Invited Speakers

P. Alsing
[TBA]

P. Chen
[Accelerating Plasma Mirrors to Investigate Black Hole Information Loss Paradox]
The question of whether Hawking evaporation violates unitarity, and therefore results in the loss of information, remains unresolved since Hawking's seminal discovery. So far the investigations remain mostly theoretical since it is almost impossible to settle this paradox through direct astrophysical black hole observations. Here we point out that relativistic plasma mirrors can be accelerated drastically and stopped abruptly by impinging ultra intense x-ray pulses on solid plasma targets with a density gradient. This is analogous to the late time evolution of black hole Hawking evaporation. A conception of such an experiment is proposed and a self-consistent set of physical parameters is presented. Critical issues such as black hole unitarity may be addressed through the measurement of the entanglement between the Hawking radiation and their partner modes.

B.-L. Hu
[Equivalence Principles for Quantum systems]
We ask the question how the (weak) equivalence principle established in classical gravitational physics should be reformulated and interpreted for massive quantum objects that may also have internal degrees of freedom (dof). This is necessary because even an elementary concept like a classical trajectory is not well defined in quantum physics -- trajectories originating from quantum histories become viable entities only under stringent decoherence conditions. For quantum composite particles freely falling in a homogeneous gravitational field we calculate the interaction between the internal dof and the translational dof and try to identify observable consequences. Concerning the effects on the translational dof, for a particular class of initial states, we show that the internal dof can lead to the dephasing, namely, the suppression of the off-diagonal terms of the density matrix, in the position basis. Contrary to a recent claim this phenomenon is not universal and the process is not decoherence, because it does not involve irreversible loss of information. Concerning the effects on the internal dof of a free-falling atom, we found a gravitational phase shift in the reduced density matrix of the internal dof. While this phase shift is a fully quantum effect, it has a natural classical interpretation in terms of gravitational red-shift and special relativistic time-dilation. From this investigation we posit two statements of the equivalence principle for quantum systems: Version A: The probability distribution of position for a free-falling particle is the same as the probability distribution of a free particle, modulo a mass-independent shift of its mean. Version B: Any two particles with the same velocity wave-function behave identically in free fall, irrespective of their masses.
Based on recent paper by C. Anastopoulos and B. L. Hu, "Equivalence Principle for Quantum Systems:
Dephasing and Phase Shift of Free-Falling Particles" arXiv:1707xxx

A. Kempf
[Predicted signature of a covariant information-theoretic Planck scale cutoff in the CMB]
I will present a prediction for how an information-theoretic Planck scale cutoff should affect the cosmic microwave background spectra. What is special in the new approach is

that we model the ultraviolet cutoff fully covariantly to avoid possible artifacts of covariance breaking. We find that the covariant cutoff results in the production of small, characteristically $k-$dependent oscillations in the CMB spectra. The size of the effect scales linearly with the ratio of the Planck to Hubble lengths during inflation. Consequently, the relative size of the effect could be as large as one part in 10^5; i.e., eventual observability may not be ruled out.

T. Kim
[Status of SKT QKD system deployment and Ion Trap development]

N. W. Kim
[On the calculation of entanglement entropy in quantum field theory]
In this talk we review and present the computation of (Renyi) entanglement entropy for free quantum field theories in various setups.

J. León
[On time and position in quantum theory]
The talk will deal with conflicting aspects of the state-field relation along the long run that leads from quantum mechanics to quantum field theory. Some of the stops along the way can be highlighted, namely: A problem with causal ordering in quantum theory. A tool to know when a particle at a place.
On the probability of detecting a system in a small region. Asymptotic detection, Born rule?, and the concept of particles in QFT.
Weak energy conditions and localization.

J. Louko
[Creation of a localized source in quantum field theory]
Creating a localized source for a quantum field will disturb the field, the more the quicker the creation. We analyze this phenomenon as a model for the firewall that has been proposed to replace the horizon of an evaporating black hole, with a view to the firewall's efficacy to break correlations between spacetime regions. We consider a set of scenarios in the rapid creation limit, finding no simple correspondence between the singularity in the energy emitted into the field and the singularity in the experiences of a localized matter system that traverses the burst of radiation.

R. Mann
[Quantum Leaks in Spacetime]
It is generally assumed that the gravitational force is one that should be as amenable to quantization as any other. While there are good arguments in support of this, the continued lack of success in obtaining a quantum theory of gravity provides motivation for challenging this conventional wisdom.
Revisiting this picture suggests that perhaps gravity is not so `tightly quantized’, and that spacetime is in some sense ‘leaky’. I will describe in this talk how methods of RQI can be used to detect the quantum leaks in spacetime. Such leaks might not only provide a new origin for dark energy, but could perhaps provide a clue to understanding the relationship between gravity and quantum physics.

E. Martin-Martinez

[Revisiting the thermalization of accelerated particle detectors]

We will explore the ramifications of the ‘Anti-Unruh’ effect, that is, the fact that for accelerated trajectories, a particle detector coupled to a KMS state of a quantum field can cool down (click less often) as the KMS temperature increases. Remarkably, this can be so even when the detector is switched on adiabatically for infinitely long times. We will discuss that this effect is characteristic of accelerated detectors, and cannot appear for inertially moving detectors (e.g., in a thermal bath). We will also explore implications that this may have in distinguishing a thermal bath from acceleration in the Minkowski vacuum.

D. Page

[Black Hole Information and Firewalls]

Black hole information is one of the greatest puzzles of theoretical physics from the 20th century that has persisted into the 21st century. After Stephen Hawking discovered black hole evaporation in 1974, in 1976 he predicted that black hole formation and evaporation would cause a pure quantum state to change into a mixed state, effectively losing information from the universe. The tide of opinion (including Hawking's) has turned against this prediction, but there remain many puzzles about black hole information, such as how it gets out (if it indeed does), and whether there are firewalls at the surfaces of old black holes that would immediately destroy anything falling in. I shall give one general argument and three more specific arguments against firewalls, focusing at the end on a qubit transfer model of my student Kento Osuga and myself for transmitting the information from a black hole to the Hawking radiation.

T. Ralph

[Decoherence of the radiation from an accelerated quantum source]

Decoherence is the process via which quantum superpositions states are reduced to classical mixtures. Decoherence has been predicted for relativistically accelerated quantum systems, however examples to date have involved restricting the detected field modes to particular regions of space-time. If the global state over all space-time is measured then unitarity returns and the decoherence is removed. Here we study a decoherence effect associated with accelerated systems that cannot be explained in this way. In particular we study a uniformly accelerated source of a quantum field state - a single-mode squeezer. Even though the initial state of the field is vacuum (a pure state) and the interaction with the quantum source in the accelerated frame is unitary, we find that the final state detected by inertial observers is decohered, i.e. in a mixed state. We extend this result to a two-mode state and find entanglement is also decohered.

R. Schützhold

[Avalanche of entanglement and correlations at quantum phase transitions]

We study the ground-state entanglement in the quantum Ising model with nearest neighbor ferromagnetic coupling J and find a sequential increase of entanglement depth with growing J. This entanglement avalanche starts with two-point entanglement, as measured by the concurrence, and continues via the three-tangle and four-tangle, until finally, deep in the ferromagnetic phase, arriving at a pure L-partite (GHZ type) entanglement of all L spins. Comparison with the two, three, and four-point correlations reveals a similar sequence and shows strong ties to the above entanglement measures for small J. However, we also find a partial inversion of the hierarchy, where the four-point correlation exceeds the three- and two-point correlations, well before the critical point is reached. Qualitatively similar behavior is also found for the Bose-Hubbard model, suggesting that this is a general feature of a quantum phase transition. This should be taken into account in the approximations starting from a mean-field limit.

