

# Geometry, Stochastics & Dynamics

Celebrating 20 years of UK-Japan Winter Schools

We have two display boards in the Physics common room, where we also hold Monday reception and Thursday' dinner, please let the organisers or the assistants know.

## Monday Morning

Chair: Xue-Mei Li

- 10:00 am  
**Registration**
- 10:55-10:58 Acknowledgement (Yoshi Maeda)
- 11:00 am -11:50 am  
Kenji Fukaya (Stony-Brook).

### **Lagrangian correspondence and Floer homology**

Lagrangian correspondence is expected to play a role of 'morphisms' in the 'category' of symplectic manifolds, as proposed by Weinstein. In this talk I will explain its relation to Floer theory together (possible) applications. The latter includes,

- 1) Study of Floer homology of symplectic quotient
- 2) Existence of generating function for immersed Lagrangian submanifolds
- 3) Relation to gauge theory

## Monday Afternoon

Chair: David Elworthy

- 2:00pm-2:50pm  
Martin Hairer (ICL)  
**Scaling limits in 1+1 dimensions**
- 3:20pm-4:10 pm  
Chris Budd (Bristol)  
**The mathematics of climate change**  
Climate change is important, controversial, and the subject of huge debate. Much of our understanding of the future climate comes from the use of complex climate models based on mathematical and physical ideas.  
In this talk, I will describe how these models work and the assumptions that go into them. I will discuss how reliable our predictions of climate change are, and show how mathematicians can give us insights into both past and future.
- 4:20pm-5:10pm  
Yoshiaki Maeda (Tohoku/Keio)  
**UK-Japan Winter School since 1999 and Geometry of Loop space and the fundamental group of contact manifolds**

I would like to talk on two topics. The first part is to give a brief introduction on the UK-Japan Winter School since 1999.

The second part of my talk is my research work collaborated with Steven Rosenberg.

The diffeomorphism and isometry groups of manifolds are fundamental objects in global analysis. Specially interest to us are integral symplectic manifolds, contact manifolds. The other fundamental objects are the fundamental groups and orbits of Hamiltonian and Reeb vector fields. I will explain the work with Steven Rosenberg in which we use Wodzicki-Chern-Simons forms to prove that the fundamental group of manifolds is infinite for a certain higher dimensional contact manifolds with a circle action. For the Kodaira-Thurston manifold, we explicitly compute that this result holds for all  $p$ . We also give the first examples of nonvanishing Wodzicki-Pontryagin forms.

## Reception, Monday 5:30pm – (Physics Common Room)

### Tuesday Morning

Chair: Yoshi Maeda

- 9:30am-10:20 am  
Darryl Holm (ICL)

#### **A Stochastic Climate Change Model**

A generic approach to stochastic climate modelling is developed for the example of an idealized Atmosphere-Ocean model that rests upon Hasselmann's paradigm for stochastic climate models. Namely, stochasticity is incorporated into the fast moving atmospheric component of an idealised coupled model by means of stochastic Lie transport, while the slow moving ocean model remains deterministic. This is joint work with D Crisan and P Korn. A remarkable property of the model is that the dynamics of its higher moments are governed by deterministic equations obtained by replacing the drift velocity of the stochastic Lie transport vector field by its expected value.

- 10:50am-11:40am (online talk)  
Takashi Sakajo (kyoto)

#### **Topological flow data analysis - theory and applications**

We construct a mathematical theory classifying topological structures of orbits generated by structurally stable Hamiltonian vector fields, which is a model of two-dimensional incompressible fluid flows. Based on the classification theory, we can show that structurally stable Hamiltonian flows are in one-to-one correspondence with Reeb graphs, and their symbolic expressions, named COT representations. By using this theory, we then develop a new way of topological data analysis, which we call Topological Flow Data Analysis (TFDA). In the present talk, after the classification theory is presented, I will talk about the recent applications of TFDA to geophysical data in atmospheric science and oceanography. The talk is based on the joint works with T. Yokoyama (Gifu U), T. Uda (Tohoku U), M. Inatsu (Hokkaido U), S. Oishi (RIKEN) and K. Koga (Kyoto U).

### Tuesday Afternoon

Chair: Yoshihiro Ohnita

- 2:00pm-2:50pm  
Graeme Segal (Oxford).

**The smooth homotopy category**

Ordinary homotopy theory describes how a space is connected-up globally, disregarding its local structure. The objects of the smooth homotopy category have a homotopy type, but also have local structure described by differential geometry. They are therefore a generalization of smooth manifolds. I shall describe the history of the idea, some examples of the structure, and reasons for being interested in it — it is a kind of classical limit of noncommutative geometry, and hence a model for a quantum space-time. Furthermore, the structure is described perturbatively both at short distances and at long distances, reflecting the infrared/ultraviolet behaviour of quantum field theory, and there is a surprising duality between the two extremes.

