Ph.D. Candidate

Masooma Ali

Graduate Academic Unit

Physics

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August 29, 2019

1:00 p.m.

Forestry/Geology Bldg.
Room 202

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Examining Board:
Dr. Abdelhaq Hamza (Physics)
Dr. Ben Newling (Physics)
Dr. Edward Wilson-Ewing (Math & Stats)
Dr. Viqar Husain (Math & Stats) Supervisor

External Examiner:
Dr. Luca Bombelli
Dept. of Physics and Astronomy
University of Mississippi

The Oral Examination will be chaired by:
Dr. Drew Rendall, Dean of Graduate Studies

BIOGRAPHY

Universities attended (with dates & degrees obtained):

2014 – present	PhD candidate, University of New Brunswick
2009 – 2011	MSc in Astrophysics, University of Bonn, Germany
2006 – 2009	BSc (Hons) Physics, Delhi University, India

Publications:

Ali, M., Hassan, S. M., and Husain, V. (2018) Monte Carlo simulations of cosmologies with dust. arXiv: 1811.05047.

Ali, M., Hassan, S. M., and Husain, V. (2018) Universe as an oscillator. Physical Review D 98, 086002.

Ali, M., Seahra, S. S. (2017) Natural Inflation from Polymer Quantization. Physical Review D 96, 103524.

Ali, M., Husain, V. (2017) Mixmaster Dynamics in the dust time gauge. Physical Review D 96, 044032.

Ali, M., Husain, V., Rahmati, S., Ziprick, J. (2016) Linearized gravity with matter time. Classical and Quantum Gravity. 33, 105012.

Conference Presentations:

Bianchi IX Dynamics in Dust time. Oral presentation at CAP Congress (2018).

Bianchi IX Dynamics in Dust time. Oral presentation at Theory Canada 13 (2018).

The Universe as an Oscillator. Oral presentation at Atlantic General Relativity (2018).

Bianchi IX Dynamics in Dust Time, Poster presentation at Making Quantum Gravity Computable Workshop (2017).

Bianchi Ix Dynamics in Dust Time, Oral presentation at Atlantic General Relativity (2017).

Linearized gravity with matter time. Oral presentation at Canadian Conference on General Relativity and Relativistic Astrophysics (2016).

Linearized gravity with matter time. Oral presentation at Atlantic General Relativity (2016).

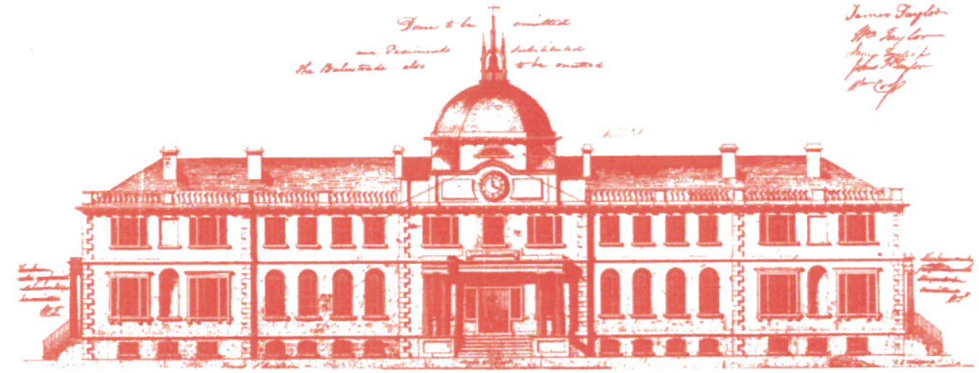
Forks on a Dusty Road

Abstract

This thesis explores the classical and quantum aspects of dust $+$ gravity systems with the dust field playing the role of time.

In the classical setting, we explored the linearized theory of dust $+$ GR around a Minkowski background. The resulting theory has three physical degrees of freedom at each spacetime point. At the linearized level, we recovered two graviton modes and an ultra-local scalar mode. Remarkably the graviton modes remain Lorentz covariant despite the time gauge fixing. The other classical models we studied were the homogeneous and anisotropic Bianchi I and IX spacetimes. The dust time gauge analysis of Bianchi IX spacetime gives a new physical picture where dust Bianchi IX dynamics is characterized by transitions between dust-Kasner solutions rather than vacuum-Kasner solutions. We derived a generalized transition law between these solutions which includes a matter component. Sufficiently close to the singularity this law reduces to the usual Belinski-Khalatnikov-Lifshitz map.

In the quantum setting we explored two homogeneous models with dust. We de-parameterized the theory using the dust time gauge before quantization. For homogeneous models this is the reduced phase space approach to quantization. The first model we studied was spatially flat Friedmann-Lemaitre-Robertson-Walker model with dust and a cosmological constant (Λ). We showed that after gauge fixing and a canonical transformation the model reduces to a simple harmonic oscillator with frequency $\sqrt{\Lambda}$. The (Lorentzian) quantum theory of this model is then immediate. The model provides a simple demonstration of non-perturbative singularity avoidance. The other model we investigated was the Bianchi I model with dust. We formulated the path integral for the model using the physical Hamiltonian obtained after gauge fixing the theory using dust as time. The quantum theory of this model is not solvable analytically. We studied the quantum dynamics using Markov Chain Monte Carlo techniques by considering the Euclidean path integral. Numerical semiclassical analysis shows that quantum fluctuations in the spatial volume and anisotropies are larger for smaller universes. We also evaluated the no-boundary wavefunction for this model. The no-boundary wavefunction implies a suppression of large universes while large anisotropies appear to dominate.



Home of the School of Graduate Studies, Sir Howard Douglas Hall was designed by J.E. Woolford in 1825 and is the oldest university building in Canada still in use.

The University of New Brunswick recognizes that the university sits on traditional Wolastoqey territory. The river that runs right by our university – the St. John River – is also known as Wolastoq, along which live the Wolastoqiyik -- the people of the beautiful and bountiful river.

University of New Brunswick
School of Graduate Studies

Oral Examination

Masooma Ali

In Partial Fulfilment of the Requirements for the Degree of

Doctor of Philosophy