Schedule: Experimental Search for Quantum Gravity

All talks will be held in the Bob Room (Perimeter Institute, 4th floor) with exception of the PI public lecture on Wednesday, which will be held at the Waterloo Collegiate Institute.

Monday, Nov 5th

Chairs: Morning session – Hossenfelder, Afternoon session – Hinterleitner

Time	Speaker	Topic
9:15	REGISTRATION	
9:45	Hossenfelder	Opening
10:00	Mavromatos	Quantum-Gravity-induced Decoherence and intrinsic CPT Violation: towards smoking-gun experimental evidence in entangled particle states?
11:15	Ng	Planck Meets Hubble and Boltzmann: Holographic Quantum Foam and Cosmology
12:30	LUNCH	
14:30	Niemeyer	Inflation with a Cutoff: Proposals and Problems
15:30	COFFEE BREAK	
16:00	Sudarsky	The quantum origin of the cosmological structure: an arena for quantum gravity phenomenology
17:00	Visser	Emergent dispersion relations — lessons for quantum gravity.
18:00	Weinfurtner	Mass-generating mechanism for Nambu-Goldstone bosons in emergent spacetime and its application for quantum gravity phenomenology

Tuesday, Nov 6th

Chairs: Morning session – Sudarsky, Afternoon session – Konopka

Time	Speaker	Topic
10:00	Hinterleitner	DSR and Classical Gravity
11:15	Girelli	Symmetry deformation from quantum relational observables
12:30	LUNCH	
14:30	Landsberg	Out-of-this-World Physics: Probing Quantum Gravity in the Lab
15:45	COFFEE BREAK	
16:15	Ellis	Towards a Phenomenology of Quantum Gravity?
17:30	Cavaglia	Phenomenology of black holes in particle colliders and cosmic ray showers

Wednesday, Nov 7th

Chairs: Morning session – Girelli, Afternoon session – Liberati

Time	Speaker	Topic
10:00	Liberati	New constraints on Planck-scale Lorentz Violation in QED from the Crab Nebula
11:00	Lämmerzahl	Possible strategies for the search for quantum gravity induced effects
12:00	LUNCH	
14:00	Sander Bais	PI COLLOQIUM
15:15	COFFEE BREAK	
15:45	Husain	Gravitational collapse in quantum gravity
17:00	Major	Phenomenology of Discrete Space: Possible Tests
19:00	PUBLIC LECTURE	John Ellis and Robert S. Orr *"The Large Hadron Collider - World's Most Powerful Microscope"*

Thursday, Nov 8th

Chairs: Morning session – Dittrich, Afternoon session – Brandenberger

Time	Speaker	Topic
10:00	Giddings	Black hole production at high energies
11:15	Brandenberger	Probing string theory through cosmological observations?
12:30	LUNCH	
14:30	Chou	Recent Results from the Pierre Auger Observatory
15:45	COFFEE BREAK	
16:15	Holman	Imprinting Short-Distance Physics on Long Distance Observables: Can this be consistent?
17:30	Danielsson	New physics from inflation
19:00		DINNER

Friday, Nov 9th

Chair: Kempf

Time	Speaker	Topic
10:00	Amelino-Camelia	A perspective on Quantum Gravity Phenomenology
11:15	Smolin	Summary
12:15	LUNCH	End of Workshop

Abstracts

(In alphabetical order)

Amelino-Camelia, Giovanni

A perspective on Quantum Gravity Phenomenology

I discuss the status of Quantum Gravity Phenomenology, focusing separately on the 3 key areas: ability to discover, ability to constrain, and ability to falsify. And I stress the importance of adopting carefully taylored test theories as a remedy to difficulties encountered when comparing experimental evidence to theory evidence.

Brandenberger, Robert

Probing string theory through cosmological observations?

If string theory is the correct theory which unifies gravity with the other forces of nature at a quantum level, it should determine the evolution of the earliest stages of the universe. I will discuss how stringy signatures of this early phase may be visible in current cosmological observations.

Cavaglia, Marco

Phenomenology of black holes in particle colliders and cosmic ray showers

If large extra dimensions exist, microscopic black holes may be created in TeV particle colliders and in Earth's atmosphere by the collisions of ultrahigh-energy cosmic rays with atmospheric nuclei. The decay of these black holes could soon be observed at the Large Hadron Collider or the Pierre Auger Observatory. Monte Carlo codes have been developed to simulate these events. In this talk I will introduce two of these codes (CATFISH for the LHC and GROKE for the PAO), and discuss how mini black holes can be distinguished from standard model or susy events.

