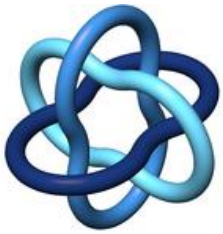
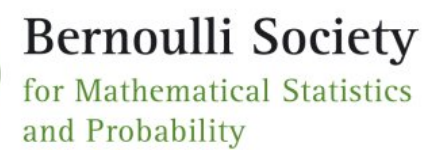
Stochastic Processes and Applications Mongolia 2015

27th July - 7th August 2015
National University of Mongolia
Ulaanbaatar
Mongolia





Final Report

Executive summary

- The research school was attended by 120 individuals, the majority of which were students, 54 of which were Mongolians. There was representation from academic institutions in 20 different countries. The lecture room remained full on every one of the 10 working days without numbers waning.
- The whole event was generously sponsored by: Centre International de Mathématiques Pures et Appliquées (CIMPA), Deutscher Akademischer Austauschdienst (DAAD), National University of Mongolia (NUM), Mongolian University of Science and Technology (MUST), the State Bank (SB), Mongolian Agricultural Commodities Exchange (MACE), Index Based Livestock Insurance Project (IBLIP) and Tenger Insurance, Mongolia (TIM). There was also a kind cash contribution from Prof. Gaëtan Borot. The total expenditure of the school came to around 56K EURO.
- Feedback indicates the event was an overwhelming scientific success and the school is likely to remain as a landmark event in the history of the Department of Mathematics at the National University of Mongolia.
- There was outstanding cultural exchange, with strong social mixing and interaction taking place following traditional norms of Mongolian hospitality. Participants experienced cultural activities on two Wednesday afternoons as well as a weekend excursion into Terelj National Park. These include throat singing, ger building, hiking, visiting a Buddhist Temple, museum exhibitions, learning about Mongolia's Soviet past, socialising at lunches and dinners with the help of an engineered 'buddy system'.
- There was significant exchange between senior Mongolian and foreign academics at the meeting regarding the current and future plight of Mongolian mathematics. A series of steps for the way forward have been formulated, which are summarised in this document.

Introduction

Stochastic Processes and their Applications, Mongolia 2015 was concluded at around 6pm, Mongolian time, on the 7th of August 2015, to a lecture theatre which was packed with well over 120 participants at the National University of Mongolia (NUM) in Ulaanbaatar. The atmosphere was that of elation and delight, with a great sense of achievement by all.

Mongolian hosts, predominantly from the Department of Mathematics at the NUM, but also with the assistance of members of the Applied Mathematics Department at NUM, as well as members of the Mathematics Department from the Mongolian University of Science and Technology (MUST), had worked tirelessly to ensure that everything ran like clockwork. Although other international meetings had taken place in Mongolia in the past, since the fall of communism in 1990, this was the largest one of its kind in the field of mathematics. Such was the vibrancy, friendship and good will at this meeting, it is hoped that the future will see this meeting as a landmark event that spawned many new opportunities.

Figure 1: Group photo on the steps of the National University of Mongolia.

In this report we provide facts and figures concerning the execution of this two-week research school, as well as indicating some of the ways forward currently being explored to ensure leverage of the investment in this event. In addition to this report, there is supplementary information which can be found at the school website:

`http://smcs.num.edu.mn/saam2015/`

A handout document that was given to all participants in hand as well as electronically is attached in the appendix to this document.

IMU Pre-school

Thanks to generous consideration of the International Mathematical Union (IMU), the opportunity to hold a pre-school to the main two-week event was offered through additional funds. This took place in the June preceding the main meeting and was aimed predominantly at mathematics students from the National University of Mongolia.

An advert was placed on all of the major stochastics electronic networks and bulletin boards asking for a volunteer to go out to Mongolia for 3 weeks to teach a course on measure-theoretic probability. Through these means, Professor Friedrich Hubalek from the Technical University of Vienna offered his services and an extremely generous portion of his time. Between 8th and 27th June 2015 Prof. Hubalek delivered his lectures to around 15 students.

Figure 2: Prof. Hubalek with some of the Mongolian students who attended his pre-school in June.

School infrastructure

All lectures and tutorials were held in a large lecture room on the third floor of Building 1 (the main building) of NUM. The lecture room was not tiered and could hold up to 150 people, visibility to the lecturing podium was very good. It was equipped with a large, four-surface blackboard, a beamer with projector screen which descended over the blackboards, and two large whiteboards on wheels which sat either side of the main lecturing podium. Speakers had the use of a lapel microphone at their disposal.

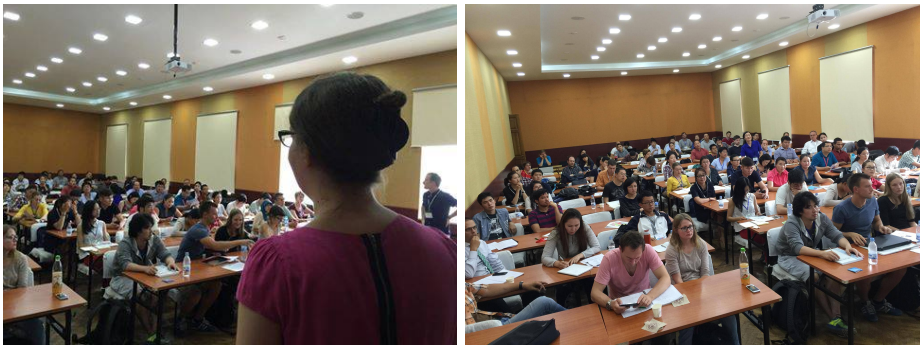


Figure 3: Two views of the lecture room (Christina Goldschmidt teaching on the left on Thursday of the first week) which held up to 150 participants.

All of the lectures, topic lecturers and seminar speakers turned up for the event as advertised on the webpage and there was no need to cancel any talks. A couple of talks were swapped to accommodate for flight arrivals and a stomach upset.

A short walk down the corridor from the main lecture room was the coffee room, which was a similar-sized lecture room to the former. This room was used for coffee breaks, the closing reception and the poster

session. It was also open during the talks for participants to use as a quiet area.

On the first floor of Building 1, next to the offices of faculty members of the Department of Mathematics, was a 'Professors' room'. This was available to speakers to prepare their talk and answer emails.

Wi-Fi was available throughout the building and no password was needed. Despite the large number of users, the Wi-Fi worked relatively well, with some parts of the building offering a stronger signal than others. Accordingly, participants were able to access the internet, occasionally with a little patience needed.

Figure 4: Two views of the coffee room where the poster session was also held. In the first photograph: contributed speaker Kumiko Hattori, left, and local organiser Tsogzolmaa Saizmaa, right.

Information about locations, timetables, course content, poster session details, contact details, hotels and more was available prior and during the school through the main webpage:

`http://smcs.num.edu.mn/saam2015/`

All participants were encouraged to communicate through, as well as to post information and photos to, the Facebook page (currently with over 300 members):

`https://www.facebook.com/groups/Stoch.Mongolia.2015/`

All electronic talks from the meeting have been stored on a webpage which is administered by Andreas Kyprianou and which will be kept live indefinitely:

`http://www.maths.bath.ac.uk/~ak257/SAAM.html`

Participation and financial support

There were a total of 118 participants. Listed by their country of the institution to which they belonged (not necessarily their nationality):

- 54 Mongolian participants
- 17 East Asian students/young researchers (9 Chinese, 4 Indonesian, 2 Japanese, 2 Korean, 1 Filipino)
- 3 Asian students/young researchers (2 Siberian Russians, 1 Pakistani)
- 14 European students/young researchers (7 Germans, 2 Austrians, 3 British, 1 French, 1 European Russia)

- 3 Other students/young researchers (1 Australian, 1 Saudi, 1 Nigerian)
- 7 course lecturers (1 Mexican, 1 Swiss, 1 Norwegian, 4 Germans)
- 5 topic lecturers (1 Mexican, 2 British, 1 German, 1 French)
- 13 non-Mongolian contributed speakers (3 Japanese, 1 Chinese, 1 Hong Kong, 2 American, 1 Canadian, 5 European)
- 2 non-Mongolian organisers (1 German, 1 British)

The whole event was generously sponsored by: Centre International de Mathématiques Pures et Appliquées (CIMPA), Deutscher Akademischer Austauschdienst (DAAD), National University of Mongolia (NUM), Mongolian University of Science and Technology (MUST), the State Bank (SB), Mongolian Agricultural Commodities Exchange (MACE), Index Based Livestock Insurance Project (IBLIP) and Tenger Insurance, Mongolia (TIM). There was also a kind cash contribution from Prof. Gaëtan Borot. The total expenditure came to around 56K EUR. Allocating funds was a particularly complicated matter as each sponsor had different stipulations on how their funds could be spent. All sponsors were acknowledged for their contributions and the three main funders' logos appeared on the welcome pack which was provided to all participants inside of a free school bag.

Figure 5: A welcome pack was given to each participant inside of a school bag containing the handout document and poster abstracts (see Appendix A and B), information about studying and additional gifts, e.g. pens, from sponsors.

All non-speaker participants from non-developing countries were self-funded, although lunches were provided for all participants for 9 out of 10 days and dinner was provided for 2 days. Moreover, all costs for Wednesday afternoon excursions were covered. The majority of participants in this category stayed in the university dormitory. Others stayed in hotels of their choice.

Course lecturers and topic lecturers had their accommodation costs covered by the NUM or by DAAD according to whether they were employed in a German university or not. German-employed course lectures had their travel costs covered by DAAD. Non-German-employed course lecturers covered their own travel costs. Contributed speakers were expected to cover all aspects of their stay, although many were placed in the H9 Hotel where they received a discounted rate. CIMPA paid the travel costs and accommodation for a number of young researchers and students. The IMU contributed to the partial travel costs of one lecturer from Mexico and to supporting lunches for the large number of participants from developing countries (including Mongolians). NUM covered a large part of the incidental costs that could not be covered by other funders. A big part of this was covering the cost of lunches next to the IMU funding, as well as contributing to excursions and dinners.

The CIMPA representative, Christian Mauduit, had his accommodation costs covered only for the first week by NUM and his travel costs covered by CIMPA. Organiser Carina Geldhauser had her accommodation costs covered by NUM and her travel costs covered by DAAD. Organiser Andreas Kyprianou had his accommodation costs covered for the second week only and he covered his own travel costs. There was funding available by DAAD for some Asian participants with regard to their accommodation and cultural activities as well as some additional incidental costs. Other financial contributions from MUST, SB, IBLIP, TIM and Prof. Borot were directed towards incidental costs.

