SAMBa ITT6: Sensing and Complex Flows
5^{th} - 9^{th} June 2017

BRLSI, Bath

Participants with resident Plesiosaur on day 2 of ITT5

Contents

1 Introduction to SAMBa

SAMBa is the EPSRC Centre for Doctoral Training in Statistical Applied Mathematics at the University of Bath. It is funded by EPSRC and aims to support 50+ PhD students over 8 years. There will be 5 intakes (in September each year) of around 10 students. 2014 was the first intake of students to SAMBa.

Students undertake a 1+3 model PhD, with taught courses in their first year, leading to an MRes qualification, and then 3 years of research funding, leading to a PhD. Throughout their time in SAMBa, and in addition to their PhD research, students will be exposed to a range of mathematical problems, faced by non-academics, and academics in non-mathematics departments, as well as those at the forefront of mathematical research. Central to this goal are the Integrative Think Tanks (ITTs).

Integrative Think Tanks bring together students, academics and external partners over a week. Problems are presented and students, with support from academic attendees from the Department of Mathematical Sciences, are expected to *formulate* research solutions, defining the routes to solving the problems, rather than solving them outright. It is hoped that discussions at ITTs will form the basis of PhD projects for some SAMBa students, hopefully a number of these will be co-funded by external partners. However, ITTs generate a range of problems that can be tackled in different ways by experts in the department through short- or long-term research projects, funded through a variety of mechanisms.

In short, ITTs provide a vibrant working environment, leading to a high volume of quality research with impact.

2 Theme and Participants

The major theme of this ITT will be *sensing and complex flows*. The partner organisations attending are Schlumberger (`http://www.slb.com/`) and the University's department of Chemical Engineering (`http://www.bath.ac.uk/chem-eng/research/`).

Schlumberger is the world's largest oilfield services company and supplies the petroleum industry with services such as seismic acquisition and processing, formation evaluation, well testing and directional drilling, well cementing and stimulation, artificial lift, well completions, flow assurance and consulting, and software and information management. The University of Bath's department of **Chemical Engineering** represent our first academic ITT partners. Chemical Engineering carry out research from the fundamental to blue skies, addressing the challenges of chemical, materials, pharmaceutical, biochemical, biomedical, water, and waste treatment industries.

Over the last few months, we have been working with them on scoping a variety of statistical applied mathematics driven problems including transport dynamics, interfacial behaviour, pore size distribution, molecular simulations, data analysis and interpretation, sensing and inverse problems, data acquisition and representation, and Bayesian inference for parameter estimation and model reduction. These subjects will be expanded further through discussion at ITT6.

The ITT is part of the SAMBa students' training programme and as such, all students who are in their first year will attend. We also welcome students who are in the later years of SAMBa, and additional PhD students from the department. Non-SAMBa students will not be expected to present or write up a report, as the SAMBa students are, but will of course be welcome to do so if they would like to.

Many academics from the Department of Mathematical Sciences will participate in the ITT, alongside academics from the departments of Physics and Chemistry. These are both academics who have worked with the partners attending, and those who have had no interaction with them.

It is expected that all participants of the ITT commit to attend for the full week and that they are fully engaged on each day. There will be plenty of flexibility in the planning so if we find that something is not working, we will be able to change the format (within reason) as we go along. The timings have deliberately been kept flexible to allow this to happen. The Friday of the ITT will be an Observation Day where people interested in future ITTs, or other ways to engage with SAMBa, will be present to see what has come out of the week.

