - 09:30 Petit-déjeuner (1221) / *Breakfast (1221)*

09:30 - 10:30 **Karl-Theodor Sturm** (University of Bonn)
"Ricci bounds for metric spaces and geometric analysis - I"

10:45 - 12:15 **Emanuel Milman** (Technion-Israel Institute of Technology)
"Isoperimetric, Functional and Concentration Inequalities - II"

12:15 - 14:00 Pause-déjeuner / *Lunch break*

14:00 - 15:00 **Thierry Coulhon** (Université de Cergy-Pontoise)
"Heat kernel estimates, Sobolev type inequalities and Riesz transform on non-compact Riemannian manifolds - I"

15:00 - 15:30 Pause-café / *Coffee break*
(Salle / *Room* 1221)

15:30 - 16:30 **Félix Otto** (University of Bonn)
"Burgers' equation as a gradient flow on two-phase Wassertein space - I"

16:45 - 17:45 **Young-Heon Kim** (University of British Columbia)
"Ma-Trudinger-Wang curvature and regularity of optimal transport - I"

Le mardi 5 juillet 2011 / *Tuesday, July 5, 2011*

08:30 - 09:30 Petit-déjeuner (1221) / *Breakfast (1221)*

09:30 - 10:30 **Karl-Theodor Sturm** (University of Bonn)
"Ricci bounds for metric spaces and geometric analysis - II"

10:45 - 12:15 **Luigi Ambrosio** (Scuola Normale Superiore Di Pisa)
"Calculus in metric measure spaces with Ricci curvature bounded from below - I"

12:15 - 14:00 Pause-déjeuner / *Lunch break*

14:00 - 15:00 **Thierry Coulhon** (Université de Cergy-Pontoise)
"Heat kernel estimates, Sobolev type inequalities and Riesz transform on non-compact Riemannian manifolds - II"

15:00 - 15:30 Pause-café / *Coffee break*
(Salle / *Room* 1221)

15:30 - 16:30 **Félix Otto** (University of Bonn)
"Burgers' equation as a gradient flow on two-phase Wassertein space - II"

16:45 - 17:45 **Emanuel Milman** (Technion-Israel Institute of Technology)
"Isoperimetric, Functional and Concentration Inequalities - III"

Le mercredi 6 juillet 2011 / *Wednesday, July 6, 2011*

08:30 - 09:30 Petit-déjeuner (1221) / *Breakfast (1221)*

09:30 - 10:30 **Karl-Theodor Sturm** (University of Bonn)
"Ricci bounds for metric spaces and geometric analysis - III"

10:45 - 12:15 **Luigi Ambrosio** (Scuola Normale Superiore Di Pisa)
"Calculus in metric measure spaces with Ricci curvature bounded from below - II"

12:15 - 14:00 Pause-déjeuner / *Lunch break*

14:00 - 15:00 **Thierry Coulhon** (Université de Cergy-Pontoise)
"Heat kernel estimates, Sobolev type inequalities and Riesz transform on non-compact Riemannian manifolds - III"

15:00 - 15:30 Pause-café / *Coffee break*
(Salle / *Room* 1221)

15:30 - 16:30 **Félix Otto** (University of Bonn)
"Burgers' equation as a gradient flow on two-phase Wassertein space - III"

16:45 - 17:45 **Young-Heon Kim** (University of British Columbia)
"Ma-Trudinger-Wang curvature and regularity of optimal transport - II"

Le jeudi 7 juillet 2011 / *Thursday, July 7, 2011*

08:30 - 09:30 Petit-déjeuner (1221) / *Breakfast (1221)*

09:30 - 10:30 **Karl-Theodor Sturm** (University of Bonn)
"Ricci bounds for metric spaces and geometric analysis - IV"

10:45 - 12:15 **Martin T. Barlow** (University of British Columbia)
"Heat equation on some fractal metric spaces - I"

12:15 - 14:00 Pause-déjeuner / *Lunch break*

14:00 - 15:00 **Thierry Coulhon** (Université de Cergy-Pontoise)
"Heat kernel estimates, Sobolev type inequalities and Riesz transform on non-compact Riemannian manifolds - IV"

15:00 - 15:30 Pause-café / *Coffee break*
(Salle / *Room* 1221)

15:30 - 16:30 **Félix Otto** (University of Bonn)
"Burgers' equation as a gradient flow on two-phase Wassertein space - IV"

16:45 - 17:45 **Young-Heon Kim** (University of British Columbia)
"Ma-Trudinger-Wang curvature and regularity of optimal transport - III"

Le vendredi 8 juillet 2011 / *Friday, July 8, 2011*

08:30 - 09:30 Petit-déjeuner (1221) / *Breakfast (1221)*

09:30 - 10:30 **Luigi Ambrosio** (Scuola Normale Superiore Di Pisa)
"Calculus in metric measure spaces with Ricci curvature bounded from below - III"

10:45 - 12:15 **Martin T. Barlow** (University of British Columbia)
"Heat equation on some fractal metric spaces - II"

12:30 - 13:30 **Young-Heon Kim** (University of British Columbia)
"Ma-Trudinger-Wang curvature and regularity of optimal transport - IV"

Appendix 2: Budget.

