Hossein Mohammadi

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Education

Sharif University of Technology	*Sep 2022 - Sep 2024*
Master of Science in Physics	GPA : 19.31/20 (3.91/4.0)

Selected Courses: Quantum Information Theory, Advanced Classical Mechanics, Bosonic String Theory, Conformal Field Theory, Advanced Mathematical Physics

Thesis Title: A Review of 2D-3D quantum gravity aiming to find new interpretations of islands.

Thesis Advisor: Dr. Amin Faraji Astaneh

Sharif University of Technology	*Sep 2017 - Feb 2022*
Bachelor of Science in Physics	GPA : 18.96/20 (3.85/4.0)

Selected Courses: General Relativity, Quantum Computation, Introductory and Advanced Quantum Field Theory, Advanced Quantum Mechanics, Introduction to String Theory, Introduction to Elementary Particles, Computer Simulationsin Physics, Group Theory, Solid State Physics, Mathematical Analysis, Algebra.

Research Interests

Conformal Field Theory - Quantum Field Theory - Quantum Gravity - String Theory - Mathematical Physics

Honors and Awards

- Awarded the top student award for being ranked 1st among 42 physics master students at Sharif University of Technology, Tehran, Iran. (2024)
- Ranked 9th in the Nationwide Graduate School (M.Sc.) Entrance Exam in Physics 2022 amongst more than 9,000 participants. (2022)
- Ranked 8th among the 61 physics bachelor students in 2017, Department of Physics, Sharif University of Technology. (2022)

Research Experience

Exploring Beyond Standard Models	*Mar 2024 – Present*

Under the supervision of Dr. Maryam Zeinali ⧉
Research Center for High Energy Physics, Sharif University of Technology.

This experience served as an introductory foundation in experimental particle physics, where I gained proficiency in various techniques, technologies, and tools essential for experimental research. I developed a working knowledge of ROOT, C++, RooFit, and Machine Learning, applying these skills to a project in high-energy experimental physics (hep-ex).

Some Deformation of String Theory Ladder Operator Algebra	*Mar 2024 – Oct 2024*

Collaborating Prof. Hesamaddin Arfaei ⧉*, and Ahmadreza Moradpouri* ⧉
Research Center for High Energy Physics, Sharif University of Technology.

Aiming to better understand string theory in the presence of the closed background fields, we infinitesimally deformed the ladder algebra and explored its physical consequences for the theory. This deformation preserves conformal symmetry and alters the action, as though a $U(1)$ gauge field were present on the string worldsheet. This rewarding collaboration marked my first intense research experience.

Holography for Orbifold Riemann Surfaces	*Sep 2022 – Oct 2024*

Under the supervision of Dr. Ali Naseh ⧉
Institute for Research in Fundamental Sciences (IPM), Tehran, Iran

We investigated three-dimensional gravity, focusing on the early advancements in its quantization and

holographic description, as pioneered by Witten and Krasnov. A key area of my curiosity throughout this project was understanding how much the boundary CFT deviates from Liouville CFT, along with addressing various quantization challenges. We began by exploring the geometric quantization of 3D gravity. Although defining a complete quantum theory posed significant obstacles, we were able to determine the dimension of the Hilbert space, a crucial result for the study of black hole holography. Ultimately, our attention shifted toward bulk holography, where we discovered a novel approach to describing the holographic aspects of these theories.

Island and its Analogy to Heat Flow   *Sep 2022 – Sep 2024*

Under the supervision of [Dr. Amin Faraji Astaneh](#) ↗
Sharif University of Technology, Tehran, Iran.

This is my M.Sc. thesis project, and we tried to interpret "Island Rule" in simple terms. The idea behind our proposal was to investigate new interpretations of the island rule. My supervisor, Dr. Amin Faraji Astaneh, motivated me to explore the world of models of 2D black holes and their details to test the ideas. Our proposal was that the "island" is actually an ice-land, and the seemingly strange rule of island can be motivated by heat flow, where the black hole plays the rule of a heat well. In the future, we want to investigate the ideas with the known 2D JT black holes and find some numerical evidence that could support this motivation

Publications

Infinitesimal Deformations in Ladder Algebras of Bosonic String Theory   Sep 2024

Hesamaddin Arfaei, ***Hossein Mohammadi***, Ahmadreza Moradpouri

To appear ↗

Holography and Orbifold Riemann Surfaces   Sep 2024

Ali Naseh, ***Hossein Mohammadi***, Behrad Taghavi

To appear ↗

Talks and Seminars

• **The Liouville boundary terms on compact Riemann surfaces**   *Feb 2024*

This talk was part of my research with Dr. Ali Naseh, which aimed to find a systematic way of finding the correct Liouville action on compact Riemann surfaces. The problem with Liouville action (which is a universal CFT in the senseof conformal block and its OPE) on a $g > 1$ Riemann surface is the boundary terms, which are necessary for both awell-defined equation of motion and a correct stress tensor. In this talk, I reviewed relatively old mathematicalmachinery, based on homology and cohomology groups of the associated uniformization of the Riemann surface, to build such a consistent action. Then, drawing on the previous results, I showed how one can generalize this method tonon-compact manifolds and find effective contributions to the action.