- 3:20pm-4:10pm  
Hiroshi Iritani (Tokyo)

**Equivariant quantum cohomology and Fourier transformation**

We discuss the relationship between Fourier transformation and quantum cohomology of symplectic reductions, following the idea of C. Teleman. We also give applications of this idea to mirror symmetry and computation of quantum cohomology. This is based on joint work with Fumihiko Sanda and Yuki Koto.

- 4:20pm-4:50pm  
Yota Samoto (Waseda)

**Mirror symmetry and Stokes structure**

To describe the asymptotic behavior of solutions of linear differential equations in one complex variable, Deligne introduced the notion of a Stokes filtered local system, or, Stokes structure. In the context of mirror symmetry conjecture, the notion can be used to relate the derived categories of coherent sheaves and the quantum cohomologies of complex manifolds. To give an equivariant analog of this application of Stokes structure to mirror symmetry, the speaker is trying to construct the theory of Stokes structure of linear difference equations as an analog of the theory of Deligne. In this talk, after introductions to these topics, we shall explain this attempt and the result.

## Wednesday Morning

Chair: Kenji Fukaya

- 9:30am-10:20am  
Peter Topping (Warwick)

**Hamilton's pinching conjecture**

The Bonnet-Myers theorem tells us that a uniform positive lower bound on the Ricci curvature of a manifold has topological implications. Richard Hamilton proposed a scale-invariant version of this theorem. I will give an introduction to the problem and

describe some of the interesting work that has been developed over the years in an attempt to solve it. This year Hamilton's conjecture has been solved as a result of new work of Deruelle-Schulze-Simon and of M.-C.Lee and myself, using Ricci flow. I will give an overview of the strategy and the innovations required to solve the conjecture.

- 10:50am-11:20 am  
Jonathan Fraser (St Andrews)

#### **Dimension interpolation in conformal dynamics**

'Dimension interpolation' is the idea that by viewing two distinct notions of fractal dimension (e.g. Hausdorff and box-counting dimension) as extremes in a carefully defined 'continua of dimensions', one may gain a more nuanced understanding of the fractal objects at hand. I will review recent developments in this area in the context of conformal dynamics.

- 11:30am-12:00am  
Ben Lambert (Leeds)

#### **Alexandrov Immersed Mean Curvature Flow**

In this talk I will introduce mean curvature flow with surgery and in particular introduce Andrews' noncollapsing estimates. We will see that noncollapsing is a vital ingredient in the mean curvature flow of embedded surfaces. Finally, we will see that all of these ideas may be extended beyond the embedded setting to allow surgery for Alexandrov immersed mean curvature flow.

### Wednesday Afternoon:

Free and discussions

### Thursday Morning

Chair: Huaizhong Zhao

- 9:30am-10:20am  
Takashi Kumagai (Waseda)

#### **Anomalous diffusions and time fractional differential equations**

Time fractional diffusion equations have been widely used to model anomalous diffusions exhibiting sub-diffusive behavior, due to particle sticking and trapping phenomena. In this talk, I will discuss how anomalous sub-diffusions and the corresponding time-fractional differential equations arise naturally as limits of random walks in random media. I will then present some results on the probabilistic representation to the solutions of time fractional Poisson equations and estimates of their fundamental solutions. This talk is based on joint works with Z.-Q. Chen (Washington), P. Kim (Seoul) and J. Wang (Fuzhou).

Coffee

Chair: Tom Cass

- 10:50am-11:20am  
Roland Bauerschmidt (Cambridge)

**Log-Sobolev inequalities for Euclidean field theories and spin models**

I will present an extension of the Bakry-Emery method for Log-Sobolev inequalities that applies to Euclidean field theories which are invariant measures of singular SPDEs. The method uses as input estimates on the renormalised potential which is the solution to Polchinski's continuous renormalisation group equation. Examples where this applies include the sine-Gordon model (with mass term) and the  $\varphi_d^4$  models in  $d < 4$  (uniformly in the volume up to the critical point), and also the near-critical Ising model in  $d > 4$ . This talk is based on joint works in Thierry Bodineau and Benoit Dagallier.

- 11:30am-12:00 am  
Seiichiro Kusuoka (kyoto)

**Construction of a non-Gaussian and rotation-invariant  $\Phi - 4$ -measure and associated flow on  $\mathbb{R}^3$  through stochastic quantization**

In this talk, we construct the  $\Phi_3^4$ -measure on  $\mathbb{R}^3$  by approximations of interactions with localization and regularization. Here, we remark that for approximations, we do not apply scaling of a torus. As an advantage of our approximations, we can prove the rotation invariance of the  $\Phi_3^4$ -measure. To prove the convergence of the approximations, we apply the stochastic quantization and the methods of singular stochastic PDEs. This is a joint work with Sergio Albeverio.