In terms of travel/accommodation from developing countries, the breakdown was as follows for DAAD and CIMPA:

- CIMPA: 10 participants. (3 Russian, 4 Indonesian, 1 Philippino, 1 Pakistani, 1 Nigerian)
- DAAD-supported: 16 participants (only accomodation, 6 Chinese, 2 Koreans, 8 Mongolians)

Visa and travel issues (for CIMPA participants)

Normally Mongolia requires most nationalities to be issued a visa before travelling to Mongolia. By good fortune, the two-week research school fell during a trial period which allowed a large number of nationalities visa-free entry to Mongolia for up to 30 days. This policy covered the majority of participating nationalities. It was, however, necessary for most of the CIMPA-selected participants to obtain visas. The only other participants which required visas were Chinese (but not Hong Kong) and Mexican nationals.

The Mongolian organisers did everything possible to assist with obtaining Mongolian visas. All individuals requiring visas were correctly advised of the procedure following a thorough investigation of the rules well in advance of the event. In all cases that a visa was necessary, the local organisers issued an invitation letter. For some nationalities, it was necessary to obtain special documents from the Ministry of Foreign Affairs on account of there being no Mongolian diplomatic mission in the respective country of origin. Despite the diligence of the local organisers there were incidents which presented difficulty at the start of the meeting.

CIMPA had selected fifteen individuals for joint financial support from CIMPA and the hosting university NUM. CIMPA policy stressed emphasis on supporting participants from Sub-Saharan Africa and Asia. Whilst travel to Mongolia from Asia is relatively straightforward thanks to good connections via Beijing, Tokyo and Hong Kong, connections from Sub-Saharan Africa are much more challenging.

Only 10 of the 15 CIMPA-supported students confirmed their attendance. Those that turned down the opportunity were located in Senegal, Madagascar, Philippines, Indonesia and Iran. Most of them cited complicated travel/visa arrangements and cost exceeding the funds offered as the main reason for turning down the CIMPA support. Of the 10 who confirmed attendance, only 8 arrived on the expected flights. The missing two were both Nigerian, but one later arrived in the middle of the first week. Of the 8 that arrived on the expected flights, one of them (from Pakistan) experienced difficulties with admission to Mongolia by the immigration authorities.

- In the case of the two Nigerian participants, both were incorrectly advised by Nigerian travel agents that they required Chinese transit visas in order to change plane in Beijing. One of the two Nigerian participants therefore rebooked their flights so as to fly directly into Ulaanbaatar with transit in Turkey and accordingly arrived late in the middle of the first week. The other participant struggled to negotiate the confusion of the incorrect visa advice, the complexities of cost and the limited flight availability. In the end, she booked a ticket with Ethiopian Airways via Addis Ababa and Beijing. Despite being issued boarding passes and accepting her luggage, she was refused boarding at the last minute, again on account of a misguided belief by the airline ground staff that a visa would be required for transit in Beijing.
- In the case of the Pakistani participant, he was correctly advised on the visa procedure, namely that a visa would be issued on arrival in Chinggis Khan airport. However, on arrival he was held back by immigration who claimed that a different, and more complicated procedure should be followed. Tsogzolmaa Saizmaa spent several hours discussing the matter with the immigration authorities. It later transpired that his initial advice was correct, however, the immigration officer of high enough

rank who had the authority to issue the visa was on holiday. Unfortunately it took 2 days for the matter to be resolved, during which time he was detained at the airport. During this time Tsogzolmaa Saizmaa ensured there was a constant stream of colleagues bringing food and standing by to assist the participant should anything change.

Aside from visa issues, the arrival and departure of the large number of international participants presented a huge logistical challenge which took a lot of preparation and effort. Participants were asked if they wanted collecting at the airport on arrival. An army of local academic staff and students was employed to ensure the safe collection and delivery of those who needed assistance to their lodgings on arrival. At the end of the meeting, individuals were asked to sign up for lifts back to the airport, which was again a large logistical operation.

Several of the participants wanted to take the opportunity, either before or after the meeting, to explore Mongolia. Assistance and advice was given where possible to help participants get in touch with the right tourist organisations.

Gender and diversity

Careful attention was given to enabling a healthy gender balance. Largely this pertained to the selection of lecturers and contributed speakers as well as selection within the context of CIMPA support. However, with regard to the remaining gender balance, this was largely self-selection. It is worth noting that in Mongolia, there is generally a healthier gender balance amongst the student population in mathematical sciences than in Europe, if not slightly biased in favour of women.

Figure 6: Some of the mathematics students of the National University of Mongolia enjoy sushi at the closing ceremony.

- The overall gender balance was 45% female to 55% male
- The gender balance amongst CIMPA+NUM-funded participants was 5 female and 4 male
- The gender balance amongst DAAD-funded Asian participants was 2 female and 6 male

- The gender balance amongst course lecturers was 2 female and 5 male (the main lecture course which was longer than the others was delivered by a female professor)
- The gender balance amongst topic lecturers was 2 female and 3 male (although one of the female topic lecturers gave twice as many lectures)
- The gender balance amongst contributed talks was 4 female and 12 male
- The gender balance amongst the principle organisers responsible for all aspects of the conception and execution of the school was 2 female and 1 male

There was one Muslim participant who asked for prayer facilities during the day and a separate room was provided to this effect.

Opening ceremony and evening reception

The opening ceremony and evening reception on the first Monday were an important part of the programme as they gave an opportunity for a number of dignitaries to come in contact with some of the more senior Mongolian members of the local organising committee. This research school was an exceptional event in the history of Mathematical Sciences in Mongolia and was an opportunity to create awareness of Mongolian ambition with regard to development in its scientific and academic agenda. Collaboration with Europe will be an important part of this development and exploring interests and mutual benefits is a process that will require the inclusion of national diplomatic representation.

The opening ceremony was held in the famous Academic Round Hall of the National University of Mongolia, which has seen many important congregations in the history of the university. Speeches were given by Bat-Erdene Regsuren, the President of the National University, Prof. Christian Mauduit from CIMPA and the German ambassador, Gerhard Thiedemann. In attendance was also Dr. Odgerel Dorjgochoo from Department of Science Policy and Coordination, Mongolian Ministry of Education, the British ambassador, Catherine Arnold, as well as senior academic staff from the National University and Mongolian University of Science and Technology. The President of the National University invited senior academics and ambassadors for coffee after the opening speeches.

Figure 7: The Academic Round Hall at the National University of Mongolia, a historically important venue (left) as well as for the opening ceremony (right). The left-hand picture is reproduced from an article on Mongolia in the March (Vol 121, No 3) 1962 edition of the National Geographic.

The evening ceremony offered a Mongolian buffet and German beer. The French and British ambassador were present, as well as an educational attaché from the German embassy and the Vice-President of the National

University of Mongolia. The French Ambassador gave a speech and impressed the congregation with his fluency in Mongolian. Participants were further treated to traditional diphonic throat singing (known as *khoomei*).

Attendance

The lecture theatre was capable of housing up to 150 people and remained as full as one sees depicted in Figure 3 throughout the course of the two weeks (a minimum of 100 present in the room at any one time). On two random occasions, one in each week, head counts were performed and consistently, around one third of the audience consisted of a core of Mongolian attendees. The attendance was very consistent throughout and did not wane at all from the first day.

It was especially notable that there was strong commitment from the Mongolian cohort. This was not just from mathematics professors and students, but also from many former graduates of the mathematics department who had since studied abroad and were now occupying academic positions in a variety of institutions around Ulaanbaatar as well as actuarial and banking positions. There was an excellent sense of importance and urgency amongst Mongolian participants that this was a rare opportunity to make and develop new international contacts.

Figure 8: Impressions from the poster session.

Lunches and dinners and the 'buddy system'

Of the 10 working days that the school was running, free lunches were provided for all participants on 9 days. This included lunches on each of the Wednesday afternoon excursions. Lunch on Thursday in the second week was left for participants to explore the city on their own. Dinner was provided at the evening reception on the first day as well as during the excursion on the first Wednesday. A variety of restaurants were used. Mostly Mongolian dishes were served, but participants also ate from Chinese and Indian sub-continent kitchens.

CIMPA insisted that students and professors would eat together to ensure close contact and integration. However, CIMPA meetings are generally much smaller and this request was much more difficult to respect given that there were over 100 participants attending each lunch. To overcome this problem the organising committee came up with the 'buddy system' for the first week. Following a daily (printed) announcement, junior participants of all nationalities were collected into groups of 3-4 and were assigned two additional senior members (buddies), one Mongolian and one non-Mongolian. Senior members were briefed in advance on the process and were included by agreement. They were asked to encourage discussion and to ensure that members of the group became familiar with one another. Junior members of groups were chosen to be of the same sex but generally of different nationalities. Each day in the first week, the senior members of groups were shuffled. The gender of senior group members did not necessarily match those of their junior members each day.

The logic to associate junior members by gender was manifold. It was an attempt to respect different cultural and gender approaches to rapid social and intellectual integration, particularly in light of the significant age spread within the definition of 'junior member' (typically 20-35). Moreover, it was deemed important that junior female participants would be able to have guaranteed access to some of the more esteemed lecturers, both male and female.

Despite concerns about gender separation amongst junior members, this scheme proved to be generally well received by all participants and equally effective in serving its purpose. In particular, it was noted that a strong familiarity had developed amongst participants of all career stages and there was no evidence of cultural, social, linguistic, gender, regional or national sub-grouping taking place. A helping factor was that neighbouring groups often interacted on large dining tables.

At the request of participants, the buddy system was continued into the second week. Shuffling became more ad-hoc during the second week with students taking up the spirit of 'optimal integration' and re-shuffling themselves to access new, interesting, group structures.

Figure 9: Members of a lunch group from Germany, Japan, Mongolia, Indonesia and China

The speakers were also taken for dinner on three additional occasions. They were hosted once by the pure mathematics department and once by the applied mathematics department. Finally, all speakers remaining were invited for dinner on the final Friday of the second week together with the body of young Mongolian students who had tirelessly helped out with organisation.

Non-scientific group activities

Another important aspect of the CIMPA and DAAD ethic that was respected in this research school was the need for social interactive time. There were three main occasions when this happened.

- On the first Wednesday, there was an excursion during the afternoon. Participants were ferried by bus, starting with lunch and then on to the Zaisan Memorial for the Russian soldiers killed during WW II. Participants were then taken to a new shopping Hunnu Mall on the outskirts of Ulaanbaatar which also houses an exceptional exhibition of dinosaur skeletons and remains collected from the Gobi Desert. The day was completed with dinner together.