Danielsson, Ulf

New physics from inflation

I discuss how physics beyond the Planck scale and before inflation might leave an imprint on the primordial spectrum. There are interesting limitations connected with the information paradox that suggests unexpected new ways to test ideas on quantum gravity.

Ellis, John

Towards a Phenomenology of Quantum Gravity?

This talk will review proposed tests of ideas about quantum gravity, including searches for quantum decoherence, probes of the possible energy-dependence of the velocity of light, and the nature of vacuum energy. Motivations will be drawn from a non-critical string theory framework.

Giddings, Steven

Black hole production at high energies

I will survey some of the physics of TeV-scale black hole production, as well as outstanding issues. I will also discuss some of the conceptual issues surrounding high-energy black hole production.

Girelli, Florian

Symmetry deformation from quantum relational observables

Observables in (quantum) General Relativity can be constructed from (quantum) reference frame – a physical observable is then a relation between a system of interest and the reference frame. A possible interpretation of DSR can be derived from the notion of deformed reference frame (cf Liberati-Sonego-Visser). We present a toy model and study an example of such quantum relational observables. We show how the intrinsic quantum nature of the reference frame naturally leads to a deformation of the symmetries, comforting DSR to be a good candidate to describe the QG semi-classical regime.

Hinterleitner, Franz

DSR and Classical Gravity

The talk gives a brief overview over different versions of doubly or deformed special relativity (DSR) and its motivation, which comes from the occurrence of a fundamental invariant length in quantum gravity (QG). Despite its QG origin, DSR is a modification of flat space geometry without explicit notion of gravity. In the literature there is a considerable amount of work done to probe deformations of special relativity in classical and quantum mechanics and quantum field theory without taking into account intermediate steps between QG and flat space, like general relativity or quantum field theory in curved space. The more special part of this contribution makes one step into this gap by comparing the DSR modifications of simple quantum scattering of a particle in flat space with the modifications caused by a weak classical gravitational field.

Holman, Richard

Imprinting Short-Distance Physics on Long Distance Observables: Can this be consistent?

We use the example of inflationary physics to discuss the possibility that short distance physics might be imprinted on long-distance observables. In particular, we focus on issues involving decoupling in field theory.

Husain, Viqar

Gravitational collapse in quantum gravity

I will describe work aimed at understanding the dynamics of gravitational collapse in a fully quantum setting. Its emphasis is on the role played by fundamental discreteness. The approach used suggests modifications of a black hole's mass loss rate and thermodynamical properties. Numerical simulations of collapse with quantum gravity corrections indicate that black holes form with a mass gap.

Lämmerzahl, Claus

Possible strategies for the search for quantum gravity induced effects

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Landsberg, Greg

Out-of-this-World Physics: Probing Quantum Gravity in the Lab

I'll give a broad review of various ways of looking for large, small, and warped extra dimensions and will give only a brief review of the black-hole business, particularly an introduction based on the original paper we wrote and recent work on Randall-Sundrum black holes.

Liberati, Stephano

New constraints on Planck-scale Lorentz Violation in QED from the Crab Nebula

We set constraints on O(E/M) Lorentz Violation in QED in an effective field theory framework. A major consequence of such assumptions is the modification of the dispersion relations for electrons/positrons and photons, which in turn can affect the electromagnetic output of astrophysical objects. We compare the information provided by multiwavelength observations with a full and self-consistent computation of the broad-band spectrum of the Crab Nebula. We cast constraints of order $10^{-}5$ at 95% confidence level on the leptons Lorentz Violation parameters.

Major, Seth

Phenomenology of Discrete Space: Possible Tests

I will discuss possible tests of the grainularity of space including modified dispersion relations in the formation of white dwarfs and neutron stars and constraints on a stochastic direction field from atomic system tests.

Mavromatos, Nikoloas

Quantum-Gravity-induced Decoherence and intrinsic CPT Violation: towards smoking-gun experimental evidence in entangled particle states?

Quantum Gravity may be entirely unconventional as a theory, leading to completely unfamiliar (compared to other fields of physics) and unexpected experimental signatures. One particularly interesting avenue for research in that field is the study of models in which quantum gravity operates as a decoherening "foamy space-time medium", with which ordinary propagating matter interacts. In such theories, which appear to involve the evolution of pure quantum mechanical states to mixed ones, at an effective low-energy level, the CPT operator of the effective low-energy field theory is ill defined, at least in its strong form, as argued in a theorem by R. Wald (1980) . This induces "Microscopic Time Irreversibility", a fundamental "arrow of time" in the effective theory. Experimentally of course, this arrow may not be observable: one may face a situation in which the experimentally accessible subspaces of quantum-mechanical states are decoherence-free subspaces, such that the relevant observables appear to be CPT symmetric, despite the strong form of CPT violation. This can happen, for instance, if cancellations of the "anomalous" CPT Violating terms between particle and antiparticle sectors occur.

