Quantum Field Theory Methods in Non-linear Stochastic Dynamics

Project for the JINR University Center

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Short Introduction

Study of complex phenomena observed in developed hydrodynamic turbulence, advection of passive admixture and non-linear non-equilibrium stochastic problems like percolation processes, kinetics of chemical reactions, influence of hydrodynamic fluctuations on phase transitions, etc., remains an intrigued challenge of modern physics. It requires using and development of robust analytical and numerical methods of the sophisticated mathematical apparatus of quantum field theory and modern methods of non-equilibrium statistical physics.

The goals of the project and student's activities

The mail goal of the project is to teach the students to use quantum field theory methods in the study of physical problems in non-standard areas of physics. We will teach how to use aforementioned methods in non-linear, non-stationary stochastic open physical systems. Especially, students will learn renormalization group (RG) approach and will apply it to the study of above mentioned problems of classical physics. RG approach and obtained RG differential equations give the possibility to find stable asymptotic scaling behavior of various statistical correlations of random fluctuating fields like concentration, velocity field and magnetic fields, order parameters, etc. Crucial quantities are anomalous dimensions which are calculated perturbatively by means of Feynman graphs. The students will calculate divergent parts of one- and two-loop Feynman graphs for percolation processes, chemical reaction of two equal active species and for advection of impurity particles by strong turbulent flows, they will determine anomalous dimensions and scaling exponents, and numerically solve differential equations and will find all stable fixed points of RG equations.

Recommended literature

1. L.Ts. Adzhemyan, N.V. Antonov, A.N. Vasil'ev: *The Field Theoretic Renorma-lization Group in Fully Developed Turbulence* (Gordon & Breach, London, 1999)
2. N. Antonov, M. Hnatich, J. Honkonen, M. Jurcisin: Turbulence with pressure: Anomalous scaling of a passive vector field. *Phys. Rev. E* **68**, (2003), 046306-1-25.
3. A. V. Gladyshev, E. Jurčišinová, M. Jurčišin, R. Remecký, and P. Zalom: *Phys. Rev. E* **86**, 036302

Acceptance criteria

The students have to be familiar with basic ideas and methods of quantum field theory and non-equilibrium statistical physics. It is also supposed that they have experience in using a package for analytic and numerical calculations MATHEMATICA.

The number of the participants is limited by two students

Supervisors of the project

Hnatic Michal, deputy director of BLTP, professor, BLTP, scientific interests – quantum field theory, critical dynamics, developed (magneto)hydrodynamic turbulence, percolation processes, study of influence of hydrodynamic fluctuations on chemical reactions, phase transitions, etc., More than 100 publications devoted to aforementioned problems.
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