- On the second Wednesday, there was again an excursion during the afternoon. Participants were taken by bus, first for lunch and then to the International Intellectual Museum. Founded in 1997 by Tumen Ulzii, it exhibits a rich variety of puzzles and logic games of various sizes. Many of these puzzles are made from wood and are designed in a traditional way by Mongolian puzzle makers. From this museum, participants were taken to the Mongolian Stock Exchange where they were given a tour. Thereafter a little time was given for participants to enjoy the beautiful blue sky over Chinggis Khan square, before going to the National Theatre for a variety performance of traditional song and dance.

- During the weekend between the two working weeks, an overnight excursion to Terelj National Park was organised. The park is around 2 hrs drive north east of the capital. Participants were taken on Saturday and Sunday walking and sightseeing. On Saturday morning participants were taken to a giant statue of Chinggis Khan and the incorporated museum underneath, which is found out in the Mongolian steppe, east of the capital. Following a picnic, in the afternoon they were brought to a series of deconstructed gers (a 'ger' is a Mongolian nomadic tent) and asked to put them together again as a group activity. Participants were then offered the opportunity to either sleep in the gers or in a neighbouring hostel. Most chose to sleep in the gers. Participants also had the opportunity to see the Mongolian nomadic way of life as well as visit a Buddhist monastery. Sunday was devoted to sightseeing and walking.

  Mongolians and those participants who were in receipt of any kind of financial assistance were invited to take part in the weekend activities for free. Participants who were self-funded were asked to contribute 123,000 MNT (approximately 60 EUR) towards the cost of the excursion and all associated meals (2 lunches, one dinner and one breakfast).

- In parallel to the above weekend trip, a second smaller party, mostly of professors, was taken out to Terelj National Park on a very similar trip but with more comfortable arrangements in terms of transport and accommodation (taking account of different age groups). This trip cost more and was paid for by the professors themselves. Both this party and the above party crossed paths at certain points.

Figure 10: Social activities: Students were asked to reconstruct a Mongolian ger (top left), Jean Bertoin and Maria Emilia Caballero visit a traditional nomadic Mongolian family (top centre) and more gers where the students stayed overnight (top right). Chinggis Khan Square (bottom).

Figure 11: The 40m tall statue of Chinggis Khan out in the Mongolian steppe, East of Ulaanbaatar, houses a museum underneath.

Closing Ceremony

The closing ceremony was an informal affair consisting of two talks followed by Mongolian beer and sushi in the coffee room.

The first of these two talks was presented by Dr. Uuganbataar Ninjbat from the hosting department of the National University of Mongolia. In his talk, he offered a brief history of Mongolian mathematics in the 20th and 21st century. His talk was received with fascination as virtually nothing is known in the West about the origins of the academic system in Mongolia and, accordingly, the development of mathematics. An example of some of the facts that came to light in his talk was that probability theory was the first field of research to be introduced at the National University of Mongolia. This came about thanks to the very first two Ph.D. graduates returning from Moscow and Kiev having been supervised by none other than, Dynkin and Skorokhod, respectively. Dr. Ninjbat's talk also reflected on the trials and tribulations of developing Mongolian mathematics, highlighting many of the challenges pertaining to Mongolia's geo-political situation over the years.

So impressive was the talk of Dr. Ninjbat that, with the help of participant Dr. Erik Baurdoux (Bernoulli web editor), it was arranged that he would write a short article based on his talk to be published in the next issue of Bernoulli News. This action is also deemed as part of the next steps to move forward from this large research school (see the next section).

The second and final talk was given by Andreas Kyprianou and offered a jovial exposition, in the form of a quiz, of how the city Ulaanbaatar had dramatically changed during recent years. His talk was based on his personal collection of old photos, some of them taken during his visits to Mongolia over the last 18 years. His talk was concluded by giving thanks to the many Mongolian academics and students who had devoted themselves to running the school so smoothly and showing immense hospitality and kindness to their guests. The key Mongolian organising team were offered gifts, the purchase of which had been arranged by some of the main speakers at the meeting whilst in Ulaanbaatar. Tsogzolmaa Saizmaa received particular thanks and recognition for her exceptional contribution and leadership in realising the vision of such a large mathematical meeting.

Figure 12: Some of the many (now unrecognisable) scenes from the personal collection of photos of Andreas Kyprianou. The Mongolian stock exchange (top left), Peace Avenue looking Westward over Ulaanbaatar in the 1960s (top right), a lonely and lost mathematical horseman out in the steppe in the late 1990s (bottom left), the National Press (bottom right).

Feedback

This two-week research school was a huge undertaking. Its preparation required two years of planning and the dedication of many academics both in Europe and Mongolia. The intricate preparations paid off and most aspects of the meeting proceeded according to plan and well within budget. Verbal feedback during and at the end of the meeting was very positive.

An anonymous written survey conducted via google forms showed that indeed the participants were very happy with most aspects of the school. The output of this questionaire is available as a separate document. We give a brief overview here.

The participants were generally very satisfied with all of the lectures without exception. Some students indicated in their feedback that they had difficulties in understanding the lectures due to lack of pre-knowledge

of the content used in the class, as well as due to lack of English listening skills. Some comments from the participant survey:

> "It was one of the most inspiring scientific events in my life. Thanks so much!"
>
> "I enjoyed the friendly atmosphere. It was lovely to get to know Mongolia and the researchers and students at the university."
>
> "I enjoyed the summer school and everything which went with it a lot. The trip was worth it for the lectures, for the people I met and for just being there. Thanks for accepting my application ☺"
>
> "The scientific programme was well balanced, with courses that were good introductions/refreshers on some basic concepts–some of which I am glad I got reminded of, by the way– some which I knew a little about but not so much (Oksendal) and some more exotic which I knew nothing about before (Bertoin, Lambert, Borot...). I am very satisfied with the quality of the conference."

Students rated the leisure programme very highly. Moreover, the participants showed extremely strong appreciation for the buddy scheme, and a few wrote additional commentary suggesting that the scheme would work even better by mixing the students every day in addition to the buddies:

> "Instead of just rotating the speaker, it could have been good to have the students group change from time to time."
>
> "Change the entire group and not just the supervisors."
>
> "Perhaps there could be some permutations among students so that everyone would get to know each other better change entire groups on a daily basis."

On the matter of food, there was again a relatively strong response for the meals provided. Participants were very forgiving when it came to the inevitable stomach upsets that come with travelling to far away lands.

With regard to the dormitory accommodation, the responses were more variable. There were issues with hot water and wifi, but responses indicated that the rooms and sanitary conditions were acceptable.

Follow-through and long term vision

Despite the success of this meeting, there is still the question of where it sits in the bigger picture for Mongolian mathematical education and research and what leverage it can create for the future. The talk of Dr. Ninjbat in the closing ceremony made clear that, whist academic development had progressed relatively well during the Soviet era, there had been some very difficult years following the collapse of communism in the 1990s and beyond. This has created what was referred to as 'the gap' in research productivity. Accordingly, there is presently a desire amongst Mongolian mathematicians to rectify this situation and to engage in a process of significant overhaul.

This research school has certainly played an important role in creating awareness for students and young researchers, helping to inspire potential new directions of research. In doing so, it has provided valuable international contacts in the broader field of stochastics. There was a pledge by the Mongolian hosts to continue the spirit of this school by running reading seminars in the future to explore further the topics that were presented in the meeting. This alone will not suffice to drive the bigger research ambition forward in the manner that is desired. Nonetheless, a clear plan amongst Mongolian mathematicians from the National University does exist to move things forward in which the energy from this research school can play a catalytic role.

The root of this plan starts with the International Mathematical Olympiad (IMO), where Mongolia has been a regular contributor over the years, in particular during the Soviet era. Indeed, it is notable that many of the current and past mathematicians in Mongolia are former olympiads. There is plenty of experience in Mongolia in this respect and confidence about how to invest securely at this level of education.

The fundamental idea is to start to develop greater interest and support for the IMO back in high schools and to cultivate a larger generation of more intensively trained mathematicians who will progress to study

mathematics at university. In preparation for that eventuality, a new bachelors programme will be developed at the National University of Mongolia to push former olympiads a little bit further than students on the existing degree programme. Thereafter, pursuing a larger drive in postgraduate study for this up-coming generation is the next step. Once again, international contacts will be a precious resource in realising this part of the long term vision.

With regard to outside support for this plan, the following recommendations are made:

- Maintaining regular contact with Mongolian academics and students will be important in upholding momentum of the longer term Mongolian ambition for enhancing research output. This may take the form of supporting the aforementioned seminar reading programme, co-supervising masters and PhD theses and trying to explore the opportunity for collaborative research.

- Creating sustained awareness of Mongolian mathematics internationally will also be important. In this respect the forthcoming article in Bernoulli News is a good first step. However, Mongolian academics should also be encouraged to attend research meetings outside of Mongolia with whatever resources can be made available (e.g. via CIMPA and other such organisations as well as personal invitations at the expense of a host's grant).

- Developing stronger open lines of communication with Chinese, Japanese and Korean academics could well be an easy and cheap way to bring visiting academics into Mongolia. The long-standing and increasing trend of Western visitors spending time at many of the strong universities in e.g. Beijing, Shanghai, Tokyo, Kyoto, Osaka, Seoul and Hong Kong also means that there is a steady stream of Western mathematicians in close proximity to Mongolia. Awareness of opportunities through such traffic is currently lacking in Mongolian institutes. An example of this happened immediately after the research school. Oxford mathematician Sir John Ball visited Mongolia later in August following an academic stay in China. The opportunity was taken to introduce him to NUM mathematicians.

- To make communication more fluid in general, Mongolian students should be exposed earlier to spoken English. This point links to the previous in that a natural exposure for students will be to enhance the current visitor programme in the department with regard to special lectures and workshops.

- Currently in China, many academic mathematics books are reproduced at significantly lower cost (approximately one tenth the cost in the West). If there is more academic traffic between e.g. Beijing and Ulan Bator, then it would not be difficult to arrange for hard copies of the latest academic research literature to be brought into Mongolia at minimal cost.

- Lobbying various scientific funding and aide organisations to be more inclusive with Mongolian projects in the future is important. For example, Newton/British Council schemes in the UK. In this respect, contact with the EU Ambassadors should be maintained where appropriate.

- Within two years, another, smaller, cheaper, more focused and less formal research school should take place in Ulaanbaatar, exclusively for Mongolians (in the spirit of the IMU pre-school), to develop some of the topics presented in the summer of 2015.

- It has also become apparent that Mongolia, like the rest of the world, has become exposed to the phenomenon of big data. More development in the direction of statistical modelling would also be welcome. Three primary directions that were identified were:

  - health care (in particular in connection with air pollution and other studies in connection with the World Health Organisation),
  - the mining industry and
  - actuarial and financial data.

  If resources can be found, then it would also seem prudent to look at holding small, focused research schools in these directions too. In the case of the latter two, encouraging further industrial investment in education, for example sponsoring PhD theses or research programmes, would also be desirable.

