Loops´17 Conference
Book of Abstracts
-Afternoon sessions-

Quantum geometry and observables:

Clement Delcamp, Perimeter Institute: *New bases for Loop Quantum Gravity*

Hilbert spaces of diffeomorphism invariant states can be explicitly realized from TQFTs with defect excitations. Choosing the BF vacuum as the underlying TQFT, we introduce for 2+1D a new basis for kinematical states, namely the fusion basis. This corresponds to a shift of focus from the original lattice to the curvature and torsion excitations themselves. This basis stable under coarse-graining is very well-suited for the study of the large scale limit of the theory and provides a completely relational way of defining regions for 2+1 gravity coupled to particles. Using a Heegaard splitting in order to represent the 3D manifold via a 2D surface, we can lift the 2+1 construction to the 3+1 case. It leads to several bases. In particular, we obtain a basis which naturally encodes curvature degrees of freedom.

Patryk Drobiński, Faculty of Physics, University of Warsaw: *The continuum BF vacuum representation*

I will present a new representation of the holonomy-flux algebra, inspired by the Pullin-Dittrich-Geiller "BF vacuum" and equivalent to its continuum limit. The work is currently complete for an Abelian (U(1)) gauge group, the SU(2) case still being investigated.

Kristina Giesel, Institute for Quantum Gravity, FAU Erlangen-Nürnberg: *Cosmological Perturbation Theory with Geometrical Clocks*

In this talk we apply the relational formalism to cosmological perturbation theory and show how geometrical clocks can be obtained that lead to the usual gauge invariant quantities used in the context of linear cosmological perturbations theory such as the Bardeen potentials and the Mukhanov Sasaki variable. We will also compare the framework of reduced phase space quantization using scalar field clocks and geometrical clocks respectively. Finally, we will discuss possible applications of this framework to higher order cosmological perturbation theory.

Florian Girelli, University of Waterloo: *A fresh look at 3d quantum gravity*

I will focus on 3d gravity (with $\Lambda = 0$) and notice that in this case, when discretizing first there exist different interesting choices of polarization: the standard loop gravity choice but also two new ones, the “dual” loop gravity case and the Chern-Simons case. The discretization schemes shows how each choice is related and we also have a clear understanding of how the classical version of a quantum group structure (the Drinfeld double) appears.

I will discuss the quantization of the “dual” loop gravity case and show how it is related to the Dijkgraaf-Witten model. If time allows, I will quickly comment on the 4d extension to this approach and on the common grounds with Dittrich and Geiller’s approach.

Christophe Goeller, Ecole Normale Supérieure de Lyon: *Ponzano Regge amplitude on the twisted torus: continuum limit and BMS character formula*

We compute the Ponzano-Regge amplitude for 3D quantum gravity on the twisted torus. We compare our result to the previous calcilations done at one-loop for 3D gravity in the asymptotitic limit and in linearized Regge calculus. And we discuss the interpretation of the amplitude as a BMS character.

Lucas Hackl, Pennsylvania State University, Institute for Gravitation and the Cosmos: ***Squeezed vacua in loop quantum***

Semi-classical states in quantum gravity are expected to exhibit long range correlations. In order to describe such states within the framework of loop quantum gravity, it is important to parametrize states in terms of their correlations. Recently, we introduced a new class of states with presecribed correlations, called squeezed vacua (see Dr. Yokomizo's talk). In this talk, I will explain node-wise and link-wise squeezing, how the resulting states relate to coherent states studied in the past, and how to encode long-range correlations.

Franz Hinterleitner, Brno University: ***Canonical LQG operators and kinematical states for plane gravitational waves***

In a 1+1 dimensional model of plane gravitational waves the flux-holonomy algebra of loop quantum gravity is modified in such a way that the new basic operators satisfy canonical commutation relations. Thanks to this construction it is possible to find kinematical solutions for unidirectional plane gravitational waves, leading to finite geometric expectation values and fluctuations, which was problematic in an earlier, more conventional approach.

Zichang Huang, Florida Atlantic University: ***SU(2) Flat Connection on Riemann Surface and Twisted Geometry with a Cosmological Constant***

SU(2) flat connection on 2D Riemann surface is shown to relate to the generalized twisted geometry in 3D space with cosmological constant. Various flat connection quantities on Riemann surface are mapped to the geometrical quantities in discrete 3D space. A proposal is that the moduli space of SU(2) flat connections on Riemann surface generalizes the phase space of twisted geometry or Loop Quantum Gravity to include the cosmological constant. I will introduce details on how to construct this map.

Alexander Kegeles, Max Planck Institute for Gravitational Physics: ***Inequivalent representations of Group Field Theory***

Group field theory is a field theoretical formulation of spin networks and simplicial geometry, in which the states are associated with excitations of basic geometrical degrees of freedom over a vacuum of the theory. The simplest type of vacuum is the state of "No geometry". However, that is not the only possible vacuum and there are many more.

In my talk I will present an algebraic formulation of Group Field Theory in which the study of different vacua of the theory can be rigorously addressed and studied. I then show the existence and explicit examples of different inequivalent vacua, based on coherent states of group field theory.

Chun-Yen Lin, University of Warsaw: ***Quantum reference frames: application in FRW LQC***

I will present our recent application of “quantum Cauchy surfaces” to the timeless Dirac theory underlying the standard FRW LQC with a massless scalar field. Two specific foliations, referring to either the scalar or the gravitation sector as the time, generate two complete sets of relational Dirac observables in the timeless physical Hilbert space. These observables then yield two interesting Schr"odinger representations to the Dirac theory. The first representation gives the familiar LQC model describing the quantum gravitational dynamics; the second yields a scalar field quantum dynamics in the background of the discretized spacetime.

Ilkka Mäkinen, University of Warsaw: *Spin coherent state representation for intertwiners in loop quantum gravity*

We introduce a representation for the intertwiner space in loop quantum gravity, based on projecting intertwiners on coherent states of angular momentum. In this representation, operators such as the Hamiltonian are reformulated as differential operators acting on polynomials of the complex variables which label the unit vectors of the spin coherent states under the stereographic projection. This opens up the possibility of investigating the action of the Hamiltonian geometrically in terms of these unit vectors, as an alternative to calculations relying on standard SU(2) recoupling theory.

Almut Oelmann, Institute for Quantum Gravity, Chair for Theoretical Physics III, University of Erlangen-Nürnberg, Staudtstraße 7 / B2, 91058 Erlangen, Germany: *Reduced Loop Quantization with four Klein-Gordon Scalar Fields as Reference Matter*

We perform a reduced phase space quantization of gravity using four Klein-Gordon scalar fields as reference matter as an alternative to the Brown-Kuchař dust model where eight (dust) scalar fields are used. The scalar fields play the role of so called reference fields that allow to construct Dirac observables for general relativity and introduce a notion of physical spatial and time coordinates. We also compare our results to an earlier model by Domagala et. al. where only one Klein-Gordon scalar field was considered as reference matter for the Hamiltonian constraint. As a result we find that the choice of four Klein-Gordon scalar fields as reference matter leads to a reduced dynamical model that cannot be quantized using loop quantum gravity techniques. However, we further discuss a slight generalization of the action for the four Klein-Gordon scalar fields and show that this leads to a model which can be quantized in the framework of loop quantum gravity.