3 List of Participants

Students and postdocs

- Román Aguirre-Pérez (PhD, Maths)
- Eleanor Barry (SAMBa 2017)
- Jack Betteridge (SAMBa 2015)
- Beth Boulton (SAMBa 2015)
- Jon Chouler (PhD, Chem Eng)
- Emiko Dupont (SAMBa 2016)
- Matt Durey (SAMBa 2014)
- John Fernley (SAMBa 2016)
- Tom Finn (SAMBa 2017)
- Carlos Galeano Rios (Postdoc)
- Lola González (PhD, Chem Eng)
- Uziel González (SAMBa 2016)
- Elizabeth Gray (SAMBa 2016)
- Matt Griffith (PhD, Maths)
- Emma Horton (PhD, Maths)
- Nadeen Khaleel (SAMBa 2016)
- Matthias Klar (SAMBa 2016)
- Amélie Klein (SAMBa 2016)
- Matt Lee (SAMBa 2016)
- Andrea Lelli (SAMBa 2015)
- Sam Moore (SAMBa 2015)
- Kgomotso Morupisi (PhD, Maths)
- Daniel Ng (SAMBa 2016)
- Sandra Palau Calderón (Postdoc)
- Owen Pembery (SAMBa 2015)
- Tom Pennington (SAMBa 2016)
- Lizzi Pitt (SAMBa 2016)
- Kate Powers (SAMBa 2015)
- Adwaye Rambojun (SAMBa 2015)
- Ben Robinson (SAMBa 2015)
- Malena Sabate Landman (SAMBa 2016)
- Tsoogii Saizmaa (SAMBa 2016)
- Will Saunders (PhD, Maths)
- Anna Senkevich (SAMBa 2015)
- Shaerdan Shataer (SAMBa 2015)
- Cameron Smith (SAMBa 2016)
- Hayley Wragg (PhD, Maths)

Academics

- Nicole Augustin (Bath Maths)
- Dorothy Buck (Bath Maths)
- Chris Budd (Bath Maths)
- Melina Freitag (Bath Maths)
- Silvia Gazzola (Bath Maths)
- Ivan Graham (Bath Maths)
- Chris Guiver (Bath Maths)
- Kari Heine (Bath Maths)
- Usama Kadri (Cardiff Maths)
- Barbara Kasprzyk Horden (Bath Chem)
- Eike Müller (Bath Maths)
- Mark Opmeer (Bath Maths)
- Steve Parker (Bath Chem)
- Rob Scheichl (Bath Maths)
- Tony Shardlow (Bath Maths)
- Euan Spence (Bath Maths)

Partners

- Inês Cécilio (Schlumberger)
- John Chew (Chem Eng)
- Mirella di Lorenzo (Chem Eng)
- Tina Düren (Chem Eng)
- Edmund Fordham (Schlumberger)
- Carmelo Herdes (Chem Eng)
- Matthew Lennox (Chem Eng)
- Nuno Reis (Chem Eng)
- Jannis Wenk (Chem Eng)
- Can Evren Yarman (Schlumberger)

SAMBa team

- Susie Douglas (Manager)
- Andreas Kyprianou (Co-Director)
- Paul Milewski (Co-Director)
- Jess Ohren (Administrator)
- Fran Staples (BIRD)

Observer Day attendees

- Aoibheann Brady (SAMBa 2015)
- Nick Brook (Dean of Science)
- Teo Deveney (SAMBa 2017)
- Shaunagh Downing (SAMBa 2017)
- Alistair Forbes (NPL)
- Jan Taylor (EPSRC)
- David Worthington (DNV GL)

We are very sad that **Darrell Patterson**, who began collaboration between SAMBa & Chem Eng, died in February. We would like to acknowledge the contribution of Darrell to making the ITT a success. We will miss him greatly this week, and in the future.

4 Summary of ITT6

Start time: 9:30 End time: before 17:30	Monday	Tuesday	Wednesday	Thursday	Friday OBSERVATION DAY
	Coffee				
Morning (before 12:30)	• Introduction to ITT • Presentations of partner problems	• Presentations of partner problems • Group discussion	• ***Student presentations*** • Team work with roving academics	• Team work with roving academics	• Consolidation of ideas/briefing • ***Student presentations***
	Lunch				
Early afternoon (before 15:30)	• Group discussion	• Group discussion • Form working teams	• Team work with roving academics	• Team work with roving academics	• ***Student presentations*** • Concluding remarks
	Coffee				
Late afternoon (before 17:30)	• Further background presentations	• Team consolidation	• Team work with roving academics	• Team work with roving academics	• Informal discussion and refreshments
	Break				
Evening	• Informal discussion with drinks	• Participant dinner		• Optional late working with pizza	

Summary of programme for ITT6

5 Structure of ITT6

5.1 Monday 5th June, 9:30 - 17:30

Aim of the day:

To gain a full understanding of high-level non-academic problems, through presentations and group discussions, and to determine the direction further discussions should take during the rest of the week.