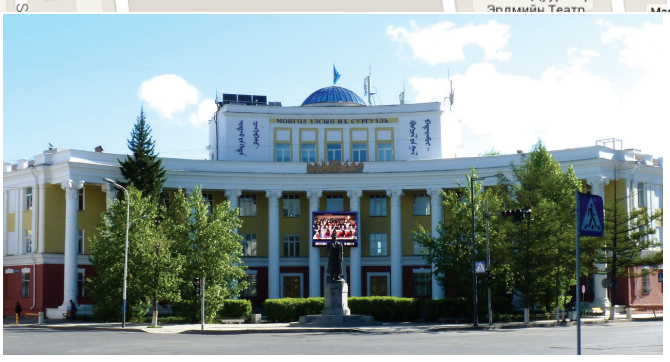
Appendix A: Handout document

The document in the subsequent pages was included in the welcome packs of all participants as well as being sent to them electronically prior to arrival.

Basic information

Venue: The meeting will take place at the National University of Mongolia. The map below shows the campus of the University which is located in the North-Eastern block relative to the Government Palace and Chinggis Khaan Square (see the red circle with arrow indicating main entrance in map below) in the very heart of down-town Ulaanbaatar.

- All lectures, contributed talks and tutorials will be held in the Room 320 at 3rd floor, Main building, NUM.
- Registration and Opening Ceremony will be held in the Academic Hall (Round Hall) at 2nd floor of the Main building.
- The welcome reception will be held at the 2nd floor of the Broadway restaurant pub which is just on the West side of Chinggis Khaan Square (see the blue circle in map below).

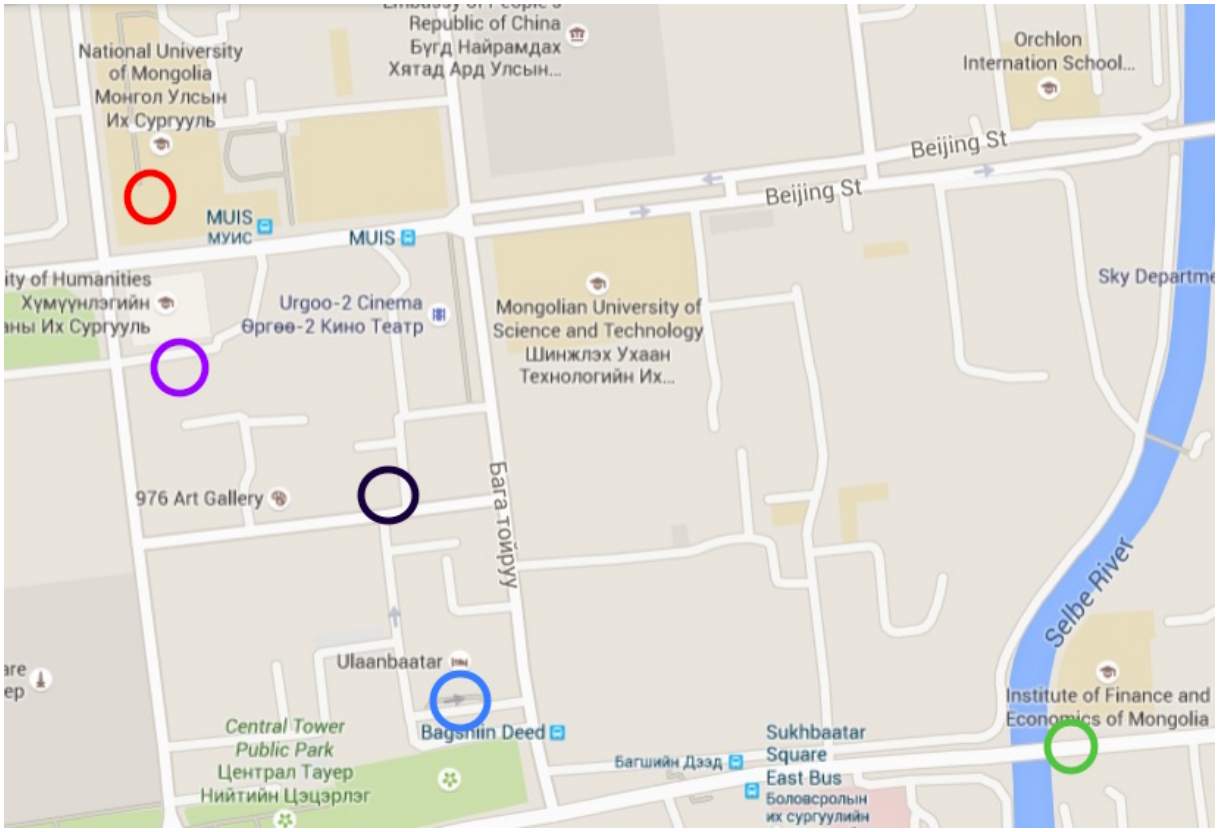


Facilities: The main venue is equipped with an electronic beamer, a blackboard and some movable white-boards. There will also be magic whiteboards which can be used on any vertical surface. White-board pens and chalk will be provided.

Breaks: Refreshments will be served between talks (see timetable below) at the conference venue.

Lunches: Arrangements for lunches will be announced at the start of the meeting.

Accommodation: Various places are being used for accommodation. The main accommodation are indicated on the map below relative to the National University (red circle): The Puma Imperial Hotel (purple circle), H9 Hotel (black circle), Ulaanbaatar Hotel (blue circle), Student Dormitories (green circle)



Mentoring: A mentoring scheme will be running which sees more experienced academics linked with small groups of junior researchers. On your arrival at the school, there will be a list with the name of a mentor and the names of a small group of 3-4 students/young researchers. At much as possible, each group will contain at least one local student. During your stay, please locate your named group members via their name tag. They will likewise be instructed to locate you.You are encouraged to spend some of your time at lunch with your group. This is not a daily obligation, but it would be a useful ice-breaker. The senior academic in your group will be the first point of contact for mathematical assistance.

WEEK1	Monday 27/07	Tuesday 28/07	Wednesday 29/07	Thursday 30/07	Friday 31/07
08:00 – 08:30	Registration				
08:30 – 09:00					
09:00 – 09:30	Opening Cermony	Caballero	Beck	Bertoin	Oksendal
09:30 – 10:00	Caballero				
10:00 – 10:30		Lecture 3	Lecture 3	Lecture 3	Lecture 3
10:30 – 11:00	Lecture 1	Break	Break	Break	Break
11:00 – 11:30	Break	Beck	Oksendal	Goldschmidt	Pardo
11:30 – 12:00	Bertoin				
12:00 – 12:30		Lecture 2	Lecture 1	Topic Lecture	Topic Lecture
12:30 – 13:00	Lecture 1	Lunch	Lunch	Lunch	Lunch
13:00 – 13:30					
13:30 – 14:00	Lunch				
14:00 – 14:30		Bertoin	Excursion	Oksendal	Goldschmidt
14:30 – 15:00	Beck				
15:00 – 15:30		Lecture 2		Lecture 2	Topic Lecture
15:30 – 16:00	Lecture 1	Break		Break	Break
16:00 – 16:30	Break	Caballero		Lambert	Baurdoux
16:30 – 17:00	Caballero				
17:00 – 17:30		Lecture 4		Topic Lecture	Topic Lecture
17:30 – 18:00	Lecture 2	Tutorials		Tutorials	Tutorials
18:00 – 18:30					
18:30 – 19:00	Welcome reception				
19:00 – 19:30					

WEEK2	Monday 03/08	Tuesday 04/08	Wednesday 05/08	Thursday 06/08	Friday 07/08
08:00 – 08:30	Registration				
08:30 – 09:00					
09:00 – 09:30	Behme	Doering	Eberlein	Doering	Borot
09:30 – 10:00					
10:00 – 10:30	Topic Lecture	Lecture 1	Lecture 3	Lecture 2	Lecture 3
10:30 – 11:00	Break	Break	Break	Break	Break
11:00 – 11:30	Eberlein	Eberlein	Borot	Borot	Doering
11:30 – 12:00					
12:00 – 12:30	Lecture 1	Lecture 2	Lecture 1	Lecture 2	Lecture 3
12:30 – 13:00	Lunch	Lunch	Lunch	Lunch	Lunch
13:00 – 13:30					
13:30 – 14:00					
14:00 – 14:30	Remco van der Hofstad	Fausto Gozzi	Excursion	Uuganbaatar Ninjbat	Kazutoshi Yamazaki
14:30 – 15:00				Gantumur Tsogtgerel	
15:00 – 15:30	Kazumasa Kuwada	Erdenebaatar Chadraa		Ricardo Romo Romero	Barsbold Bazarragchaa
15:30 – 16:00	Break	Break		Break	Break
16:00 – 16:30	Kumiko Hattori	Studying in Germany		Yue Yuen Kwok	Josef Najundel
16:30 – 17:00		(Panel discussion)			
17:00 – 17:30	Yanxia Ren	Poster Session		Ju-Yi Jen	Andrej Depperschmidt
17:30 – 18:00	Tutorials	and Reception		Tutorials	Closing ceremony
18:00 – 18:30					

Minicourses

Fragmentation-coalescence models and applications.

(*Prof. Jean Bertoin*):

The basic concept of exchangeable partitions of the natural numbers is introduced and how this plays a fundamental role in building Markov processes that are valued in the space of such partitions. The case of fragmentation and coalescent processes are developed with focus on their applications. In the case of fragmentation processes, applications in the mining industry are mentioned. In the case of coalescent processes, connections with modeling genetic diversification are mentioned.

Introduction to PDEs.

(*Prof. Lisa Beck)*:

In this course we discuss some basic results and techniques from the PDE theory, which arise in the study of stochastic differential equations. In this way, we provide some background for the course "Introduction to stochastic calculus and applications". We start with some fundamental properties of harmonic functions (i.e. of solutions to the Laplace equation), such as the mean value property, the maximum principle and Harnack's inequality, which allow for a stochastic reformulation in terms of a stopped Brownian motion. We then present some variants for time-dependent PDEs, with an emphasis on the heat equation as model equation for general diffusion processes. Finally, we draw a connections between partial differential equations and optimization / minimization problems, by explaining some basics of the Euler-Lagrange formalism. The theory covered in this course will be illustrated by several reoccuring examples, both during the lectures and tutorials.

An introduction to random matrix theory.

(*Dr. Gaëtan Borot)*:

Random matrix theory is chiefly concerned with the distribution of eigenvalues and eigenvectors of random matrices of size n. In fairly simple models (like random matrices with independent Gaussian entries), the limit laws appearing in the large n limit can be computed. As the eigenvalues are strongly correlated variables, these laws differ notably from the limit laws known for i.i.d. More interestingly, the same limit laws appear in more complicated ensembles of random matrices, as well as in many other areas of mathematics and physics (sometimes without obvious link to random matrices).

