Quantum Gravity in Cracow^4
Correlations in Complex Systems
8-10 May 2015

List of Talks

Jerzy Jurkiewicz *(Fri, May 8th, 17:00)*
Causal Dynamical Triangulations
The aim of the talk is to explain the basic ideas of Dynamical Triangulations, starting with the simplest example of two-dimensional Euclidean Dynamical Triangulation model. The role of the entropy of configurations is explained in the process of formulating the amplitude of the quantum evolution of one-dimensional geometric states. The restriction of space-time cosmologies by the causality condition is explained, leading to a formulation of the model of Causal Dynamical Triangulations. The model can be generalized to higher dimensions. The most interesting is the case 3+1. We briefly explain the parameters of the model, the phase structure and the importance of studying phase transitions from the point of view of the continuum limit of the theory. Detailed discussion of results will be presented in other talks.

Andrzej Görlich *(Fri, May 8th, 18:00)*
How to define the continuum limit in CDT?
In this talk I will sketch how to define the continuum limit within the framework of Causal Dynamical Triangulations. I will introduce a notion of 'lines of constant physics' in the coupling constant space and investigate the renormalization group flow in CDT. Basing on simple assumptions, I will show what is the outcome of numerical simulations in 4D.

Jakub Gizbert-Studnicki *(Sat, May 9th, 9:30)*
A Spontaneous Signature Change in CDT Quantum Gravity?
I will present a study of the effective transfer matrix and the associated effective action of four-dimensional CDT. The transfer matrix allows one to analyze CDT phase transitions and leads to a discovery of a new phase. I will discuss some geometric properties of the newly discovered 'bifurcation' phase and show the likely microscopic mechanism of transition between 'de Sitter' and 'bifurcation' phases. I will argue that for sufficiently large lattice volumes the kinetic term of the effective action has a different sign in each of the two phases, which can be viewed as a spontaneous Wick rotation of the metric.

Daniel Coumbe *(Sat, May 9th, 10:10)*
What is Dimensional Reduction Really Telling Us?
We review the evidence for dimensional reduction across a number of independent approaches to quantum gravity, with a particular focus on CDT. Motivated by the radical consequences of accepting the reality of dimensional reduction we argue that dimensional reduction should not be viewed as a real physical phenomena, and that its appearance in large number of independent approaches to quantum gravity is instead suggesting the need for a modified description of time.

Jerzy Lewandowski *(Sat, May 9th, 11:30)*

Loop Quantum Gravity

Jakub Mielczarek *(Sat, May 9th, 12:30)*

Signature-change quantum cosmology

Signature change at high density has been obtained as a possible consequence of deformed space-time structures in models of loop quantum gravity. The purpose of the talk is to provide a conceptual discussion of implications of the effect for cosmological scenarios. Especially, the role of the characteristic problem for the mixed-type partial differential equations describing evolution of cosmological perturbations will be stressed. Furthermore, our current understanding of the signature-changing quantum space-time will be presented.

Boris Bolliet *(Sat, May 9th, 13:10)*

The primordial tensor power spectrum in LQC

Loop quantum cosmology tries to capture the main ideas of loop quantum gravity and to apply them to the Universe as a whole. Two main approaches within this framework have been considered to date for the study of cosmological perturbations: the dressed metric approach and the deformed algebra approach. They both have advantages and drawbacks. In this talk, we will compare their predictions. In particular, we present the computation of the associated primordial tensor power spectra. We will see – numerically and analytically – that the large scale behavior is similar for both approaches and compatible with the usual prediction of general relativity. The small scale behavior is, the other way round, drastically different. Most importantly, in a range of wavenumbers explicitly calculated, both approaches do agree on predictions that, in addition, differ from standard general relativity and do not depend on unknown parameters. These features of the power spectrum at intermediate scales might constitute a universal loop quantum cosmology prediction that can hopefully lead to observational tests and constraints.

Norbert Bodendorfer *(Sat, May 9th, 15:00)*

Symmetry reductions in loop quantum gravity based on classical gauge fixings

We discuss a new strategy to perform a symmetry reduction in loop quantum gravity based on classically gauge fixing the spatial diffeomorphism constraint. Symmetry reductions can then be performed by demanding the vanishing of certain classical phase space functions, which translates into implementing (some part of) spatial diffeomorphism invariance on the reduced phase space, thus solving the spatial diffeomorphism constraint ”twice”. We illustrate how this process works for reductions to Bianchi I cosmological models, and if time permits, also for spherical symmetry.

Mehdi Assanioussi *(Sat, May 9th, 15:40)*

Hamiltonian operator for LQG coupled to a scalar field

This talk will be focused on the construction of a physical Hamiltonian operator in the deparametrized model of loop quantum gravity coupled to a massless scalar field. I will briefly present the regularization procedure for the Hamiltonian of the theory, then I will discuss the properties of the resulting operator and the dynamics it induces.