Julian Rennert, University of Waterloo: *Quantization of quasi-Poisson spaces and the Turaev-Viro model*

Quantum systems with quasitriangular Hopf algebra symmetry, such as the Turaev-Viro model with real deformation parameter, can be considered as quantizations of phase spaces with Poisson Lie group symmetry. The model 'phase space' for 3D gravity with a positive cosmological constant is the double SU(2)xSU(2), which is not a proper phase space but a quasi-Poisson space and does not have a classical r-matrix. The Turaev-Viro model, however, is defined in terms of certain representations of a Hopf algebra at q root of unity. Following work by G. Mack and V. Schomerus we will argue that it is more consistent with our classical setting to consider the Turaev-Viro model in terms of a quasi-Hopf algebra. Within this setting we can construct certain geometric operators probing the quantum geometry and a Hamiltonian constraint whose kernel gives rise to the Turaev-Viro amplitudes.

Johannes Thürigen, Laboratoire de Physique Théorique, Université Paris-Sud XI: *The spectral dimension of spin-foam spacetime*

The spectral dimension has proven to be a very informative observable to understand the properties of quantum geometries in approaches to quantum gravity. In Spin-foam quantum gravity, explicit evaluation of physically relevant observables remains one of the most pressing issues.
As a first step towards determining the spectral dimension of spin-foam quantum spacetime, we provide the framework for its definition and various methods for calculation, based both on analytical results as well as numerical (Monte-Carlo) methods. Furthermore, we perform the computation of the spectral dimension of spacetime in the simplified cuboid spin-foam model. We find evidence for a generic flow of the spacetime dimension which can be related to the renormalization group flow as obtained in spin-foam coarse graining.

Marko Vojinovic, Institute of Physics, University of Belgrade, Serbia: *Categorical generalization of spinfoam models --- review and applications*

We will give a review of the construction and applications of a spinfoam-like model based on a 2-group, a categorical generalization of the notion of a group. Starting from the Poincare 2-group, one can construct the so-called spincube model of quantum gravity, which features labeled edges of a triangulation, thus allowing for straightforward coupling of matter fields. The coupling of matter fields to the spincube model enables us to apply it to various interesting topics, such as the study of the cosmological constant, the symmetry-protected entanglement between gravity and matter, and grand-unification schemes. We will discuss each of these applications in turn, and give prospects for future research.

Mingyi Zhang, Albert Einstein Institute: *Holographic entropy from group field theory*

I will present recent results on calculating the holographic entanglement entropy from the group field theory. I will show a dictionary between group field theory (thus, spin networks and random tensors) states and generalized random tensor networks. Then, I will present how to use this dictionary to compute the R'{e}nyi entropy of such states and recover the Ryu-Takayanagi formula, in three different cases corresponding to three different truncations/approximations, suggested by the established correspondence.

Quantum constraints and dynamics:

Vadim Belov, II. Institute for Theoretical Physics, Hamburg: ***BF Gravity and the Poincare group***

The significance of the “volume constraint” in the current Spin Foam models is highlighted, and indications are provided on its possible violation in models discretized over cell complexes more general than triangulations. Motivated by these findings, a possible interpretation and a tentative solution are proposed, by modifying the starting point and revisiting the action principle. The classical analysis of the resulting theory and of its gauge symmetries is performed combining both Lagrangian and Hamiltonian methods, which are shown to give equivalent results. A novel form of continuum linear simplicity constraints is proposed.

Christoph Charles, École Normale Supérieure de Lyon: ***Canonical quantization of the simplicity constraints: a 3d toy-model***

The simplicity constraints are one of the points that must be implemented in order to understand Loop Quantum Gravity without the time-gauge. We explore the possibility of imposing such constraints at the quantum level in the context of canonical quantization. We suggest a new possibility to define such constraints using a natural extension of the Loop Quantum Gravity phase space to include the vielbein. We explore the idea in the context of discrete 3d quantum gravity which can act as a solvable toy-model for 4d quantum gravity. The construction requires the introduction of a dual support graph hinting towards a reduction to Regge geometries if applied in 4 dimensions. We discuss the generalization of our work to the continuum and to 4 dimensions.

Elena De Paoli, Università degli Studi Roma Tre: ***Sach's free data in real connection variables***

We present various results for GR on a null foliation in the first order formalisms, with real connection variables. We begin with the non-trivial constraint structure, which includes tertiary constraints, and use the Newman-Penrose formalism to clarify its geometric meaning. We then present Sachs’s constraint-free data as the shear of an affine congruence, which is made geodesic and twist-free by the torsion-less condition; and show that the propagating Einstein’s equations, which are tertiary constraints in the formalism, have the role of preserving the metricity of the affine shear under retarded time evolution. Interestingly, what turns the propagating equations into constraints is the same mathematical identity that plays a role in Ashtekar’s construction of radiative data on scri in terms of asymptotic shear.

Pietro Dona, Centre de Physique Theorique, Marseille: ***Computing Lorentzian spin foam amplitudes: Overview***

Explicit evaluations of spin foam transition amplitudes are hindered by their sheer complexity. This is particularly true for Lorentzian models, e.g. the EPRL model, due to the presence of non-compact integrals. An important step forward is possible thanks to the factorization property of SL(2,C) Clebsch-Gordan coefficients in terms of the more known and manageable SU(2) ones.

For the first time a number of analytical and numerical advances are possible, in particular a general estimation of scaling properties and divergences, as well as explicit numerical tests of the asymptotic formulas. The techniques developed can be applied also to generalized spin foams and drastic simplification happens in the extensions to imaginary Immirzi parameter. In this talk I will give an overview of the factorization procedure and the results obtained for the EPRL model, mentioning some convenient and simplified models. Two associated talks will present more specific details.

Marco Fanizza, Scuola Normale Superiore di Pisa: ***Computing Lorentzian spin foam amplitudes: Semiclassics of the 15j symbol***

We provide the first numerical confirmation of the asymptotic formula obtained by Barrett and collaborators for the SU(2) 15j symbol. The asymptotic is reached surprisingly fast, and the next-to-leading order has the same oscillating frequency. We also consider the case of the evaluation on Lorentzian boundary data, for which the amplitude is exponentially suppressed, and comment on its role in the EPRL model. We show how Barrett's analysis can be extended to polytopes, which is relevant for generalised spin foams such as the KKL model.

Marco Finocchiaro, Max Planck Institute for Gravitational Physics.: ***A new 4d Spinfoam model for euclidean Quantum Gravity. Analysis of the leading order radiative corrections.***

In my talk I will present several recent results regarding a new class of 4d Spinfoam models (SF) for euclidean Quantum Gravity. They are obtained, as usual, by imposing at the quantum level the required geometricity constraints. Thus they depend on the prescriptions for defining and implementing the constraints as well as on additional choices in the construction (operator ordering, faces weights, etc). In the first part of the talk I will review the above issues by comparing the resulting SF amplitudes for different models. I will then introduce a new 4d SF model defined in terms of non-commutative flux variables with Duflo quantization map, providing the corresponding formula of the effective edge amplitude encoding the constraints as restrictions on the spins. Its properties have been studied numerically and will be presented in the second part of the talk. In the last part I will exploit the Group Field Theory (GFT) reformulation of the model to study the leading order radiative corrections to its n-point correlation functions (n<= 5). For this purpose the relevant (bulk) Feynman amplitudes have been evaluated via analytical and numerical methods focusing, in particular, on their large-j scaling behaviour. I will motivate the importance of this analysis, summarizing the main results and comparing them to those already known in the literature.

Igor Kanatchikov, School of Physics and Astronomy, University of St Andrews: ***Analysis of constraints and quantization within the De Donder-Weyl Hamiltonian formulation of GR***

De Donder-Weyl theory in the calculus of variations can be viewed as a generalization of Hamiltonian formulation without the space-time decomposition. I show how the machinery of Poisson brackets, constraints and quantization is generalized to the vielbein GR within this approach and which type of quantum theory of gravity it leads to.

