Subhobrata Chatterjee

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Citizenship: India

Research interests

Quantization of manifolds/supermanifolds, supergeometry, Markov processes, discrete dynamics, geometric quantization, deformation quantization, quantum Darboux theorems

Education

2019 – Present **University of California** – Davis, United States
PhD in Physics
Advisor: Andrew Waldron.

2014 – 2019 **National Institute of Science Education and Research** – Jatni, India
Integrated Masters (BSc+MSc) in Physics
Advisor: Loganayagam R.

Honors and scholarships

2023 UC Davis Dean's Graduate Summer Fellowship

2022 UC Davis Physics Department Summer Fellowship

2019 Best master's thesis award (NISER, India)
Computed and characterized novel non-local divergences arising in renormalization of non-unitary open quantum field theories.

2018 S N Bhatt Fellow (International Center for Theoretical Sciences, Bengaluru)
Worked on triangle loops in open quantum field theory under the guidance of Dr. Loganayagam R.

2017 Indian Academy of Sciences Summer Student Research Fellow (Delhi University, India)
Worked on supersymmetric quantum mechanics under the guidance of Dr. Debajyoti Choudhury

2017 Finished in top 1% at the national level of National Graduate Physics Examination, India

2015 Represented India in the 9th Asian Science Camp, Thailand

2015 Awarded Certificate of Merit for outstanding academic performance in the first semester of undergrad at NISER

2014-2019 INSPIRE fellow throughout undergrad (NISER, India)

2014 Awarded gold medal for outstanding academic performance in grade 12

Current Research

Nov 2023 – Present **Quantization of Markov processes**

Mentor: Andrew Waldron (UC Davis).

In [CWY23], we showed that supergeometry could be used to describe dynamics of discrete probabilistic systems. As a toy model, we studied the system of two Grassmann variables and found that it resembles Markov chains and the probabilities rotate around some equilibrium state. This opens the door to a plethora of interesting questions including how classical probabilities/expectation values get generalized to quantum probabilities/expectation values. The solution to the Schrodinger equation is easy in this case but we want to understand how the measurement theories relate to each other viz. how geometric structures like star product, Clifford map, affine connection generalize to the quantum setting. We have some interesting ideas to explore like smearing out of quantum expectation values into classical expectation values. We wish to draw a precise connection between classical probability distributions and statistical ensembles. Another aspect we want to explore is the thermodynamic limit and how classical physics emerges out of a large quantum mechanical system. Ultimately, we would like to establish a supergeometric picture of quantum statistical mechanics.

June 2021 – Present

Quantization beyond formality

Mentor: Andrew Waldron (UC Davis).

Quantization is the data of a flat connection on a Hilbert/Weyl-algebra bundle over a manifold [Fed94]. In [CHW21], the authors showed that the three-dimensional round sphere could be quantized exactly. Not only that, the spectrum of the Hamiltonian exhibited a remarkable property: multiplet shortening! This boiled down to the fact that the three sphere is a Lie group; it admits global frames that close under commutators and forms a Lie algebra ($\mathfrak{su}(2)$). Quantizing exactly or proving existence of a flat connection on the Weyl algebra bundle over a manifold is a hard problem in deformation theory. Kontsevich showed that any Poisson manifold admits a formal qunatization [Kon03]. But the problem of exact quantization is still open. We approach this problem by trying to quantize a close cousin of the three-sphere, the seven sphere. The seven sphere is parallelizable, just like the three-sphere. The three-sphere is isomorphic to unit quaternions while the seven-sphere is isomorphic to unit octonions. We use the homogeneous model of the seven sphere corresponding to the action of the compact symplectic group $Sp(2, \mathbb{Q})$ to construct Maurer-Cartan coframes. We also find an embedding of the lie algebra $\mathfrak{sp}(2)$ into the Weyl algebra A_3 with three sets of Heisenberg generators. We are currently working on global questions related to the pulled back differential forms on the seven-sphere and also globality of classical limits.

Undergraduate Research

June 2018 – Aug 2019

Renormalization of open quantum field theories

Mentor: Loganayagam R (ICTS)

Non-unitary open quantum field theories seem to be plagued with novel non-local divergences that do not allow usual Wilsonian renormalization. The goal of this project was to compute and characterize all non-local divergences arising in open scalar field theories. We found interesting geometric interpretations of these divergences reminiscent of the amplitudehedron program. My thesis is here.

Teaching experience

Spring 2024	**Associate Instructor, PHY 9A: Introduction to Physics for physical science and engineering majors**
Summer 2022, Winter 2023, Spring 2023, Winter 2024	**Associate Instructor, PHY 7A,7C: Introduction to Physics for bio majors**
Spring 2022	**Teaching assistant, PHY 110B: Electricity and Magnetism**
Winter 2022	**Teaching assistant, PHY 104B: Computational Methods in Physics**
Winter 2022	**Teaching assistant, PHY 155: General Relativity (undergrad)**
Fall 2021	**Teaching assistant, PHY 260: Introduction to General Relativity (grad)**
Spring 2021	**Teaching assistant, PHY 115A: Foundations of Quantum Mechanics**
Winter 2020, Spring 2020, Summer 2020, Fall 2020, 2022	**Teaching assistant, PHY 7A: Introduction to Physics for bio majors**
Fall 2019, Winter 2021, Summer 2021	**Teaching assistant, PHY 7B: Introduction to Physics for bio majors**

Talks and Seminars

Feb 20, 2024 — **Probabilities and Supergeometry: Measurement theory for dynamical discrete systems** UC Berkeley Representation theory and tensor categories seminar Slides are here.

Jan 22, 2024 — **Probabilities and Supergeometry: Measurement theory for dynamical discrete systems** UC Davis Mathematical physics seminar

Dec 4, 2023 — **Supergeometry and Discrete-state dynamics** UC Davis graduate student colloquium

May 22, 2023 — **Supergeometry and Measurement theory of Discrete Dynamics** poster presentation at Geometry & Physics (GAP) 2023 on "Homotopy Algebars and Higher Structures" at IHP, Paris

Jan 11, 2023 — **Quantization and Geometry** at the Student-Run Research Seminar at the math department, UC Davis

2021-2022 — Internal research group seminars on Fedosov quantization, classical BRST, Sasakian geometry, Batchelor's theorem

Preprints and Publications

Nov 9, 2023 — **Discrete dynamics and supergeometry** with Andrew Waldron and Cem Yetismisoglu, arXiv:2311.05711

Mentorship

Oct 2021 – Feb 2022 — **Directed Reading Program (DRP) Mentor**
Guided an undergraduate student in a reading project on differential geometry

References

Andrew Waldron
Professor of Mathematics
University of California, Davis
Email: wally@math.ucdavis.edu

Roger Casals
Associate Professor of Mathematics
University of California, Davis
Email: casals@math.ucdavis.edu

Bibliography

[CHW21] Roger Casals, Gabriel Herczeg, and Andrew Waldron. Dynamical Quantization of Contact Structures. 3 2021.

[CWY23] Subhobrata Chatterjee, Andrew Waldron, and Cem Yetişmişoğlu. Discrete Dynamics and Supergeometry. 11 2023.

[Fed94] Boris V. Fedosov. A simple geometrical construction of deformation quantization. *Journal of Differential Geometry*, 40(2):213 – 238, 1994.

[Kon03] Maxim Kontsevich. Deformation quantization of Poisson manifolds. 1. *Lett. Math. Phys.*, 66:157–216, 2003.