JIAYUE YANG

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Personal Webpage

Publications

Education

Associate Graduate Student, Perimeter Institute| ***Physics*** September 2022 – Present

Waterloo, Canada

Advisor: Prof. Niayesh Afshordi

Courses Taken: PSI Gravitational Phys Review(CR), PSI Quantum Field Theory 1(CR), PSI Quantum Field Theory 2(CR) (Note: all PSI course grades are either "credit" or "no credit")

Master Program, University of Waterloo| ***Physics*** September 2022 – Present

Waterloo, Canada

Advisor: Prof. Robert Mann

Courses Taken:General Relativity (97/100), Quantum Information Processing (95/100), Advanced General Relativity (91)

Average Score: 94.3/100

Undergraduate Program, Jilin University | ***Physics*** September 2018 – June 2022

Changchun, China

Major: Tang Aoqing Honors Program in Science (Physics)

Average Score: 91.16/100 GPA: 3.80/4.00

Advanced Courses Taken: Quantum Field Theory (98/100), General Relativity (97/100), Topology (93/100), Quantum Quench (4.0/4.0)

Areas of interest

High Energy Physics - Theory (hep-th), General Relativity and Quantum Cosmology (gr-qc)
Quantum Information in Gravity, Black Hole Thermodynamics, Analogue Gravity

Publications

[1] Yang, J., Frey, A.R. Complexity, scaling, and a phase transition. J. High Energ. Phys. 2023, 29 (2023). https://doi.org/10.1007/JHEP09(2023)029

[2] Yang, J., Mann, R.B. Dynamic behaviours of black hole phase transitions near quadruple points. J. High Energ. Phys. 2023, 28 (2023). https://doi.org/10.1007/JHEP08(2023)028

[3] Lu, M., Yang, J., Mann, R. B. (2024). Gravitational Wormholes. Universe, 10(6), 257. https://doi.org/10.3390/universe10060257

Thesis/Dissertation

Bachelor Thesis: Research on Holographic Entanglement Entropy. (2022). Jilin University. Bachelor's Honours. Number of Pages: 46 Supervisor: He, Song

In Chapter 1, we give a brief introduction to the basic concepts of black hole physics. In Chapter 2, we review the recent most significant breakthroughs in the field of holographic entanglement entropy. In

chapter 3, we show how to calculate the island position and radiation fine entropy of the asymptotically flat eternal Schwarzschild black hole as the first example. In Chapter 4, we introduce the second example of holographic entangled entropy, the case of an AdS black hole eternally coupled to the bath. Finally, we mainly discuss the relationship between quantum information and spacetime structure. The introduction of more examples of holographic entanglement entropy, the relationship between holographic entanglement entropy and holographic complexity, and the future directions of quantum gravity are also included.

Research experience

Wormholes in the Einsteinian cubic gravity September 2023 – 2024

University of Waterloo *Advisor: Prof. Robert Mann*

The paper is in progress.

Spacetime wormholes are evidently an essential component of the construction of a time machine. Within the context of general relativity, such objects require for their formation exotic matter – matter that violates at least one of the standard energy conditions. Here we explore the possibility that higher-curvature gravity theories might permit the construction of a wormhole without any matter at all. In particular we consider the simplest form of a generalized quasi topological theory in 4 spacetime dimensions known as EInsteinian Cubic Gravity. This theory has a number of promising features that make it an interesting phenomenological competitor to general relativity, including having non-hairy generalizations of the Schwarzschild black hole and linearized equations of second-order around maximally symmetric backgrounds. We find numerical evidence that strong asymptotically AdS wormhole solutions can be constructed, with strong curvature effects ensuring the wormhole throat can exist.

Entropy of Analogue Black Holes September 2022 – 2023

University of Waterloo *Advisor: Prof. Niayesh Afshordi*

The paper is in progress.

In analogue gravity studies, the goal is to replicate black hole phenomena, such as Hawking radiation, within controlled laboratory settings. In the realm of condensed matter systems, our focus center on graphene. In particular, we undertake a comparative analysis between the tilted Dirac cone of the graphene band structure and the tilted light cone in the framework of curved spacetime . Additionally, we calculate entropy of the condensed matter system, and find it has the same form as black hole entropy. We also derive Hawking temperature from the condensed matter system by considering the gradient of the tilt parameter. Hence, the totally tilted Dirac cone can be potential analogues of black hole horizons in this context. These results provide a distinctive opportunity to gain insights and potentially illuminate various facets of black hole physics.