T. Takayanagi
[Liouville Action as Computational Complexity: From Continuous Tensor Networks to AdS/CFT]
We introduce a new optimization procedure for Euclidean path integrals which compute wave functionals in conformal field theories (CFT)s. The optimization is performed by minimizing certain functional, which can be interpreted as a measure of computational complexity, with respect to background metrics for the path-integrals. In two dimensional CFTs, this functional is given by the Liouville action. We also formulate the optimization for higher dimensional CFTs and, in various examples, find that the optimized hyperbolic metrics coincide with the time slices of expected gravity duals. Moreover, if we optimize a reduced density matrix, the geometry becomes two copies of the entanglement wedge and reproduces the holographic entanglement entropy. Our approach resembles a continuous tensor network renormalization and provides a concrete realization of the proposed interpretation of AdS/CFT as tensor networks.

D. R. Terno
[Effects of black hole radiation: horizon avoidance and firewalls]
Event horizons are the defining feature of classical black holes. They are the key ingredient of the information loss paradox which, as paradoxes in quantum foundations, is built on a combination of predictions of quantum theory and counterfactual classical features. Within the semi-classical theory we investigate the possibility that black hole radiation still does not allow for a finite time crossing of the Schwarzschild radius of collapsing matter as seen by distant observers. The exact form of the pre-Hawking radiation is not yet settled, and we make only minimal assumptions about its nature.
Collapse and evaporation of massive thin shells is studied in detail. In a generic spherically symmetric space-time of radiative exterior they do not cross their Schwarzschild radius. We extend these results to the Oppenheimer-Snyder collapse of dust ball and to a model of a rotating shell. The mechanism of avoidance depends on the details of the radiation process and the resulting metric. There classes of models, including the popular outgoing Vaidya metric, where a co-moving observer encounters firewall-like energy density and flux, but bounded with a natural cut-off.
We conjecture that horizon avoidance is a general feature of collapse already in the semi-classical theory. The non-existence of event horizons dispels the information loss paradox, but opens up important questions about thermodynamic properties of the resulting objects and correlations between different degrees of freedom.

W. G. Unruh
[Cosmological constant from high matter vacuum energy]
The cosmological constant problem is that the high, divergent vacuum energy seemingly is in conflict with the low cosmological constant. We argue that the large vacuum energy directly causes the low measured expansion rate by a process of very weak parametric resonance, with spacetime on the small scale being highly dynamic (Wheeler's spacetime foam).
Phys. Rev. D 95, 103504 (2017)

L. Vaidman
[Nonlocal variables, weak values, and the past of quantum particles]
I will review results about measurability of nonlocal variables in view of relativistic constrains. I will argue that the weak values is a property of single quantum system and not just a conditional average as it frequently considered. Finally I will discuss attributing physical meaning to the past of quantum particles.

A. Coutant
[Black hole superradiance in a bathtub vortex]
I will discuss the possibilities to mimic black hole physics in fluid flows. The starting point is an analogy discovered by Unruh between the propagation of sound in a flowing fluid and waves around a black hole. In these analog setups, it is possible to test various black hole effects, and challenge their robustness. In a recent water wave experiment, we have shown how to exploit this analogy to observe superradiant scattering, that is, the amplification of waves by extraction of angular momentum from a rotating flow.

B. Yoshida
[Decoding the Hawking radiation]
We present a simple probabilistic decoding protocol for reconstructing a quantum state from the Hawking radiation in the Hayden-Preskill black hole thought experiment and discuss its relation to out-of-time ordered correlation functions.

15min talk speakers

1. Pawel Caputa

[Out of Time Ordered Correlators and Quantum Chaos]

I will introduce the Out of Time Ordered Correlators as measures of quantum chaos in many-body systems and describe their main features from the quantum information perspective.

2. Hing-Tong Cho

[Quantum Brownian motion with nongaussian stochastic forces]

Quantum Brownian motion models with higher order couplings are considered. The resulting stochastic force in the influence functional approach is found to be nongaussian in general. The probability density function of the stochastic force is then derived perturbatively. We also discuss the related fluctuation-dissipation relation. Finally, both the corresponding Langevin and master equations are presented.

3. Andrzej Dragan

[Counting the Unruh particles]

We discuss the problem of how many particles can be found in a finite region due to acceleration.

4. Ian Thomas Durham

[Optical Cavities as Quantum Accelerometers]

The spontaneous emission of a photon from an atom is a property of the atom-vacuum system, rather than of the atom itself. The irreversibility of such systems arises from the fact that an infinite number of vacuum states is typically available to the radiated photon. Modifications to the vacuum states can thus be used to either inhibit or enhance the spontaneous emission. One such modification involves placing an excited atom between mirrors in an optical cavity. The resulting change to the transition rate of the atom is known as the Purcell effect. If the atom-cavity system is then accelerated in unison, relativistic effects produce a further change to the transition rate of the cavity. Such a system can thus be used as a quantum accelerometer.

5. Naoki Watamura

[Entanglement Growth and Probability Distribution]

In quantum field theory, the entanglement structure of the vacuum can be changed by acting with a local operator, and so the Entanglement Entropy (EE). We found that for the scalar field case, this change of EE can be related with the probability distribution of quasi particles created by the inserted local operator. We propose a toy model, which reproduces this excess. In this model, a quasi particle is propagating freely, and the probability distribution of it gives the excess of EE.

6. Kazuhiro Yamamoto

[Entanglement-induced quantum radiation]

Quantum entanglement of the Minkowski vacuum state between left and right Rindler wedges generates thermal behavior in the right Rindler wedge, which is known as the Unruh effect. In this letter, we show that there is another consequence of this entanglement, namely entanglement- induced quantum radiation emanating from a uniformly accelerated object. We clarify why it is in agreement with our intuition that incoming and outgoing energy fluxes should cancel each other out in a thermalized state.

7. Ki Hyuk Yee

[Superstition and Grover search algorithm in the presence of a closed timelike curve]

The superposition principle is one of the most intriguing consequences of quantum mechanics. Recently, a no-go theorem is proposed that the creation of superpositions of unknown quantum states is impossible. In this presentation, we first extend the recently proposed no-go theorem to the case of one known and one unknown state. Second, using both Deutsch and post-selected teleportation approaches, we show that the the no-go theorems can be circumvented in the presence of closed timelike curves, allowing .superpositions of one unknown quantum state and one known state. Further, we investigate the possibility of speed-up of Grover search algorithm assisted by closed timelike curves. Moreoever, we examine the condition in which the power of closed timeline curves via post selection is equivalent to that of Deutschian closed time like curves.

5min talk speakers

1. Aida Ahmadzadegan
[Strong Transient Modulation of Horizon Radiation]
The Unruh effect is the well-known phenomenon that particle detectors that are accelerated can click even in the vacuum. We calculate the trajectories which maximize the probability for such Unruh processes to occur. On these trajectories, Unruh processes are significantly more likely than on trajectories of uniform acceleration with the same initial and final velocities. The Unruh effect is closely related to the Hawking effect, via the equivalence principle. Our results indicate, therefore, that matter falling into a black hole could significantly modulate the outgoing Hawking radiation, which is of information-theoretic interest. We show that the underlying mathematical phenomenon is that varying positive frequencies induce concomitant negative frequencies, and vice versa, both in the Unruh-DeWitt detector formalism and in the Bogolubov transform formalism.