Introduction and welcome, *30 minutes*

Andreas Kyprianou, Paul Milewski, and Susie Douglas, of SAMBa will welcome everyone to the ITT and explain the format of the week. This will augment the information provided in this booklet.

Presentation of problems and discussion

The first two days will be devoted primarily to understanding the nature of the problems that Chemical Engineering and Schlumberger have, and distilling them into mathematical language. It is important at this stage that the ITT participants fully understand the context of the problems that they are being presented with. Therefore, this session should be seen as a very open and supportive one, with no question being judged as trivial or stupid.

There will be a number of presentations from non-academic and academic participants who have experience of working on the sorts of problems being presented. Whilst non-academic representatives will present high level problems that their organisations are facing, the academics will give a flavour of the approaches that can be used to work on these sorts of problems. It is not expected that the approaches described will necessarily be the ones that are taken forward during the rest of the ITT, where the focus is primarily on developing new areas of research, and exploring a range of different routes to do this.

Presentation of *procedure* **problems** *2 hours*

The session will be chaired by **Andreas Kyprianou** and presenters are:

- Nuno Reis (Modelling of bubble size distribution and mass transfer in steady and unsteady gas-liquid flows)
- John Chew & Jannis Wenk (Growth and break-up of microbubbles)
- Inês Cécilio (Online Bayesian inference for the detection and monitoring of hazardous events in drilling operations)
- Edmund Fordham (Fully Bayesian analysis of multi-exponential decays in low resolution NMR)
- Carmelo Herdes (*(a)* Surfactant design assisted by Molecular Simulation, the lost CMC *(b)* PSD by Tikhonov's regularization method. Can we do better?)

Group discussions on presented problems *2 hours*

Following the presentations, there will be a chance to discuss the information presented in a plenary session. The participants will then split into small, pre-determined **groups** and work together to identify 3 or 4 key mathematical questions that have arisen from the information so far and that

they feel warrant further discussion during the week. Each of these groups has been assigned an academic chair, who is responsible for ensuring that discussions stay on track and that everyone contributes.

After the group discussion, there will be a further plenary session where the groups will share the questions that they have identified and these will be clustered into potential areas for further work during the week.

Further presentations *1 hour*

The day will end with some background presentations that may come in useful during the remainder of the week.

- Paul Milewski (Bubbles and flows with bubbles)
- Ron Scheichl (Multilevel Monte Carlo)
- Ivan Graham (Mathematical and numerical problems arising from full waveform inversion)

Informal discussion

There is the opportunity to stay on after day 1 to meet more of the participants, drinks will be provided at the BRLSI.

5.2 Tuesday 6th June, 9:30 - 17:30

Aim of the day:

To gain a full understanding of high-level non-academic problems, through presentations and group discussions, to determine the direction further discussions should take during the rest of the week, and to form teams for working on problem formulation for the rest of the week.

Presentation of *model* problems *2 hours*

The session will be chaired by **Paul Milewski** and the day 2 presenters are:

- Jon Chouler (Electroactive responses of bacteria for monitoring water quality)
- Evren Yarman (Waves with less)
- Tina Düren & Matthew Lennox (Small holes, big problems - getting the most out of Metal Organic Frameworks)

Group discussions on presented problems *2 hours*

Initially there will be a review and discussion of the information presented during a plenary session. The participants will then split into small, pre-determined **groups** and work together to identify 3 or 4 key mathematical questions that have arisen from the information so far and that they feel warrant further discussion during the week. Each of these groups has been assigned an academic chair, who is responsible for ensuring that discussions stay on track and that everyone contributes.