Dynamic Behaviours of Black Hole Phase Transitions Near Quadruple Points September 2022 – 2023

University of Waterloo *Advisor: Prof. Robert Mann*

Published on Journal of High Energy Physics(JHEP), https://doi.org/10.1007/JHEP08(2023)028

Treating the horizon radius as an order parameter in a thermal fluctuation, the free energy landscape model sheds light on the dynamic behaviour of black hole phase transitions. Here we carry out the first investigation of the dynamics of the recently discovered multicriticality in black holes. We specifically consider black hole quadruple points in D = 4 Einstein gravity coupled to non-linear electrodynamics. We observe thermodynamic phase transitions between the four stable phases at a quadruple point as well as the weak and strong oscillatory phenomena by numerically solving the Smoluchowski equation describing the evolution of the probability distribution function. We analyze the dynamic evolution of the different phases at various ensemble temperatures and find that the probability distribution of a final stationary state is closely tied to the structure of its off-shell Gibbs free energy.

Complexity, Scaling, and a Phase Transition January 2021 – October 2021

Mitacs Globalink Research Internship, University of Winnipeg *Advisor: Prof. Andrew Frey*

Published on Journal of High Energy Physics(JHEP), https://doi.org/10.1007/JHEP09(2023)029

We investigate the holographic complexity of CFTs compactified on a circle with a Wilson line, dual to magnetized solitons in AdS_4 and AdS_5. These theories have a confinement-deconfinement phase transition as a function of the Wilson line, and the complexity of formation acts as an order parameter for this transition. Through explicit calculation, we show that proposed complexity functionals based on volume and action obey a scaling relation with radius of the circle and further prove that a broad family of potential complexity functionals obeys this scaling behavior. As a result, we conjecture that the scaling law applies to the complexity of conformal field theories on a circle in more general circumstances.

$T\bar{T}$ Deformation with Generalized JT Gravity September 2020 – April 2021

Undergraduate Research Project, Jilin University *Advisor: Prof. Song He*

In this project, we coupled the flat JT gravity and generalized JT gravity to matter fields. By calculating the equation of motion and stress-energy tensor, I showed they could be interpreted as the TTbar deformation of the matter. Using the first-order formalism, I rewrote the action as a TTbar deformation with the deforming parameter given by a function of the dilaton.

Looping Pendulum – China Undergraduate Physics Tournament December 2018 – August 2019

China Undergraduate Physics Tournament Organizing Committee and Jilin University *Advisor: Prof. Liufang Xu*

We investigated the Looping Pendulum phenomenon by establishing a theoretical model and conducting qualitative experiments. We compared the theoretical results obtained by FORTRAN programming with the experimental results recorded by Tracker, and they were found to be strikingly consistent. On behalf of Jilin University, we participated in the 10th China Undergraduate Physics Tournament and won the national second prize in the final.

Presentations

Talk:Dynamic Behaviours of Black Hole Phase Transitions Near Quadruple Points December 21 , 2023
Chongqing Workshop on Cosmology and Fundamental Physics 2023 Chongqing Universoty

Talk: Quantum Information in Gravity: Holographic Complexity October 27 , 2023
Relativistic Quantum Information Conference(RQI conference) University of Waterloo

Poster: Quantum Information in Gravity: Holographic Complexity October 23-27 , 2023
Puzzles in the Quantum Gravity Landscape Conference Perimeter Institute for Theoretical Physics

Talk: Black Hole Phase Transitions September 15 , 2023
Perimeter Institute Graduate Students' Conference 2023 Perimeter Institute for Theoretical Physics

Poster: Complexity, Scaling, and a Phase Transition July 31-August 4 , 2023
It from Qubit 2023 Perimeter Institute for Theoretical Physics

Poster: Dynamic Behaviours of Black Hole Phase Transitions July 4-7 , 2023
Women in Physics Canada Conference 2023 Video (English) University of Manitoba

Talk: Entropy of Analogue Black Hole June 5-9 , 2023
Quantum Simulators of Fundamental Physics Video (English) Perimeter Institute for Theoretical Physics

Poster: Holographic Complexity in AdS/CFT September 7, 2021
16th annual Randy Kobes Poster Symposium Video (English) University of Winnipeg

Talk: Holographic Complexity of AdS Soliton August 19, 2021
WITP Summer Student Symposium 2021 Video (English) Winnipeg Institute for Theoretical Physics

Talk: $T\bar{T}$ Deformation with Generalized JT Gravity April 30, 2021
Group Meeting Presentation Video Center for Theoretical Physics, Jilin University

Teaching experience

Quantum Field Theory November 2023-Present
Free online teaching courses Video Department of Physics and Astronomy , University of Waterloo

General Relativity September 2023-Present
Free online teaching courses Video Department of Physics and Astronomy , University of Waterloo

Introductory Astronomy May-December, 2023
Teaching Assistant SCI 238, University of Waterloo

Formulation of Quantum Statistics November 29, 2020
Statistical Mechanics Seminar Presentation Video College of Physics, Jilin University

Differentiable Manifold June 26, 2020
Topology Class Presentation Video College of Physics, Jilin University

Noether's Theorem March 28, 2020
Analytical Mechanics Class Presentation Video College of Physics, Jilin University

Analytical Mechanics March 15, 2020-January 31, 2021
Free online teaching courses Video College of Physics, Jilin University