2. Natacha Altamirano
[Simulating a cosmological constant with a measurement-feedback mechanism in the Classical Channel Gravity model]
Eversince the discovery of the accelerated expansion of the universe there have been efforts devoted to build a theoretical model that can explain the observed value of the cosmological constant. In this work we explore the idea that a cosmological constant and ultimate accelerated expansion of the universe can be explained in the framework of Classical Channel Gravity (CCG). CCG was first introduced by Kafri, Taylor and Milburn as a theory of gravity with decoherence that is unable to convey entanglement, and in this sense the gravitational interaction is purely classical. Mathematically, CCG relies on measurement- feedback processes that occur infinitly fast. We review the extention of this model in to a cosmological scenario argue that CCG naturrally introduces a cosmological constant and analyze different thoretical and observational constraints.

3. Ivan Dario Arraut Guerrero
[Entanglement of systems and the way how the Nambu-Goldstone bosons disperse]
It has been demonstrated by the author that the spontaneous symmetry breaking condition can be formulated as a triangular relation between pairs of Nambu-Goldstone bosons and the vacuum. This brings a natural explanation of the vacuum degeneracy as well as the reason for unusual dispersion relations for Goldstone bosons in some circumstances. Here we extend the analysis in order to see how the entanglement of two systems might affect the dispersion relations of the Nambu-Goldstone bosons.

4. Alessio Belenchia
[Phenomenology of Non-Local Theories via Unruh-DeWitt Detectors]
Non-local kinetic operators, i.e., kinetic operators containing infinitely many derivatives, arise in several models of quantum gravity when spacetime is assumed to be discrete while preserving Lorentz Invariance. Unruh-DeWitt detectors have been shown to be highly sensitive to the non-locality scale --- which is the free-parameter of non-local field theories --- and as such constitute a low-energy window for spacetime phenomenology. After a brief overview of Causal Set theory --- a quantum gravity model in which space-time is assumed to be discrete and Lorentz Invariance is preserved --- I will discuss the response of Unruh-DeWitt detectors couple to non-local field theories inspired by Causal Set theory. The case of a single detector shows a power-law dependence of its response on the

non-locality scale. The case of two detectors shows instead the effect of non-locality on the transmission of information between two observers. In particular, as a consequence of the non-locality, the signaling is not vanishing even when the detectors are completely time-like related, i.e., there are Huygens' principle violations. These results make manifest the high sensitivity of low-energy Unruh-DeWitt detectors to the microscopic structure of spacetime in discrete and Lorentz Invariant models. Based on works in collaboration with: D.Benincasa; E.Martin-Martinez; S.Liberati and M.Saravani

5. Wan Mohamad Husni Bin Wan Mokhtar
[The Cost of Building a Wall for a Fermion]
We analyse the energy cost of building or demolishing a wall for a massless Dirac field in (1+1)-dimensional Minkowski spacetime and the response of an Unruh-DeWitt particle detector to the generated radiation. Although the field's energy density generically diverges on the future lightcones of the time dependent sections of the wall, there exist subfamilies of evolution for which the energy density vanishes and there is no energy cost. The detector's response is finite for any smoothly evolving wall but diverges in the limit of rapid wall creation or demolition for at least one subfamily of evolution with vanishing energy. The results highlight the disparity between the response of a localised matter system and the local expectation values of field observables such as the energy density. This disparity has potential interest for quantum information transfer scenarios.

6. Esteban Castro Ruiz
[Dynamics of quantum causal structures]
One of the most remarkable aspects of quantum theory is the fact that dynamical quantities are not defined independently of their measurement. Yet, the standard formulation of the theory assumes the existence of a fixed spacetime background. In general relativity, on the other hand, the spacetime metric possesses dynamical degrees of freedom. In view of the different roles played by spacetime in these two fundamental theories, it is pertinent to ask wether one can formulate quantum mechanics without the assumption of a definite causal structure. In this contribution, I would like to introduce the process matrix formalism, which is a framework that accomplishes such a task. After describing the main features of the framework, I will focus on the dynamics of causal structures, that is, on the type of transformations that take us from one causal structure to another. Based on the idea that, in nature, dynamics is continuous and reversible, I will analyze continuous and reversible causal structure transformations, and the restrictions obtained thereof.

7. Aidan Emile Chatwin-Davies
[Cosmic Equilibration: A Holographic No-Hair Theorem from the Generalized Second Law]
In a wide class of cosmological models, a positive cosmological constant drives cosmic evolution toward an asymptotically de Sitter phase. Here we connect this behaviour to the increase of entropy over time, based on the idea that de Sitter is a maximum-entropy state. We prove a cosmic no-hair theorem for Robertson-Walker and Bianchi I spacetimes that admit a "quantum" holographic screen with certain entropic properties: If generalized entropy, in the sense of the cosmological version of the Generalized Second Law conjectured by Bousso and Engelhardt, increases up to a finite maximum value along the screen, then the spacetime is asymptotically de Sitter in the future. The theorem follows from purely information-theoretic considerations; we do not use the Einstein field equations in our proof, nor do we assume the existence of a positive cosmological constant. As such, asymptotic relaxation to a de Sitter phase can, in a precise sense, be thought of as

cosmological equilibration.

8. cancel

9. Paulina Corona Ugalde
[Gravity is not a Pairwise Local Classical Channel]
There is no question that macroscopic systems interact gravitationally, and have firm experimental evidence that even systems comprising thousands of atoms exhibit quantum properties e.g. obey the superposition principle. However there is no current consistent theory of quantum gravity. Gravity-inspired modifications to quantum mechanics have led to a host of models built on the hypothesis that gravity remains classical at a fundamental level.?Two of such models are the Diosi-Penrose (DP) model and the Kafri-Taylor-Milburn (KTM) model, where the classicality of gravitational interactions is enforced in different ways: in DP classicality is understood as the lack of coherent superpositions of sufficiently massive particles, while in KTM it is understood as the inability of gravity to increase entanglement between pairs of masses. Proving or falsifying one of such models would have strong implications for our understanding of the nature of gravity. We show how the conceptual difference between the two models results in their widely disparate predictions. In particular, recent single-atom interferometric experiments achieving large spatial superpositions present strong evidence against the KTM model, while they do not constrain the DP model. The experiments are thus showing that gravitational interactions cannot be described as pairwise local classical channels between massive particles. The talk is based on [N. Altamirano, P. Corona-Ugalde, R.B. Mann, M. Zych, “Gravity is not a Pairwise Local Classical Channel”, arXiv:1612.07735]

10. Nicholas Funai
[Gauge invariance of the light-matter interaction in the relativistic regime]
In fundamental quantum optics and light-matter interactions the minimally coupled Hamiltonian (p.A) has historically posed issues by apparently producing gauge dependent physical predictions from an inherently gauge invariant theory. One of the first steps forward to cope with this issue was introduced by Göppert-Mayer in 1931 by introducing the dipole coupling Hamiltonian (r.E), making Schrödinger's equation entirely free from gauge terms. The validity of the E.r Hamiltonian combined with the dipole approximation was consolidated over time as experimental results seemed to agree with theoretical predictions, such as those presented by Lamb (1952). Clarity over this issue was produced by Lamb, Schlicher and Scully (1987) by properly exploiting the local gauge freedom of the electron wavefunction to ensure gauge invariance of physical and experimentally measurable quantities, resolving the disparity between p.A and r.E for pointlike-atoms. However, the validity of the dipole approximation in common setups in relativistic quantum information remains to be studied in detail. This includes phenomena such as entanglement harvesting, detection of vacuum fluctuations, quantum energy teleportation, and other scenarios where we couple atomic probes to the vacuum state of the electromagnetic field. Our work is focussed on testing the validity of the electric dipole approximation in these types of scenarios, given the ever broadening range of experimentally viable regimes. Our results show how to build gauge invariant physical quantities using fully featured Hydrogen-like atomic orbitals. We demonstrate how the assumptions of the dipole approximation break down in the simplest of RQI phenomena, i.e. vacuum excitations; and present bounds on the errors induced when using the electric dipole approximation.