Klaus Liegener, Friedrich-Alexander University of Erlangen-Nurnberg: ***An effective Hamiltonian for Cosmology from full LQG dynamics***

Starting with the scalar constraint of LQG as regularized by Thiemann we derive an effective Hamiltonian for Cosmology. This is achieved by picking the coherent state of a semiclassical isotropic spacetime and computing the expectation value of the Hamiltonian, which agrees with the dynamics of effective LQC at leading order and includes full-theory-corrections of order hbar.

Jan Sikorski, Faculty of Physics, University of Warsaw: ***Numerical take on evolution in LQG***

I will present a numerical approach to dynamics in deparametrized LQG. We consider spin networks supported on a single fixed graph, and use a non graph changing version of the hamiltonian to numerically evaluate evolution of states.

Quantum cosmology:

Chris Beetle, Florida Atlantic University: *A diffeomorphism-invariant cosmological sector of loop quantum gravity*

This talk will summarize a scheme to define a sector of homogeneous and isotropic states of loop quantum gravity at the diffeomorphism-invariant level, and to embed the state space of loop quantum cosmology into that sector. It will focus on developing methods to compare dynamics and observables in the two theories.

Jibril Ben Achour, Fudan University, Shanghai, China: *The Thiemann Complexifier in Loop Cosmology*

We will present recent work where, in the context of Loop Quantum Cosmology, we study the fate of the complexifier, that is the generator of the canonical transformations shifting the Immirzi parameter, for the flat, homogeneous and isotropic FRW cosmology. We will focus on the closed CVH algebra for canonical general relativity consisting in the complexifier, the 3d volume and the Hamiltonian constraint. In standard cosmology, for gravity coupled to a scalar field, the CVH algebra is identified as a su(1,1) Lie algebra, with the Hamiltonian as a null generator and the complexifier as a boost. The su(1,1) Casimir is given by the matter density. In the loop gravity cosmology approach, the gravitational Hamiltonian is regularized in terms of SU(2) holonomies. In order to keep a closed CVH algebra, we show that the complexifier and inverse volume factor needs to be similarly regularized. Then the su(1,1) Casimir is given by the matter density and the volume gap. The action of the Hamiltonian constraints and the complexifier can be exactly integrated. This is straightforward to extend to the quantum level: the cosmological evolution is described in terms of SU(1,1) coherent states and the regularized complexifier generates unitary transformations. This means that, in the physical Hilbert space, the Immirzi ambiguity is to be distinguished from the volume gap, it can be rescaled unitarily and ultimately disappears from physical predictions of the theory. Finally, we show that the complexifier becomes the effective Hamiltonian when deparametrizing the dynamics using the scalar field as a clock, thus underlining the deep relation between cosmological evolution and scale transformations. This new realisation of LQC opens up new perspectives both for the full theory and for the quantisation of symmetry reduced systems with local degrees of freedom.

Eugenio Bianchi, Pennsylvania State University: *Emergence of space-like correlations in loop quantum gravity*

The vacuum state of a quantum field in a curved space-time has non-trivial correlations at space-like separation. The stretching and squeezing of such correlations plays a crucial role in inflationary cosmology. In this talk I discuss a pre-inflationary scenario where space-like correlations of quantum perturbations arise from an initially unentangled state in loop quantum gravity. This scenario relies on recent results on squeezed vacua and entanglement in loop quantum gravity.

Jakub Bilski, Fudan University: *Matter fields in the framework of reduced loop gravity*

Considering the sector of LQG that describes the models with diagonal spatial component of the metric, I will show how to construct well defined HCO's for all the Standard Model fields and gravity. I will present how at the leading order, the actions of HCO's reproduce the appropriate classical expressions. The next to the leading order corrections can be considered as perturbations in the Effective Hamiltonian Equation (EHE). I will point out the role of a proper weight of observables and an idea how to tame lattice corrections arising from matter degrees of freedom.

Joseph Bunao, Ateneo de Manila University: ***An Essentially Self-Adjoint Spacetime Four-Volume Operator in Unimodular Loop Quantum Cosmology***

This study constructs an essentially self-adjoint operator $hat{T}$ corresponding to the classical on-shell spacetime four-volume $tilde{T}$ in the context of unimodular loop quantum cosmology for a finite patch of homogeneous and isotropic spacetime with flat spatial slices and no matter sources. As shown in [J. Bunao, Class. Quant. Grav. 34, 035003 (2017)], the action of $hat{T}$ on states in the usual kinematic Hilbert space $mathcal{H}^{kin}$ of loop quantum cosmology is derived from its commutation relation with $hat{Lambda}$ - the operator corresponding to the on-shell cosmological "constant" $tilde{Lambda}$ canonically conjugate to $tilde{T}$. An appropriate domain $D(hat{T})$ is assigned to $hat{T}$ in a separable Hilbert subspace $mathcal{H}_0 subset mathcal{H}^{kin}$ so that its eigenstates $Phi^{e backslash o}_m in D(hat{T})$ are orthonormal with corresponding real and discrete eigenvalues $tau^{e backslash o}_m$. It is then shown that the eigenstates $Phi^{e backslash o}_m$ form a complete set and that $hat{T}$ is indeed essentially self-adjoint in $mathcal{H}_0$.

Marco de Cesare, King's College London: ***Cosmological implications of the group field theory approach to quantum gravity***

I will discuss the impact of quantum gravity effects for cosmology, considering the emergent spacetime scenario based on the group field theory framework. Considering some simple models, I will show that there are significant departures from the standard picture for the history of our Universe, both at early and late times. In particular, I will show how it is possible to achieve a bounce and an early epoch of accelerated expansion in this approach. (based on Phys.Lett. B764 (2017) 49-53 and Phys.Rev. D94 (2016) no.6, 064051)

Jonathan Engle, Florida Atlantic University: ***Uniqueness of the kinematical Hilbert space of LQC with curved edges***

The two new key elements in this work are (1.) the inclusion (as in full LQG) of holonomies along non-straight analytic edges in the basic algebra of LQC, building on the work of Fleischhack, and (2.) the proof that invariance under residual diffeomorphisms and existence of a self-adjoint momentum operator are sufficient to uniquely fix the resulting kinematical Hilbert space. Quite remarkably, this Hilbert space is none other than the standard one used in LQC up until now, even though the standard LQC Hilbert space was derived with only holonomies along straight edges. In addition, a derivation of the LQC phase space from scratch via symmetry reduction of the Holst action and its Dirac analysis, is presented for the first time. This work was published in papers with Maximilian Hanusch and Thomas Thiemann.

Sean Gryb, University of Bristol: ***Singularity resolution with dynamical quantum geometry***

We offer a new proposal for singularity resolution in quantum cosmology based upon quantum evolution. In particular, we advocate a new approach to the quantization of mini-superspace leading to a Schrodinger equation for the universe. For models with a massless scalar field and cosmological constant we show that: i) well-behaved quantum observables can be constructed; ii) self-adjoint extensions of the Hamiltonian lead to unitary, non-singular evolution; and iii) specific solutions display novel phenomenology including a cosmic bounce, the necessity of a positive cosmological constant in the semi-classical limit, and an effective inflationary epoch.