I will mainly consider on eigenvalue distributions in Wishart matrices and Gaussian matrices, and explain some applications to statistical analysis of high dimensional data (biology, finance, ...) and statistical physics. The lectures aim at giving basic ideas to study random matrices and an overview of limit laws occuring there, as well as introducing tools (Stieltjes transform, free probability, potential theory, determinantal processes) that can lead to proofs in the simplest cases.

Introductory stochastic calculus and applications.

(*Prof. Maria-Emilia Caballero*):

This course will give an introduction to the theory of stochastic calculus and will serve as a foundation for the other mini-courses. The course will introduce Brownian motion as a Markov process and focus largely on the construction of the Brownian integral and its associated Ito calculus. En route examples of where stochastic calculus is important will be mentioned, leaving open the possibility for further discussion with students during the research school. The course will conclude with some attention given to the case of Lévy processes and the generalization of Itos calculus for this class of processes.

Self-Similar Markov Processes.

(*Prof. Leif Döring*):

Positive Self-Similar Markov processes are closely connected to Lévy Processes. The aim of this lectures is to discuss a reformulation of Lampertis representation through stochastic differential equations (SDEs) driven by Poisson point processes. Lampertis representation is equivalent to the Lamperti SDE for positive initial conditions but in contrast to Lampertis representation the Lamperti SDE readily extends to zero initial conditions. On the way existence and uniqueness for jump-type SDEs will be discussed.

Introductory models in mathematical finance.

(*Prof. Ernst Eberlein*):

This course will provide a rapid introduction into classical Black-Scholes theory and its deficiencies. The course will then move on to discussing a more modern perspective on financial modeling, drawing attention to the large variety in different types of financial contracts as well as the rich family of off-the-shelf stochastic processes and statistical methods, which are used to model such pricing scenarios. The ideology of using mathematics to establish fair pricing and giving a quantitative perspective to "risk exposure" will be central to the presentation. This course will be aimed equally at analysts from the several large banks in Mongolia as much as academic participants.

Stochastic control theory.

(*Prof. Bernt Øksendal*):

Building on the first course on stochastic analysis, this course will introduce some basic principles of optimal stochastic control theory in the setting of models driven by Brownian motion and, more generally, Lévy processes. Two main solution methods will be presented, namely (i) the stochastic maximum principle and (ii) dynamic programming and the HJB equation. Applications that are of pertinence to mathematical finance will also be discussed, for example the problem of optimal portfolio choice and risk minimization in a financial market.

Topic Lectures

Erik Baurdoux

Title: Optimal stopping theory and applications

Abstract: We start with the classical secretary problem, where our aim is to choose the best candidate out of a number of applicants appearing in front of us in a random order, without having the option of going back to a previously rejected applicant. This example of an optimal stopping problem has been well studied and it allows us to illustrate in a rather simple setting some fundamental properties of more general optimal stopping problems. We will then move our attention to Lévy processes, which form a surprisingly rich class and for example include Brownian motion and (compound) Poisson processes.

In the general Lévy setting we consider the well-known optimal stopping problem of the American put option as well as an optimal prediction problem where the aim is to approximate optimally the time at which a Lévy process attains its maximal value. By studying these examples, we will also be touching on some important concepts from the general theory of optimal stopping.

Anita Behme

Title: Time Series Analysis in a nutshell

Abstract: In many scientific fields the data to be analyzed (e.g. meteorological data, stock prices, ...) form a sequence of observations given at a sequence of time points. Therefore, as counterpart to the stochastic processes in continuous time which are treated in several other courses of this school, this lecture introduces basic concepts of stochastic processes in discrete time, that is of time series. Here, our main focus will lie on introducing fundamental time series models which are widely used in practice and for which we will discuss some of their properties and possible applications.

Christina Goldschmidt

Title: Random trees

Abstract: Tree structures are very common in nature, and we often want to model trees which are somehow randomly generated. In mathematics, we think of trees as connected graphs (or networks) with no cycles. In these lectures, I will discuss some simple models of random trees and what we can say about large instances of them. The first lecture will focus on Galton-Watson branching processes. We think of an idealised biological population (say of cells) in which each individual lives for a unit of time, gives birth to a random number of children (with a given distribution) and then dies. What can we say about the way the population size evolves? Or about the family tree of that population?

In the second lecture, we will take a more combinatorial perspective. What does a tree with n vertices, chosen uniformly at random from all the possibilities, look like for large n? It turns out that we can use Galton-Watson branching processes to help us answer this question. Along the way, we will encounter several beautiful bits of combinatorics and probability, including Cayley's formula, random walks and (finally) Brownian motion.

Amaury Lambert

Title: Random trees in evolutionary biology

Abstract: We will review some of the main models of random trees used in evolutionary biology to model gene trees or species trees. We will study the reconstructed tree, which is the tree spanned by alive individuals/species at the same fixed time, sometimes also called the coalescent tree. Time allowing, we will display two one-parameter families of binary random trees interpolating between the caterpillar tree on the one hand, and on the other hand the the maximally balanced tree, or the Kingman coalescent, respectively.

Juan Carlos Pardo

Title: Lévy processes

Abstract:We will give a basic introduction to the theory of Lévy processes. Our objective will be to cover the basic definition and construction of the general class. In particular using Poisson point processes, we give the classical Lévy-Itô decomposition, showing how every Lévy process can be broken into the sum of three independent processes: a diffusive process, a compound Poisson process of 'large' jumps and a third process which arises as the limit (in an appropriate sense) of a sequence of compensated compound Poisson processes, which deals with up to a countable infinity of small jumps. We shall also mention various special cases of Lévy processes as well as alluding to a variety of applications

Contributed Talks

Barsbold Bazarragchaa

Title: Optimal Control for Minimizing Ruin Probability of a Controlled Diffusion Process with a Linear Control

Abstract: In this research, we consider stochastic optimal control problem for minimizing ruin probability of a controlled diffusion process with linear control terms in the drift and diffusion parts. By means of ruin we understand the first occurence of such event that the state variables drop below given lower bound. A main goal is to describe optimal control and optimal process in terms of problem data. In order to achieve it, we formulate the corresponding Hamilton-Jacobi-Bellman equation. We do not solve it explicitly. However this, we find the optimal control and describe optimal process. Under some convinient assumptions the optimal process has a closed form solution. In order to demonstrate practical importance of this class of problems, we consider also optimal investment problem for insurance company as a case study.

Erdenebaatar Chadraa

Title: Modelling Financial Time-Series with COGARCH processes

Abstract: In this presentation, a family of continuous-time generalized autoregressive conditionally heteroskedastic (COGARCH) processes, generalizing the COGARCH$(1,1)$ process of Klüppelberg, et. al. (2004), is introduced. The resulting COGARCH(p,q) processes, $q \geq p \geq 1$, exhibit many of the characteristic features of observed financial time series, while their corresponding volatility and squared increment processes display a broader range of autocorrelation structures than those of the COGARCH$(1,1)$ process. We established sufficient conditions for the existence of a strictly stationary non-negative solution of the equations for the volatility process and, under conditions which ensure the finiteness of the required moments, determined the autocorrelation functions of both the volatility and squared increment processes. The volatility process was found to have the autocorrelation function of a continuous-time ARMA process while the squared increment process has the autocorrelation function of an ARMA process. The least-squares method was used to estimate the parameters of the COGARCH$(2,2)$ processes. We gave conditions under which the volatility and the squared increment processes are strongly mixing, from which it follows that the least-squares estimators are strongly consistent and asymptotically normal. Finally, the model was fitted to a high frequency dataset.

Andrej Depperschmidt

Title: Random walk in dynamic random environment generated by the reversal of discrete time contact process

Abstract: We consider a random walk in a dynamic random environment generated by the time reversal of the discrete time contacts process. Alternatively, it can be interpreted as a random walk on the backbone of the oriented percolation cluster. Via a suitable regeneration construction we obtain a law of large numbers and a central limit theorem (averaged and quenched). As time permits, we also discuss some generalisations of the above random walk.
Based on joint work with Matthias Birkner, Jiri Cerny and Nina Gantert.

Fausto Gozzi

Title: Stochastic Control in Infinite Dimension: why it worth studying

Abstract: In this talk we present some applied problems (mainly in Economics and Finance) which are naturally formulated as stochastic control problems in infinite dimensional spaces. Then we briefly discuss the available methods of solution and some recent results.

Kumiko Hattori

Title: Self-avoiding walk, loop-erased random walk and self-repelling walk on a fractal.

Abstract: A self-avoiding walk and a loop-erased random walk are typical examples of non-Markov random walks. We construct a one-parameter family of self-avoiding walks on the Sierpinski gasket, connecting the loop-erased random walk and the 'standard' self-avoiding walk continuously. We prove the existence of the scaling limits and show some properties of the limit processes.

Remco van der Hofstad

Title: Recent progress in high-dimensional percolation.

Abstract: It is now 25 years ago that Hara and Slade published their seminal work on the mean-field behavior of percolation in high-dimensions, showing that at criticality there is no percolation and identifying several percolation critical exponents. The main technique used is the lace expansion, a perturbation technique that allows us to compare percolation paths to random walks based on the idea that faraway pieces of percolation paths are almost independent in high dimensions.

In the past few years, a number of novel results have appeared for high-dimensional percolation. I intend to highlight the following topics:

(1) The recent computer-assisted proof, with Robert Fitzner, that identifies the critical behavior of nearest-neighbor percolation above 11 dimensions using the so-called Non-Backtracking Lace Expansion (NoBLE). While these results are expected to hold above 6 dimensions, the previous and unpublished proof by Hara and Slade only applied above 18 dimensions;

(2) The identification of arm exponents in high-dimensional percolation in two works by Asaf Nachmias and Gady Kozma, using a clever and novel difference inequality argument;

(3) The finite-size scaling for percolation on a high-dimensional torus, where the largest connected components share many features to the Erdos-Renyi random graph. In particular substantial progress has been made concerning percolation on the hypercube, where in joint work with Asaf Nachmias we have managed to avoid the lace expansion altogether.

We assume no prior knowledge about percolation.

Kazumasa Kuwada

Title: Optimal transport, heat flow and coupling of Brownian motions.

Abstract: In this talk, I will survey recent developments in the connection between the theory of optimal transport and geometric analysis of heat flows. The latter one can be regarded as a gradient flow in the space of probability measures equipped with a structure coming from the optimal transport. In this context, both of them are closely related with the synthetic notion of lower Ricci curvature bound of Sturm, Lott and Villani. If time permits, I would like to mention an application of them to new construction of a coupling of canonically associated diffusion processes ("Brownian motions") which works even on non-smooth spaces.