11. Flaminia Giacomini

[Quantum mechanics in quantum reference frame]
In all our known theories, our description of the physical world always relies on the existence of a classical, ideal reference frame. If we abandon this idealised view and consider a reference frame as a physical system, we need to take into account the dynamical degrees of freedom of the reference frame. Here, we address the question of describing physics within quantum reference frames. By quantum reference frame we mean a physical system showing quantum properties such as superposition and entanglement. We describe how it is possible to change perspective from the classical external reference frame to a quantum reference frame, we show how the quantum state transforms, and we address the measurement in quantum reference frames. Moreover, we consider the dynamical laws and derive the Schrodinger equation in quantum reference frames. In particular, we analyse the situation in which the new reference frame is in a superposition of velocities from the point of view of the old one, and show that the transformation corresponding to a superposition of Galilean boosts; preserves the covariance of the Schrodinger equation.

12. Daniel Grimmer
[A model of open dynamics for relativistic quantum fields]
Work in collaboration with: Robert B. Mann, Achim Kempf, Eduardo Martin-Martinez, and Eric Brown. The dynamics of open quantum systems, i.e., of systems interacting with an environment, forms the basis of numerous active areas of research. Open dynamics is central to foundational questions such as the quantum measurement problem and gravitational decoherence. This is particularly relevant in the interaction of quantum fields with atoms. We will analyze the entropy flows in the emergent open dynamics of a particle detector undergoing rapid repeated interactions with a quantum electromagnetic field. We show that there are strong constraints on the ability of the interaction to allow for entropy flows from the detector to the quantum field. We will also show how a detector repeatedly interacting with a fully relativistic quantum field can display a range of thermodynamic behaviors such as thermalization, purification, and dephasing. We will discuss the impact of our results in some of the most common setups in Relativistic Quantum Information. We will pay special attention to the usage of the Gaussian formalism in the context of information flows between particle detectors and fields.

13. Piotr Tadeusz Grochowski
[Effect of relativistic acceleration on continuous variable quantum teleportation and dense coding]
We investigate how relativistic acceleration of the observers can affect the performance of the quantum teleportation and dense coding for continuous variable states of localized wavepackets [1]. Such protocols are typically optimized for symmetric resources prepared in an inertial frame of reference. A mismatch of the senders and the receivers accelerations can introduce asymmetry to the shared entanglement, which has an effect on the efficiency of the protocol that goes beyond entanglement degradation due to acceleration. We show how these asymmetry losses can be reduced by an extra LOCC step in the protocols.
[1] P.T. Grochowski et al., arXiv:1701.02251, to be published in Phys. Rev. D

14. Laura J Henderson
[Entanglement Harvesting in the BTZ blackhole vacuum]
A pair of Unruh-DeWitt (UDW) detectors can be used to probe the entanglement structure of a quantum field by studying entanglement harvesting. Entanglement harvesting is highly

sensitive to the background spacetime and topology; however, it is not known how the presence of a blackhole will effect this quantity. We analyze the entanglement harvested from the BTZ blackhole Hartle-Hawking vacuum of a conformally coupled massless scalar field through a pair of identical UDW detectors. These detectors are stationary and located at different radii from the singularity. We find the entanglement harvested rapidly falls off when the detectors are very close to the blackhole. Additionally, we find that while the mass of the blackhole as little effect on entanglement harvesting, it has a non-trivial dependance on the AdS length of the spacetime.

15. C. T. Marco Ho
[Violation of a causal inequality with definite causal order]
Causally indeterminate processes are of interest due to their importance in situations where gravity and quantum physics are important. In a similar way to how entanglement may violate Bell inequalities, causally indeterminate processes may violate a causal inequality which quantifies quantum correlations that arise from a lack of causal order. In this paper we show that the causal inequality can be violated even in a causal structure such as Minkowski space-time when non-point particles are considered viz. we consider gaussian-localised particles. We quantify the violation of the inequality and determine the optimal causal ordering of observers.

16. Philipp Höhn
[Lorentz transformations from quantum communication]
In most approaches to fundamental physics, spacetime symmetries are postulated a priori and then explicitly implemented in the theory. This includes Lorentz covariance in quantum field theory and diffeomorphism invariance in quantum gravity, which are seen as fundamental principles to which the final theory has to be adjusted. In this talk, we suggest, within a much simpler setting, that this kind of reasoning can actually be reversed, by taking an operational approach inspired by quantum information theory. We consider observers in distinct laboratories, with local physics described by the laws of abstract quantum theory, and without presupposing a particular spacetime structure. We ask what information-theoretic effort the observers have to spend to synchronize their descriptions of local physics. If there are "enough" observables that can be measured universally on several different quantum systems, we show that the observers' descriptions are related by an element of the orthochronous Lorentz group O^+(3,1), together with a global scaling factor. Not only does this operational approach predict the Lorentz transformations, but it also accurately describes the behavior of relativistic Stern-Gerlach devices in the WKB approximation, and it correctly predicts that quantum systems carry Lorentz group representations of different spin. This result hints at a novel information-theoretic perspective on spacetime.

17. Nicholas Hunter-Jones
[Chaos, Complexity, and the Spectrum]
Through the lens of quantum information, we aim to study universal properties of black holes as maximally chaotic systems. Recent progress has made evident that understanding quantum chaos might be a fruitful path to gain insight into gravitational systems and the quantum nature of black holes. It has been long known that random matrix theory is a powerful tool in capturing certain universal features of chaotic spectra. By relating probes of chaos, the out-of-time ordered (OTO) correlators, to the frame potential, a measure of an ensemble's ability to reproduce to Haar moments, we can then

assess the relevance of random matrix ensembles in capturing universe properties of gravitational systems. We derive relations between OTO correlators, spectral functions, and measures of unitary k-design behavior, quantify the time-scales in which chaotic systems approach random matrix behavior, and comment on the relation between spectral statistics and OTO behavior.

18. Robert H. Jonsson
[Wireless Quantum Communication and Symmetry]
How can relativistic fields be used for quantum information transmission?]
In wireless communication symmetrically emitted signals can carry classical information to many receivers. However, due to no-cloning, such symmetry is an obstacle to quantum information transmission, e.g., it renders the quantum capacity from the sender to any single receiver to zero. Nevertheless, it may be possible to exploit the effects of symmetry in other tasks akin to, e.g., quantum secret sharing or quantum bit commitment.
The study of these questions requires a non-perturbative treatment of matter-light interactions. We present such a framework consisting of localised signalling devices which communicate via a relativistic quantum field, and study different scenarios of quantum state transfer in 1+1 spacetime dimensions.
Joint work with Katja Ried, Eduardo Martin-Martinez and Achim Kempf.