You will find below a summary of expenditures and income. The pages that follow contain a detailed budget.

EXPENDITURES	
Speakers - travel and local expenses	31,138.67$
Student participants - student residences and travel support	34,550.00$
Other expenditures - meals, advertisement, staff pay etc	10,231.29$
TOTAL EXPENDITURES - estimated	**75,919.96$**
INCOMES - grants and registration fees	**75,220.00$**

Notes for the pages that follow:

1. The expenditures that are only estimated at this time (due to delays with various transactions, reimbursements etc) are in blue.

2. By an arrangement with the MSRI, the students supported by this Institute have their travel expenses reimbursed directly by the MSRI. The relevant amounts are also estimated and included in our global budget in green.

SMS 2011 - detailed budget.

SMS 2011 EXPENDITURES							
Speakers	**Arrival**	**Departure**	**Cost of hotel**	**Travel cost**	**Taxi/bus+**	**Perdiem**	**Total**
Luigi Ambrosio, Scuola Normale Superiore, Pisa	4/7/2011	10/7/2011	742.86$	652.50 €	67.00$	315.00$	
Martin Barlow, University of British Columbia	2/7/2011	8/7/2011	742.86$	1,070.36$	156.00$	315.00$	
Thierry Coulhon, Université de Cergy-Pontoise	2/7/2011	8/7/2011	742.86$	695.50 €	70.00$	315.00$	
Guy David, Université Paris-Sud, Orsay	26/6/2011	8/7/2011	1,385.48$	586.50 €	40.00$	585.00$	
Piotr Hajlasz, University of Pittsburgh	26/6/2011	5/7/2011	1,014.05$	1,000.00$		450.00$	
Vitali Kapovitch, University of Toronto	26/6/2011	08/7/2011	1,385.48$	1,000.00$		585.00$	
Young-Heon Kim, University of British Columbia	26/6/2011	9/7/2011	1,509.29$	799.32$	117.00$	585.00$	
Pekka Koskela, University of Jyväskylä	27/06/2011	5/07/2011	890.24$	859.90 €	35.00$	405.00$	
Robert McCann	27/06-29/06	3/07-07/07	742.86$	378.74$	180.00$	360.00$	
Emanuel Milman, Technion, Haif	29/6/2011	6/07/2011	766.43$	1,394.75$	115.27$	360.00$	
Yann Ollivier, CNRS, Université Paris-Sud, Orsay	26/6/2011	1/7/2011	619.05$	499.23 €	72.00$	270.00$	
Felix Otto, Max Planck Institute, Leipzig	03/07/2011	08/7/2011	619.05$	781.97 €	85.26 €	270.00$	
Karl-Theodor Sturm, University of Bonn	03/07/2011	10/07/2011	766.43$	1,300.00$		360.00$	
			11,926.94$	13,056.57$	980.16$	5,175.00$	**31,138.67 $**
Student participants	**Arrival**	**Departure**	**Univ. Housing**	**Living Costs**	**Travel supp.**		**Total**
Albandik, Suliman (Gottingen)	25/6/2011	11/7/2011	440.00$	210.00$			650.00$
Andres, Sebastian (UBC)	26/6/2011	9/7/2011	440.00$	210.00$			650.00$
Basilio, Jorge (CUNY)	25/6/2011	8/7/2011	440.00$	210.00$			650.00$
Bavarian, Mohammad (UBC)	26/6/2011	9/7/2011	440.00$	210.00$	250.00$		900.00$
Chen, Li (Paris-Sud) – F	26/6/2011	9/7/2011	440.00$	210.00$			650.00$
Choi, Jong Keun (Korea)	26/6/2011	13/7/2011	440.00$	210.00$			650.00$
Deng, Qintao (China)	24/6/2011	11/7/2011	440.00$	210.00$	250.00$		900.00$
Duan, Jian (Arkansas) - F	25/6/2011	9/7/2011	440.00$	210.00$	250.00$		900.00$
Eldredge, Nathaniel (Cornell)	25/6/2011	9/7/2011	440.00$	210.00$			650.00$
Goldman, Dorian (Paris-6)	26/6/2011	10/7/2011	440.00$	210.00$	250.00$		900.00$
Gong, Jasun (Pittsburgh)	26/6/2011	9/7/2011	440.00$	210.00$			650.00$
Griffin, Heather (Arkansas) - F	26/6/2011	9/7/2011	440.00$	210.00$			650.00$
Hillion, Erwan (Switzerland)	26/6/2011	8/7/2011	440.00$	210.00$			650.00$
Huang, Xueping (Bielefeld)	25/6/2011	9/7/2011	440.00$	210.00$			650.00$
Jassionnesse, Lionel (Bourgogne)	26/6/2011	8/7/2011	440.00$	210.00$			650.00$
Kolasinski, Slawomir (Warsaw)	25/6/2011	9/7/2011	440.00$	210.00$			650.00$
Kozhevnikov, Artem (Paris-Sud)	26/6/2011	9/7/2011	440.00$	210.00$			650.00$
Lee, Woon Yin (Paul) (Berkeley)	26/6/2011	9/7/2011	440.00$	210.00$			650.00$
Liang, Xiangyu (Paris-Sud) - F	26/6/2011	9/7/2011	440.00$	210.00$			650.00$
Liu, Shiping (Max Planck Leipzig)	26/6/2011	9/7/2011	440.00$	210.00$			650.00$
Loehr, Wolfgang (Essen)	25/6/2011	10/7/2011	440.00$	210.00$			650.00$
Makitu Kivuvu, Charly (South Africa)	26/6/2011	10/7/2011	440.00$	210.00$	250.00$		900.00$
Munn, Michael	26/6/2011	8/7/2011	440.00$	210.00$			650.00$
Nolot, Vincent (Bourgogne)	26/6/2011	8/7/2011	440.00$	210.00$			650.00$
Seis, Christian (Leipzig)	25/6/2011	9/7/2011	440.00$	210.00$			650.00$

