Title:

Key problems in fundamental physics

Lectures:

(1) Physical time and the beginning Universe 11.11.

- Clocks and the vacuum
- Time coordinates in general relativity and cosmology
  (proper time, conformal time, cosmic time)
- Field transformations and frame invariance:
  Is the age of the Universe 13.8 billion years?
- Physical time for the beginning Universe
- What is the meaning of expanding space and slowing time?

(2) What is quantum gravity? 25.11.

- Fields and symmetries
- General coordinate invariance as a gauge symmetry
- Quantum field theory for metric or vierbein
- The role of metric fluctuations
- Asymptotic safety
- Lattice approaches and string theory
- Can one observe quantum gravity effects?

(3) Origin of wave functions and operators for quantum mechanics 9.12.

- Evolution in classical probabilistic systems
- Wave functions and time local probabilities in classical statistics
- Transfer matrix and step evolution operator
- The non-commuting structures in classical statistics
- Unitary evolution and quantum mechanics
- Probabilistic cellular automata as simple quantum systems

(4) Quantum field theory from classical probabilities 20.1.

- Functional integral approach to quantum field theory
- Generalized Ising models as "functional integrals“
- Minkowski and euclidean time
- Fermions as Ising spins
- Simple probabilistic cellular automaton for fermionic quantum field theory
  in one time and one space dimension
- Vacuum, operators and correlation functions

(5) Cosmological constant and dynamical dark energy