Yue Kuen Kwok

Title: Analytic Pricing of Discrete Exotic Variance Swaps and Timer Options.

Abstract: We consider pricing of exotic variance swaps and timer option written on the discretely sampled realized variance of an underlying asset under stochastic volatility models. Timer options are barrier style options in the volatility space. A typical timer option is similar to its European vanilla counterpart, except with uncertain expiration date. The finite-maturity timer option expires either when the accumulated realized variance of the underlying asset has reached a pre-specified level or on the mandated expiration date, whichever comes earlier. Thanks to the analytical tractability of the joint moment generating functions of the affine models, we manage to derive closed form analytic formulas for variance swap products with corridor features. Interestingly, the closed form pricing formulas of the continuously sampled counterparts can be deduced from those of the discretely sampled variance swaps, while direct derivation of pricing formulas of the corridor type variance swaps based on continuously sampling may appear to be insurmountable. We also propose an effective analytic approach for pricing finite-maturity discrete timer options under 3/2-model by decomposing into a portfolio of timelets. The challenge in the pricing procedure is the incorporation of the barrier feature in terms of the accumulated realized variance instead of the usual knock-out feature of hitting a barrier by the underlying asset price.

Josef Najnudel

Title: On sigma-finite measures related to the Martin boundary of recurrent Markov chains

Abstract: In this talk, we construct, from a recurrent Markov chain X, some sigma-finite measures which can be informally considered as laws of X conditioned to go to infinity in a suitably way. These sigma-finite measures are directly related to the Martin boundary of the Markov chain.

Uuganbaatar Ninjbat

Title: Probabilistic aspects of voting

Abstract: In this talk we discuss some classical results in voting theory that involve probability including Bertrand's ballot problem, Condorcet's jury theorem and Gibbard's random dictator theorem. By doing so, we aim to explore an application of probability theory into the domain of social sciences.

Yanxia Ren

Title: Central Limit Theorems for supercritical superprocesses

Abstract: We establish a central limit theorem for a large class of general supercritical superprocesses with spatially dependent branching mechanisms satisfying a second moment condition. We are able to characterize the limit Gaussian field. In the case of supercritical super Ornstein-Uhlenbeck processes with non-spatially dependent branching mechanisms, our central limit theorem reveals more independent structures of the limit Gaussian field.
We also establish some functional central limit theorems for the supercritical superprocesses mentioned above. In the particular case when the state E is a finite set and the underline motion is an irreducible Markov chain on E, our results are superprocess analogs of the functional central limit theorems of Janson(2004) for supercritical multitype branching processes.

Ricardo Romo Romero

Title: Discrete time Stochastic Processes.

Abstract: In this talk, we introduce the Backward Stochastic Differential Equations and Filtration Enlargement Theory but in discrete time context. Also, we present new results that we do not have in continuous time and some applications.

Gantumur Tsogtgerel

Title: The Navier-Stokes equations with random initial data

Abstract: We In this expository talk, we will discuss some interesting recent results on the Navier-Stokes equations with random initial data. These results reveal that evolution equations with random initial data apparently behave much better than their deterministic counterparts, although at the moment it is not completely clear how one could meaningfully compare deterministic and randomized results, and what would be the impact of these results on the Navier-Stokes regularity problem.

Kazutoshi Yamazaki

Title: Optimality of Refraction Strategies for Spectrally Negative Lévy Processes.

Abstract: We revisit a stochastic control problem of optimally modifying the underlying spectrally negative Lévy process. A strategy must be absolutely continuous with respect to the Lebesgue measure, and the objective is to minimize the total costs of the running and controlling costs. Under the assumption that the running cost function is convex, we show the optimality of a refraction strategy. The proof of convergence to the reflection strategy as well as numerical illustrations are also given.

Ju-Yi Yen

Title: Regenerative process Monte Carlo methods

Abstract: Let $(S, \mathcal{S}, \pi)$ be a measure space. Let $f : S \to \mathbb{R}$ be $\mathcal{S}$ measurable and integrable with respect to π. Let $\lambda \equiv \int_S f d\pi$. An important problem in the theory and application of statistical methods to many areas of sciences and humanities is the estimation of λ. If π is a probability measure (i.e. $\pi(S) = 1$), there are currently two well-known statistical procedures for this. One is based on iid sampling from π, also called IID Monte Carlo (IIDMC); the other method is Markov chain Monte Carlo (MCMC). Both IIDMC and MCMC require that the target distribution π is a probability distribution or at least a totally finite measure. In this talk, we discuss Monte Carlo methods to statistically estimate the integrals of a class of functions with respect to some distributions that may not be finite (i.e. $\pi(S) = \infty$) based on regenerative stochastic processes in continuous time such as Brownian motion.

Committees

School Coordinators

- Prof. Jean Bertoin (University of Zurich)
- Prof. Andreas Kyprianou (University of Bath, UK)
- Dr. Tsogzolmaa Saizmaa (National University of Mongolia)

International Organizers

- Dr. Erik Baurdoux (London School of Economics, UK)
- Carina Geldhauser (Bonn University, Germany)

Local Organizers

- Chair: Prof. Bayarmagnai Gombodorj (NUM, Mongolia)
- Prof. Sarantuya Tsedendamba (MUST, Mongolia)
- Dr. Baljinnyam Ts. (MUST, Mongolia)
- Dr. Uuganbaatar Ninjbat (NUM, Mongolia)
- Dr. Ganbat Atarsaikhan (NUM, Mongolia)
- Prof. Barsbold Bazarragchaa (NUM, Mongolia)
- Dr. Tsogzolmaa Saizmaa (NUM, Mongolia)
- Dr. Otgonbayar Uuye (NUM, Mongolia)
- Dr. Bayerjargal Batsukh (NUM, Mongolia)

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- Dr. Christina Goldschmidt (Oxford University, UK)
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- Dr. Otgonbayar Uuye (NUM, Mongolia)

Sponsorship

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ADIYASUREN	VANDANJAV	MONGOLIA	NATIONAL UNIVERSITY OF MONGOLIA
ALTANGEREL	LKHAMSUREN	MONGOLIA	GERMAN MONGOLIAN INSTITUTE OF TECHNOLOGY
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ARCEDE	JAYROLD	PHILIPPINES	CARAGA STATE UNIVERSITY
ARIUNGEREL	JARGAL	MONGOLIA	MONGOLIAN UNIVERSITY OF SCIENCE AND TECHNOLOGY
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BECK	LISA	GERMANY	UNIVERSITY OF AUGSBURG
BEHME	ANITA	GERMANY	TECHNICAL UNIVERISTY OF MUNICH
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BLACQUE	PIERRE	UNITED KINGDOM	IMPERIAL COLLEGE LONDON
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CHU	WEIJUAN	CHINA	NANJING UNIVERSITY
CHULUUNDORJ	BEKH-OCHIR	MONGOLIA	NATIONAL UNIVERSITY OF MONGOLIA
CHULUUNTSETSEG	L	MONGOLIA	MONGOLIAN UNIVERSITY OF SCIENCE AND TECHNOLOGY
DAI	JUN	CHINA	FUDAN UNIVERSITY, SHANGHAI
DAVAASUREN	CHULUUNBAATAR	MONGOLIA	INSTITUTE OF FINANCE AND ECONOMICS
DELGERMAA	MAGSARJAV	MONGOLIA	DARKHAN UNIVERSITY OF TECHNOLOGY
DEPERSCHMIDT	ANDREJ	GERMANY	UNIVERSITY OF FREIBURG
DI GIROLAMI	CRISTINA	ITALY	UNIVERSITY OF PESCARA
DIECKMANN	MARTIN	GERMANY	BIELEFELD UNIVERSITY
DIOP	FATOU NÉNÉ	SENEGAL	ALIOUNE DIOP UNIVERISTY
DOERING	LEIF	GERMANY	MANNHEIM UNIVERSITY
DONG	YUCHAO	CHINA	FUDAN UNIVERSITY, SHANGHAI
DORJSUNDUI	GOMBOHURTS	MONGOLIA	NATIONAL UNIVERSITY OF MONGOLIA
EBERLEIN	ERNST	GERMANY	UNIVERSITY OF FREIBURG
ERDENEBAATAR CHADRAA	ERDENEBAATAR	UNITED STATES	MINNESOTA STATE UNIVERSITY
ESENBEK	KEREI	MONGOLIA	NATIONAL UNIVERSITY OF MONGOLIA
ESSAKY	EL HASSAN	MOROCCO	CADI AYYAD UNIVERSITY
FAIZ	FAIZULLAH	PAKISTAN	NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY
FISHKOV	ALEXANDER	RUSSIA	ST. PETERSBURG, RUSSIAN ACADEMY OF SCIENCES
GANBAT	ATARSAIKHAN	MONGOLIA	NATIONAL UNIVERSITY OF MONGOLIA
GANBAT	BATMUNKH	MONGOLIA	OLONLOG SCHOOL
GANTUMUR	TSOGTGEREL	CANADA	McGILL UNIVERSITY, MONTREAL
GELDHAUSER	CARINA	GERMANY	UNIVERSITY OF BONN
GERELMAA	GERELT-OD	MONGOLIA	NATIONAL UNIVERSITY OF MONGOLIA
GERELTUYA	BAYANMUNKH	MONGOLIA	NATIONAL UNIVERSITY OF MONGOLIA
GOLDSCHMIDT	CHIRSTINA	UNITED KINGDOM	UNIVERSITY OF OXFORD
GOZZI	FAUSTO	ITALY	LUISS UNIVERSITY OF ROME
HÄPPÖLÄ	JUHO	SAUDI ARABIA	KAUST
HATTORI	KUMIKO	JAPAN	TOKYO METROPOLITAN UNIVERSITY
HE	HUI	CHINA	BEIJING NORMAL UNIVERSITY
HORTON	EMMA	UNITED KINGDOM	UNIVERSITY OF BATH
JAMIYANSHARAV	BATCHULUUN	MONGOLIA	NATIONAL UNIVERSITY OF MONGOLIA
KHONGORZUL	DASH	MONGOLIA	NATIONAL UNIVERSITY OF MONGOLIA
KIM	SOJUNG	SOUTH KOREA	KAIST
KUMAR	CHAMAN	UNITED KINGDOM	UNIVERSITY OF EDINBURGH
KUNTSCHIK	ANDREA	GERMANY	FRANKFURT UNIVERSITY
KUWADA	KAZUMASA	JAPAN	TOKYO INSTITUTE OF TECHNOLOGY
KWOK	YUE KUEN	HONG KONG	HKUST
KYPRIANOU	ANDREAS	UNITED KINGDOM	UNIVERSITY OF BATH
LALAOUI BEN CHERIF	SIDI MOHAMED	MOROCCO	CADI AYYAD UNIVERSITY
LAMBERT	AMAURY	FRANCE	UNIVERSITY OF PARIS VI AND COLLEGE DE FRANCE
LOZANO TORRUBIA	PABLO	UNITED KINGDOM	UNIVERSITY OF NOTTINGHAM
MA	CHUNHUA	CHINA	NANKAI UNIVERSITY
MAKHGAL	GANBOLD	MONGOLIA	NATIONAL UNIVERSITY OF MONGOLIA