Andrea Dapor *(Sat, May 9th, 16:20)*

Rainbows from Quantum Gravity

I will describe a general mechanism for emergence of a rainbow metric from quantum gravity. This idea is based on QFT on a quantum spacetime. I will show that, under general assumptions, the fundamental quantum spacetime on which the field propagates can be described by a classical metric. It turns out that this effective metric depends explicitly on the mode of the field: as shown by an analysis of dispersion relations, quanta of different energy propagate on different metrics, similar to photons of different colors in a refractive material (hence the name ''rainbow''). The talk is based on arXiv:1412.6000.

Włodzimierz Piechocki *(Sun, May 10th, 9:30)*

Towards resolving generic singularity problem of general relativity

We present classical and quantum dynamics of the Bianchi IX model that underlies the generic solution to general relativity called the BKL scenario. At semi-classical level the periodic dynamics includes quantum big bounce, and classical recollapse far away from the bounce. We use compound quantization (based on affine coherent states and canonical methods) and adiabatic approximation. The resolution of singularity is due to repulsive potential generated by the affine quantization. During contraction of the universe the quantum energy of anisotropic degrees of freedom grows much slower than the classical one. Main part of presentation is based on our two papers: arXiv:1501.07871 and arXiv:1202.5448.

Lisa Glaser *(Sun, May 10th, 10:20)*

The Hartle-Hawking wave function in Causal Set theory

We define a Hartle-Hawking type wave function for Causal Set quantum gravity which we implement on an ensemble of 2 dimensional causal sets using Monte Carlo simulations. Using the average action obtained through the simulations we approximate the wave function and examine which final states are most likely. We find that the most likely states show rapid expansion and a crystalline structure.

Luis Pires *(Sun, May 10th, 11:20)*

On the role of the extra kinetic term coupling in Horava Lifshitz gravity

While motivated as a putative theory of quantum gravity, the classical limit of Horava-Lifshitz gravity is an interesting model in itself. The main difference between this theory and GR lies in the presence of a new dimensionless coupling in the kinetic term of the action, the so-called little lambda whose role is still up for debate. As a starting point for our work, we look at two apparently contradictory statements about its effect on the theory and show that they actually refer to two different versions of it, distinguishable by the way the lapse function is defined. We then focus on the so-called non-projectable theory, where the lapse is a function of spacetime, and show how the presence of lambda gives rise to a non-trivial constraint algebra, reminiscent of the conditions present in the CMC gauge of GR.

Sean Gryb *(Sun, May 10th, 12:00)*

An Introduction to Shape Dynamics: A Review of the Basic Principles, Formalism and Key Results

There exists a particularly useful foliation for General Relativity where the local gauge-invariant degrees of freedom are conformally invariant. Shape Dynamics is an approach to gravity where this observation is taken seriously to motivate an ontological shift from a spacetime picture to a picture of evolving conformal 3-geometry. Several exciting possibilities arise if one embraces such an ontology: different possibilities exist for what happens behind the horizons of black holes, new insights are gained about the arrow of time, and, perhaps most promising, new scenarios arise for describing a UV completion of General Relativity. In this talk, I will review the basic formalism for Shape Dynamics, discuss some recent results and speculate about the implications for the quantum theory.

Michał Eckstein *(Sun, May 10th, 12:40)*

Rethinking microscopic causality via noncommutative geometry

Causality is one of the most fundamental concepts in physical theories. It lies at the heart of modern formulations of quantum field theory and many approaches to quantum gravity. I will demonstrate that within the framework of noncommutative geometry the notion of causality naturally extends to the space of states of a physical system. I will illustrate this concept on a simple model of two-sheeted space-time and show that it sheds new light on Zitterbewegung - the trembling motion of the electron.

Tomasz Trześniewski *(Sun, May 10th, 13:20)*

The κ-Carroll particle from 3d gravity

Classical gravity in 2+1 dimensions can be formulated as the Chern-Simons theory with a local isometry group as the gauge group. Point particles may be coupled to this theory in a natural way. In principle one can then integrate out the gravitational degrees of freedom and obtain the effective particle action but in the case of de Sitter space it is rather difficult. On the other hand, de Sitter gauge group locally factorizes into the Lorentz group and the group AN(2). For vanishing cosmological constant, corresponding to the flattening of the AN(2) component one recovers a particle in at spacetime and with the momentum space given by the Lorentz group. It turns out that if one instead flattens the Lorentz component it leads to the ultrarelativistic particle solution, known as the Carroll particle but with the AN(2) momentum space. Interestingly, the AN(2) group is related to the so-called three-dimensional κ-Poincaré algebra, a well-studied example of deformations of relativistic symmetries which hypothetically arise in the quantization of gravity.