After the group discussion, there will be a further plenary session where the groups will share the questions that they have identified and these will be clustered into potential areas for further work during the week.

Review material and form working teams *1 hour*

At the end of the two group discussions, there should be a fair number of problems (5-10) that have been identified for further work during the week. The next step is to determine which of these problems will be pursued and who will be part of the associated **teams** working on them.

There will be an initial discussion between the student participants and the SAMBa management to determine what problems the students are keen to pursue and ensure that there are a quorum of 2-3 students per team. These teams and problems will then be presented briefly to the rest of the participants. It is expected that some participants will immediately identify with one problem and will therefore commit to that team for the rest of the week. This is particularly the case for non-academic attendees whose expertise will be essential during the team work, but it is also hoped that a small number of academics will join each team.

Some of the academics may feel that they have interests across more than one problem, some expertise that underpins a large amount of the mathematics being discussed, or an area of research that they would like to pursue independently of the teams that have been formed. All of these situations are acceptable and indeed welcome. Academics may choose to:

- *Float* between teams, sharing the outputs of discussion where relevant

- *Tutor* teams in a mathematical concept fundamental to the discussion by running short tutorials that participants can attend
- *Splinter*, forming an academic discussion team on a different topic

Although some indication of the role each participant will play should be given during day 2, it will be possible to change teams and roles during the course of the week. Student participation is fixed for the whole week.

Consolidation of information and team planning *2 hours*

There will be a chance during the afternoon of day 2 to begin working on the problems that have been identified. Teams may choose to start working together immediately but this is also the chance for individuals to have some time to review what they have been presented with, and pursue further reading and investigation should they wish to do so. There is no prescribed way of working through the information and every approach is acceptable. However, it is important that from the beginning of day 3, the team is ready to start working intensively together.

On the evening of day 2, there will be a participant dinner held at Hall and Woodhouse. This will be a chance for further discussion on what has been covered during the first 2 days and other opportunities.

5.3 Wednesday 7th June, 9:30 - 17:30

Aim of the day:

To begin developing problem formulation. Students to present (*for assessment*) on early approaches being taken.

Consolidation of information and team planning *1 hour*
There will be a short time in the morning to consolidate ideas and to put material together for short presentations on the approaches that are planned. These presentations are meant to be short and introductory - a change for participants to see where teams plan to develop their ideas during the week.

Student presentations *1.5 hours*

At least one student member of each team presents for *5 minutes* on the approach that is being discussed. SAMBa students are expected to present at least once during the week, and will be assessed on this but, time permitting, other students are also encouraged to present.

This is a chance to obtain feedback and further expertise on the problems, and it is not expected that what teams present here will be their final approach to the problem.

Team work *5 hours*

Teams focus on the problems, considering how they could develop a challenging and quality research project from it. Those participants not in teams will *float*, *tutor* or *splinter*, or a combination of the three.

5.4 Thursday 8th June, 9:30 - 17:30

Aim of the day:

To formulate a research problem that can be taken forward into a future project.

Team work *all day*

Teams will work together, utilising the resources around them and interacting where necessary. There will be the chance to come back together into plenary, if requested by the participants.

Those who would like to stay late on Thursday should let us know by lunch time and we will order **pizza** to help the thought process.

5.5 Friday 9th June, 9:30 - 15:00

Aim of the day:

To consolidate and summarise the problem formulation via *assessed student presentations*. To identify outputs, determine next steps and share feedback.

Observer Briefing *1.5 hours - in parallel*

Invited observers will meet with SAMBa management who summarise the week. There is then the chance to network with ITT participants.

Consolidation of ideas *1.5 hours - in parallel*

A chance for teams to finalise their problem formulation and consider the future work which could ensue.

Student presentations *2.5 hours*

At least one student member of each team presents for *10 minutes* on the final formulation of the problem that they have discussed. SAMBa students will be assessed on this (and *must* present if they have not earlier in the week) but other students are also encouraged to present, time permitting.