LAMBERT	AMAURY	FRANCE	UNIVERSITY OF PARIS VI AND COLLEGE DE FRANCE
LOZANO TORRUBIA	PABLO	UNITED KINGDOM	UNIVERSITY OF NOTTINGHAM
MA	CHUNHUA	CHINA	NANKAI UNIVERSITY
MAUDUIT	CHRISTIAN	FRANCE	CIMPA/MARSAILLE-LUMINY
MAKHGAL	GANBOLD	MONGOLIA	NATIONAL UNIVERSITY OF MONGOLIA
MANDUKHAI	OTGONBAATAR	MONGOLIA	NATIONAL UNIVERSITY OF MONGOLIA
MATETSKI	KONSTANTIN	UNITED KINGDOM	UNIVERSITY OF WARWICK
MAULIDI	IKHSAN	INDONESIA	BOGAR AGRICULTURAL UNIVERSITY
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MUNKHJARGAL	BATKHUYAG	MONGOLIA	INSTITUTE OF FINANCE AND ECONOMICS
NAJNUDEL	JOSEPH	FRANCE	UNIVERSITY OF TOULOUSE PAUL SABATIER
NANZADRAGCHAA	DAMBASUREN	MONGOLIA	NATIONAL UNIVERSITY OF MONGOLIA
NARANJARGAL	PUREV-OCHIR	MONGOLIA	NATIONAL UNIVERSITY OF MONGOLIA
NAVCHAA	TSERENDORJ	MONGOLIA	NATIONAL UNIVERSITY OF MONGOLIA
NIKITENKO	ANTON	AUSTRIA	INSTITUTE OF SCIENCE AND TECHNOLOGY
NOBA	KEI	JAPAN	KYOTO UNIVERSITY
OKSENDAL	BERNT	NORWAY	UNIVERSITY OF OSLO
ORGIL	BAT-ULZII	MONGOLIA	INSTITUTE OF FINANCE AND ECONOMICS
OTGONBAYAR	UUYE	MONGOLIA	NATIONAL UNIVERSITY OF MONGOLIA
OYUN	BATKHUYAG	MONGOLIA	TENGER INSURANCE
OYUNDELGER	M	MONGOLIA	NATIONAL UNIVERSITY OF MONGOLIA
OYUNERDENE	NARANKHUU	MONGOLIA	NATIONAL UNIVERSITY OF MONGOLIA
OYUNERDENE	NAMSRAI	MONGOLIA	NATIONAL UNIVERSITY OF MONGOLIA
OYUNERDENE	SELENGE	MONGOLIA	STATE BANK
PAN	YUQING	AUSTRALIA	UNIVERSITY OF MELBOURNE
PAPAGEORGIOU	IOANNIS	SWEDEN	UPPSALA UNIVERSITY
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PUREVSUREN	DAMBA	MONGOLIA	NATIONAL UNIVERSITY OF MONGOLIA
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SARANTUYA	TSEDENDAMBA	MONGOLIA	MONGOLIAN UNIVERSITY OF SCIENCE AND TECHNOLOGY
SAVINKINA	EKATERINA	RUSSIA	SOBOLEV INSTITUTE, NOVOSIBIRSK
SCHREITER	MAXIMILIAN	GERMANY	UNIVERSITY OF LEIPZIG
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SONG	YANG	CHINA	FUDAN UNIVERSITY, SHANGHAI
SULISTIANINGSIH	EVY	INDONESIA	TANJUNGPURA UNIVERSITY
SUMIYA	BAASANDORJ	MONGOLIA	MONGOLIAN STATE UNIVERSITY OF EDUCATION
SURYAWAN	HERRY PRIBAWANTO	INDONESIA	SANATA DHARMA UNIVERSITY
TAIVANSAIKHAN	TSETSENDELGER	MONGOLIA	NEW MONGOL INSTITUTE OF TECHNOLOGY
TSERENBAT	OIROV	MONGOLIA	NATIONAL UNIVERSITY OF MONGOLIA
TSOGZOLMAA	SAIZMAA	MONGOLIA	NATIONAL UNIVERSITY OF MONGOLIA
TSUKADA	HIROSHI	JAPAN	OSAKA CITY UNIVERSITY
TUMENBAYAR	DAVAANYAM	MONGOLIA	NATIONAL UNIVERSITY OF MONGOLIA
UDOYE	ADAOBI MMACHUKWU	NIGERIA	UNIVERSITY OF IDABAN
UNDARMAA	ENKHBAYAR	MONGOLIA	TENGER INSURANCE
UNDRAM	CHINGGIS	MONGOLIA	
UUGANBAATA	NINJBAT	MONGOLIA	NATIONAL UNIVERSITY OF MONGOLIA
UUGANBAYAR	SODNOM	MONGOLIA	STATE BANK
VAKEROUDIS	STAVROS	CYPRUS	UNIVERSITY OF CYPRUS
VAN DER HOFSTAD	REMCO	NETHERLANDS	TECHNICAL UNIVERSITY OF EINDHOVEN
WETZER	ELISABETH	AUSTRIA	VIENNA UNIVERSITY OF TECHNOLOGY
WRESCH	LUKAS	GERMANY	BIELEFELD UNIVERSITY
XU	QING	CHINA	FUDAN UNIVERSITY, SHANGHAI
YAMAZAKI	KAZUTOSHI	JAPAN	KANSAI UNIVERSITY
YANG	TING	CHINA	BEIJING INSTITUTE OF TECHNOLOGY
YEN	JU-YI	UNITED STATES	UNIVERSITY OF CINCINATI
YU	LICHAO	CHINA	FUDAN UNIVERSITY, SHANGHAI
ZAMANDII	SANDAGDORJ	MONGOLIA	NATIONAL UNIVERSITY OF MONGOLIA
ZHUO	YU	CHINA	FUDAN UNIVERSITY, SHANGHAI
ZOLBAYAR	E	MONGOLIA	NATIONAL UNIVERSITY OF MONGOLIA
ZOLJARGAL	MUNKHJARGAL	MONGOLIA	NATIONAL UNIVERSITY OF MONGOLIA
ZORIGT	CHOINKHOR	MONGOLIA	MONGOLIAN STATE UNIVERSITY OF EDUCATION

Appendix B: Poster Session abstracts

The following list of abstracts for the poster session was distributed in the welcome pack.

Jongchun Bae

Title: Schauder estimates of nonlocal operators in generalized Hölder spaces

Abstract:

We prove Schauder estimates in generalized Hölder spaces $C^{\psi}(\mathbb{R}^d)$. These spaces are characterized by a general modulus of continuity ψ, which cannot be represented by a real number. We consider linear operators $\mathcal{L}$ between such spaces. The operators $\mathcal{L}$ under consideration are integro-differential operators with a functional order of differentiability φ which, again, is not represented by a real number. Assuming that $\mathcal{L}$ has ψ-continuous coefficients, we prove that solutions $u \in C^{\varphi\psi}(\mathbb{R}^d)$ to linear equations $\mathcal{L}u = f \in C^{\psi}(\mathbb{R}^d)$ satisfy a priori estimates in $C^{\varphi\psi}(\mathbb{R}^d)$.

Carina Geldhauser

Title: The continuum limit of a particle system with long-range interaction

Abstract: The goal of this project is to describe the macroscopic behavior of an interacting particle system: Given N particles whose trajectories are described by stochastic ordinary differential equations, which are coupled together by the so-called interaction term, we would like to "zoom out" and describe only the effective behavior of the whole system. By scaling the appearing terms and imposing certain conditions on the interaction strength, we are able to pass to the limit as the number of particles tend to infinity to arrive at a well-posed stochastic partial differential equation.

Juho Häppölä

Title: Error analysis in Fourier Methods for option pricing for exponential Lévy processes

Abstract: We derive an error bound for utilising the discrete Fourier transform method for solving Partial Integro-Differential Equations (PIDE) that describe European option prices for exponential Levy driven asset prices. We give sufficient conditions for the existence of a L_∞ bound that separates the dynamical contribution from that arising from the type of the option in question. The bound achieved does not rely on information of the asymptotic behaviour of option prices at extreme asset values. In addition, we demonstrate improved numerical performance for select examples of practical relevance when compared to established bounding methods.

Sidi Mohamed Lalaoui

Title: Fourier based valuation formula and computation of Greeks in the Lévy forward process model

Abstract: A key issue of quantitative finance is to compute the expectations arising as prices of derivative products. Efficient methods are crucial in this context in particular for calibration purposes. During a calibration procedure in each iteration step typically a large number of model prices has to be computed and compared to market prices. A method which almost always works to get expectations is Monte Carlo simulation. Its disadvantage is that it is computer intensive and therefore too slow for many purposes. Another classical approach is to represent prices as solutions of partial differential equations (PDEs) which in the case of Lévy processes with jumps become partial integro–differential equations (PIDEs). This approach applies to a wide range of valuation problems, in particular it allows to compute prices of American options as well. Nevertheless the numerical solution of PIDEs rests on sophisticated discretization methods and corresponding programs. In this paper we concentrate on the third, namely the Fourier based approach.
For most derivative products in finance, one wants to use a dynamic hedging strategy. For this the trader needs to know Greeks which are the derivatives of the pricing functional with respect to specific parameters. Greeks are traditionally estimated by means of a finite difference approximation. Two kinds of errors are produced this way: the first one comes from the approximation of the derivative by a finite difference and the second one results from the numerical computation of the expectation. To eliminate one of the sources of error, Fournié *et al.* (1999) adopted a new approach which consists in shifting the differential operator

from the pricing functional to the diffusion kernel. This procedure results in an expectation operator applied to the payoff multiplied by a random weight function.

