Virtual Institute of Physics

Office address: High Energy Physics Institute of Tbilisi State University
9 Univesity street, GE-0186, Tbilisi, Georgia, Tel.: (+99532) 18-73-17, Fax: (+99532) 18-98-52

Lectures on:	**Monte-Carlo Methods in Quantum Mechanics and Quantum Field Theory**
by:	**Akaki Rusetsky (University of Bonn, Germany)**
will be held in the:	**Lecture hall of „Kvali“ association** 2nd block of Tbilisi State University, 3 Chavchavadze Ave.
time:	**Tuesdays 12:00** (lectures) **Thursdays 12:00** (exercises)

Master students are invited to attend
Course language: English/Georgian at the discretion of the audience

Topics:

- Path integrals in QM and QFT
- Introduction to Monte-Carlo algorithms
- Quantum scattering on the lattice
- Discretization of the Klein-Gordon equation
- Lattice fermions
- Spin systems

Monte-Carlo methods in Quantum Mechanics and Quantum Field Theory

1. Path integral formulation of quantum mechanics
    - Evolution operator in path integral formulation
    - Wick rotation
    - Green functions, spectrum of the Hamiltonian, wave function
    - Transfer operator
    - Relation to the statistical physics
    - Discretization error and improved actions
2. Monte-Carlo methods
    - Importance sampling
    - Numerical algorithms
    - Evaluation of the errors
3. Examples
    - Harmonic oscillator
    - Anharmonic oscillator
    - Double-well potential and instantons
    - Generalized eigenvalue equations
4. Quantum mechanics in a finite volume
    - Determination of the spectrum in the momentum space
    - Angular momentum on the cubic lattice
    - Scattering length
    - Scattering phase
    - Resonances
5. Free scalar field*
    - Discretization of the Klein-Gordon Lagrangian

- Propagator of the free scalar field on the lattice

6. Dirac equation on the lattice*
   - Spectrum of the Dirac operator on the lattice: the doublers
   - Wilson fermions
   - Kogut-Susskind fermions
   - Chiral symmetry on the lattice
   - Axial anomaly on the lattice
7. Ising model*
   - Mean field approximation
   - Phase transition
   - Numerical simulations

References

[1] R. P. Feynman and A. R. Hibbs, "Quantum Mechanics and Path Integrals," McGraw-Hill, Inc. (1965).

[2] J. Smit, "Introduction to quantum fields on a lattice: A robust mate," Cambridge Lect. Notes Phys. **15** (2002) 1.

[3] I. Montvay and G. Münster, "Quantum fields on a lattice," *Cambridge, UK: Univ. Pr. (1994) 491 p. (Cambridge monographs on mathematical physics)*

[4] G. P. Lepage, "Lattice QCD for Novices," arXiv:hep-lat/0506036.

[5] M. Creutz and B. Freedman, "A Statistical Approach To Quantum Mechanics," Annals Phys. **132** (1981) 427.

[6] M. Lüscher, "Two particle states on a torus and their relation to the scattering matrix," Nucl. Phys. B **354** (1991) 531;

[7] M. Lüscher, "Volume Dependence of the Energy Spectrum in Massive Quantum Field Theories. 2. Scattering States," Commun. Math. Phys. **105** (1986) 153.

[8] A. K. Das, "Field theory: A Path integral approach," World Sci. Lect. Notes Phys. **52** (1993) 1.