Margherita Disertori

Academic career

1996	Diploma Thesis in Physics, University of Trento, Italy
1999	PhD in Theoretical Physics, École Polytechnique, Paris, France
2000 - 2002	Postdoc, Institute for Advanced Study, Princeton, NJ, USA
2002 - 2005	Postdoc, ETH Zürich, Switzerland
2005 - 2014	Maître de conférences, University of Rouen, France
2011	Habilitation à diriger des recherches in Mathematics, Paris Diderot University (Paris 7), France
Since 2014	Professor (W2), University of Bonn

Invited Lectures

2009	International Congress on Mathematical Physics, Prague, Czech Republic
2010	Institute of Mathematical Statistics Annual Meeting, Gothenburg, Sweden
2010	Invited lecture series on “Supersymmetric technique”, IMPA Rio de Janeiro, Brazil
2012	SUSY and Random Matrices, IHP Paris, France

Research Projects and Activities

Project A08 “Nonlinear sigma models”
within DFG Collaborative Research Center SFB 1060 “The Mathematics of Emergent Effects”, Principal Investigator
Oberwolfach Workshops on “The Renormalization Group”,
Organizer, 2011, 2016

Research profile

A large number of problems in modern statistical mechanics and theoretical physics can be translated into the study of suitable functional integrals. These are integrals over many variables, or more generally measures on spaces of functions or distributions.
Most of these integrals cannot be computed explicitly. Nevertheless much useful, precise information can be gained using a mixture of analytical and algebraic tools, including complex analysis and saddle point methods, multiscale analysis, rigorous renormalization group, cluster and contour expansions for functions of many variables, functional analysis on Grassman algebras, harmonic analysis on surfaces.
My current research focuses mainly on models for order/disorder transition in classical mechanics (nematic phase), quantum diffusion (random Schroedinger operators and random matrices) and stochastic processes with reinforcement (random walks in a random environment). Some of these models can be mapped into the study of certain supersymmetric nonlinear sigma models (i.e. field theories where the target space is a nonlinear manifold, described by even and odd elements in a Grassmann algebra). The symmetries of the nonlinear manifold give rise to a family of equations (Ward identities), from which much useful information can be extracted on the corresponding functional integrals.
Though a phase transition was proved for the reinforced stochastic process [4, 7, 8], the behavior of the system near the transition point is still out of reach (except on certain tree-like graphs). In the context of Random Schroedinger operators and random matrices, even the existence of a phase transition in dimensions larger than two remains an open problem. Supersymmetric Ward identities may help solving at least some particular examples (as the one

dimensional chain). More generally, symmetry-generated identities coupled with more robust techniques such as multiscale analysis and constructive renormalization may allow to understand other open problems in stochastics, classical and quantum field theory, for example, stochastic systems without determinantal correlations (that can be represented via fermionic functional integrals) and noncommutative quantum field theories (that can be represented via interacting matrix models).

Research Area G My research deals mostly with certain functional integrals arising in the

context of quantum and classical statistical mechanics, but also stochastics processes. Edge reinforced random walks and vertex reinforced jump processes are history dependent stochastic processes, where the particle tends to come back more often on sites it has already visited in the past. For a particular scheme of reinforcement these processes are random walks in a random environment (mixing of reversible Markov chains) whose mixing measure can be related to a superymmetric nonlinear sigma model introduced in the context of random matrix models for quantum diffusion. This relation allows to prove, in particular, transience for weak reinforcement of both processes, in dimension larger than two [6]. Recently Sabot, Tarrès and Zeng discovered a relation between these models and a random Schrödinger operator with a particular choice of diagonal disorder, opening up a new line of research. In particular this relation allowed them to prove recurrence of the edge reinforced random walk for any reinforcement in dimension 2. A key tool in this construction is an infinite family of martingales, which turned out to be the first instance in a whole hierarchy derived from supersymmetric Ward identites in the nonlinear sigma model [2].

Research Area B My research deals mostly with certain functional integrals arising in the

context of quantum and classical statistical mechanics. In particular I am interested in models where an order/disorder transition is expected. One example are random matrix models for quantum diffusion in disordered materials. The corresponding functional integrals involve complex and Grassman variables and only few cases have been rigorously studied [1, 9, 10]. In the context of classical mechanics, a system of molecules with purely hard core interaction and strongly asymmetric geometry (for example elongated shapes) can exhibit a transition between a purely disordered phase, at very low density, and a (partially) ordered nematic phase, at higher density. In some simplified models this transition was proved rigorously [6]. To understand the general case one needs to understand how the measure associated to the system (more precisely the symmetries of the measure) behaves in the thermodynamic limit.
The core of the problem lies in the restriction of the integral to some nonlinear manifold (nonlinear sigma model). For the so called H2—2 model introduced by Zirnbauer in the context of quantum diffusion a phase transition was proved in dimension 3 and larger [7, 8]. The proof uses a new multiscale analysis construction based on a family of Ward identitites generated by internal symmetries.

Supervised theses

Master theses: 2, currently 1
PhD theses: 2, currently 2

Selected publications

[1] Margherita Disertori and Mareike Lager. Density of states for random band matrices in two dimensions. *Ann. Henri Poincar'e*, 18(7):2367–2413, 2017.

[2] Margherita Disertori, Franz Merkl, and Silke W. W. Rolles. A supersymmetric approach to martingales related to the vertex-reinforced jump process. *ALEA Lat. Am. J. Probab. Math. Stat.*, 14(1):529–555, 2017.

[3] Margherita Disertori and Sasha Sodin. Semi-classical analysis of non-self-adjoint transfer matrices in statistical mechanics i. *Ann. Henri Poincar'e*, 17(2):437–458, 2016.

[4] Margherita Disertori, Christophe Sabot, and Pierre Tarrès. Transience of edge-reinforced random walk. *Comm. Math. Phys.*, 339(1):121–148, 2015.

[5] Margherita Disertori, Franz Merkl, and Silke W. W. Rolles. Localization for a nonlinear sigma model in a strip related to vertex reinforced jump processes. *Comm. Math. Phys.*, 332(2):783–825, 2014.

[6] Margherita Disertori and Alessandro Giuliani. The nematic phase of a system of long hard rods. *Comm. Math. Phys.*, 323(1):143–175, 2013.

[7] M. Disertori and T. Spencer. Anderson localization for a supersymmetric sigma model. *Comm. Math. Phys.*, 300(3):659–671, 2010.

[8] M. Disertori, T. Spencer, and M. R. Zirnbauer. Quasi-diffusion in a 3d supersymmetric hyperbolic sigma model. *Comm. Math. Phys.*, 300(2):435–486, 2010.

[9] Margherita Disertori and Vincent Rivasseau. Random matrices and the anderson model. In *Random Schrödinger operators*, volume 25 of *Panor. Synthèses*, pages 161–213. Soc. Math. France, Paris, 2008.

[10] M. Disertori, H. Pinson, and T. Spencer. Density of states for random band matrices. *Comm. Math. Phys.*, 232(1):83–124, 2002.

[11] M. Disertori and V. Rivasseau. Continuous constructive fermionic renormalization. *Ann. Henri Poincar'e*, 1(1):1–57, 2000.

[12] M. Disertori and V. Rivasseau. Interacting fermi liquid in two dimensions at finite temperature. ii. renormalization. *Comm. Math. Phys.*, 215(2):291–341, 2000.