Jeffrey Morais

Honours Physics BSc at McGill University

Research Experience

Fall 2023 **Researcher**, *Fudan University*, Shanghai, China

Using quantum neural networks and topological quantum field theory, we look at stochastic Ricci flow for renormalization group flow in quantum gravity. We also look at connecting this to topological wormholes and string defects.

Supervisor: Prof. Antonino Marcianò

Present **Undergraduate Researcher**, *NSERC, University of Alberta*, Edmonton, Canada

Study of topological wormholes and holographic entanglement occurring in quantum mechanics. Through a correspondence between the wormhole partition function and the Rényi entropy of entangled states, we investigate this formalism to qubit networks. We study these networks to describe the emergence of spacetime structure.

Supervisor: Prof. Igor Boettcher

2022 **Honours Bachelor Thesis**, *McGill University*, Montréal, Canada

Study of the problematic non-existence of vacua with de Sitter isometries occurring in type II string theory and M-theory. We studied generalized coherent states over super Minkowski space with these isometries to allow for non-singular compactifications to the de Sitter spacetime dS_4, a candidate to model our Lorentzian universe.

Supervisor: Prof. Keshav Dasgupta

Summer 2022 **Undergraduate Researcher**, *NSERC, McGill University*, Montréal, Canada

Characterization of U(1) topological defect (cosmic string) signals occurring in a class of renormalizable quantum field theories. We developed statistics to extract these signals from primordial ΛCDM background noise in 21cm signal cosmological observations.

Supervisor: Prof. Robert Brandenberger

Winter 2022 **Undergraduate Researcher**, *McGill University*, Montréal, Canada

Study of the interaction of light and dynamical Casimir effect occurring in photon recycling via scalar quantum field theory. We computed the quantum corrections via loop diagrams using a spatially dependent interaction vertex and relativistically moving boundary conditions for the mirrors.

Supervisor: Prof. Andrew Higgins

Fall 2021 **Undergraduate Researcher**, *McGill University*, Montréal, Canada

Characterized fast radio burst repeater signals detected from the direction of the M81 galaxy group with the CHIME/Pulsar & CHIME/FRB systems amongst non-linear cosmological noise: Measuring scintillation and decorrelation bandwidths.

Supervisor: Prof. Victoria Kaspi

Summer 2021 **Undergraduate Researcher**, *BSA, McGill University Health Center*, Montréal, Canada

Construction and training of models administering tumour suppressing radiation with neural networks. We investigated dose volume tensor estimation models with helically distributed electromagnetic waves.

Supervisor: Prof. Marija Popovic

Summer 2020 **Undergraduate Researcher**, *SURA, McGill University*, Montréal, Canada

Study of γ-rays and Cherenkov radiation in superluminous supernovae and tidal disruption events with the NASA Fermi-LAT: Unbinned/binned likelihood analyses, upper limit analyses, extended source analyses.

Supervisor: Prof. Kenneth Ragan

2019 **Undergraduate Researcher**, *Vanier College*, Montréal, Canada

Numerically solved the quantum Hamilton-Jacobi equations of motion and generating trajectories for de Broglie-Bohm theory with recurrent neural networks and the Crank-Nicolson method.

Supervisor: Prof. Ivan Ivanov

Summer 2018 **Undergraduate Researcher**, *Concordia University*, Montréal, Canada

Study of topological confinement in a nanobeam microcavity. We characterized resonant modes of electromagnetic waves in nano-scale photonic crystal ring resonators with MIT Electromagnetic Equation Propagation.

Supervisor: Prof. Pablo Bianucci

Presentations

July 2023 **8th Interstellar Symposium**, *McGill University*, Montréal, Canada

Presented the effects of light interference and the dynamical Casimir effect in photon recycling via scalar quantum field theory.

May 2019 **Physics & AI Workshop**, *McGill University*, Montréal, Canada

Presented numerically computed quantum Hamilton-Jacobi trajectories for de Broglie–Bohm Theory using recurrent neural networks and the Crank-Nicolson method.

Educational Background

2019-2023 **B.Sc. in Honours Physics**, *McGill University*, Montréal, Canada. GPA: 3.84/4.0

2017-2019 **DEC. in Honours Pure & Applied Sciences**, *Vanier College*, Montréal, Canada. R Score: 33.4/50

Awards and Distinctions

May 2023 **NSERC USRA - Undergraduate Student Research Award**, *University of Alberta, Department of Physics.*

May 2022 **NSERC USRA - Undergraduate Student Research Award + FRQNT Supplement**, *McGill University, Department of Physics.*

May 2022 **SURE - Summer Undergraduate Research in Engineering Award (Declined)**, *McGill University, Department of Mechanical Engineering.*

May 2021 **BSA - Banner Student Award**, *McGill University Faculty of Medicine, Medical Physics Unit.*

May 2020 **SURA - Science Undergraduate Research Award**, *McGill University, Department of Physics.*

Personal Engagement

Sept 2022 **Group Study**, *Superstring Theory*, Took a course on superstring theory following modern research papers and textbooks by Kiritsis, & Polchinski.

May 2022 **Self Study**, *Quantum Field Theory*, Finished off the content of quantum field theory by going through the non-Abelian gauge theory section of Peskin's *Introduction to Quantum Field Theory* textbook: Part III.

Jan 2022 **Review Paper**, *Particle Physics*, Review of the observational constraints of dark matter candidates in cosmology and type IIB string theory.

Jan 2022 **Group Study**, *Gauge Theory*, Went through Baez's *Gauge Fields, Knots and Gravity* textbook, as well as Kibble's *Classification of Topological Defects and Their Relevance to Cosmology* paper: Part I-II & Chp 1-6, respectively.

Nov 2021 **Physics Hackathon**, *McGill University*, Montréal, Canada

Numerically reproduced the interference pattern in the double slit experiment with path integrals using the Metropolis-Hastings algorithm and Glauber dynamics for the Markov chain Monte Carlo method.

May 2021 **Self Study**, *Quantum Field Theory*, Went through Srednicki's *Quantum Field Theory* textbook, and Peskin's *Introduction to Quantum Field Theory* textbook: Sec 1-10 & Part I, respectively.

Feb 2020 **Self Study**, *Differential Geometry*, Went through Grinfeld's *Introduction to Tensor Analysis and the Calculus of Moving Surfaces* textbook, and Caroll's *Spacetime and Geometry: An Introduction to General Relativity* textbook: Chp 1-9 & Chp 1-5, respectively.