Mercedes Martín-Benito, Instituto de Astrofísica e Ciências do Espaço, Universidade de Lisboa: ***Dirac fields in cosmology: unitary dynamics as a uniqueness quantization criterion***

The Fock quantization of fields is in general subject to an infinite ambiguity, even for free field theories. In order to fix the quantization, we ask for a unitary implementation of the classical symmetries. However in non-stationary backgrounds this is generally not sufficient. In such situations, the additional criterion of a unitary implementation of the dynamics might be the key to remove the ambiguity. This is a non-trivial requirement, as Bogoliubov transformations, like those describing the field dynamics, might not be implementable as unitary operators in Fock space. We investigate this issue in the case of a Dirac field propagating on a homogeneous and isotropic cosmological background. Our main result is that the criterion of unitarity of the dynamics indeed selects a unique Fock quantization (up to unitary equivalence). To obtain it, we first characterize the Fock representations for the canonical anticommutation relations that admit a unitary implementation of the field evolution. Then, once a convention for the notion of particles and antiparticles is set, we show that these representations are all unitarily equivalent.

Killian Martineau, Laboratoire Physique Subatomique et Cosmologie: ***New results on the background dynamics and perturbations in LQC***

In this talk, I will present several clarifications recently derived in loop quantum cosmology. Firstly, I will address the issue of the robustness of the LQC predictions for the background dynamics when varying several fundamental unknown parameters: the initial conditions, the amount of shear at the bounce, and the shape of the inflaton potential. Secondly, I will address the trans-plackian issue. As a first phenomenological step in this direction I will show the consequences of implementing modified dispersion relations.

Guillermo A. Mena Marugán, Instituto de Estructura de la Materia, CSIC.: ***Title: Fermions in hybrid loop quantum cosmology***

We introduce Dirac fields in hybrid loop quantum cosmology and discuss their treatment as primordial perturbations, additional to those of the geometry and the inflaton field. Adopting a Born-Oppenheimer ansatz, we show how to deduce a Schrodinger equation that dictates the quantum evolution of these fermionic perturbations. Remarkably, such evolution is unitary, and couples the fermion field with an infinite sequence of quantum moments of the homogeneous geometry. We also investigate issues related with the quantum backreaction produced by the Dirac fields.

Phillip Mendonca, Florida Atlantic University: ***Embedding FLRW into Bianchi I, and Other (Relatively) Simple Tasks***

This talk will discuss the application of the embedding procedure introduced in the talk by C. Beetle to Bianchi I and other toy models, with the intent to exhibit successes to be expected and challenges to be faced when embedding into the full LQG.

Flavio Mercati, University of Rome `La Sapienza': ***Shape Dynamics: doing physics with 3D conformal geometry***

This is an update on the status of Shape Dynamics, a theory which assumes that the reduced configuration space of gravity is conformal superspace. Using York's method, one can build Einstein spacetimes using only curves in conformal superspace. This allows to describe spacetime with 3D conformal geometry, and also to define a dynamics on conformal superspace that is classically equivalent to that of GR. The equivalence, however, fails in certain situations: at the Big Bang and in presence of horizons. The conformal dynamics can be continued uniquely past these points, and leads to a prescription for gluing together regions of spacetime that admit a CMC foliation. This has interesting consequences for cosmology and the theory of black holes, and possibly for the quantum theory.

Javier Olmedo, Pennsylvania State University: ***Perturbations in anisotropic loop quantum cosmology spacetimes***

Here, we analyze the evolution of primordial perturbations in anisotropic spacetimes (Bianchi I). We start by identifying gauge-invariant scalar and tensor perturbations following a canonical formalism. Then, we characterize the classical space of solutions to the equations of motion with scalar-tensor and tensor-tensor couplings. We adopt a Fock representation where these interactions are not treated perturbatively. For a given choice of vacuum state, we compute the 2-point functions of the quantum perturbations. Eventually, we discuss the consequences of the presence of anisotropies in standard general relativity and loop quantum cosmology, and the predictions that could eventually be compared with observations.

Abdulmajid Osumanu, University of Waterloo: ***Bicrossproduct model in 3d quantum gravity***

It is well-known that the Drinfeld quantum double is relevant to 3d quantum gravity, either in the BF formulation or the Chern-Simons formulation. Different recent works by Osei, Majid and Schroers, have shown how semi-dualization can give rise to the bicrossproduct quantum group from the quantum double. This was specifically used in the Chern-Simons formulation and the semi-dualization is associated to passing to different regimes. We intend to discuss such semi-dualization procedure in the BF formulation. Interestingly this could be relevant to quantum information models such as Kitaev?s model. This is work done in collaboration with Prince Osei and Florian Girelli.

Tomasz Pawłowski, Center for Theoretical Physics, Polish Academy of Science: ***(Loop) quantum dynamics of Bianchi I universe***

The dynamics of flat anisotropic homogeneous universe with matter is studied on the genuine quantum level within the strict formulation of impruved dynamics of the loop quantum cosmology framework.

Andreas Pithis, King's College London: ***Aspects of GFT condensate cosmology***

In the context of the Group field theory (GFT) quantum gravity condensate analogue of the Gross-Pitaevskii equation for Bose-Einstein condensates (BEC), we analyze the behaviour of static and relationally evolving GFT models with effective interactions. More precisely, we firstly study the expectation value of the volume operator imported from Loop Quantum Gravity (LQG) in an isotropic restriction for a free and then interacting condensate system. For these one finds a non-vanishing condensate population which is dominated by the lowest nontrivial configurations of the quantum geometry. This suggests that the condensate consists of many smallest building blocks giving rise to an effectively continuous geometry and that the interpretation of the condensate to correspond to a geometric phase might be appropriate. In a second step, we study the relational evolution of initially anisotropic condensate systems, demonstrate that they quickly isotropize and that from their effective dynamics the classical Friedmann equation can be recovered. The talk is (mostly) based on the material presented in the articles arXiv:1607.06662, 1612.02456, 1606.00352.

Giorgio Sarno, Università di Torino: ***From Analytical to Numerical: The EPLR 4-Simplex Asymptotic Behavior***

We present different analytic and numerical results for the Lorentzian EPRL model. These include the details of the factorization procedure and the structure and behavior of the edge propagators, which allows us to establish scaling properties. We then focus on the case of a 4-simplex amplitude, providing the first numerical evidence of Barrett's asymptotic formula for the EPRL model. We show that for Euclidean boundary data, the asymptotic is directly inherited from the factorized SU(2) 15j symbol. For Lorentzian boundary data we uncover the key role the edge propagators plays in the asymptotic behavior of the 4-simplex EPLR amplitude.

David Sloan, University of Oxford: ***Through the Big Bang***

I will show how the intrinsic definition of observables in relativity through dynamical similarity leads to the continuation of Einstein's equations classically through the big bang singularity in simple cosmological scenarios. By appealing to general principles I argue that this is a generic feature, and that the singularity can be viewed as an artifact of the redundant description imposed by absolute length scales. I will then lay out some other welcome features of intrinsic relational systems, and discuss the broader questions raised by a theory of physics that is independent of physical dimensions such as mass and length.

Gabriele Vittorio Stagno, Dipartimento di Fisica, "Sapienza" Università di Roma, Piazzale Aldo Moro 2, 00185 Roma, Italy: ***Lorentian generalized spinfoams and dipole cosmology***

We study generalised KKL-spin foams for the Lorentzian EPRL model with two dipole boundary graphs, and applications to cosmology. We discuss integrability conditions and properties of partial foam resummations based on scaling laws. We present analytical and numerical results that show an unexpected strong factorisation property and complete lack of oscillations that raise delicate questions on the use of non-simplicial spin foams.