19. Sebastian Paul Kish
[Quantum limited measurement of space-time curvature with scaling beyond the conventional Heisenberg limit]
We study the problem of estimating the phase shift due to the general relativistic time dilation in the interference of photons using a Mach-Zender interferometer setup. By introducing two non-linear Kerr materials, one in the bottom and one in the top arm, we can measure the non-linear phase produced by the curvature and achieve a scaling of the standard deviation with photon number (N) of 1/N^(3/2), which exceeds the conventional Heisenberg limit for linear systems. The non-linear phase shift is an effect that is amplified by the intensity of the probe field. In a regime of high photon number, this effect can dominate over the linear phase shift.

20. cancel

21. Yuya Kusuki
[Evolution of Entanglement Entropy in Orbifold CFTs]
In this work we study the time evolution of Renyi entanglement entropy for locally excited states created by twist operators in cyclic orbifold (T^2)^n/Z_n and symmetric orbifold (T^2)^n/S_n. We find that when the square of its compactification radius is rational, the second Renyi entropy approaches a universal constant equal to the logarithm of the quantum dimension of the twist operator. On the other hand, in the non-rational case, we find a new scaling law for the Renyi entropies given by the double logarithm of time log?log?t for the cyclic orbifold CFT.

22. Marco Letizia
[Sorkin entropy of quantum fields in causal set theory]
Entanglement entropy plays a crucial role in several areas of modern quantum physics, particularly in quantum gravity. The presence of UV divergences, when studying EE in the context of QFT, suggests a profound connection between EE and the microscopic structure

of spacetime. A global definition of entropy was recently proposed by Sorkin that is well-defined also when the spacetime is not gloabally hyperbolic, or even when spacetime is replaced by a discrete causal set, thus it can be seen as a covariant generalization of the usual concept of EE. In this talk I will discuss Sorkin EE for quantum fields living in a causal set in various spacetime dimensions. In particular, I will focus on the relationship between the discrete structure of a causal set and the emergence of an area-law.

23. Richard Lopp
[Randomness and relativity]
Quantum theory provides a fundamental source of randomness. Extracting pure randomness from non-relativistic quantum systems (e.g., atoms) in the presence of quantum fields can be spoiled by vacuum fluctuations which entangle the atoms and the quantum field, even when both systems start in their respective vacuum states. We will analyze how the fluctuations of the electromagnetic field can be used by an adversary to compromise randomness generation based on unbiased measurements on the atom. In particular we will focus on the case of realistic light-matter interactions in (3+1) dimensions. We will carefully explore the amount of randomness which is harvested by modelling the atom as a fully featured hydrogenoid atom. In doing so, we go beyond the simple scalar field-Unruh-DeWitt toy model usually employed in these setups and study the behaviour for adiabatic and non-adiabatic couplings between atom and electric field, studying the role that the exchange of angular momentum plays in these scenarios. We find that, against non-relativistic intuition, an equal superposition of ground and excited energy eigenstates of the atom is more resilient against loss of randomness than a ground-state atom in the presence of the electromagnetic vacuum. We also show that full randomness is difficult to achieve in a realistic setting, in contrast to what common approximations of Quantum Optics would predict, in particular for short interaction times in the adiabatic case, and for long interaction times with non-adiabatic coupling. Work in collaboration with Eduardo Martin-Martinez.

24. Krzysztof Lorek
[Effect of acceleration on localized fermionic Gaussian states]
We study the effects of acceleration on fermionic Gaussian states of localized modes of a Dirac field. We consider two wave packets in a Gaussian state and transform these to an accelerated frame of reference. In particular, we formulate the action of this transformation as a fermionic quantum channel. Having developed the general framework for fermions, we then investigate the entanglement of the vacuum, as well as the entanglement in Bell states. We find that with increasing acceleration vacuum entanglement increases, while the entanglement of Bell states decreases. Notably, our results have an immediate operational meaning given the localization of the modes. The talk will be based on the paper: Phys. Rev. D 95, 076004

25. Keiji Matsumoto
[Total detecton probability in general probabilistic theory - asymetry of state space and channel capacity]
The qubit state space is a beautiful sphere, but the high-dimensional one is increasingly asymmetric in proportion to the dimension. Similar observations also apply to classical systems. Here, we investigate this phenomenon in the light of general probabilistic theory, and conclude“ the asymmetry is caused by the increase of contained information.” To start, we introduce total detection probability N of a set of states, and show it nicely quantifies

asymmetry of the state space. Next, information theoretic meaning of N is investigated. Almost by definition, N is not less than the number of distinguishable states, and by application of N to the set of the receiver's states of a channel, we obtain the (maximized) product of the number of messages and the success probability of decode. In quantum mechanical systems, N is written using Renner's max-relative entropy, and an upper bound to the channel capacity by N is compared with Holevo's bound

26. Akira Matsumura
[Quantum Entanglement in de Sitter Spacetime]
We investigate quantum entanglement between two symmetric spacial regions in the Bunch-Davies vacuum, which is a vacuum state of a minimal coupling scalar field in de Sitter spacetime. We consider a harmonic chain model of the theory and use the logarithmic negativity to quantify the bipartite entanglement between two regions. In our numerical analysis, we find that the logarithmic negativity exists when the distance between them is over the horizon scale. Also, we examine an effective order parameter of the scalar field to use the entanglement. When the size of each region is beyond the Hubble horizon, the parameter differs from unit and monotonically increases.

27. Emma McKay
[The ultraviolet cutoff cannot hide: when will a qubit's interaction show what shape it is inside?]
Work done in collaboration with: Adrian Lupascu, Eduardo Martin-Martinez. In the light-matter interaction, detectors are often idealized as point-like particles. This is, for example, the case in the usual treatment of the Unruh-DeWitt detector. The shape of a particle detector has an influence on the number of degrees of freedom of the field that are accessible: detectors only see field modes contained in the support of the Fourier transform of its shape. This is a similar effect to that of UV cutoffs in the dynamics of field-particle interactions, and if not treated with care, can destroy the causal behaviour of an otherwise relativistic theory. We will analyze the influence of the shape of the detector and possible cutoff models in the observable physics of particle detectors. These studies are necessary to know whether models with UV cutoffs, often used as convenient regularizations, could produce results of note in experimental observations. We will discuss the consequences of these studies both in fundamental setups and in the physics of superconducting circuits where recent progress has made this kind of study necessary.

28. cancel

29. Keith K.C. Ng
[Distinguishing the Schwarzschild black hole from the RP3 geon using local measurements]
Recent results have highlighted that local measurement of a quantum field can reveal information about the global structure of spacetime. We therefore investigate the RP3 geon, which is identical to the Schwarzschild black hole except for a topological identification behind the event horizon. In order to model local measurements, we use the Unruh-DeWitt particle detector model. We find that a suitable detector can detect differences in the Hawking radiation that the detector measures in the two different spacetimes. We will analyze and discuss the implications of this result.

30. Kento Osuga

[Unitary Black Hole Evaporation without Firewalls]
The recently proposed firewall argument based on quantum entanglement suggests the necessity of modifying our current understanding of quantum field theories in order to consistently couple with gravity. It seems to me that locality of quantum field theories is the most dubious requirement. Hence, an open question is, how to incorporate nonlocality with today's observations, which are based on local quantum field theory. One such modification is to confine nonlocality in the gravity sector so that nonlocality of quantum gravity may not have much observable effect on experiments in laboratories. I will present a unitary qubit model of nonlocal gravity without firewall and explore interpretations of this model to shed light on how to formulate quantum gravity.