• **JT gravity, matrix models and its subtle connection to 3D-gravity**   *Dec 2023*

The gist of this talk was to cure the ailments of the spectrum of 3D gravity, with some contributions motivated by JT gravity. I went through a complete review of JT gravity and matrix models, and then the proposal was suggested and debated over. This talk was based on this work by Maxfield and Turiaci, and most of its time was devoted to familiarizing the participants with the basics of 2D gravity.

• **Geometric Quantization Approach to 3D quantum gravity**   *Feb 2023*

This talk was presented at IPM. I showed how valuable lessons about the quantization of gravity could be achieved by reviewing the program of "geometric quantization." Defining Hilbert space, choosing a pre-quantum line bundle, and a suitable polarization were the skeleton of this talk. Ultimately, I discussed why this program could not be applied to gravity conveniently.

• **Representation Theory in Quantum Mechanics**   *Sep 2019*

Physics students in our university form circles to study various topics. I presented in these gatherings about group theory, representation theory, and advanced topics in quantum mechanics. More specifically, I tried to elucidate the relation between representation theory and some topics in quantum mechanics, such as symmetries and angular momentum.

Course Projects

Quantum Algorithms for Simulating Quantum Field Theories	Fall 2022
Course: Quantum Information Theory	
On NS5-Brane and its Tension	Spring 2021
Course: Introduction to String Theory	
Delayed choice experiment: from Idea to Realization	Spring 2021
Course: Advanced Quantum Mechanics	
Lamb Shift and its Modern Description	Fall 2020
Course: Introduction to Particle Physics	

A comprehensive list of my coursework is avaialbe in my [website](#) ⬀.

Attended Schools

G.R. on Mathematica using xAct package	Spring 2021

The specialized program was intended to cover modern computational methods in GR with Mathematica. Tensor calculation, tetrad formalism, and QFT in curved spacetime were among the most fascinating topics.)

Teaching Assistant Experience

Advanced Mathematical Physics (Ph.D. Course)	Spring 2024
Instructor: Dr. Vahid Karimipour (✉ vahid.karimipour@gmail.com)	
Group Theory	Spring 2024
Instructor: Dr. Ali Rezakhani (✉ rezakhani@sharif.edu)	
Advanced Quantum Field Theory (Ph.D. Course)	Fall 2023
Instructor: Dr. Amin Faraji Astaneh (✉ faraji@sharif.edu)	
Quantum Mechanics 2	Spring 2022
Instructor: Dr. Laleh Memarzadeh (✉ memarzadeh@sharif.edu)	
Modern Physics Laboratory	Fall 2021
Instructor: Dr. Naimeh Naseri(✉ naseri@sharif.edu)	

For comprehensive details of each teaching assistantship, please visit my [website](#) ⬀.

Extracurricular Activities

- Event organizer of Research Center for High Energy Physics, Sharif University of Technology.
- Writer in physics department's magazines, ["Takaaneh"](#) ⬀ and ["Shabaahang"](#) ⬀ in Persian at the Sharif University of Technology, Tehran, Iran.
- Organizer of "High Energy Physics Journal Club", held weekly about recent advances in Theoretical High Energy Physics.
- Sharif University of Technology Open day, performing experiments for high-school students

Academic References

- **Prof. Hesamaddin Arfaei** (✉ h.arfaei@gmail.com)

  Department of Physics, Sharif University of Technology, Iran.

- **Dr. Amin Faraji Astaneh** (✉ aminfaraji65@gmail.com)

  Department of Physics, Sharif University of Technology, Iran.

- **Dr. Ali Naseh** (✉ naseh@ipm.ir)

  School of Particles and Accelerators, IPM, Iran.

- **Dr. Ali Rezakhani** (✉ rezakhani@sharif.edu)

  Department of Physics, Sharif University of Technology, Iran.

Computer Skill and Languages

Programming Languages/Skills: C, C++, Python, LaTeX, ROOT, git, Machine Learning, Web Front-End Programming (HTML/CSS/Javascript/JQuery)

Softwares: Wolfram Mathematica, Matlab, Numpy, Pandas, Tensorflow, scikit-learn

Persian: Native
English: Fluent. (TOEFL iBT: 107)
Kurdish: Fluent