Summing up

This session will be led by the SAMBa Management and will summarise the outputs of the week, and outline the next steps. Feedback in writing is also requested after the event.

Informal discussion

There will be a chance to interact with all participants less formally, reflecting on the achievements and hard work of the week. Refreshments will be provided.

5.6 After the ITT

There will be a number of activities that will be pursued post-ITT

SAMBa student proposals

SAMBa students must each write a proposal for a project, based on the formulation that was developed during the ITT week. The aim of this is to give students a chance to develop their skills in developing a route to pursue research. A document, based on the style of an EPSRC call for proposals, outlining the expected structure and content of the ITT proposal, is included as an annex. The proposals submitted will be assessed by the SAMBa Management team and other participants where deemed appropriate.

Future projects

Non-academic partners will discuss the potential projects that have been identified, with the SAMBa Management team, determining the routes to how they could be supported. This could take a number of routes:

- Student PhD projects, wholly or partially supported by partners
- Student PhD projects, with influence from partners
- Short-term, focussed, application-motivated projects
- Student reading courses (run through a semester as an assessed course)
- Student mini projects (run though a semester as an assessed course, or alongside an existing PhD project)
- Development of a proposal to a funder, such as EPSRC, to explore fundamental mathematical concepts with associated financial support
- A project taken by a student as an internship (a 3-6 month break from their PhD studies, paid for by partner)
- Further discussion and contemplation of an idea with additional expertise from the Department, University, or further afield

Developing future ITTs

ITT7 takes place in January 2018 and the experience and feedback from ITT6 will be essential in planning for this and future ITTs. Please complete your feedback forms to make sure that we can keep improving the experience.

6 Annex 2: Call for ITT proposals

Submission deadline: 26th June 2017

As part of the SAMBa training programme, students are expected to learn about and experience the process of writing grant proposals.

6.1 Writing a research proposal

All academics in the UK fund their research through a mixture of sources. This funding pays for the time of permanently based academics on the project (typically one of which will be formally applying for funding), as well paying for temporary research costs, such as a PhD studentship, 2-3 years of a postdoctoral researcher's salary, scientific equipment, travel, networking meetings and much more.

There are a number of major funders supporting Mathematics research in the UK and they all have different schemes and routes to funding.

These are:

- **Engineering and Physical Sciences Research Council (EPSRC):** a Government agency which is part of Research Councils UK (RCUK) and funds 200M GBP of Mathematical Sciences research in the UK. RCUK also consists of BBSRC (Biotechnology and Bio Sciences Research Council), NERC (Natural Environment Research Council), STFC (Science and Technology Facilities Council), AHRC (Arts and Humanities Research Council), ESRC (Economic and Social Science Research Council). All of these Councils also fund Mathematics research where it has an impact on their research areas.
- **European Commission:** this includes a large number of different schemes and mechanisms including the Marie Skłodowska-Curie programme, the European Research Council and Horizon 2020. All areas of research and training are funded and the impact of the research is as important as quality.
- **Leverhulme Trust:** a charitable body which supports research in all areas. They are particularly keen on research which has a benefit to society.
- **Royal Society:** a learned society, which funds primarily fellowships and networking activities in science, engineering and medicine.
- **London Mathematical Society:** a learned society which awards a variety of small grants for internships, travel, conference attendance and networking, amongst other things.
- **Institute of Mathematics and its Applications:** funds small grants and networking activities across Universities and schools.

Research proposals for these agencies are peer reviewed. That is to say, leading academics in the field are asked to provide a commentary on the quality, novelty, impact and relevance of the proposed research. In many cases, and in order to guarantee a degree of uniformity, reviewers are asked to complete a standard form which asks them to address specific questions about the

proposal. These forms are collated and brought to a further panel of experts who finally decide which proposals will receive funding.