Ilya Vilensky, Florida Atlantic University: ***Spinfoam cosmology with the proper vertex amplitude***

The proper vertex amplitude is derived from the EPRL vertex by restricting to a single gravitational sector in order to achieve the correct semi-classical behaviour. We apply the proper vertex to calculate a cosmological transition amplitude that can be viewed as the Hartle-Hawking wavefunction. To perform this calculation we deduce the integral form of the proper vertex and use extended stationary phase methods to estimate the large-volume limit. We show that the resulting amplitude satisfies an operator constraint whose classical analogue is the Hamiltonian constraint of the Friedmann-Robertson-Walker cosmology. We find that the constraint dynamically selects the relevant family of coherent states and demonstrate a similar dynamic selection in standard quantum mechanics. The effects of dynamical selection on long-range correlations are analyzed.

Anzhong Wang, Baylor University: ***Pre-inflationary universe in loop quantum cosmology***

The evolutions of the flat FLRW universe and its linear perturbations are studied systematically in {em the dressed metric approach} of LQC. When the evolution of the background at the quantum bounce is dominated by the kinetic energy of the inflaton, it can be divided into three different phases prior to the preheating, {em bouncing, transition and slow-roll inflation}. During the bouncing phase, the evolution is independent of not only the initial conditions, but also the inflationary potentials. In particular, the expansion factor can be well described by the same exact solution in all the cases considered. In contrast, in the potential dominated case such a universality is lost. It is also because of this universality that the linear perturbations are independent of the inflationary models, too, and are obtained exactly. During the transition phase, the evolution of the background is first matched to that given in other two phases, whereby the e-folds of the expansion are obtained. In this phase the perturbation modes are all oscillating, and are matched to the ones given in other phases. Considering two different sets of initial conditions, one is imposed during the contracting phase and the other is at the bounce, we calculate the Bogoliubov coefficients and find that the two sets yield the same results and all lead to particle creations at the onset of the inflation. Due to the pre-inflationary dynamics, the scalar and tensor power spectra become scale-dependent. Comparing with the Planck 2015 data, we find constraints on the total e-folds that the universe must have expanded since the bounce, in order to be consistent with current observations.

Quantum models of black holes:

Marios Christodoulou, CPT Marseille: ***Black to White Hole transition and Gravitational Tunneling in Spinfoams***

An overview of recent progress in covariant LQG regarding the calculation of the lifetime of a trapped region before it transitions to an anti-trapped region. We review the conceptual setup and present the results of an explicit estimation from EPRL amplitudes.

William Cuervo, Universidad Nacional Autonoma de Mexico: ***Loop quantum effective geometry and Schwarschild singularity: exact results***

Quantum Geometry effects Ă la Loops is applied to the region where classical general relativity fails and the Schwarzschild singularity appears. Using an effective semiclassical geometry as well as the qualitative theory of ordinary differential equations we show that at this regime the spacetime is not singular:
i) Effective Hamilton's equations for the geometry fulfill the conditions of a theorem for extendibility of solutions to first order differential equations and hence the corresponding space-time can be extended to arbitrary large proper times.
ii) The Raychauduri equation is finite term by term, resolving the singularities of classical geodesic congruences.
iii) All effective curvature invariants are bounded and hence curvature singularities are absent.
iv) The volume does not evolve towards zero in a finite proper time ruling out strong singularities.

Tommaso De Lorenzo, Centre de Physique Theorique, Marseille, CNRS: ***Light Cone Thermodynamics***

We show that to null surfaces emanating from a sphere in Minkowski spacetime can be assigned thermodynamical properties that are in strict formal correspondence with those of black holes in curved spacetimes. Such null surfaces, made of pieces of light cones, are bifurcating conformal Killing horizons for suitable conformally stationary observers. Those observers perceive the Minkowski vacuum state as a thermal state at a given light cone temperature, given by the standard expression in terms of the (generalisation of) surface gravity for conformal Killing horizons. Exchanges of conformally invariant energy as measured by these special observers across the conformal horizon are described by a first law with an entropy term that is given by 1/4 of the area of the bifurcating surface--the shining sphere--in Planck units. These conformal horizons can be extremal and non-extremal. They satisfy the zeroth to the third laws of thermodynamics in an appropriate way. Extremal horizons are horizons emanating from a single event; they have zero temperature and zero entropy.

Konstantin Eder, Ludwig-Maximilians-Universität München: ***Title: The entropy of charged black holes***

We describe the quantum theory of isolated horizons with charge in a setting in which both electromagnetic and gravitational field are quantized. We consider the spherically symmetric and the distorted case. The resulting picture depends significantly on the choices made for the quantization and the definition of the state counting. We show that there is a choice such that the Bekenstein-Hawking relation holds.

Mohammed Ezzi, Quantum black holes, Foundations of quantum gravity: *Black Hole Theorem for the Non-Extensive Entropy in Loop Quantum Gravity*

We apply non-extensive statistical mechanics, characterized by a free parameter q, to calculate black hole entropy in loop quantum gravity. For a given horizon area, the entropy of the black hole is given by the Bekenstein-Hawking area law for arbitrary real positive values of the Barbero-Immirzi parameter Îł. In this work, we find a correlation between Îł, q and s (where s=j_{max}). We conclud in our result that Hawking radiation for 0â‰şqâ‰ş1 is important also for massive black holes, is therefore possible That those Black Holes have also been a source of radiation since the beginning of the universe without being eroded by the decline of mass. For black holes that have M>M_{min} lose their mass over time due to Hawking radiation at a rate proportional to its mass. For the non-extensive entropy, Hawking radiation is important for the small masses and also for the supermassive black hole. This result can explain to us that there are premordial supermassive black holes still present today, and even massive black holes formed at the center of the galaxies would be much larger than the current predicted mass, otherwise they would be consumed by Hawking radiation, which may represent explanation of the dark matter problem

Rodolfo Gambini, Instituto de Fisica, Facultad de Ciencias, Igua 4225 esa Mataojo, C.C.11400, Montevideo Uruguay: *Quantum fluctuating geometries and the information paradox*

We study Hawking radiation on the quantum space-time of a collapsing null shell. We show that there are departures from thermality in the radiation even though we are not considering back reaction. One recovers the usual profile for the Hawking radiation as a function of frequency in the limit where the space-time is classical.

However, when quantum corrections are taken into account, the profile of the Hawking radiation as a function of time contains information about the initial state of the collapsing shell.

Hal Haggard, Bard College: *Complex Quantum Tunneling and the Decay of Black Holes*

Quantum effects render black holes unstable. In addition to Hawking radiation, which leads to the prediction of an extraordinary lifetime for black holes, there is the possibility of quantum tunneling of the black hole geometry itself. A robust possibility for treating the quantum tunneling of a spacetime geometry is to complexify the gravitational variables. I will illustrate this technique with an analytically solvable 1D quantum potential and describe the present state of the calculation for spherically symmetric black holes.

Antonino Marciano, Fudan University: *Kac-Moody instantons in space-time foam on black holes*

In an ongoing collaboration with Andrea Addazi, Pisin Chen and Yong-Shi Wu, we propose an alternative scenario to the one developed by Hawking, Perry and Strominger, and elaborate on the role of the Kac- Moody charges — in stead of BMS symmetries charges — in the resolution of the black hole information paradox. The same role of BMS charges may be indeed played by an infinite set of symmetries that emerge in the space-time foam predicted by quantum gravity. Specifically, we focus on Yang-Mills theories and on the Holst formulation of gravity, and argue that the Yang-Mills and gravitational self-duality conditions in space-time bubbles are related to a new infinite dimensional global symmetry, hidden in the Lagrangian. Such a symmetry is manifested by the Kac-Moody algebra, with zero central charges. This implies the existence, in the space-time foam, of an infinite number of different instantons that are interconnected by the Kac-Moody symmetry. These solutions punctures the horizons of the building block of the space-time bubbles. The new result carries consequences on the no-hair theorem and on the study of quantum black holes.

