

# Quantum Geometry, Stochastic Geometry, Random Geometry, you name it workshop

## Talk Schedule

Events for:  
**Monday, June 15th - Friday, June 19th**

### Monday, June 15th

9:30am **Vincent Vargas - SCGP 102**

**Title:** Liouville quantum field theory on Riemann surfaces I, Part 1

**Abstract:** " will present the first rigorous (probabilistic) constructions of Liouville quantum field theory (LQFT) on Riemann surfaces (sphere, disk, torus, etc...). These constructions yield non trivial conformal field theories and we will derive some of their fundamental properties like conformal covariance under PSL action, the KPZ scaling laws, the KPZ formula and the Weyl anomaly (Polyakov-Ray-Singer) formula. The constructions are based on Polyakov's path integral (1981) and on the mathematical side on Kahane's 1985 Gaussian multiplicative chaos theory (random measures formally defined by the exponential of the Gaussian Free Field). In this talk, we will work in the context of the subcritical LQFT and below the so-called Seiberg bounds. Based on joint works with F. David, Y. Huang, A. Kupiainen, H. Lacoin, R. Rhodes.

10:30am **Tea - SCGP Cafe**

11:00am **Misha Sodin - SCGP 102**

**Title:** Random nodal portraits: few results and many questions, Part 1

**Abstract:** The theme of the mini-course will be statistics of the number of connected components of the zero sets of random functions of several real variables. The primary examples are various Gaussian ensembles of real-valued Polynomials (algebraic or trigonometric) of large degree on the sphere or torus, and translation-invariant smooth Gaussian functions on the Euclidean space restricted to large domains. The lectures will be based on joint works with Fedor Nazarov.

12:00pm **Lunch - SCGP Cafe**

1:30pm **Damien Gayet - SCGP 102**

**Title:** Universal components of random real algebraic hypersurfaces, Part 1

**Abstract:** In this talk-mini-course, I will explain the proof of the following result obtained in collaboration with Jean-Yves Welschinger: for any compact smooth connected hypersurface  $S$  of  $\mathbb{R}^n$ , and any real homogeneous polynomial of degree  $d$  in  $n+1$  variables, denote by  $N(S,P)$  the number of components of the vanishing locus of  $P$  in  $\mathbb{R}P^n$  which are diffeomorphic to  $S$ . Then, there is a positive constant  $c(S)$ , not depending on  $d$ , such that if  $P$  is chosen at random for a natural measure, the expectation of  $N(S,P)$  is asymptotically bounded from below by  $c(S)$  times  $d^{\{n/2\}}$  when  $d$  grows to infinity. I will in fact consider the more general case of random real holomorphic sections of a real holomorphic line bundle over a real compact Kähler manifold.

2:30pm **Yaiza Canzani - SCGP 102**

**Title:** On the structure of the zero set of monochromatic random waves

**Abstract:** There are several questions about the zero set of Laplace eigenfunctions that have proved to be extremely hard to deal with and remain unsolved. Among these are the study of the size of the zero set, the study of the number of connected components, and the study of the topology of such components. A natural approach is to randomize the problem and ask the same questions for the zero sets of random linear combinations of eigenfunctions. In this talk I will present some recent results in this direction. This is joint work with Boris Hanin.

3:30pm **Coffee - SCGP Cafe**

4:00pm **Boris Hanin - SCGP 102**

**Title:** Nodal Sets of Random Eigenfunctions of the Harmonic Oscillator

**Abstract:** Random eigenfunctions at energy  $E$  of the isotropic harmonic oscillator in  $\mathbb{R}^d$  have an  $U(d)$  symmetry and are in some ways analogous to random spherical harmonics of fixed degree on  $S^d$ , whose nodal sets have been the subject of many recent studies. However, there is a fundamentally new aspect to this ensemble, namely the existence of allowed and forbidden regions. In the allowed region, the Hermite functions behave like spherical harmonics, while in the forbidden region, Hermite functions are exponentially decaying and it is unclear to what extent they oscillate and have zeros. The purpose of this talk is to present several results about the expected volume of the zero set of a random Hermite function in both the allowed and forbidden regions. This is joint work with Steve Zelditch and Peng Zhou

**Tuesday, June 16th**

9:30am **Vincent Vargas - SCGP 102**

**Title:** Liouville quantum field theory on Riemann surfaces I, Part 2

**Abstract:** I will present the first rigorous (probabilistic) constructions of Liouville quantum field theory (LQFT) on Riemann surfaces (sphere, disk, torus, etc...). These constructions yield non trivial conformal field theories and we will derive some of their fundamental properties like conformal covariance under PSL action, the KPZ scaling laws, the KPZ formula and the Weyl anomaly (Polyakov-Ray-Singer) formula. The constructions are based on Polyakov's path integral (1981) and on the mathematical side on Kahane's 1985 Gaussian multiplicative chaos theory (random measures formally defined by the exponential of the Gaussian Free Field). In this talk, we will work in the context of the subcritical LQFT and below the so-called Seiberg bounds. Based on joint works with F. David, Y. Huang, A. Kupiainen, H. Lacoin, R. Rhodes.