Steinhurst, Benjamin (Cornell)	25/6/2011	9/7/2011	440.00$	210.00$			650.00$
Valtorta, Daniele (Milano)	24/6/2011	9/7/2011	440.00$	210.00$	250.00$		900.00$
Pivarski, Melanie	26/6/2011	9/7/2011	440.00$				440.00$
Salahaddine, Boutayeb	01/07/2011	9/7/2011	440.00$		250.00$		690.00$
David Guy (UCLA)	26/6/2011	9/7/2011	440.00$	210.00$			650.00$
Jun, Chanyoung (Illinois)	26/6/2011	8/7/2011	440.00$	210.00$	250.00$		900.00$
Kinneberg Kyle (UCLA)	26/6/2011	9/7/2011	440.00$	210.00$			650.00$
Vellis, Vyron (UIUC)	26/6/2011	9/7/2011	440.00$	210.00$			650.00$
Kamalinejad, Ehsan (Toronto)-CMS Fellowship	26/6/2011	8/7/2011	440.00$	560.00$			1,000.00$
Chen, Shibing (Toronto) - CMS Fellowship	26/6/2011	8/7/2011	440.00$	560.00$			1,000.00$
Austin, Alex (UIC) - MSRI support	25/6/2011	9/7/2011	440.00$	750.00$			1,190.00$
Gur, Metin Alper (Indiana) - MSRI support	26/6/2011	9/7/2011	440.00$	750.00$			1,190.00$
Harvey, John (Notre Dame) - MSRI support	26/6/2011	9/7/2011	440.00$	750.00$			1,190.00$
kitagawa, Jun (Princeton) - MSRI support	26/6/2011	9/7/2011	440.00$	750.00$			1,190.00$
Larson, Eric (Washington State) - MSRI support	25/6/2011	9/7/2011	440.00$	750.00$			1,190.00$
Lierl, Janna (Cornell)-F - MSRI support	25/6/2011	9/7/2011	440.00$	750.00$			1,190.00$
Song, Shichang - MSRI support	27/6/2011	8/7/2011	440.00$	750.00$			1,190.00$
Zhang, yongsheng (SUNY) - MSRI support	26/6/2011	8/7/2011	440.00$	750.00$			1,190.00$
			18,920.00$	**13,630.00$**	**2,000.00$**		**34,550.00$**
Other expenditures							**Total**
Advertisement (poster design and production)							1,918.97$
Student breakfast							2,554.69$
2 Receptions							896.10$
2 Speaker's dinners							1,290.30$
Staff pay							1,926.00$
Other expenditures (equipment, rental, postage)							1,645.23$
							10,231.29$
Total Expenditures							**75,919.96$**
SMS 2011 - INCOME							
CRM	20,000.00$						
Analysis Laboratory of CRM	10,000.00$						
ISM	7,500.00$						
Concordia (Arre)	5,000.00$						
Fields Institute	10,000.00$						
PIMS	10,000.00$						
MSRI	9,520.00$						
CMS	2,000.00$						
Registration fees (20 $ /per participant)	1,200.00$						
Total Income	**75,220.00$**						**75,220.00$**