

**SFT-2026**  
**Lectures on Statistical Field Theories**  
**Galileo Galilei Institute**  
**Florence, 2-13 February 2026**

**Program of lectures**

**Bernard Derrida** (Collège de France)

*Large deviations of non-equilibrium diffusive systems (10h)*

After an introduction to large deviations and Markov process [2,5,6], these lectures will try to show, through simple examples, that non-equilibrium systems have a number of properties which contrast with those of systems at equilibrium: phase transitions in one dimension [3], non local free energy functional, long range correlations [1,4,5], etc. . These lectures will also try to give a review of theoretical methods such as the matrix ansatz, the Bethe ansatz, or the macroscopic fluctuation theory [1], developed in the theory of non-equilibrium phenomena, which allow one to calculate the fluctuations and large deviations of the density and of the current in non-equilibrium steady states [1,4,5] of systems like exclusion processes.

[1] L Bertini, A De Sole, D Gabrielli, G Jona-Lasinio & C Landim, *Macroscopic fluctuation theory*, Rev. Mod. Phys. 87 (2015) 593-636.

[2] I Burenev, D Cloete, V Kharbanda & H Touchette, *An introduction to large deviations with applications in physics*, SciPost Phys. Lect. Notes 104 (2025).

[3] B Derrida, *An exactly soluble non-equilibrium system: the asymmetric simple exclusion process*, Phys. Rep. 301 (1998) 65-83.

[4] B Derrida, *Non-equilibrium steady states: fluctuations and large deviations of the density and of the current*, J. Stat. Mech. (2007) P07023.

[5] B Derrida, *Lecture notes on large deviations in non-equilibrium diffusive systems*, preprint (2025) arXiv:2505.15618.

[6] H Touchette, *The large deviation approach to statistical mechanics*, Phys. Rep. 478 (2009) 1-69.

**Jérôme Dubail** (Université de Strasbourg)

*Introduction to 2d CFT for stat-phys and cond-mat students (10h)*

I intend to give an introductory course on basic concepts of 2d CFT, with a focus on how to derive simple universal results in problems from statistical physics and condensed matter. If time permits, I would like to cover:

1. Conformal mapping
2. How to calculate with the Gaussian free field
3. Basic structures of CFT (stress-tensor and central charge, OPEs, Hilbert space of a 2d CFT)
4. Phase diagrams of 2d stat-mech models and matching with CFT. Glimpse of random geometric phenomena (critical percolation)
5. Universality in 1d quantum critical systems. Luttinger liquids, entanglement entropy, heat capacity, etc.

**Gregory Falkovich** (Weizmann Institute of Science)

*Introduction to Information Theory (6h)*

This is an informal and nontechnical introduction for physicists. It is panoramic to let you see how many problems in physics, mathematics, engineering, biology, brain science, economics, and linguistics could be solved by physicists who know what entropy and free energy are. Will also include basics of quantum information and black hole entropy.

Based on the recently published textbook  
<https://press.princeton.edu/books/hardcover/9780691266534/the-physical-nature-of-information>

**Paul Fendley** (University of Oxford)

*The basics of non-invertible symmetries and dualities (6h)*

I will explain the basic structure of non-invertible symmetries and dualities using various quantum spin chains. I will first show how Kramers-Wannier duality provides a canonical example. The key to finding more general analogs is to define a Hamiltonian using a fusion category; most well-known quantum spin chains can be defined in such a fashion. Non-invertible symmetries and dualities are then built in from the start. Topological defects provide a key tool, as their action implements the symmetry/duality.

I won't assume any prior knowledge of duality or categories. It would be useful to understand a little about the quantum Ising Hamiltonian in advance; the level of Wikipedia should be sufficient (search "transverse-field Ising model"). Most of the material will come from the pair of papers I wrote with Aasen and Mong ([1601.07185](#) and [2008.08598](#)), but I'll be presenting it from a somewhat different starting point. Thus there's no requirement to read them in advance, although of course a glance wouldn't hurt.

**Maria Vozmediano** (ICM-CSIC, Madrid)

*Thermal transport, geometry, and anomalies (6h)*

The aim of this course is to introduce students to the ideas and techniques that, originating in so-called 'high-energy' physics, have become standard tools in statistical physics and condensed matter physics in the 21st century. In particular, we will revisit effective actions, introduce quantum anomalies and anomaly-related transport, and the relationship between thermal transport and general relativity. The course is motivated by some of the new developments in condensed matter physics in the 21st century that have led to a new grand unification of high- and low-energy physics.

Prerequisites:

- Mechanics: Lagrangean and Hamiltonian formalism, canonical transformations, Poisson brackets [1].
- Classical fields: special relativity, Lorentz transformations. The electromagnetic field [2].
- Quantum Mechanics: Path integral formulation [3].
- Statistical Physics: Partition function, Green's functions [4]
- Condensed matter: The Landau Fermi liquid [4]

[1] Landau series Vol. 1. *Mechanics*.

[2] Landau series Vol. 2. *The Classical Theory of Fields*.

[3] A Altland and B D Simons, *Condensed Matter Field Theory*, Cambridge Univ. Press (2010).

[4] A A Abrikosov, L P Gorkov, I E Dzyaloshinski and R A Silverman, *Methods of Quantum Field Theory in Statistical Physics*, Dover Pub. (1975).

Tentative program:

1. Introduction and generalities. Why QFT? From classical mechanics to QFT. Classical fields and special relativity. Gauge fields. The action. Path integral formalism. Constructing an action. Symmetries. Effective actions (1). The Lorentz group: Scalars, vectors, tensors, spinors. Fermions in  $D=2,3,4$ . Helicity and chirality.
2. QFT and CM. The XXth century revolution in CM: graphene. The Dirac equation. The vacuum: the Dirac sea. The Landau Fermi liquid. The vacuum: the Fermi sea. Renormalization in QFT: The renormalization group. Effective actions (2). Landau Fermi liquid as a fixed point of RG. Luttinger liquid in (1+1). The case of graphene in (2+1).
3. Symmetries and anomalies. Global and local gauge invariance. Gauge fields. The Noether's theorems. QFT anomalies. Chiral anomaly and mixed chiral-gravitational anomaly. Anomaly induced transport. Applications to condensed matter.
4. Geometry and thermal transport. The energy-momentum tensor. Components. Noether construction (flat space) versus metric stress tensor (curved space). Kubo formula for the thermal conductivity. Luttinger trick. Applications to condensed matter.

For references, see [here](#).

**Paul Fendley**  
(University of Oxford)

# TWO CULTURES SEPARATED BY A COMMON LANGUAGE

Mathematics and physics have different cultures and are practiced by different tribes. Much invective has been designed to instill tribal loyalty, with pronouncements ranging from “Mathematics is the handmaiden of physics” to “Throughout mathematics, inspiration and the hard work of completing proofs are necessary. No guide from physics can help.” Nonetheless, quality research bridging the two is easy to find. Mathematics is at the core of physics, and time and time again, results in physics have proved essential to mathematics. I’ll argue that there’s no meaningful dividing line between the two disciplines, and that both cultures would be better off if we stopped worrying about maintaining purity.

**SPRITZ  
OF  
SCIENCE**

**Monday, February 9  
6 p.m.**



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