10:30am **Tea - SCGP Cafe**

11:00am **Damien Gayet - SCGP 102**

**Title:** Universal components of random real algebraic hypersurfaces, Part 2

**Abstract:** In this talk-mini-course, I will explain the proof of the following result obtained in collaboration with Jean-Yves Welschinger: for any compact smooth connected hypersurface  $S$  of  $\mathbb{R}^n$ , and any real homogeneous polynomial of degree  $d$  in  $n+1$  variables, denote by  $N(S,P)$  the number of components of the vanishing locus of  $P$  in  $\mathbb{R}P^n$  which are diffeomorphic to  $S$ . Then, there is a positive constant  $c(S)$ , not depending on  $d$ , such that if  $P$  is chosen at random for a natural measure, the expectation of  $N(S,P)$  is asymptotically bounded from below by  $c(S)$  times  $d^{n/2}$  when  $d$  grows to infinity. I will in fact consider the more general case of random real holomorphic sections of a real holomorphic line bundle over a real compact Kähler manifold.

12:00pm **Lunch - SCGP Cafe**

1:00pm **SCGP weekly talk: Kahler geometry in physics and probability - SCGP 102**

**Speaker:** Semyon Klevtsov

**Title:** Kahler geometry in physics and probability.

**Abstract:** Recent advances in Kahler geometry provide new tools for the analysis of the Quantum Hall effect, for random geometry and for other probabilistic aspects of physics. Electron configurations define singular Kahler metrics on a Riemann surface, with the probability of a configuration defined by the Laughlin state. The statistics of configurations are governed by Kahler geometric functionals. The same Kahler analysis can be used to study the statistics of random smooth Kahler metrics as well. My talk will survey the methods, results and open problems in the area.

2:00pm **Misha Sodin - SCGP 102**

**Title:** Random nodal portraits: few results and many questions, Part 2

**Abstract:** The theme of the mini-course will be statistics of the number of connected components of the zero sets of random functions of several real variables. The primary examples are various Gaussian ensembles of real-valued Polynomials (algebraic or trigonometric) of large degree on the sphere or torus, and translation-invariant smooth Gaussian functions on the Euclidean space restricted to large domains. The lectures will be based on joint works with Fedor Nazarov.

3:30pm **Coffee - SCGP Cafe**

4:00pm **Dmitry Jakobson - SCGP 102**

**Title:** Probability measures on manifolds of Riemannian metric

**Abstract:** This is joint work with Y. Canzani, B. Clarke, N. Kamran, L. Silberman and J. Taylor. We construct Gaussian measures on the manifold of Riemannian metrics with the fixed volume form. We show that diameter, Laplace eigenvalue and volume entropy functionals are all integrable with respect to our measures. We also compute the characteristic function for the  $L^2(E_{\text{bin}})$  distance from a random metric to the reference metric.

### Wednesday, June 17th

9:30am **Rémi Rhodes - SCGP 102**

**Title:** Liouville quantum field theory on Riemann surfaces II, Part 1

**Abstract:** In this talk, we complete the picture drawn in the talk by Vincent Vargas by explaining the conjectures relating Liouville quantum field theory to the scaling limit of the volume form of large finite random planar maps conformally embedded in the Riemann sphere and coupled to conformal field theories with central charge strictly less than 1. Then we will focus on the critical phase of the theory as well as the threshold of the Seiberg bounds, which are no more superrenormalizable. This requires extending Kahane's theory to its critical threshold. This will allow us to extend the previous conjectures to random planar maps conformally embedded in the Riemann sphere and coupled to conformal field theories with central charge equal to 1. Based on joint works with B. Duplantier, F. David, A. Kupiainen, H. Lacoïn, S. Sheffield and V. Vargas.

10:30am **Tea - SCGP Cafe**

11:00am **Tankut Can**

**Title:** Collective Field Theory of Quantum Hall States as Random Geometry

12:00pm **Lunch - SCGP Cafe**

1:30pm **Laszlo Lempert - SCGP 102**

**Title:** Uniqueness in geometric quantization

2:30pm **Leon Takhtajan - SCGP 102**

**Title:** Kaehler geometries of conformal maps

3:30pm **Coffee - SCGP Cafe**

4:00pm **Song Sun - SCGP 102**

**Title:** Balanced embedding of pairs and logarithmic K-stability

**Abstract:** In this talk I will give an application of the large  $N$  technique in the study of K-stability of a pair  $(X, D)$ , which is one of the input in the recent resolution of Kahler-Einstein problem on Fano manifolds. This involves constructing an “approximately balanced” embedding of the pair into  $P^N$ , and controlling the behavior of the error term as  $N$  tends to infinity. I will explain the relevant notions, and describe the proof. This talk is based on a relatively old paper arXiv: 1108.4603.