Yuki Yokokura, RIKEN: ***A Model of Black Hole Evaporation and 4D Weyl Anomaly***

We analyze time evolution of a spherically-symmetric collapsing matter from a point of view that black holes evaporate by nature. We consider conformal matters and solve the semi-classical Einstein equation by using the 4-dimensional Weyl anomaly with a large c coefficient. Here the expectation value of energy-momentum tensor contains the contribution from both the collapsing matter and Hawking radiation. The solution indicates that the collapsing matter forms a dense object and evaporates without horizon or singularity, and it has a surface but looks like an ordinary black hole from the outside. Any object we recognize as a black hole should be such an object. [arxiv: 1701.03455]

Thomas Zilker, Friedrich-Alexander-Universität Erlangen-Nürnberg: ***Surface holonomies and their quantization***

Exponentiating the isolated horizon boundary condition (IHBC), one obtains an expression in terms of the E-field on the right hand side, which corresponds to the surface holonomies known from higher gauge theory. The main part of the talk will be dedicated to the quantization of these surface holonomies with the use of the Duflo-Kirillov map. In order to estimate our chances of finding solutions to the quantized IHBC we study the determinant of the quantized surface holonomies.

Quantum gravity phenomenology:

Suddhasattwa Brahma, Fudan University: ***Deformation of classical spacetimes in loop quantum gravity***

Quantum corrections appearing from loop quantum gravity (LQG) tend to deform the notion of covariance in the quantum theory leading to the emergence of non-Riemannian spacetimes. The main physical effect of this seems to be signature change with deeply interesting consequences. In this talk, I shall discuss how this might lead to constraining LQG from phenomenology by relating quantization ambiguities to observable quantities. Finally, how these deformations can be avoided (using certain quantization choices) shall also be briefly demonstrated.

Anuj Kumar Dubey, Physics Department, Assam University, Silchar , India: ***Gravitational Redshift in Kerr-Newman Geometry Using Gravity's Rainbow***

Gravitational redshift is generally reported by most of the authors without considering the influence of the energy of the test particle using various spacetime geometries such as Schwarzschild, Reissner-Nordstrom, Kerr and Kerr-Newman geometries for static, charged static, rotating and charged rotating objects respectively. In the present work, the general expression for the energy dependent gravitational redshift is derived for charged rotating body using the Kerr-Newman geometry along with the energy dependent gravity's rainbow function. It is found that the gravitational redshift is influenced by the energy of the source or emitter. One may obtain greater correction in the value of gravitational redshift, using the high energy photons. Knowing the value of gravitational redshift from a high energy sources such as Gamma-ray Bursters (GRB), one may obtain the idea of upper bounds on the dimensionless rainbow function parameter (ξ). Also there may be a possibility to introduce a new physical scale of the order of ξ.

Aaron Held, Institute for Theoretical Physics, Heidelberg University: ***A weak-gravity bound from the matter content in asymptotic safety***

Asymptotic safety conjectures a combined UV fixed-point for matter and gravity. I will present how the existence of an ultraviolet completion for interacting Standard-Model type matter can put constraints on the viable microscopic dynamics of asymptotically safe quantum gravity. A fundamental constraint -- the weak-gravity bound -- is rooted in the destruction of quantum scale-invariance in the matter system by strong quantum-gravity fluctuations. As the effective gravitational interaction strength grows quantum gravity induces new UV-divergences in the matter interactions. Beyond a critical strength of gravity, no Standard-Model type matter can be incorporated in a UV-complete model of asymptotic safety any longer.

Viqar Husain, University of New Brunswick: ***Low energy Lorentz violation from modified dispersion at high energies***

Many quantum theories of gravity propose Lorentz violating dispersion relations of the form $\omega=|k|f(|k|/M)$, with recovery of approximate Lorentz invariance at energy scales much below M. We show that a quantum field with this dispersion predicts drastic low energy Lorentz violation in atoms modeled as Unruh-DeWitt detectors, for any f that dips below unity somewhere. This test may rule out all Lorentz violating theories. (Based on VH, J. Louko, PRL 116 (2016) 061301)

Niccolò Loret, University of Rome La Sapienza: ***k-Poincaré non-Riemannian properties***

The approaches to the Quantum Gravity problem through space-time noncommutativity have found in the Hopf algebras a powerful tool (see for instance [arXiv:hep-th/0306013]) to formalize Planck-scale deformed space-time symmetries. The phenomenological implications of these deformations are still debated as the physical interpretation of many Hopf algebras features is unclear.
A few years ago, it was formulated the so called Relative Locality interpretation [arXiv:1101.0931] which formalizes the symmetry algebra deformation as an effect of some momentum-space curvature. From this point of view Hopf algebras could be re-expressed just as Riemannian geometry in momentum-space. This idea, however, is not entirely accurate, and in this talk I will show how Hopf algebras actually hold several non-Riemannian (and apparently nonlocal) features. As a guidance I will use the simple k-Poincaré (bicrossproduct basis) model which was already employed to unravel the duality [arXiv:1305.5062] between the energy-dependent photon velocity in some Quantum Gravity phenomenology models and the redshift in an expanding space-time. In doing so, I will be able to trace-back the modified composition-law for momenta (due to nontrivial Hopf algebras coproducts), as well as apparent violations of the energy-momenta conservation laws, to the relations of distant observers in deSitter space-time.

Jakub Mielczarek, Jagiellonian University: ***Compact phase spaces and loops***

Recently, a new class of field theories called Nonlinear Field Space Theory (NFST) has been proposed. Within the approach, the standard field phase spaces are generalized to the non-affine manifolds. The compact case associated with finite dimensionality of Hilbert space is especially worth considering. Moreover, the spherical field phase space geometry reveals an interesting relation with the spin physics, leading to the so-called Spin-Field Correspondence. As an example, the duality is applied to the Heisenberg XXZ model, which turns out to be related with the Klein-Gordon field. Consequences of the correspondence, especially in the domain of cosmology are outlined. Furthermore, relationship between the spherical phase space under consideration and the polymer quantization techniques are discussed. Based on this, perspectives of generalizing (in the spirit of NFST) both LQC and LQG to the compact phase space case, are discussed.

Christian Pfeifer, University of Tartu, Institute of Physics, Laboratory for Theoretical Physics: ***Covariant momentum dependent spacetime geometry: The kappa-Poincare dispersion relation on curved spacetimes***

The kappa-Poincare dispersion relation is one of the most studied dispersion relation in the context of quantum gravity phenomenology. It emerges as Casimir operator of the kappa-quantum deformation of the Poincare algebra and can be connected to quantum gravity by identifying the deformation parameter kappa with the inverse of the Planck length. Phenomenological studies about the observable consequences on particle motion induced by the kappa-Poincare dispersion focused so far on maximally symmetric spacetimes. In this talk we will construct covariant kappa-deformations of generically curved spacetimes, which have the property that locally they look like Minkowski spacetime equipped with the kappa-Poincare dispersion relation. This can be understood as generalisation from local Lorentz invariant spacetimes used in general relativity to local kappa-Poincare invariant spacetimes. Having established the notion of local kappa-Poincare spacetimes we study the kappa-deformations of Schwarzschild and FLRW geometry including observable effects of the deformation on the photon sphere, the redshift and the time of arrival of photons.