Methods of Mathematical Physics January 14, 2020 - January 26, 2021
Free online teaching courses Video College of Physics, Jilin University

Conferences and lectures participation

It from Qubit 2023 — July 31-August 4 2023
Perimeter Institute for Theoretical Physics — *It from Qubit community*

Strings 2023 — July 24-29 2023
Perimeter Institute for Theoretical Physics — *String theory community*

Women in Physics Canada Conference — July 4-7, 2023
University of Manitoba — *WIPC community*

Quantum Simulators of Fundamental Physics — June 5-9, 2023
Perimeter Institute for Theoretical Physics — *QSimFP community*

Applications of Quantum Information in QFT and Cosmology — November 22 - 24, 2021
The University of Lethbridge — *Prof. Robert Myers, Prof. Robert Brandenberger et al.*

Wormholes, Black Holes and Entanglement / Round Workshop on Cosmology — October 20, 2021
Institute for Advanced Study, Princeton University / Central China Normal University — *Prof. Juan Maldacena*

Summer School in Theoretical Physics and Particle Physics — August 23 – 26, 2021
School of Physics, Peking University — *Prof. Yinan Wang, Prof. Qinghong Cao et al.*

Cambridge Academic Programme - Statistical Physics — July 21 – 27, 2021
University of Cambridge and Jilin University — *Prof. Sergei Taraskin*

Spacetime and Geometry — May 23 – June 6, 2021
Department of Physics, Sichuan University — *Prof. Bo Ning*

Summer School in Particle Physics — July 6-11, 2020
Tsung-Dao Lee Institute,Shanghai Jiao Tong University — *Prof. Tsutomu Yanagida, Prof. Michael Ramsey-Musolf et al.*

Winter School in High Energy Physics — January 17 – 19, 2020
BESIII Collaboration — *Prof. Changzheng Yuan, Prof. Weimin Song et al.*

Honors and awards

Mitacs Globalink Graduate Fellowship — 2022-2023

Dean's Scholarship — 2022

Mitacs Globalink Research Internship Award — 2021

Wolfram Technology Certified Level 1 for Mathematica — February 2021

Second Team Prize in 2019-2020 Tang Aoqing Honors Program of Research and Practice — June 2020

Stony Brook University Sponsorship for Jilin University Honor Students (2/273) — April 2020

College Excellent Student Scholarship (Top 10%) — April 2020

Second Class Scholarship (Top 10%) — April 2020

Second prize of the 10th China Undergraduate Physics Tournament — August 2019

First prize of the Northeast China Undergraduate Physics Tournament — May 2019

First prize of the China Undergraduate Physics Tournament at Jilin University — March 2019

Champion of 2018 Astronomy Knowledge Competition at Jilin University — December 2018

Extracurricular Activities / Community involvement

As the Organizer of "Quantum Information in Gravity Seminar" 4 hours/week Sept-present 2023
Organize weekly zoom seminars among different Universities Waterloo, Canada

Volunteer Service Activities to Kids' Science Open House 6 hours October 28 2023
The main hands-on experiment I assisted is polarization art. Waterloo, Canada

Volunteer Service Activities to Astronomy Outreach 6 hours August 12 2023
Help organizing Perseids Sky-watching Party and Astronomy Lecture Waterloo, Canada

Mentoring Activities on junior students 2 hours May 13 2023
Share graduate program application experience to junior students from Shandong University Shandong, China

Mentoring Activities on junior students 2 hours April 17 2022
Share research experience on course "Career Development and Employment Guidance" Changchun, China

Mentoring Activities on junior students 2 hours April 16 2022
Share graduate program application experience Changchun, China

Volunteer Service Activities to Science Outreach February-March 2022
Organize the distribution of 20 free popular science books for Jilin University students Changchun, Jilin

As a Judge of Undergraduate Physics Tournament at Jilin University 8 hours April 10, 2021
Evaluate and grade contestants of Undergraduate Physics Tournament at Jilin University Changchun, Jilin

As a Organizer of 2020 Astronomy Knowledge Competition at Jilin University 8 hours October 2020
Organize Astronomy Knowledge Competition at Jilin University Changchun, Jilin

Director of Academic Department of Jilin University Astronomy Society 4 hours/week 2019 – 2020
Organize astronomy seminars to help beginners experience the charm of cosmology Changchun, Jilin

Volunteer Service Activities to Recycle Old Books 30 hours May 11, 2019
Give my old books to people who need them Changchun, Jilin

Volunteer Service Activities to Help Young Students 60 hours February 2019
Free tutoring for a girl from low-income family in physics Chongqing, China

Skills and hobbies

Languages: English (TOEFL:96), Chinese (Native)
Programming: Mathematica, MATLAB, C Programming
Document Creation: LaTeX, Notion, Microsoft Office Suite
Hobbies: Star gazing, Hiking, Skiing, Rock climbing, Mountain climbing, Drawing and Photography