31. Roberto Pierini
[Do Ideal clocks exist?]
Time rate of ideal clocks are assumed to be independent from acceleration so that they can measure proper time along arbitrary paths. The time rate of any physically realizable device has ultimately to be traced back to fundamental process like life time of unstable particles. Here, we show that the decay rate of a particle undergoing a circular motion induced by a magnetic field deviates from its free particle value at high acceleration. This observation proves that ideal clocks are not conceivable.

32. Jason Pye
[On a Covariant Minimum Length in Quantum Field Theory]
There are many arguments suggesting that combining quantum theory with gravity induces an effective minimum length scale. A key step in understanding quantum gravity is to find a consistent description for such a minimum length structure. A particular challenge is to find a model which is Lorentz-invariant. Here we examine a modification of quantum field theory which aims to provide an effective low-energy model for such a Lorentz-invariant minimum length. This modification is a covariant bandlimitation of quantum field theory, which is based on a covariant version of the generalised uncertainty principle. In particular, I will present recent work on determining the implications of such a covariant bandlimit, such as how it would manifest itself in interacting theories. I will also discuss the possibility of a low-energy detection of the covariant bandlimit.

33. Nayeli Azucena Rodríguez Briones
[Quantum energy teleportation as a tool to keep quantum computers cool]
Combining quantum thermodynamics with concepts of quantum field theory such as the quantum interest conjecture and quantum energy teleportation, we show that a long standing upper bound on the limits of algorithmic cooling can be broken by exploiting system correlations due to internal interaction. In particular, we exploit quantum energy teleportation to consume correlations present due to the internal interaction while extracting work locally, resulting in the purification of a target qubit. Furthermore, we will explore the ongoing efforts to implement these methods in superconducting-qubits experiments. Work in Collaboration with: Achim Kempf, Raymond Laflamme and Eduardo Martin-Martinez.

34. Marcello Rotondo
[Fisher information in de Sitter space and the effect of quantum-to-classical transition]
In classical estimation theory, Fisher information (FI) provides an upper bound to how precisely the parameters of a measurement probability distribution can be estimated. It is

naturally extended to quantum estimation theory, with quantum Fisher information (QFI) being its maximisation over all quantum measurements.
Considering the two-mode squeezed vacuum resulting from the evolution of the (Bunch-Davies) vacuum of a massless scalar field in FLRW metric, we evaluate the QFI and the classical FI for the field amplitude and occupation number measurement with respect to a generic cosmological parameter. We show as an example the results for the estimation of the Hubble parameter in the specific case of pure de Sitter expansion and de Sitter expansion followed by a radiation dominated phase, discussing the role that the squeezing parameters play in the QFI of the state and providing some quantitative and qualitative considerations on how a quantum-to-classical transition affects the information contained in the original quantum state.

35. Allison Morgan Sachs
[Entanglement harvesting and divergences in quadratic Unruh-DeWitt detectors pairs]
Work in collaboration with: Eduardo Martín-Martínez and Robert B. Mann. The vacuum state of a quantum field, such as the electromagnetic field, possesses correlations, both classical and quantum, between spacelike separated regions [1,2]. By reading out correlations in the vacuum fluctuations, we can gather information about the structure of spacetime [3,4]. Additionally, vacuum correlations can, in principle, be used as a resource for quantum communication and other quantum information tasks. Past works have studied this phenomenon, called entanglement harvesting [5,6], in the case of detectors coupling linearly to a bosonic field; e.g. two atoms coupled to the electromagnetic field. While vacuum entanglement harvesting from a scalar field is well understood, as of today, the entanglement structure of the fermionic vacuum has not been studied in detail. The chief reason is that we lacked an adequate divergence-free equivalent to the Unruh-DeWitt particle detector model for fermionic fields. Using recently developed renormalized detector models for quadratic coupling to bosonic and fermionic fields [7], we will carry out a comparative study of the phenomenon of entanglement harvesting in different situations. Namely, we compare detectors coupled linearly to a bosonic vacuum with detectors coupled quadratically to bosonic fields, with the latter being a lead into fermionic entanglement harvesting. We expect that these studies will shed some light on the nature of fermionic field vacuum entanglement, which displays distinctive features not present in the bosonic case as observed in the study of the Unruh effect [8,9]. Notably, when we analyze entanglement between pairs of detectors quadratically coupled to a real scalar field, we find that, while a single quadratically coupled Unruh-DeWitt (UDW) detector is finite, there are persistent divergences when one considers pairs of detectors. Such divergences are not renormalized by the techniques employed in [7] to renormalized the single detector model, and they appear at the same (leading) order in perturbation theory. We will show that these divergences are present in the entanglement negativity but not the mutual information of the quadratic UDW-like detector pair. Thus, we can quantify the correlations exhibited between two UDW detectors without utilizing the divergent entanglement negativity.
[1] S. J. Summers and R. F. Werner, Phys. Lett. A 110 , 257 (1985).
[2] S. J. Summers and R. F. Werner, J. Math. Phys. 28, 2
[3] G. V. Steeg and N. C. Menicucci, Phys. Rev. D 79, 044027 (2009).
[4] E. Martin-Martinez, A. R. H. Smith, D. R. Terno, Phys. Rev. D 93, 044001 (2016)
[5] A. Valentini, Physics Letters A 153, 321 (1991).
[6] B. Reznik, Foundations of Physics 33, 167 (2003).
[7] D .Himmer,E.Martin-Martinez,andA.Kempf Phys.Rev.D93,024019(2015)

[8] P. M. Alsing, I. Fuentes-Schuller, R. B. Mann, and T. E. Tessier, Phys. Rev. A, 74, 032326 (2006)
[9] N. Friis, P. Kihler, Eduardo Martin-Martinez, and Reinhold A. Bertlmann Phys. Rev. A 84, 062111 (2011),
[10] M. Montero and E. Martin-Martinez Phys. Rev. A 83, 062323 (2011),
[11] M. Miguel Montero, J. Lein, and Eduardo Martin-Martinez Phys. Rev. A 84, 042320 (2011)

36. Petar Simidzija

[All coherent field states entangle equally]

It has been know for a long time that different regions of the vacuum state of a free quantum field are entangled [1,2]. This knowledge, together with the critical importance of entanglement to quantum information processing tasks, has inspired work on protocols of entanglement harvesting, in which two initially unentangled particle detectors become entangled through their local interactions with the field [3,4]. Thinking along these lines, we asked the question: if we shine two Unruh-DeWitt particle detectors with a laser (i.e. we allow them to interact with a coherent field state), then how much entanglement can they harvest from the field? We find a remarkable result: for arbitrary detector properties and spacetime dimensionality, the eigenvalues of the post-interaction density matrices of i) a single detector, ii) two detectors, and iii) the partial transpose of the latter, are all independent of which coherent state the field was in, at least to second order in the coupling strengths of the detectors to the field. For the case of detectors that obey Dirac-delta switching functions, we show that these results also hold in the non-perturbative regime. A particular consequence of these findings is that a detector pair can harvest the same amount of entanglement from any coherent field state as from the vacuum.

