Quantum Information Theory in Quantum Gravity
Théorie de l'information quantique en gravité quantique

(Org: **David Kribs** (Guelph) and/et **Fotini Markopoulou** (Perimeter Institute))

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Decoherence, broadcasting and the emergence of phase-space

The only data available in the search for a quantum theory of gravity is its classical limit. Unfortunately we do not understand how to define, nor derive, the classical limit of a general quantum theory. I present technical results which make precise the idea that classical physics emerges as information redundantly stored in an environment—as proposed in the latest refinement of the theory of decoherence. Such information is always characterized by a single generalized observable (aka POVM) which relates the quantum system to an effective classical system. This shines new light on the role played by coherent states and symmetries in relating known classical theories to their quantum foundations. An important point for gravity is that this framework does not assume a preexisting notion of time.

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q-Deformed Spin Networks and Topological Quantum Computation

This talk will discuss how q-deformed $\mathrm{SU}(2)$ spin networks (aka Temperley–Lieb Recoupling Theory) can produce unitary representations of the Artin Braid Group. These representations include the well-known Fibonacci model that is quantum-computationally universal. Our approach to these networks is based on the bracket polynomial state sum for the Jones polynomial. The talk will discuss quantum algorithms for computing the colored Jones polynomials and the Witten–Reshetikhin–Turaev invariant. We also discuss the background of these spin networks (they are a braided version of the original spin networks of Roger Penrose) and the role of these networks in loop quantum gravity.

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On an information theoretic ultraviolet cutoff in curved space

Under certain circumstances, space-time can possess the differentiability properties of manifolds as well as the ultraviolet finiteness properties of lattices. This is the case when physical fields possess merely a finite density of degrees of freedom, in the information theoretic sense: if a field's amplitudes are given on any sufficiently dense set of discrete points this could already determine the field's amplitudes at all other points of the manifold. Any arbitrary set of samples that is sufficiently densely spaced, say at a Planck density, could be used for the reconstruction. The mathematical disciple concerned with classes of functions that can be reconstructed completely from any set of sufficiently densely chosen discrete samples, namely sampling theory, is at the heart of information theory.

Sampling theory establishes the link between continuous and discrete forms of information and is used in ubiquitous applications from scientific data taking to digital audio. Here, we present new results on sampling theory on curved space which utilize methods of spectral geometry. Further results on sampling theory on curved space-time will be presented in this meeting by my collaborator Robert Martin.

ROBERT MARTIN, University of Waterloo, 200 University Ave. West, Waterloo, ON N2L 3G1

Towards sampling theory on spacetime

The ultraviolet divergencies of quantum field theories and several quantum gravity arguments suggest the existence of an ultraviolet cutoff on the modes of physical fields in nature. Such an ultraviolet cutoff for fields on a spacetime manifold must be fully covariant since physical laws are independent of the choice of co-ordinate system. In this talk we consider a covariant ultraviolet cutoff which generalizes the space of bandlimited functions (Paley–Wiener space) to curved manifolds. We show that, generalizing Shannon sampling theory, the space of fields obeying this ultraviolet cutoff or ‘bandlimit’ can possess a finite density of degrees of freedom on one and two dimensional hypersurfaces. Recent results for expanding FRW spacetimes are discussed in detail.