In industry, where scientific research is taking place in a large organisation, it is often the case that research groups or individuals must write cases for internal financial support following a similar pattern to the way academics obtain funding. The main difference in that case is that the awarding body is the company itself, and no public funds are involved. For this reason, the criteria used to assess proposals may be quite different from those of, for example, EPSRC. Nonetheless, it is an important part of the process that the applicant can demonstrate the relevance of the research against the criteria of the awarding body.

6.2 ITT proposal

Following the ITT, students are asked to prepare a report in the style of a research proposal (the **Case for Support**). The format of this proposal, outlined below, is styled on a real call document. The main difference, however, is that the proposal need not specify details concerning the financial costing of the proposed research.

6.2.1 Introduction

For the purposes of this exercise, this proposal should be written as if the project has every intention of being carried out. It is likely that some of the proposals will form the basis of thesis formulation reports but they will not be supported as proposed.

Proposals will be reviewed using forms mimicking that attached in **Annex 2**. In addition reviewers will be asked to assign a score to each section and an overall score out of 100.

6.2.2 Assessment Criteria

There are a number of criteria which proposals will be assessed against. These are:

- **Quality:** the novelty and timeliness of the research proposed, in the context of the research area more generally
- **Impact:** including how realistic the impact described is, what activities will be undertaken to realise it, and whether the right interested parties have been identified
- **Approach:** the methodology proposed, whether this is feasible and appropriate for the challenges described, and whether the routes to involve partners is appropriate

6.2.3 Case for Support

Description of proposed research and its context (max. 7 sides of A4)[1]: Describe the proposed research and its context, to aid those reviewing your proposal in understanding what you plan to do and achieve, and where it fits into the current research activity. The document should include:

- **Background.** Introduce the proposal topic and explain its academic and applied context. To do this, you need to demonstrate understanding of related past and current work, explain the

[1]Lists of references and illustrations should be included in the seven A4 page limit, and not be submitted as additional attachments or as an annex.

long term effects of the proposed research, how it contributes to the health of other research disciplines, current or future economic success, future development of emerging industries or addresses societal challenges.

- **Impact.** Describe how your research would benefit researchers in the field and related disciplines, and what will be done to ensure that they can benefit. Explain collaborations with other researchers and their role in the project. Describe who potential beneficiaries outside the academic research community might be, and how the research might impact them.
- **Research hypothesis and objectives.** Set out your research ideas or hypotheses. Explain why the proposed project is novel and timely, both from societal and academic viewpoints. Identify the overall aims of the project, and the measurable objectives the outcome of the work will be assessed against.
- **Programme and methodology.** Detail and justify research methodology. Describe the work programme, detailed for each member of the research team, indicating research to be undertaken and milestones that will be used to monitor its progress. Explain how the programme of research will be managed.

In a real proposal, the Case for Support is your opportunity to convince peer reviewers that your research should be funded. Therefore, it needs to be written in a clear, concise and jargon free style. Describe how potential benefits align with existing priorities; and how it complements other research activity in the field. Explain what is exciting about the research to your audience, in particular your reviewers. You need to convince experts in the relevant research field about the value of your project. Convince reviewers your proposal is original, and describe your objectives clearly and succinctly. In real life, proposals are not rejected just because others are doing similar work, but if you don't describe the novelty of your approach or the likelihood of success, the value of your proposal is uncertain. Don't leave it to the proposal assessor to ask questions. Show that you have thought the proposal through, and explain how it will succeed. Potential applications might be obvious to you, but make sure you spell them out to reviewers.

7 Annex 3: Assessment form for ITT proposals

Assessment Criteria

- **Quality:** the novelty and timeliness of the research proposed, in the context of the research area more generally
- **Impact:** including how realistic the impact described is, what activities will be undertaken to realise it, and whether the right interested parties have been identified
- **Approach:** the methodology proposed, whether this is feasible and appropriate for the challenges described, and whether the routes to involve partners is appropriate

Quality

/35

Impact

/30

Approach

/35

Other comments

Conclusions

/100

Notes

Notes