

Report on the Trimester Program

Probabilistic methods in quantum field theory

May 5 - August 15, 2025

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Topics

The trimester programme was organised around three core topics of wide interest. The first was *integrable QFT*, including minimal models, probabilistic construction of CFTS, bosonization, near-critical perturbations, and Coulomb gas methods. The second was *random geometry, SLE, and connections to QFT*, encompassing scaling limits of critical lattice models, Liouville quantum gravity, and the interplay with Schramm–Loewner Evolutions. The third was *gauge theories and spin systems*, including models with continuous symmetry, connections between lattice gauge theory and advances in quantum gauge theories in 3D and 4D.

Goals

The programme brought together researchers from probability theory and random geometry with those from mathematical physics and QFT, with the aim of fostering interaction between these communities around shared problems in the rigorous foundations of quantum field theory. With this combined expertise, the program aimed to address some of the main challenges and key open questions in the field, including in the following areas:

- advances in quantum gauge theories in 3D and 4D
- rigorous constructions of exactly solvable quantum field theories, especially in 2D

- more generally, analysis of probabilistic aspects of quantum field theories
- the theory of phase transitions, in particular for systems with continuous symmetry, and related phenomena

The programme also placed significant emphasis on the training and development of junior researchers, who participated actively in all aspects of the scientific programme. (See the quotes for some feedback.)

Organization

The trimester was structured around a summer school and three workshops, spaced throughout the programme to align with its three core topics.

The opening summer school (May 12–16) provided an introduction to the main themes of the trimester, with lecture courses by Morris Ang, Malin Palö Forsström, Christophe Garban, and Antti Kupiainen, alongside contributed talks by junior participants. This was followed immediately by the first workshop on Random geometry and its connections to QFT (May 19–23). The second workshop on Integrable QFT (June 23–27) and third workshop on Gauge theories and spin systems (July 28 – August 1) took place at roughly monthly intervals thereafter, each featuring around 14 invited speakers.

Throughout the trimester, a weekly research seminar featured talks by programme participants and invited external speakers. A junior research seminar ran in parallel, providing a dedicated forum for early-career participants. The programme also included a mini-course series, with courses delivered by Avelio Sepúlveda (Domain Markov properties), Eric Schippers (Teichmüller space and the Segal moduli space), Guillaume Baverez and Antoine Jego (The CFT of SLE loop measures and the Kontsevich–Suhov conjecture), and Thierry Lévy (Probabilistic aspects of 2D Yang–Mills theory).

Two further activities were designed specifically to promote collaborative research among junior participants. Following the initial summer school and workshops, senior researchers posed a selection of open problems and early-career participants self-organised into small working groups to tackle them. Later in the programme, a weekly arXiv reading group was run by early-career participants, who took turns presenting recent preprints relevant to the themes of the trimester.

Quotes from participants

“I felt that the summer school in particular was particularly well organized, with talks of high quality, and the schedule was quite cleverly built to permit links between successive talks, without the days being too intense either. The facilities were very comfortable, and I would like to express warm acknowledgements to the HIM team, for their professionalism, availability, and devotion to make this stay so enjoyable for us.”

“I also had the opportunity to learn about other questions a priori unrelated to mine but for which discussions gave rise to unexpected connections.”

“My stay was very pleasant. I appreciate the help I received from the administrative and technical staff, and found the working environment excellent. The bike-rental arrangement was extremely useful. My only minor criticism concerns the electronic blackboards in the offices : they are cumbersome to operate and get stuck often, in the middle of a session, making them impractical to use. For this reason, there was high demand for the few actual blackboards in the building.”

“I am also grateful to the institute’s staff for assisting me in organizing kindergarten and summer camp arrangements for my child, which enabled me to focus more on my research.”

“My stay at HIM Bonn was highly enjoyable and professionally rewarding. I am grateful to the HIM team for their warm welcome and for organising the programme with such efficiency and care, which made it possible to engage deeply with the science and the community.”

“The workshop during my final week (“Gauge theories and spin systems: Yang-Mills theory, continuous symmetry, and disorder”) was fantastic – the talks were of exceptionally high quality. I enjoyed both the workshop and my stay in the two weeks preceding, and will highly recommend participate at HIM programs to my colleagues in the future.”