[1] S. J. Summers and R. F. Werner, Phys. Lett. A 110, 257 (1985).
[2] S. J. Summers and R. F. Werner, J. Math. Phys. 28, 2440 (1987).
[3] A. Valentini, Physics Letters A 153, 321 (1991).
[4] B. Reznik, Foundations of Physics 33, 167 (2003).

37. cancel

38. Daiqin Su

[Squeezed black hole]

It is well known that plane gravitational waves do not generate particles, which is analogous to that free plane electromagnetic waves do not produce electron-positron pairs. It would be interesting to explore whether this is also true in general curved background spacetimes. We study particle production by gravitational perturbations around a Schwarzschild black hole, which are characterised by the quasi-normal modes. The quasi-normal modes oscillate with particular frequencies, and meanwhile decay due to the emission of gravitational waves to the spatial infinity and into the event horizon. We show that the gravitational perturbations around a black hole do produce particles, which is a multimode squeezing process. The gravitational perturbations play the role as a multimode squeezer and squeeze the quantum states of the black hole. The strength of squeezing depends on the amplitude and frequency (both real and imaginary parts) of the quasi-normal modes

39. Sho Sugiura

[Universality in volume-law entanglement of pure quantum states]

In broad classes of pure quantum states, their entanglements increases in proportional to

their subsystem size. This property is called the volume-law of entanglement.For example, excited energy eigenstates and states after quantum quenches obey the volume-law. However, when the subsystem size is close to the half of the size of the system, the entanglement deviates from the volume-law and eventually vanishes. This behavior is called the Page curve. In this talk, we reveal the behavior of the Page curve. We analytically derive the Page curve of a class of thermal pure states, and numerically show that our result correctly predicts the Page curves of many kinds of pure states [1]. We focus on the 2nd Renyi entropy and the von Neumann entropy. We analyze the volume-law of the 2nd Renyi entropy using the thermal pure quantum states and obtain its exact result. Our results are so universal that entanglement structures in many kinds of equilibrium states are explained by it. Moreover, our formula can be exploited as a diagnostic of chaotic systems; we can distinguish integrable models from chaotic ones and can detect many-body localization with high accuracy. Regarding the von Neumann entropy, we show some new asymptotic results and conjecture that a dip of the Page curve at the middle is always a constant number[2].
[1] H. Fujita, Y. O. Nakagawa, S. Sugiura, M. Watanabe, "Universality in volume law entanglement of pure quantum states", arXiv 1703.02993, (2017).
[2] H. Fujita, Y. O. Nakagawa, S. Sugiura, M. Watanabe, in preparation.

40. Fumika Suzuki
[Internal entanglement and choice of space]
Interference of composite objects is an important problem with applications in many areas of physics. A composite object possesses internal degrees of freedom, which are often entangled with each other and with external degrees of freedom. This entanglement may act as a source of decoherence in one of the coordinates. We call the entanglement among internal degrees of freedom present in the composite system as “internal entanglement” to stress that both entangled degrees of freedom equivalently describe the composite system, as opposed to the situation when the system concerned is entangled with an external object. The behaviour of this internal entanglement largely depends on properties of space with imposed boundary conditions where wave-function is living. We will discuss how the choice of space and boundary conditions affect the internal entanglement of wave-functions, and how this fact leads to physical phenomena and the entanglement dynamics different depending on the choice of space.
F. Queisser and W. G. Unruh, Phys. Rev. D. 94, 116018 (2016).
F. Suzuki, M. Litinskaya and W. G. Unruh, arXiv:1701.04899 (2017).

41. Keisuke Suzuki
[Black Hole as Localizations of a Field of Positive Characteristic]
It is pointed out that a black hole may be thought of as localizations of a field of positive characteristic. A mass shell may represent units of the ring of integers of a field of positive characteristic, and the Bekenstein-Hawking entropy may be related to the p-adic logarithm of the mass shell's degrees of freedom.

42. Tadas Nakamura
[Relativistic Global Temperatures and Quantum Vacua]
It is well known that the classical covariant temperature can be defined based on a four vector of inverse temperature, whose components correspond to the four components of energy-momentum. In a similar way, it is possible to define an inverse temperature tensor based on angular momentum tensor. Possible implications of these classical temperatures

to quantum vacua will be discussed.

43. Zehua Tian

[Detecting the Curvature of de Sitter Universe with Two Entangled Atoms]

Casimir-Polder interaction arises from the vacuum fluctuations of quantum field that depend on spacetime curvature and thus is spacetime-dependent. Here we show how to use the resonance Casimir-Polder interaction (RCPI) between two entangled atoms to detect spacetime curvature. We find that the RCPI of two static entangled atoms in the de Sitter-invariant vacuum depends on the de Sitter spacetime curvature relevant to the temperature felt by the static observer. It is characterized by a 1/L^2 power law decay when beyond a characteristic length scale associated to the breakdown of a local inertial description of the two-atom system. However, the RCPI of the same setup embedded in a thermal bath in the Minkowski universe is temperature-independent and is always characterized by a 1/L power law decay. Therefore, although a single static atom in the de Sitter-invariant vacuum responds as if it were bathed in thermal radiation in a Minkowski universe, using the distinct difference between RCPI of two entangled atoms one can in principle distinguish these two universes.

44. Jose Daniel Trevison

[Second order superrotation charges on Rindler horizons]

We obtained the second order contribution to the gravitational superrotation charges, for a 1+3 dimensional Minkowski background with Rindler horizons plus a gravitational perturbation. This work is a continuation of previous work [1] which was focused on the linear approximation.

[1] M. Hotta, J. Trevison and K. Yamaguchi, Gravitational Memory Charges of Supertranslation and Superrotation on Rindler Horizons, Phys. Rev. D 94, 083001 (2016).

45. Koji Umemoto

[Quantum Entanglement for Lorentz boosted subsystems via Holography]

We study the entanglement entropy and mutual information in relativistic/non-relativistic quantum field theories for Lorentz boosted subsystems in the context of gauge/gravity duality. Some of the quantum field theories having the dual gravitational descriptions are called holographic QFTs, in which Ryu-Takayanagi formula provides the geometrical method of caluculation of the holographic entanglement entropy. In holographic conformal field theories (CFTs), which are dual to asymptotically Anti de Sitter spacetimes (AdS), we find that the mutual information gets divergent in a universal way when the endpoints of two subsystems are light-like separated. In non-relativistic theories dual to Lifshitz and hyperscaling violating geometries, we show that the holographic entanglement entropy is not well-defined for a Lorentz boosted subsystem when the subsystem is sufficiently small. This strongly suggests that in non-relativistic theories we cannot make a local real-space factorization of the Hilbert space on a generic time slice except the constant time slice, as oppesed to relativistic theories. It implies that if a boosted observer does an experiment of a condensed matter system at a non-relativistic critical point, he/she may encounter some sort of non-local effects.

46. Guillaume Verdon-Akzam

[On the Energetics of Vacuum Entanglement]

The relation between vacuum entanglement and energy/geometry has been a central theme of Relativistic Quantum Information and Quantum Gravity, usually studied in the context of black hole thermodynamics or the Unruh effect. In this work [1] we analyze the energetics of the vacuum entanglement of a ball-shaped subregion of a spacelike hypersurface. For this bipartition of the field's Hilbert space, we explicitly find the Schmidt basis for the entangled pure state. We show that the vacuum can be expressed as a tensor product of squeezed vacua between interior and exterior modes, whose mode functions we construct from Jacobson's Modular Hamiltonian flow [2].

