Cracow–Poznań–Warsaw Mathematical Physics Seminar

Summer Semester 2021. Fridays 14:15 CET.
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- 14.05.2021 **Kasia Rejzner (University of York)** *Thermal states in Sine-Gordon model in Lorentzian signature.*

> This talk concerns massive Sine-Gordon model in the ultraviolet finite regime in thermal states over the two-dimensional Minkowski spacetime. In the recent joint work with D. Bahns and N. Pinamonti we have applied the methods of perturbative algebraic QFT in Lorentizan signature combined with some estimates inspired by older Eucildean QFT results to construct interacting observables in the massive Sine-Gordon model in thermal states.

- 16.04.2021 **Vitaly Moroz (Swansea University)**. *Thomas-Fermi type models for graphene*

> We discuss density functional theories of Thomas-Fermi and Thomas-Fermi-von Weizsacker type which describe the response of a single layer of graphene to an external electric charge. Mathematically, this amounts to the analysis of two nonlocal variational problems which involve Coulombic terms and a Hardy type potential. We develop the variational framework in which the proposed energy functionals admit minimizers and prove the uniqueness and regularity of the ground states for the associated Euler-Lagrange equations which involve the fractional Laplacian. In addition, we discuss positivity and decay rate of the ground states and present several open problems. This is a joint work with Jianfeng Lu (Duke) and Cyrill Muratov (NJIT, USA).

- 09.04.2021 **Michał Wrochna (Université de Cergy-Pontoise)**. *Spectral actions on asymptotically Minkowski spacetimes*

> The spectral theory of the Laplace–Beltrami operator on Riemannian manifolds is known to be intimately related to geometric invariants such as the Einstein-Hilbert action. These relationships have inspired many developments in physics including the Chamseddine–Connes action principle in the non-commutative geometry programme. However, a priori they do only apply to the case of Euclidean signature. The physical setting of Lorentzian manifolds has in fact remained largely problematic: elliptic theory no longer applies and something different is needed.In this talk I will report on joint work on this problem with Nguyen Viet Dang. We consider perturbations of Minkowski space and more general spacetimes on which the d'Alembertian P is essentially self-adjoint (thanks to recent results by Dereziński–Siemssen, Vasy and Nakamura–Taira). It is then possible to define functions of P, and we demonstrate that their Schwartz kernels have geometric content largely analogous to the Riemannian setting. In particular, we define a Lorentzian spectral zeta function and relate one of its poles to the Einstein–Hilbert action, paralleling thus a result in Euclidian signature attributed to Connes, Kastler and Kalau–Walze.The primary consequence is that gravity can be obtained from a spectral action directly in Lorentzian signature. The proofs involve mathematical ingredients from Quantum Field Theory on curved spacetime, in particular the Feynman propagator.

- 19.03.2021 **Paweł Duch (University of Leipzig)**. *Renormalization of the stochastic quantization equation of the Φ^4_3 model with the use of the Polchinski flow equation.*

> Stochastic quantization is a method of constructing models of Euclidean quantum field theory with the use of stochastic partial differential equations driven by a random force called the white noise. Stochastic quantization equations of nontrivial QFT models are typically ill-posed. They require renormalization and admit only distributional solutions. A general solution theory for such equations was developed only recently by Martin Hairer. His breakthrough work triggered much interest in singular stochastic PDEs in the mathematical community and was awarded the Fields Medal in 2014.
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> In the first part of the talk, I will give a short introduction to the stochastic quantization technique. In the second part, I will outline a new method of constructing solutions of singular stochastic PDEs. I will illustrate the method with the example of the stochastic quantization equation of the Φ^4 model in 3 dimensions. A distinctive feature of my construction is the use of the Wilsonian renormalization group theory and the Polchinski flow equation.

- 12.03.2021 **Abhishek Goswami (University at Buffalo)**. *Mass generation of fermions via the Higgs mechanism.*

> In the Standard Model of particle physics, the interaction of a particle with the Higgs boson is responsible for its mass generation. This principle is known as the Higgs mechanism. Fermions interact with the Higgs boson through a Yukawa coupling constant. The presences of a Higgs-like particle and the Yukawa coupling have now been confirmed at the CERN Large Hadron Collider (LHC). In this talk, I will discuss a rigorous, non-perturbative proof of the fermion mass generation. I will start with a weakly coupled U(1) Higgs-Yukawa theory on a unit lattice in d=4 and show exponential decay of two-point fermion correlation function. This is the mass gap. Mass gap implies that all the particles in the theory i.e. the U(1) gauge boson, the Higgs boson and the fermions have a non-zero physical mass.