However, there are concrete quantum-gravity models of space time foam (some within the context of (non-critical) string theory), in which there are clear, and possibly unique ("smoking-gun" type), experimental signatures of such an intrinsic CPT violation, manifesting themselves in induced modifications of the Einstein-Podolsky-Rosen (EPR) correlations of entangled states of neutral mesons in the appropriate meson factories. In the talk I will review the situation in some detail, discussing some indicative estimates of the effect, within some specific (non-critical) string models of space time foam for concreteness, as well as outlining the current experimental limits in phi- and B-meson factories and prospects for improvement in upcoming meson facilities, such as a possible upgrade of DaPhiNe. As I will argue, some models of this type of intrinsic CPT Violation may be falsified in such upgraded facilities.

Ng, Jack

Planck Meets Hubble and Boltzmann: Holographic Quantum Foam and Cosmology

Quantum fluctuations of spacetime give rise to quantum foam, and black hole physics dictates that the foam is of holographic type. One way to detect quantum foam is to exploit the fact that an electromagnetic wavefront will acquire uncertainties in direction as well as phase as it propagates through spacetime. These uncertainties can show up in interferometric observations of distant quasars as a decreased fringe visibility. The Very Large Telescope interferometer may be on the verge of probing spacetime fluctuations which, we argue, have repercussions for cosmology, requiring the existence of dark energy/matter, critical cosmic energy density, and accelerating cosmic expansion in the present era. We speculate that, in the framework of holographic quantum foam, the dark energy is composed of an enormous number of inert "particles" of extremely long wavelength. These "particles" necessarily obey infinite statistics (quantum Boltzmann statistics) in which all representations of the particle permutation group can occur. For every boson or fermion in the present observable universe there could be $\sim 10^{31}$ such "particles".

Niemeyer, Jens

Inflation with a Cutoff: Proposals and Problems

The possible existence of a physical UV cutoff in dynamical spacetimes raises a number of conceptual and practical questions. If the validity of Lorentz Invariance is considered unreliable above the cutoff, the creation or destruction of quantum modes and the choice of their initial state need to be described explicitly. It has been proposed that these trans-Planckian effects might leave an oscillatory imprint on the power spectrum of inflationary perturbations. However, taking into account the fluctuations of the cutoff, the signal is smeared out beyond recognition.

Sudarsky, Daniel

The quantum origin of the cosmological structure: an arena for quantum gravity phenomenology

I will review the shortcomings of the standard account of the origin of anisotropies and in-homogeneities in inflationary cosmology. I will argue that something beyond the established paradigm of physics in needed for a satisfactory explanation of the process by which the seeds of structure emerge from the inflaton vacuum and will consider the application of a generalization of the ideas of R Penrose about a quantum gravity induced dynamical collapse of the quantum mechanical state of a system as a promising avenue to address the issue. I will show i) that the proposal offers paths to test the viability of rather specific ideas about the mechanism of collapse, ii) that generically it can led to some precise features in

the primordial spectrum of density fluctuations, which can in turn be looked for, in the observational data, and used to set bounds on certain aspects the quantum gravity phenomenology, and iii) that it leads to other rather robust predictions that can be confronted with experiments.

Visser, Matt

Emergent dispersion relations — lessons for quantum gravity.

The dispersion relations that naturally arise in the known emergent/analogue spacetimes typically violate analogue Lorentz invariance at high energy, but do not do so in completely arbitrary manner. This suggests that a search for arbitrary violations of Lorentz invariance is possibly overkill: There are a number of natural and physically well-motivated restrictions one can put on emergent/analogue dispersion relations, considerably reducing the plausible parameter space.

Weinfurtner, Silke

Mass-generating mechanism for Nambu-Goldstone bosons in emergent spacetime and its application for quantum gravity phenomenology.

Effective field theories (EFTs) have been widely used as a framework in order to place constraints on the Planck suppressed Lorentz violations predicted by various models of quantum gravity. There are however technical problems in the EFT framework when it comes to ensuring that small Lorentz violations remain small – this is the essence of the "naturalness" problem. Herein we present an "emergent" space-time model, based on the "analogue gravity" programme, by investigating a specific condensed-matter system that is in principle capable of simulating the salient features of an EFT framework with Lorentz violations. Specifically, we consider the class of two-component BECs subject to laser-induced transitions between the components, and we show that this model is an example for Lorentz invariance violation due to ultraviolet physics. Furthermore our model explicitly avoids the "naturalness problem", and makes specific suggestions regarding how to construct a physically reasonable quantum gravity phenomenology.