<b>Thursday, June 18th</b>
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9:30am **Rémi Rhodes - SCGP 102**

**Title:** Liouville quantum field theory on Riemann surfaces II, Part 2

**Abstract:** In this talk, we complete the picture drawn in the talk by Vincent Vargas by explaining the conjectures relating Liouville quantum field theory to the scaling limit of the volume form of large finite random planar maps conformally embedded in the Riemann sphere and coupled to conformal field theories with central charge strictly less than 1. Then we will focus on the critical phase of the theory as well as the threshold of the Seiberg bounds, which are no more superrenormalizable. This requires extending Kahane’s theory to its critical threshold. This will allow us to extend the previous conjectures to random planar maps conformally embedded in the Riemann sphere and coupled to conformal field theories with central charge equal to 1. Based on joint works with B. Duplantier, F. David, A. Kupiainen, H. Lacoin, S. Sheffield and V. Vargas.

10:30am **Tea - SCGP Cafe**

11:00am **Steven Morris Zelditch - SGCP 102**

**Title:** Brownian motion on the space of Kahler metrics

**Abstract:** A basic construction in Kahler geometry is the correspondence between positive Hermitian matrices and special metrics called Bergman metrics. Brownian motion on the space of positive Hermitian matrices induces such a motion on metrics. My talk discusses the large  $N$  limit of this Brownian motion, which corresponds to high powers of a line bundle. Joint work with Semyon Klevtsov.

12:00pm **Lunch - SCGP Cafe**

1:30pm **Xiaonan Ma - SCGP 102**

**Title:** Equidistribution for zeros of holomorphic sections of singular Hermitian line bundles

**Abstract:** We explain the equidistribution of zeros of random holomorphic sections of powers of a semipositive singular Hermitian line bundle, with an estimate of the convergence speed.

2:30pm **Michael Douglas - SCGP 102**

**Title:** Holography and operator traces Abstract:

3:30pm **Coffee - SCGP Cafe**

4:00pm **Frank Ferrari - SCGP 102**

**Title:** Bose-Einstein Condensation, Irreversibility, large  $N$  and Quantum Black Holes

**Abstract:** the aim of the talk will be to explain, in simple terms, how seemingly unrelated ideas can be used to shed light on the puzzling physics of quantum black holes. Each piece of relevant physics will be introduced without assuming familiarity from the audience. In particular, we shall discuss the crucial problem of information loss (or unitarity violation) as well as some aspects of the physics of the horizon. The relevance of the phenomenon of Bose-Einstein condensation is completely new and can be derived rigorously in some particular models.

6:00pm **Workshop Banquet**

<b>Friday, June 19th</b>
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9:30am **Vincent Pasquier - SCGP 102**

**Title:** Which fluid dynamics models the Quantum Hall Effect?

**Abstract:** I will review some aspects of the Bulk edge correspondence in the quantum Hall effect and relate it to integrable models of fluid dynamics, in particular Benjamin-Ono and its various deformations.

10:30am **Tea - SCGP Cafe**

11:00am **Seung Yeop Lee - SCGP 102**

**Title:** Large degree asymptotics of characteristic polynomials in 2D Coulomb gas

11:30am **Lætitia Leduc - SCGP 102**

**Title:** 2D quantum gravity on Kähler manifolds: a first-principles computation

**Abstract:** "Nowadays, two-dimensional quantum gravity can be studied in two different approaches, one involving discrete theories (triangulation, matrix model...), the other continuous ones, mainly based on the so called Liouville action which universally describes the coupling of any conformal field theory to gravity. While the Liouville action is relatively well understood, the appropriate functional integral measure is however rather complicated. Nevertheless, a formula for the area dependence of the quantum gravity partition function in the presence of conformal matter has been obtained, under the simplifying assumption of a free-field measure. Notwithstanding its non-rigorous derivation, this formula has since been verified in many instances and has scored many successes. In this talk I will present a new approach on this old problem, based on the Kähler formalism and a general spectral cutoff regularization on curved space-times developed recently. I will present the results of a first-principles computation of the fixed-area partition function up to and including all two-loop contributions, by considering the Liouville action. Counterterms are required, but the finiteness of the two-point function fixes all of them but one. Finally, I will discuss the three-loop order: the (un)expected divergences, the counterterms needed and their remaining freedom."

12:00pm **Roberto Bondesan - SCGP 102**

**Title:** Multifractality in the quantum Hall effect revisited

12:30pm **Lunch - SCGP Cafe**

3:30pm **Coffee - SCGP Cafe**