Joseph C. Schindler

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Curriculum Vitae

Research Areas

- **Quantum Information and Thermodynamics**
  Foundations of non-equilibrium quantum statistical mechanics. Multipartite entanglement and multipartite quantum correlations. Quantum measurement. Black hole thermodynamics.
- **General Relativity and Gravity**
  Classical and semiclassical general relativity. Quantum field theories in curved spacetime. Classical and quantum black holes. Black hole evaporation.
- **Differential Geometry**
  Applications of geometric (Clifford) algebra in pseudo-Riemannian geometry.

Education and Training

2019–2020 PostDoc, Theoretical Physics, Santa Cruz Institute for Particle Physics

Research Highlights:

- Proposed a family of multipartite quantum correlation measures with a simple statistical mechanical interpretation related to coarse-graining, and proved the main properties of measures in this class.
- Numerically studied quantum correlations and entanglement in mixed and multipartite systems.
- Helped generalize the framework of quantum coarse-grained ("observational") entropy to consider general quantum instruments and operations, and apply this framework in the context of field theories and gravity.
- Proved key theorems allowing a simpler constructive definition of geometric (Clifford) calculus on pseudo-Riemannian manifolds.
- Numerically studied internal structure in the Kerr-Schild class of charged, rotating, regular black holes, with applications to the inner horizon mass inflation problem.
- Developed an analysis of the black hole unitarity problem within the context of well-defined semiclassical evaporation models, connecting with results in holographic quantum gravity.

2019 PhD, Physics, University of California Santa Cruz

Advisor: Anthony Aguirre
Thesis: The structure of evaporating black holes

Research Highlights:

- Developed new theoretical algorithms for explicitly computing Penrose diagrams (a visualization of relativistic structure) in a large class of spacetimes, and systematically characterized the geometry of spacetimes in this class.
- Numerically implemented the new algorithms, allowing exact visualization of causal structure and stress-energy content in spacetimes with nontrivial time evolution.
- Applied these tools to a detailed study of the structure in semiclassical models of both regular and singular evaporating black holes.

2013 MA, Experimental Physics, Wesleyan University
Advisor: Fred Ellis
Thesis: PT-Symmetric Electronics
Research Highlights:

- Experimentally and numerically investigated novel wave dynamics in PT-symmetric and non-Hermitian media.
- Prototyped radio frequency circuits and designed PCB implementation of radio frequency apparatus.
- Designed and implemented digital control structure (PC-FPGA-hardware) for experimental apparatus.

2012 BA, Physics, Wesleyan University

Employment

2021–2021 Consultant, Foundational Questions Institute
2019–2020 PostDoc, Theoretical Physics, Santa Cruz Institute for Particle Physics
2018–2018 Graduate Student Instructor, University of California Santa Cruz
2013–2019 Graduate Teaching and Research Assistant, University of California Santa Cruz
2012–2013 Graduate Research Assistant, Wesleyan University
2008–2012 Teaching and Research Assistant, Wesleyan University

Awards and Honors

2021 Invited Speaker, AstroMeet2022
2021 Invited Speaker, *GSGAC*2022
2019 Journal Reviewer Board, *Entropy*
2017 Most Valued Reviewer Award, *Physics of the Dark Universe*
2017 Marilyn Stevens Memorial Award, UC Santa Cruz
2012 Research Highlighted by APS *Physics* (physics.aps.org, "Synopsis: Circuit Analysis")
2012 Phi Beta Kappa, Wesleyan University
2012 Karl Van Dyke Prize in Physics, Wesleyan University
2011 Karl Van Dyke Prize in Physics, Wesleyan University

Teaching

Research Mentor, Theoretical Physics — Aguirre Theory Group

- Supervised PhD students and undergraduates in research projects involving quantum information theory and curved spacetime quantum field theory. Mentored incoming theory students in quantum information theory and differential geometry.

Instructor/Lecturer, Intermediate Lab for Physics Majors — University of California Santa Cruz

- Redesigned curriculum to focus on modern computational tools, leading to improved student engagement and learning outcomes.
- Developed Python programming tutorial which has remained in use in the course in subsequent years.
- Directed student experiments in electronics, optical spectroscopy, and gamma ray absorption.

Teaching Assistant, Advanced Lab for Physics Majors — University of California Santa Cruz

- Educated advanced students in data analysis, laboratory techniques, and scientific writing.
- Directed numerous experiments, including topics in optics, NMR, electron spin resonance, nonlinear mechanics, and electronics.

Teaching Assistant/Grader, Other Courses — University of California Santa Cruz

- Courses: Graduate and undergraduate Quantum Mechanics. Graduate and undergraduate General Relativity. Introductory Mechanics, Electromagnetism, and Fluids and Optics. Introductory labs.