Michele Ronco, Sapienza University of Rome and INFN: ***Spacetime-noncommutativity regime of Loop Quantum Gravity***

A recent study by Bojowald and Paily provided a path toward the identification of an effective quantum-spacetime picture of loop quantum gravity, applicable in the "Minkowski regime," the regime where the large-scale (coarse-grained) spacetime metric is flat. A pivotal role in the analysis is played by loop-quantum-gravity-based modifications to the hypersurface deformation algebra, which leave a trace in the Minkowski regime. We here show that the symmetry-algebra results reported by Bojowald and Paily are consistent with a description of spacetime in the Minkowski regime given in terms of the κ-Minkowski noncommutative spacetime, whose relevance for the study of the quantum-gravity problem had already been proposed for independent reasons.

Giacomo Rosati, Dipartimento di Fisica, UniversitĂ di Cagliari & INFN, Sezione di Cagliari Cittadella Universitaria, 09042 Monserrato, Italy: ***Testing Planck-scale in-vacuo dispersion with gamma-ray-burst neutrinos and photons***

The recent data on astrophysical neutrinos provided by the IceCube telescope offer a striking opportunity to test in vacuo dispersion of ultra-relativistic particles propagating in quantum spacetime scenarios inspired by phenomenological approaches to quantum gravity. Recently (Phys.Lett.B761(2016)318) we proposed a novel method of investigation of these effects based on a statistical analysis of the correlation between the energy (~O(100TeV)) of an observed neutrino and the difference between the time of observation of that neutrino and the trigger time of a GRB. We find a surprisingly high correlation, and estimate a very low probability for the effect to be produced accidentally by (still unknown) source features or background neutrinos. In a following study (arXiv:1612.02765), accepted for publication in Nature Astrophysics, we compare the neutrino analysis with a similar analysis for GRB photons (E~O(10GeV)), showing that the two features are roughly compatible with a description such that the same effects apply over four orders of magnitude in energy.

Tomasz Trześniewski, University of Wroclaw: ***LQG, the signature-changing Poincare algebra and spectral dimension***

It has been observed that quantum corrections to the hypersurface deformation algebra (which describes local diffeomorphisms of spacetime), predicted within loop quantum gravity, may lead to the changing signature of spacetime metric. In the linearized case the (quantum-corrected) hypersurface deformation algebra becomes simply (a deformation of) the Poincare algebra of spacetime symmetries. By assuming certain reasonable conditions we obtained a specific form of the deformation, characterized by the signature change, and considered it as our toy model. We showed that, in the most natural Ansatz, such a deformed Poincare algebra can be extended by the standard Heisenberg algebra of phase space variables. Consequently, the model is characterized by deformed Lorentz transformations and an invariant energy scale, as well as a non-trivial invariant measure on momentum space. Moreover, we also studied a fictitious diffusion process on spacetime endowed with these deformed symmetries and calculated the corresponding spectral dimension. Depending on the deformation parameter, we either find the constant dimension of spacetime or the small-scale dimensional reduction to one. The latter result agrees with the ultralocal limit of the symmetry algebra and the asymptotic silence scenario from cosmology.

Foundations and mathematical aspects of gravity theories:

Andrea Addazi, Fudan University: ***Topological M-theory and Loop Quantum Gravity: S-branes and Space-time foam***

We show two curious coincidences which may shine light on a new correspondence principle between Loop Quantum Gravity and M-theory, in certain kinematical regimes. First, the low wave-lenght limits of topological M-theory on G2 manifolds can re-construct the $3+1$ gravity in self-dual variables formulation. Second, we argue that non-trivial gravitational holonomies correspond to a class of Space-like M-branes (SM-branes). Can that suggest "a new duality" among the two so different candidates of quantum gravity?

Yannick Herfray, Ecole normale superieur de Lyon: ***3D and 4D gravity from 3-forms in 6D and 7D***

In arXiv:1605.07510, arXiv:1705.01741 and arXiv:1705.04477 we studied the dimensional reduction of a certain theory of 3-forms due to Hitchin from 6D and 7D to 3D and 4D. The resulting theories turns out to be pure gravity for the 3D case and some modified theory of gravity coupled with other fields in 4D. We will briefly review Hitchin theory of stable forms and describe the resulting dimensional reductions.

Florian Hopfmueller, Perimeter Institute, Waterloo, ON, Canada: ***Metric Gravity Degrees of Freedom on a Null Surface***

A canonical analysis for metric general relativity is performed on a null surface without fixing the diffeomorphism gauge, and the canonical pairs of configuration and momentum variables are derived. Next to the well-known spin-2 pair, also spin-1 and spin-0 pairs are identified. The boundary action for a null boundary segment of spacetime is obtained, including terms on codimension two corners.

F. Hopfmüller and L. Freidel, Phys. Rev. D 95, no. 10, 104006 (2017), arXiv:1611.03096

Maciej Kolanowski, University of Warsaw: ***Null observables and deformed Poincare symmetry***

Introduction of physical observator is one of possible approaches to the problem of observables in general relativity. Construction of such observator (and associated coordinates) using null geodesics will be given. Possible obstruction against their existence will also be discussed together with some physical examples. Transformations between such frames can be thought to form, in some suitable sense, Poincare group deformed by curvature. Explanation of the exact meaning of this statement will be followed by more detailed analysis of the obtained structure. The talk will be concluded by the comparison between these symmetries and Bondi-Mertzner-Sachs group.

Isha Kotecha, Albert Einstein Institute: ***Statistical Equilibrium in Group Field Theory***

The issue of defining statistical mechanics in a covariant setting is well-known. A group field theory is inherently covariant, with no a priori preferred time variable. This translates to no preferred Hamiltonian defined for the system, and hence no conventional notion of equilibrium a la Gibbs. In this talk, I will discuss our investigation into defining equilibrium for a quantum group field theory system. It has been realised that the relevant Hilbert space of spin networks of arbitrary number of nodes (each with an arbitrary but fixed valency) can be given in the form of a Fock space. Using this representation of the GFT Weyl algebra, we define states which are at equilibrium with respect to certain automorphisms of the same algebra. These are the Gibbs states which we find are the unique KMS states for these automorphisms. Such states are fundamentally distinct from the standard ones in the sense that they define equilibrium with respect to internal parameters.

Suzanne Lanéry, Centro de Ciencias Matemáticas, Universidad Nacional Autónoma de México, Morelia, Mexico: ***Projective State Spaces for Quantum Field Theory and Quantum Gravity***

Instead of formulating the states of a Quantum Field Theory (QFT) as density matrices over a single large Hilbert space, it has been proposed by Kijowski to construct them as consistent families of partial density matrices, the latter being defined over small 'building block' Hilbert spaces. In this picture, each small Hilbert space can be physically interpreted as extracting from the full theory specific degrees of freedom (aka. 'coarse-graining' the continuous theory). This allows to reduce the quantization of a classical field theory to the quantization of finite-dimensional sub-systems, while obtaining robust and well-controlled quantum states spaces. I will present new results obtained in this framework, and discuss its benefits eg. for connecting canonical and covariant approaches to exploit their respective strengths, or for investigating the classical regime of background-independent Quantum Gravity.

Pierre Martin-Dussaud, ENS Lyon: ***Asymptotics of Lorentzian polyhedra propagator revisited***

We revisit and extend Jack Puchta's large spin analysis of the propagator for the Lorentzian EPRL model. In particular, we compare its method with the spinorial methods more commonly used in spin foam asymptotic, and discuss subtle aspects of the approximation, its numerical confirmation, and more importantly its extension to the non-diagonal case which is crucial to restore non-trivial dihedral angles.