Using this explicit state expression, we study contributions to the stress energy tensor for three cases of variations from the ground state. The first two cases consist of varying the Schmidt squeezing parameters, to either amplify or reduce the entanglement unitarily. In the third case, we break the entirety of the interior-exterior entanglement by measuring the interior Schmidt modes' number occupancy. We show that the observable of this measurement is, by construction, the observable in the interior region which provides the maximal amount of information about the state in the exterior region. We explicitly show that in this case of maximal entanglement breaking via measurement, one creates a "firewall" of energy mostly concentrated at the region's boundary, and we provide visualizations of this firewall. In all three cases, we compare the entanglement's spatial profile to the stress-energy tensor expectation values, for both a linear harmonic chain and continuum quantum field theory.

47. I-Chin Wang

[Quantum Steerability in relativistic motion]

We study quantum steerability based on the model that two Unruh-DeWitt detectors coupled with a quantum scalar field initially in the Minkowski vacuum. We investigate two cases that one detector(Alice) is at rest, the other detector(Bob) is approaching or leaving Alice in constant velocity. We find that the steerability can be explained by relativistic effect such as time dilation and frame dependence, which is expected in special relativistic motion.

48. Chih-Hung Wu

[Broken bridges: A counter-example of the ER=EPR conjecture]

The ER=EPR relation was proposed as a fundamental principle of quantum gravity. It states that for a pair of maximally entangled black holes, there should be an Einstein-Rosen bridge between them. Since both of the ER bridge and the EPR entangled pair should respect the principle of locality, we constructed a counter-example through realizing the breakdown of locality. Due to the vacuum decay of the anti-de Sitter background toward a deeper vacuum, two parts of maximally entangled black holes can be trapped by bubbles. If these bubbles are reasonably large, then within the scrambling time, there should appear an Einstein-Rosen bridge between the two black holes. Now by tracing more details on the bubble dynamics, one can identify parameters such that one of the two bubbles either monotonically shrinks or expands. Because of the change of vacuum energy, one side of the black hole would evaporate completely. Due to the shrinking of the apparent horizon, a signal from one side of the Einstein-Rosen bridge can be viewed from the opposite side. In the talk, I will also discuss recent debates with J. Maldacena regarding whether we can construct a traversable wormhole.

49. Koji Yamaguchi

[Entanglement beyond Page curves in black-hole evaporation qubit model]

We propose a model with multiple qubits, and which reproduces the thermal properties of 4-dim Schwarzschild black holes in high-temperature regimes by simultaneously taking account of the emission of Hawking par-ticles and the decay of the horizon-area degrees-of-freedom. We study the evolution of the entanglement entropy, and the results verify that the entanglement entropy between a qubit and other subsystems, including emitted radiation, is much larger than the Bekenstein-Hawking entropy analogue of the qubit, even in the last stage of evaporation, as opposed to the Page curve prediction.

50. Shingo Kukita

[Perturbative dynamics of open quantum systems by renormalization group method]

To investigate the nature of quantum fields on curved spacetimes, particle detectors interacting with the quantum fields are often used. The particle detectors can be treated as open quantum systems. We present a new method for evaluating perturbative dynamics of open quantum systems by using the renormalization group (RG) method. The solution obtained from the RG method approximates the exact solution for a long time. Moreover, the RG equation causes a reduction of the dynamics of the composite system under some assumptions. We show that this reduced dynamics is closely related to a quantum master equation for the open quantum system.

Poster Presentation

(The title and abstract of 5min speakers are presented above.)

1 Altamirano, Natacha
2 Arraut Guerrero, Ivan Dario
3 Belenchia, Alessio
4 Bin Wan Mokhtar, Wan Mohamad Husni
5 Castro Ruiz, Esteban
6 Chatwin-Davies, Aidan Emile
7 Chemissany, Wissam

8 Chou, Chung-Hsien
[Extensiveness of collective entanglement in a bosonic Gaussian system]
We show that under some assumptions the bipartite entanglement between two systems is extensive, i.e. additive with respect to the entanglements between a system and the other subsystems, in terms of a quasi entanglement measure stemming from Peres-Horodecki-Simon criterion. Thus despite the complicated nature of entanglement, for such systems entanglement is as if it is added up bit by bit by their constituents. We also show the non-extensive aspect of the same model, and compare it with some characteristics of multipartite entanglement.

9 Funai, Nicholas
10 Giacomini, Flaminia
12 Grimmer, Daniel
13 Henderson, Laura J
14 Ho, C. T. Marco
15 Jonsson, Robert H
16 Kish, Sebastian Paul
17 Kusuki, Yuya
18 Letizia, Marco

19 Lin, Shih-Yuin
[Unruh-DeWitt Detectors as Mirrors]
We describe the mirrors in terms of the derivative-coupling Unruh-DeWitt harmonic-oscillator detector theory in (1+1) dimensions. The reflectivity of a detector/mirror is dynamically determined by the interaction of the detector's internal degrees of freedom and the field. We demonstrate how the field spectrum in a cavity of this type of mirrors evolves from continuous to quasi-discrete after the coupling is switched on. Using this theoretical device we would be able to study the Casimir effect, dynamical Casimir effect, entanglement of mirrors and field, and quantum friction with a better consistency.

20 Lopp, Richard
21 Lorek, Krzysztof
22 McKay, Emma
23 Nagle, Ian

24 Nakagawa, Yuya
[Numerical studies on the relative entanglement entropy in critical spin chains]
We study the relative entanglement entropy (EE) among various primally excited states in critical spin chains: the S=1/2 XXZ chain and the transverse field Ising chain at criticality. For the S=1/2 XXZ chain, which corresponds to the c=1 free boson conformal field theory, we numerically calculate the relative EE by exact diagonalization and find a perfect agreement to the predictions by the conformal field theory. We also calculate the Renyi relative EE and again the numerical results agree well the analytical predictions. For the critical transverse field Ising chain, which corresponds to the c=1/2 Ising conformal field theory, we analytically relate its relative EE to that of the S=1/2 XXZ chain and confirm the relation numerically. Our results are the first direct confirmation of the conformal field theory prediction on the relative EE.

25 Nakamura, Tadas
26 Ng, Keith K.C
27 Osuga, Kento
28 Pierini, Roberto
29 Pye, Jason
30 Rodríguez Briones, Nayeli Azucena
31 Rotondo, Marcello
32 Simidzija, Petar
33 Su, Daiqin
34 Sugiura, Sho
35 Suzuki, Keisuke

37 Tokusumi, Tomoro
[Qubit Model of Hawking Radiation]
Almheiri-Marolf-Polchinski-Sully have noted a paradox with respect to Hawking process and that one way of resolving it is to postulate which prevent something fall into inside of black hole. The key of above discussion is known as which fundamental limitation of behavior of quantum information. We would like to present some models of hawking process motivated by quantum circuit to investigate time evolution of entanglement on evaporating process of black hole. We evaluate multipartite entanglement between black hole and Hawking radiation using negativity in this model and discuss about the monogamy relation.

38 Umemoto, Koji
39 Verdon-Akzam, Guillaume
40 Wang, I-Chin
41 Wu, Chih-Hung
42 Suzuki, Fumika
43 Grochowski, Piotr
44 Trevison, Jose Daniel
45 Yamaguchi, Koji
46 Sachs, Allison M.
47 Corona Ugalde, Paulina
48 Ahmadzadegan, Aida
49 Tian, Zehua

as of June 29, 2017