



SCIENTIFIC ACTIVITY

SLAVA RYCHKOV has continued collaboration with his former postdocs Apratim Kaviraj and Emilio Trevisani on the Parisi-Sourlas supersymmetry. A long paper prepared in 2020 has resolved a long-standing puzzle concerning the phase transition in lattice models with magnetic impurities (Random Field Ising Model). That work explained from the renormalization group theory point of view why an old and famous conjecture by Giorgio Parisi and Nicolas Sourlas, that this transition must exhibit a form of supersymmetry and the same critical exponents as the ordinary Ising model in 2 dimensions lower, holds only above certain critical dimension. This work has now been published by the *Journal of High Energy Physics*. In 2021, they have subjected their theory to further tests. In particular, they showed that in the random field model with a cubic, as opposed to the quartic, interaction, supersymmetry persists for any dimension. This finding is in agreement with numerical simulations of the model.

Slava Rychkov has also continued his collaboration with his Ph.D. student Jiaxin Qiao and postdoc Petr Kravchuk (IAS Princeton) on analytic continuation of Euclidean conformal field theories to the Lorentzian signature. In a long paper published by the *Journal of High Energy Physics*, they showed how conformal Lorentzian four-point correlation functions can be constructively obtained from Euclidean four-point correlation functions. They showed how expected properties of Lorentzian correlation functions (Wightman axioms) follow from the commonly accepted Euclidean CFT axioms, such as a convergent operator product expansion.

Slava Rychkov has started a new collaboration with Prof. Tom Kennedy (University of Arizona) on the rigorous theory of the tensor network renormalization group. The final goal of this project is to establish the rigorous existence of lattice renormalization group fixed points corresponding to the critical points of the Ising model in two dimensions and, in a longer-term, in three dimensions. Tensor network renormalization group is a novel approach to this problem, which holds certain advantages compared to the more traditional Wilson-Kadanoff approach. As a first step, Rychkov and Kennedy proved a theorem about the stability of the high-temperature fixed point under the tensor network renormalization group.

Finally, Slava Rychkov proposed a new algorithm in the numerical conformal bootstrap, in collaboration with his Ph.D. student Benoît Sirois, postdoc Marten Reehorst (IHES), Prof. Balt van Rees (École polytechnique), Prof. David Simmons-Duffin (Caltech), and postdoc Ning Su (University of Pisa). This algorithm replaces the binary “allowed/excluded” information previously used in the numerical conformal bootstrap searches, by a continuous measure of success, called the “navigator function”. Applying gradient descent methods to the navigator function, conformal bootstrap searches are made much faster.

Slava RYCHKOV

Theoretical Physics,
permanent professor since 2017.

DISTINCTIONS

New Horizons Prize in Physics (2014)

Institut Universitaire de France, junior member (2012-2017)

Grand prix Mergier-Bourdeix, Académie des sciences de Paris (2019)

Editor of:

SciPost Physics



CONFERENCES

France

International Network on Quantum Fields and Strings Kickoff Meeting, Fédération Denis Poisson, Tours (9 June) **Conformal Bootstrap: Recent Numerical and Analytical Developments** (video conference)

Germany

Theory Seminar, Mathematisches Institut - University of Bonn (23 April) **Deligne categories in Quantum Field Theory and Lattice Mode** (video seminar)

Condensed Matter Theory Group Seminar, Technische Universität München (3 November) **Tensor RG Approach to High-temperature Fixed Point** (video seminar)

Italy

Exact Quantisation and Applications to Condensed Matter Physics, SISSA, Trieste (27 September) **Tensor RG Approach to High-temperature Fixed Point** (conference)

Switzerland

Theory Colloquium, Department of Theoretical Physics, CERN, Geneva (15 September) **The Dream of Non-perturbative Precision RG** (video conference)

United Kingdom

Paths to Quantum Field Theory, Durham University (23 August) **Renormalization Group Transformations without Truncations** (video conference)

United States

Theory Seminar, Stanford University (2 February) **Replicas and RG: Case Study of Random Field Ising Model** (video seminar)

Quantum Field Theory Seminar, Oxford University (2 March) **Some Mathematical Problems Posed by the Conformal Bootstrap Program** (video seminar)

Mathematical Physics Seminar, Rutgers University (2 June) **Long-range Ising Model and Relatives: a Renormalization-group Laboratory** (video seminar)

2021 Ph.D. School of the Simons Bootstrap Collaboration, Simons Foundation, New York (9 July) **Lorentzian CFT and QFT Axioms, Lecture 1** (video lecture) - (12 July) **Lorentzian CFT and QFT Axioms, Lecture 2** (video lecture) - (14 July) **Lorentzian CFT and QFT Axioms, Lecture 3** (video lecture)



PUBLICATIONS

With A. Kaviraj and E. Trevisani

Random Field Ising Model and Parisi-Sourlas Supersymmetry II. Renormalization Group

J. High Energ. Phys. **03** (2021) 219, pre-publication arXiv:2009.10087.

With A. Giuliani and V. Mastropietro

Gentle Introduction to Rigorous Renormalization Group: a Worked Fermionic Example

J. High Energ. Phys. **01** (2021) 026, pre-publication arXiv:2008.04361.

With P. Kravchuk and J. Qiao

Distributions in CFT II. Minkowski Space

J. High Energ. Phys. **08** (2021) 094, pre-publication arXiv:2104.02090.

With M. Reehorst, D. Simmons-Duffin, B. Sirois, N. Su and B. van Rees

Navigator Function for the Conformal Bootstrap

SciPost Physics **11**, 072 (2021), pre-publication arXiv:2104.09518.

With T. Kennedy

Tensor RG Approach to High-temperature Fixed Point

Pre-publication arXiv:2107.11464.

With A. Kaviraj and E. Trevisani

The Fate of Parisi-Sourlas Supersymmetry in Random Field Models

Pre-publication arXiv:2112.06942.