Prince Osei, Perimeter Institute for Theoretical Physics: ***Title: Quaistriangular structure and twisting of the 2+1 bicrossproduct model***

We show that the bicrossproduct model quantum Poincare group in 2+1 dimensions acting on the Majid-Ruegg quantum spacetime model is related by a Drinfeld and module-algebra twist to the quantum double acting on the spin quantum spacetime model. We obtain this twist by taking a scaling limit as q--> 1 of the q-deformed version of the above where it corresponds to a previous theory of q-deformed Wick rotation from q-Euclidean to q-Minkowski space. We also recover a twist known at the Lie bialgebra level. Our method is general and applies to all compact real forms of complex simple groups and to the quantum group case.

Carlos I. Perez Sanchez, Mathematics Institute, University of Münster: ***Corrrelation functions of colored random tensors and their Schwinger-Dyson equations***

Tensor models are a random geometry framework that generalizes, to arbitrary dimension, matrix models. They are used to model quantum gravity but, lately, also some applications to AdS/CFT were discovered. Colored tensor models are the orientable geometry sector of tensor models. We scrutinize the correlation functions of colored tensor models and give briefly their geometric interpretation in terms of bordisms. Based on a Ward-Takahashi identity, we give the Schwinger-Dyson Equations they obey. We proceed non-perturbatively.

Matti Raasakka, Independent researcher: ***Finite-dimensional Local Quantum Physics and Spacetime Structure***

Local Quantum Physics (and its generally covariant generalization) provides a rigorous way to define quantum field theories (QFTs) on arbitrary globally hyperbolic spacetimes by assigning observable algebras to local spacetime regions. For QFTs, the local observable algebras are known to be infinite-dimensional, while physical considerations (e.g., the finiteness of black hole entropy) seem to suggest that, at the fundamental level, finite local spacetime regions carry only a finite number of degrees of freedom, and therefore should be assigned finite-dimensional observable algebras. This motivates the study of finite-dimensional models in the framework of Local Quantum Physics. In this talk, I discuss the formulation and the physical interpretation of finite-dimensional models in Local Quantum Physics, and their implications for spacetime structure. In particular, I show that local Lorentz covariance follows from the assumption that the vacuum is in equilibrium on minimal local observable algebras isomorphic to the algebra of 2-by-2 complex-valued matrices, i.e, the observable algebra of a single qubit. This result provides a direct relationship between the microscopic structure of the quantum vacuum and spacetime geometry: The connection between local inertial reference frames can be extracted by comparing the local restrictions of the vacuum state. Hopefully, this observation will lead to an improved understanding of the interplay between quantum physics and spacetime structure.

The talk is partially based on the preprint arXiv:1705.06711.

Robert Seeger, Friedrich-Alexander-Universität Erlangen-Nürnberg: *Towards Gaussian states for the holonomy-flux algebra*

Quasifree states are very important in standard QFT, since they contain the Fock states. As a toy model, we consider the U(1) holonomy-flux algebra. We show that it is a Weyl-algebra and consider quasifree states for it. (They have to be diffeomorphism non-invariant due to uniqueness theorems). We find a new class of states that are "almost quasifree" in the sense that they are Gaussian for the electric flux, but similar to the Ashtekar-Lewandowski state for holonomies. We show an example that, curiously, involves states of the harmonic oscillator. We also discuss necessary conditions for true quasifree states, and the extension of our results to SU(2).

Daniel Siemssen, University of Warsaw: *Feynman propagators and the self-adjointness of the Klein-Gordon operator*

I will discuss the construction of Feynman propagators for the Klein-Gordon equation on curved spacetimes. It is generally accepted that there exists no preferred Feynman propagator on curved spacetimes. However, in some cases a distinguished choice may exist. This is related to some curious open problems related to the self-adjointness of the Klein-Gordon operator.

Tatjana Vukasinac, : *Weakly isolated horizons and Holst action*

Weakly isolated horizons are quasilocal generalizations of event horizons and their definition is purely geometrical, and independent of the variables used in describing the gravitational field. On the other hand, the formulation of an action principle and its corresponding Hamiltonian formulations is very sensitive to the choices of variables and boundary terms. With an eye towards a canonical formulation we consider general relativity in terms of connection and vierbein variables and their corresponding first order action, the Holst action. We focus on the role of the internal gauge freedom that exists, in the consistent formulations of the action principle.

Renormalization and continuum limit:

Seth Kurankyi Asante, Perimeter Institute, *The Hamilton-Jacobi functional for 3D and 4D gravity on bounded regions*

We discuss how Regge calculus can be used to establish the Hamilton-Jacobi functional for gravity in three and four dimensions. In the three-dimensional case we discuss how this leads to the one-loop partition function for gravity, that also establishes a holographic duality for bounded regions. We will also for the first time derive a tensor network description from a gravity model. In the four-dimensional case we describe a program to establish a perfect action for 4D gravity and how this can be used to determine the one-loop partition function for bounded regions in four-dimensional gravity.

Benjamin Bahr, University of Hamburg, *Renormalization group flow in truncated spin foam models*

I will give details on recent results of the RG flow in symmetry restricted spin foam models. I will in particular discuss the existence of an interacting fixed point, as well as its connection to diffeomorphism symmetry.

Norbert Bodendorfer, Ludwig Maximilian University of Munich, *Coarse graining and LQC*

Within a full theory embedding of LQC using highly symmetric quantum states inspired by GFT condensates, the question of coarse graining simplifies significantly. We discuss how invariance of the dynamics under coarse graining or refining is mapped to a scaling property of LQC quantum states relevant for fiducial cell independence. These results allow to address coarse graining in a simplified setting using LQC techniques.

Giovanni Rabuffo, University of Hamburg, *Towards a Cosmological subsector of Spin Foam Quantum Gravity*

I will examine the EPRL-FK spin foam model by restricting the state sum to certain symmetric configurations which resemble the geometry of a flat homogeneous and isotropic universe. The asymptotic form of the vertex amplitude will be derived, recovering in this limit a Regge-type action, as well as an explicit form of the Hessian matrix, which captures quantum corrections. I will show that this model presents a large intersection with computations done in the context of cosmological modelling with Regge Calculus. I will also discuss some results concerning the renormalization properties of the EPRL-FK spin foam model in the symmetry restricted setting.

Saeed Rastgoo, Universidad Autonoma Metropolitana, Mexico, *Emergent space(time) from renormalizing discrete metric spaces*

I present a novel "geometric renormalization method", in the spirit of the Wilsonian RG, by which we aim at formulating the emergence of smooth space(time) from discrete metric spaces, specifically graphs, interpreted as discrete structure(s) underlying the smooth space(time). This method introduces a RG flow in the space of locally compact metric spaces -a parallel to the concept of the "theory space"- possibly leading to fixed points and attractors, whose continuum limit would be the classical spacetime. I will discuss the basic contents of the model and its current most important results, including the conditions on the existence of the continuum limit of relevant graphs, dimension and its integerness, as well as its stability under this RG flow.

Fleur Versteegen, Heidelberg University, ***An asymptotically safe gauge coupling***

In the search for a fundamental theory of quantum gravity and matter, we use non-perturbative functional Renormalization Group methods to examine a system composed of a charged scalar and a U(1) gauge field, coupled to asymptotically safe quantum gravity. Without quantum gravity, the system features a Landau pole at high energies, i.e., the model features the so-called triviality problem and breaks down in the ultraviolet and ``new physics" is needed. We explore the hypothesis, that the ``new physics" is quantum gravity. Preliminary results for the flow of the gauge coupling show evidence for the existence of two fixed points, providing a possible solution to the triviality problem. The most significant result is the irrelevant nature of the coupling at one of the fixed points, hinting towards the possibility of predicting its value at low energies.