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Quantum Information

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Section Editor-in-Chief

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Section Information:

In calling for papers we are guided by two remarkable aspects of the field of Quantum Information Science (QIS):

- QIS has led to the refinement and enlargement of principles of both information theory and quantum mechanics, outside of its own boundaries where the two essentially overlap. It has opened new windows and suggested deeper foundational principles for statistical mechanics. It has given new meaning to the second law of thermodynamics. Intimate connections are being found with gravity and the structure of space–time.
- Regarding practical applications, QIS has produced breakthroughs in metrology. Quantum cryptographic devices are now produced and sold commercially, while more advanced schemes continue to be discovered. QIS has spawned new methods in quantum chemistry and in correlated many-body systems. QIS is useful in addressing questions regarding the possible role of quantum coherence in biological systems.

Section Quantum Information

Featured Papers

DOI: 10.3390/e23020138

Electronic Wave-Packets in Integer Quantum Hall Edge Channels: Relaxation and Dissipative Effects

Authors: Giacomo Rebora, Dario Ferraro, Ramiro H. Rodriguez, François D. Parmentier, Patrice Roche and Maura Sassetti

Abstract: We theoretically investigate the evolution of the peak height of energy-resolved electronic wave-packets ballistically propagating along integer quantum Hall edge channels at filling factor equal to two. This is ultimately related to the elastic scattering amplitude for the fermionic excitations evaluated at different injection energies. We investigate this quantity assuming a short-range capacitive coupling between the edges. Moreover, we also phenomenologically take into account the possibility of energy dissipation towards additional degrees of freedom—both linear and quadratic—in the injection energy. Through a comparison with recent experimental data, we rule out the non-dissipative case as well as a quadratic dependence of the dissipation, indicating a linear energy loss rate as the best candidate for describing the behavior of the quasi-particle peak at short enough propagation lengths.

DOI: 10.3390/e22101103

Complex Systems in Phase Space

Author: David K. Ferry, Mihail Nedjalkov, Josef Weinbub, Mauro Ballicchia, Ian Welland and Siegfried Selberherr

Abstract: The continued reduction of semiconductor device feature sizes towards the single-digit nanometer regime involves a variety of quantum effects. Modeling quantum effects in phase space in terms of the Wigner transport equation has evolved to be a very effective approach to describe such scaled down complex systems, accounting from full quantum processes to dissipation dominated transport regimes including transients. Here, we discuss the challanges, myths, and opportunities that arise in the study of these complex systems, and particularly the advantages of using phase space notions. The development of particle-based techniques for solving the transport equation and obtaining the Wigner function has led to efficient simulation approaches that couple well to the corresponding classical dynamics. One particular advantage is the ability to clearly illuminate the entanglement that can arise in the quantum system, thus allowing the direct observation of many quantum phenomena.

DOI: 10.3390/e23010055

Applicability of Squeezed- and Coherent-State Continuous-Variable Quantum Key Distribution over Satellite Links

Authors: Ivan Derkach and Vladyslav C. Usenko

Abstract: We address the applicability of quantum key distribution with continuous-variable coherent and squeezed states over long-distance satellite-based links, considering low Earth orbits and taking into account strong varying channel attenuation, atmospheric turbulence and finite data ensemble size effects. We obtain tight security bounds on the untrusted excess noise on the channel output, which suggest that substantial efforts aimed at setup stabilization and reduction of noise and loss are required, or the protocols can be realistically implemented over satellite links once either individual or passive collective attacks are assumed. Furthermore, splitting the satellite pass into discrete segments and extracting the key from each rather than from the overall single pass allows one to effectively improve robustness against the untrusted channel noise and establish a secure key under active collective attacks. We show that feasible amounts of optimized signal squeezing can substantially improve the applicability of the protocols allowing for lower system clock rates and aperture sizes and resulting in higher robustness against channel attenuation and noise compared to the coherent-state protocol.

DOI: 10.3390/e22060696

Quantum-Gravity Stochastic Effects on the de Sitter Event Horizon

Authors: Claudio Cremaschini and Massimo Tessarotto

Abstract: The stochastic character of the cosmological constant arising from the non-linear quantum-vacuum Bohm interaction in the framework of the manifestly-covariant theory of quantum gravity (CQG theory) is pointed out. This feature is shown to be consistent with the axiomatic formulation of quantum gravity based on the hydrodynamic representation of the same CQG theory developed recently. The conclusion follows by investigating the indeterminacy properties of the probability density function and its representation associated with the quantum gravity state, which corresponds to a hydrodynamic continuity equation that satisfies the unitarity principle. As a result, the corresponding form of stochastic quantum-modified Einstein field equations is obtained and shown to admit a stochastic cosmological de Sitter solution for the space-time metric tensor. The analytical calculation of the stochastic averages of relevant physical observables is obtained. These include in particular the radius of the de Sitter sphere fixing the location of the event horizon and the expression of the Hawking temperature associated with the related particle tunneling effect. Theoretical implications for cosmology and field theories are pointed out.

Selected Topic Collection

Quantum Information

Collection Editor: Jay Lawrence

Entropy is eager to launch a special collection on quantum information, which will build on the success of the recent Special Issue on this topic. We expect that the journal will provide a niche for investigators working at the interface of quantum information with other subjects in which information and entropy are of particular interest. Such subjects are found within broader disciplines ranging from biology, through quantum chemistry and many-body physics, to general relativity. In addition to the many fascinating ways in which quantum coherence and quantum entanglement are manifested in material systems, there are also compelling foundational issues involving the relationships among quantum mechanics, information, thermodynamics, statistical mechanics, relativity, and space-time itself. What principles are primary, and what is derived? Does one have a choice? What are the most interesting open questions?

Closed Special Issues

Practical Quantum Communication

Guest Editors: Xiang-Bin Wang, Cong Jiang and Leong Chuan Kwek

Quantum Darwinism and Friends

Guest Editors: Sebastian Deffner, Raymond Laflamme, Juan Pablo Paz and Michael Zwolak

Physical-Layer Security, Quantum Key Distribution and Post-quantum Cryptography

Guest Editor: Ivan B. Djordjevic

Quantum Dynamics with Non-Hermitian Hamiltonians

Guest Editor: Alessandro Sergi

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