## Thursday Afternoon

Chair: Takashi Kumagai

- 2:00pm -2:50pm  
Terry Lyons (Oxford/Turing institute)

**TBA**

coffee

- 3:20pm-3:50pm  
Ajay Chandra (ICL)

**Stochastic quantisation of gauge theories**

Abstract: In this talk I will introduce quantum gauge theories, describe some of the difficulties around their construction, and finally describe recent progress on this problem that uses stochastic analysis to construct an associated dynamic, this is joint work with Ilya Chevyrev, Martin Hairer, and Hao Shen.

- 4:00pm-4:30 pm  
Masato Hoshino (Osaka)

**A regularity structure for the quasilinear generalized KPZ equation**

We consider the renormalizations of quasilinear stochastic PDEs. Our approach is an extension of the theory of regularity structures based on Bailleul, Debussche, and Hofmanova's approach. If the noise is space-time white and we consider the approximation

of the noise by even mollifiers, then we can obtain the renormalization counterterm as a local function of the solution. This talk is based on a joint work with Ismael Bailleul (Université Rennes 1) and Seiichiro Kusuoka (Kyoto University).

## Conference Buffet Dinner – (Thursday, Physics Common Room)

Display boards are in available in the physics common room.

### Friday Morning

Chair: John Bolton

- 9:30am-10:20am

Mark Pollicott (Warwick) **Zeta functions for closed geodesics**

In 1956 Selberg defined a complex function of a single complex variable for closed Riemann surfaces of constant negative curvature by analogy to the famous Riemann zeta function in number theory. In Selberg's zeta function the closed geodesics play the role of prime numbers in the Riemann zeta functions. Over the past decade there has been progress in understanding the more general setting of variable negative curvature or surfaces with boundary and I will describe some of these results. This talk is intended for a general mathematical audience.

Coffee

Chair: Jurgen Berndt

- 10:50am-11:20am

Asma Hassannezhad (Bristol)

#### **A tour on Steklov eigenvalue problem**

We discuss the importance and the beauty of the Steklov eigenvalue problem and its connection to the Laplace eigenvalue problem. The talk will be a brief tour of some classic results and recent developments on the subject.

- 11:30am-12:20am

Adam Harper (Warwick)

#### **Random multiplicative functions: progress and problems**

A random multiplicative function is a random function on the natural numbers, that is constructed from a sequence of independent random variables in a way that respects the multiplicative structure. These objects arise naturally in analytic number theory as models for things like Dirichlet characters, but can also be thought of simply as probabilistic objects with an interesting dependence structure. In this talk I will try to survey what we know about random multiplicative functions, and some open problems, in a way that is (hopefully) accessible and interesting to number theorists, probabilists, and others.

### Public Lecture (Friday Evening)

Embassy of Japan (Entrance strictly by registration)

See next page for detail

**Public Lecture (Friday Evening)**  
Embassy of Japan (Entrance strictly by registration)

- 5:15 pm–6:00 pm  
Martin Hairer (ICL)

**On Coin Tossing, Atoms and Forest Fires**

We will encounter some of the mathematical objects arising naturally in probability theory, as well as some of their surprising properties. In particular, we will see how one of these objects was involved in the confirmation of the existence of atoms over 100 years ago and how new properties of related objects are still being discovered today.

Profile: Sir Martin Hairer KBE FRS is a professor of mathematics and currently holds a chair in probability and stochastic analysis at Imperial College London. Hairer works in probability theory, including stochastic dynamics and stochastic partial differential equations. He is a Fellow of the Royal Society, of the American Mathematical Society, of the Academy of Sciences Leopoldina, and of the Austrian Academy of Sciences. His work was distinguished with a number of prizes, most notably the Fermat prize and a Fields Medal.

- 6:00 pm–6:50 pm  
Hiroshi Ooguri (Caltech and Kavli IPMU)

**The Science of the Man from the 9 Dimensions**

*This consist of a short video talk, with a 30 minutes movie provided by Miraikan – the national museum of Engineering Science and Innovation.*

The Man from the 9 Dimensions” is a science movie on Superstring Theory, the leading candidate for the unified theory of forces and matters, including gravity. Professor Ooguri will explain the science behind the movie, which takes us from the microscopic world of elementary particles to the macroscopic world of the universe, and to its beginning - the Big Bang.

Profile: Professor Hiroshi Ooguri is a Japanese physicist, the Fred Kavli Professor for Theoretical Physics and Mathematics and the Director of the Walter Burke Institute for Theoretical Physics at California Institute of Technology, and the Director of the Kavli Institute for the Physics and Mathematics of the Universe at the University of Tokyo. He received a Medal of Honour with Purple Ribbon from the Emperor of Japan and the Eisenbud Prize from the American Mathematical Society. He is a Fellow of the American Academy of Arts and Sciences.

- 6:50pm-8:00pm  
Reception, Embassy of Japan.