In this paper we focus on the Lévy forward process model which has been introduced in Eberlein and Özkan (2005). A major advantage of this model is that the driving process remains a time–inhomogeneous Lévy process under the backward induction that is necessary to get the rates in a convenient homogeneous form. To be more precise, the measure changes along the tenor structure are analytically much simpler compared to the corresponding measure changes in the LIBOR model. The reason is that in each induction step the forward process itself represents up to a norming constant the density process on which the measure change is based. As a consequence any approximation such as the 'frozen drift' approximation or more sophisticated versions of it are completely avoided. This means that the corresponding approximation error with which one has to struggle in the LIBOR approach does not show up in the forward process approach. In addition in the latter model the increments of the driving process translate directly into increments of the LIBOR rates. This is not the case for the LIBOR model where the increments of the LIBOR rates are proportional to the corresponding increments of the driving process scaled with the current value of the LIBOR rate. Expressed in terms of the terminology which will be developed in sections **??** and **??** this means that in the Lévy LIBOR model

$$L(t+\Delta t,T_k)-L(t,T_k)\ \sim\ L(t,T_k)(L_{t+\Delta t}^{T_{k+1}}-L_t^{T_{k+1}}) \tag{1}$$

whereas in the Lévy forward process model

$$L(t+\Delta t,T_k)-L(t,T_k)\ \sim\ \delta_k^{-1}(L_{t+\Delta t}^{T_{k+1}}-L_t^{T_{k+1}}). \tag{2}$$

The first goal of this paper is to give a closed Fourier based valuation formula for a caplet in the framework of the Lévy forward process model. The second aim is to study sensitivities. We discuss two approaches for this purposes. The first is based on the integration–by–parts formula, which lies at the core of the application of the Malliavin calculus to finance as developed in Fournié *et al.* (1999), León *et al.* (2002), Petrou (2008), Yablonski (2008). The second approach consists in using Fourier based methods for pricing derivatives. For a survey of Fourier based methods see Eberlein (2013). We illustrate the result by applying the formula to the pricing of a caplet where the jump–part of the underlying model is driven by a time–inhomogeneous Gamma process and alternatively by a Variance Gamma process. We will derive an explicit valuation formula for standard interest rate derivatives such as caps and floors in the Lévy forward process model. Since floor prices can be derived from the corresponding put–call–parity relation we concentrate on caps. Recall that a cap is a sequence of call options on subsequent LIBOR rates. Each single option is called a caplet. The payoff of a caplet with strike rate K and maturity T_i^* is

$$\delta_i^*\left(L(T_i^*,T_i^*)-K\right)^+ \tag{3}$$

where the payment is made at time point T_{i-1}^*. The forward LIBOR rates $L(T_i^*,T_i^*)$ are the discretely compounded, annualized interest rates which can be earned from investment during a future interval starting at T_i^* and ending at T_{i-1}^* considered at the time point T_i^*. These rates can be expressed in terms of the forward prices as follows

$$L(T_i^*,T_i^*)=\frac{1}{\delta_i^*}\left(F(T_i^*,T_i^*,T_{i-1}^*)-1\right). \tag{4}$$

Its time–0–price, denoted by $Cplt_0(T_i^*,K)$, is given by

$$Cplt_0(T_i^*,K)\ \ =\ \ B(0,T_{i-1}^*)\delta_i^*\mathbb{E}_{\mathbb{P}_{T_{i-1}^*}}\left[(L(T_i^*,T_i^*)-K)^+\right]. \tag{5}$$

Instead of basing the pricing on the Lévy LIBOR model one can use the Lévy forward process approach (see Eberlein and Özkan (2005)). It is then more natural to write the pricing formula (5) in the form

$$Cplt_0(T_i^*,K)=B(0,T_{i-1}^*)\mathbb{E}_{\mathbb{P}_{T_{i-1}^*}}\left[\left(F(T_i^*,T_i^*,T_{i-1}^*)-\widetilde{K}_i\right)^+\right] \tag{6}$$

where $\widetilde{K}_i := 1 + \delta_i^* K$.
Define the random variable $X_{T_i^*}$ as the logarithm of $F(T_i^*, T_i^*, T_{i-1}^*)$. Therefore,

$$X_{T_i^*} = \ln\big(F(0, T_i^*, T_{i-1}^*)\big) + \int_0^{T_i^*} \lambda(s, T_i^*) dL_s^{T^*} + d(T_i^*, T_i^*). \tag{7}$$

Proposition 0.1. *Suppose there is a real number $R \in (1, 1+\varepsilon)$ such that the moment generating function of $X_{T_i^*}$ with respect to $\mathbb{P}_{T_{i-1}^*}$ is finite at R, i.e. $M_{X_{T_i^*}}(R) < \infty$. Then*

$$\begin{aligned} \mathrm{Cplt}_0(T_i^*, K) = \frac{\widetilde{K}_i B(0, T_{i-1}^*)}{2\pi} \int_{\mathbb{R}} \Bigg\{ \left(\frac{F(0, T_i^*, T_{i-1}^*)}{\widetilde{K}_i} \right)^{R+\mathrm{i}u} \\ \times \exp\left(\int_0^{T^*} \int_{\mathbb{R}} e^{x\Lambda^{i-1}(s)} \left[\left(e^{(R+\mathrm{i}u)x\lambda(s,T_i^*)} - 1 \right) - (R+\mathrm{i}u) \left(e^{x\lambda(s,T_i^*)} - 1 \right) \right] F_s^{T^*}(dx) ds \right) \\ \times \exp\left(\int_0^{T^*} \frac{c_s}{2} (R+\mathrm{i}u)(R+\mathrm{i}u-1) \lambda^2(s, T_i^*) ds \right) \Bigg\} \frac{du}{(R+\mathrm{i}u)(R+\mathrm{i}u-1)} \end{aligned} \tag{8}$$

Ekaterina Savinkina

Title: Explicit estimates of an unknown parameter in one power regression problem

Abstract: The subject of my research work is to estimate an unknown parameter in a special nonlinear regression problem. Suppose we observe random variables $\{Y_i\}$ represented in a way

$$Y_i = \sqrt{1 + \alpha x_i} + \varepsilon_i, i = 1, 2, ...,$$

where $\{\varepsilon_i\}$ are unobserved random variables and $\{x_i > 0\}$? some non-random observations. We require the following usual conditions to be met:

$$\mathbb{E}\varepsilon_i = 0, 0 < \mathrm{Var}(\varepsilon_i) = \sigma^2 < \infty. \tag{9}$$

Our aim is to estimate unknown parameter $\alpha > 0$.

This problem was first mentioned in E.Z. Demidenko's monograph [2] as a standard example of nonlinear regression where ordinary least squares estimation faces some serious computing difficulties. During my research work it was found that explicit unbiased estimate of the unknown parameter can be represented as a ratio of two linear statistics depending on specially chosen constant values $\{c_{ni}, n = 2, 3..., i = 1, ..., n\}$:

$$\alpha_n^* = \sum_{i=1}^n c_{ni} Y_i^2 \Big/ \sum_{i=1}^n c_{ni} x_i,$$

where

$$\sum_{i=1}^n c_{ni} = 0, \sum_{i=1}^n c_{ni} x_i \neq 0. \tag{10}$$

Moreover two theorems were stated and proven.

Theorem 1: Let random variables $\{c_{ni} Y_i^2\}$ satisfy Lindeberg condition. Also conditions (1) and (2) must be met. Then

$$\frac{\alpha_n^* - \alpha}{d_n} \Rightarrow \mathcal{N}(0, 1), \tag{11}$$

where

$$d_n^2 = \sum_{i=1}^n c_{ni}^2 \mathrm{Var}(\xi_i) \Big/ \Big(\sum_{i=1}^n c_{ni} x_i \Big)^2,$$

$\xi_i = 2\varepsilon_i \sqrt{1 + \alpha x_i} + \varepsilon_i^2 - \sigma^2$.

Theorem 2: Suppose $\{\xi_i\}$ have non-zero variances for all i. Then the following inequality holds for each set of $\{c_{ni}\}$ satisfying (2):

$$d_n^2 \geq d_{n,opt}^2 > 0, \tag{12}$$

where

$$d_{n,opt}^2 = 2K_0 \Big/ \sum_{i \neq j} \frac{(x_i - x_j)^2}{\mathrm{Var}(\xi_i)\mathrm{Var}(\xi_j)}, \;\; K_0 = \sum_{i=1}^{n} \frac{1}{\mathrm{Var}(\xi_i)}.$$

Furthermore equality in (4) is achieved if and only if $\{c_{ni}\}$ satisfy the following condition:

$$c_{ni} = K c_{ni,0}, \text{ where } \quad c_{ni,0} = \frac{x_i}{\mathrm{Var}(\xi_i)} - \frac{1}{K_0 \mathrm{Var}(\xi_i)} \sum_{i=1}^{n} \frac{x_i}{\mathrm{Var}(\xi_i)}$$

for all $i \leq n$ and some constant value $K \neq 0$.

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[1] G.A.F. Seber, C.J. Wild, Nonlinear Regression, Hoboken, John Wiley & Sons, Inc., 2003.

[2] E.Z. Demidenko, Optimization and Regression, Moscow, Nauka, 1989.

[3] Yu.Yu. Linke, A.I. Sakhanenko, Asymptotically Normal Parameter Estimation in One Fractional Linear Regression Problem, Siberian Mathematical Journal, 41, 1 (2000), 150 - 163.

[4] K.V. Yermolenko, A.I. Sakhanenko, Explicit Asymptotically Normal Estimates of An Unknown Parameter in One Partially Linear Regression Problem, Siberian Electronic Mathematical Reports, 10 (2013), 719 - 726.

[5] Yu.Yu. Linke, A.I. Sakhanenko, Asymptotically Optimal Estimation in A Linear Regression Problem With Random Errors in Coefficients, Siberian Mathematical Journal, 51, 1 (2010), 128 - 145.

Hiroshi Tsukada

Abstract: In this poster, I study a Tanaka formula for the local time of one-dimensional stable processes with index $\alpha \in (1, 2)$ in a framework of Itô's stochastic calculus.

Elisabeth Wetzer

Title: Development of computer based quantification and analysis of movement

Abstract: Over the past few years algorithms used to identify objects in motion and to quantify e.g. the velocities and trajectories have greatly improved. However, each application needs very individual tuning of parameters and the methods used in face recognition or surveillance purposes differ widely from the approach used in animal experiments. To study longterm effects of pharmaceuticals on the shoaling behavior of guppies, we wrote a software that uses image processing tools and adaptive Gaussian mixture models to distinguish between the back- and foreground to detect the moving fish. The tracking itself relies on Kalman filtering, which is a widely used method in tracking applications. By using the motion information of the target objects in previous frames the filter predicts the future location based on a linear motion model to which white Gaussian noise is added. An implementation of the Hungarian algorithm finds the nearest neighbors among detections and predictions in case of multiple objects and in the corrector phase the estimated target positions are adjusted by the observed values thus minimizing the residual differences between predictions and detections.