Teaching Assistant, Other Courses — Wesleyan University

- Courses: Quantum Mechanics. Waves and Oscillations. Introductory labs.

Publications

Journal Articles

- J. Schindler, E. Frangipane, and A. Aguirre, "Unitarity and the information problem in an explicit model of black hole evaporation", Class. Quantum Grav. **38**, 075025 (2021), arXiv:2012.07973 [gr-qc].
- D. Šafránek, A. Aguirre, J. Schindler, and J. M. Deutsch, "A brief introduction to observational entropy", Found. Phys. **51**, 101 (2020), arXiv:2008.04409 [quant-ph].
- J. Schindler, "Basics of observational entropy", (2020), arXiv:2010.00142 [quant-ph].
- J. C. Schindler, A. Aguirre, and A. Kuttner, "Understanding black hole evaporation using explicitly computed Penrose diagrams", Phys. Rev. D **101**, 024010 (2020), arXiv:1907.04879 [gr-qc].
- J. Schindler, D. Šafránek, and A. Aguirre, "Quantum correlation entropy", Phys. Rev. A **102**, 052407 (2020), arXiv:2005.05408 [quant-ph].
- J. C. Schindler, "Geometric calculus on pseudo-Riemannian manifolds", (2019), arXiv:1911.07145 [math.DG].
- J. C. Schindler and A. Aguirre, "Algorithms for the explicit computation of Penrose diagrams", Class. Quantum Grav. **35**, 105019 (2018), arXiv:1802.02263 [gr-qc].
- M. Chitsazi, S. Factor, J. Schindler, H. Ramezani, F. M. Ellis, and T. Kottos, "Experimental observation of lasing shutdown via asymmetric gain", Phys. Rev. A **89**, 043842 (2014).
- Z. Lin, J. Schindler, F. M. Ellis, and T. Kottos, "Experimental observation of the dual behavior of PT-symmetric scattering", Phys. Rev. A **85**, 050101 (2012), arXiv:1205.2176 [cond-mat.mes-hall].
- H. Ramezani, J. Schindler, F. M. Ellis, U. Günther, and T. Kottos, "Bypassing the bandwidth theorem with PT symmetry", Phys. Rev. A **85**, 062122 (2012), arXiv:1205.1847 [physics.class-ph].
- J. Schindler, Z. Lin, J. M. Lee, H. Ramezani, F. M. Ellis, and T. Kottos, "PT-symmetric electronics", J. Phys. A **45**, 444029 (2012), arXiv:1209.2347 [cond-mat.other].
- J. Schindler, A. Li, M. C. Zheng, F. M. Ellis, and T. Kottos, "Experimental study of active LRC circuits with PT symmetries", Phys. Rev. A **84**, 040101 (2011), arXiv:1109.2913 [cond-mat.other].

Theses

- J. Schindler, *The Structure of Evaporating Black Holes*, PhD Thesis, University of California Santa Cruz, 2019.
- J. Schindler, *PT-Symmetric Electronics*, Master Thesis, Wesleyan University, 2013.

Talks

- J. Schindler, "Cores of regular black holes with charge and rotation", Invited talk, ASTROMEET2022, Copenhagen, in preparation, 2022.
- J. Schindler, "Explicitly computed penrose diagrams and black hole evaporation in regular and singular models", Invited talk, Global Summit on Gravitation, Astrophysics, and Cosmology, Tokyo, Japan, in preparation, 2022.
- J. Schindler, "Entanglement entropy and the statistical mechanics of coarse-graining", Invited Physics Colloquium, Wesleyan University, 2021.
- J. Schindler, "Quantum correlations, observational entropy, and generalized measurements", Invited Seminar, Quantum Information Theory Group, Universitat Autonoma de Barcelona, 2021.
- J. Schindler, "Statistical mechanical entropy of quantum correlations", Invited Seminar, Faculty of Mathematical Methods in Physics, University of Warsaw, 2021.
- J. Schindler, "The multivector approach to differential geometry: a simpler foundation for general relativity", SCIPP Theory Seminar, Santa Cruz Institute for Particle Physics, 2019.
- J. Schindler, "The structure of evaporating black holes", Dissertation Defense, University of California Santa Cruz, 2019.
- J. Schindler, "Causal structure of black hole formation and evaporation", University of California Santa Cruz, 2016.
- J. Schindler, "Deriving special relativity from causal sets", Theoretical Physics Seminar, Wesleyan University, 2012.
- J. Schindler, "Pt symmetric electronics", Thesis Defense, Wesleyan University, 2012.
- J. Schindler, H. Ramezani, A. Li, M. Zheng, T. Kottos, and F. Ellis, "Experimental observation of brachistochrone wave dynamics in pt symmetric structures", APS March Meeting Abstracts, 2012.

Citations

Via Google Scholar, July 2021
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