CV of **Pritam Sarkar**

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PERSONAL PROFILE

How do I know there's anything there except what I'm conscious of? - N. Chomsky

A gritty, curious, independent and resourceful mind, constantly generalizing 'its and bits' of the perceived world. Courage to explore something on my own, allowed me to spontaneously swim against the current at all odds, and still question the very unconventional but significant aspects of the world around me. Equipped and motivated to explore the universal aspects of many-bodies, I aim to develop the theoretical foundation behind the emergence of the irreducible *more* from the simple *ones*, because the interplay of perception, nature and mathematical structures - not only intrigues, but also bothers me the most.

EDUCATION

Secondary 2011-2017

Jadavpur Vidyapith, Kolkata Percentage: 96

Higher Secondary 2017-2019

Jadavpur Vidyapith, Kolkata Percentage: 84.4

Integrated BS-MS with Physics Major 2019 - 2024

Indian Association for the Cultivation of Science, Kolkata CGPA: 7.6

RELEVANT MODULES

- Intermediate Statistical Mechanics
- Advanced Quantum Mechanics (I + II)
- Advanced Statistical Mechanics
- Quantum Field Theory (I + II)
- Condensed Matter Theory
- Statistical Field Theory
- Differential Geometry
- Operator Theory
- Physics of Black Holes and Gravitational Waves
- Data Structures and Algorithms
- Advanced Machine Learning

RESEARCH

Paper | *Susceptibility of entanglement entropy: An universal indicator of quantum criticality* Sep 2024
Author(s) | *Pritam Sarkar* arXiv: 2412.02236

An universal model-agnostic formalism to compute how sensitive the entanglement entropy is accross the parameter space of a many-body quantum system, is proposed and its finite-size scaling behaviors are demonstrated numerically to find interesting power-laws which have been analytically explained with an elegant concoction of special functions to reveal the geometric structure behind a quantum dynamics; opening a window of greater discoveries for Quantum Information and controlling Quantum Technologies.

CONFERENCE

Best Poster Award | *Wiley CMMSSP-24* Aug 2024
Work presented: | *Susceptibility of Entanglement Entropy : a universal indicator of quantum criticality [doc, certificate]*

Undergraduate Physics Symposium | *Presision Presidency Physics Summit* Apr 2024
Work presented: | *Information and Geometry in a Quantum Phase Transition [doc, certificate]*

ACADEMIC BACKGROUND

Perfect Score | *Advanced Statistical Mechanics Course* Dec 2022

- Non-Equilibrium Physics, Transport processes, Landau-Ginzburg theory, Renormalization Group and Scaling laws.
- Achieved a perfect score and received personal commendation of 'absolutely outstanding' performance in the final exam by Prof. Jayanta K. Bhattacharjee.

Perfect Score | *Differential Geometry* Dec 2023

- Topological Foundations of Differential Geometry, adapting with the language of proofs and constructions.
- While preparing for a talk on *De-Rham Cohomology* I learnt the language of categorical techniques like *Exact Sequences*, *Mayer-Vietoris Sequence*, Homology, and *de-Rham Theorem*.
- I can separetely appreciate the language of Physics and Mathematics, and the point where they coalesce into one.

Master's Research Work I | *First Order Quantum Field Theories* Aug 2022 - July 2023

- Demonstrated equivalence between Second order and First order field theories at the classical level,
- Quantized First Order Field Theories to find simpler vertices (particularly for momentum dependent interactions) but twice many propagators and proved different contributions but Exact equivalence of On-Shell Amplitudes between Second order and First order Quantum Field Theories.
- Renormalized First Order Scalar Electrodynamics using Dimensional Regularization to find similar RG-Group Beta Function and Phase Diagram in 4D.
- Proved Ward Identities in First Order Formalism ensuring Gauge Invariance of the UV-Complete theory.

Master's Research Work II | *Adiabatic Gauge Potential and Signatures of Quantum Criticality* Aug 2023 - Aug 2024

- Reinterpreting Adiabatic Gauge Potentials as *generators of translation in the parameter space of a quantum many-body system*.
- Its relation to Information Geometry of the spectrum, and their Divergent Behaviour near the critical point - to study Quantum Information using both Condensed Matter Theory and Riemannian Geometry that generalizes Fisher Information, studied conventionally.
- Learnt to develop novel (Counter-Diabatic/Transitionless) driving protocols of systems with arbitrary time-dependence, while revealing deeper geometric structure of a quantum dynamics.

Contribution in *elphbolt*: A Scienific Computation Software, developing in HU Berlin | *solved an issue* Oct 2024

- Learnt the fundamentals of *modern Fortran*, *parallel computation* and *git*.
- Learnt the basics of *ab-initio computation of spectral properties of materials*.
- Pulled a request to solve an issue and enhance a feature, which was approved and merged by the author.

Term Project | *Geometric Phase in Quantum Theory* Jun-Aug 2021

- Path Independent Geometric Phases like Berry, Pancharatnam, Aharanov-Bohm Phases and its interpretation as holonomy of parallel transport on $U(1)$ bundle over the parameter space of a Quantum System. link

Interest | *Spin System evolution using Monte-Carlo Algorithm* May 2022

- From a few mentions in Statistical Physics course I learned the perspectives of Monte-Carlo like Random-Sampling Algorithms, also how they are useful for numerical studies of systems with high degrees of freedom. link

Term Project | *Information Geometry of Spin Systems* Jul 2022

- Information Geometric characterisation of Phase Transition in Classical Ising model. link

Project on Deep Neural Network | *Optimal Geometry of Latent Variable Models* Sep 2023 - present

- Address the Identifiability/Mode-Collapse problem in the latent space of generative deep neural networks by pulling back distinguishability metric from the observation space to the latent space
- Information Geometry of Gaussian Process Latent Variable Models (GPLVM) and its relation to accurate interpolation and latent space clustering, that most optimally follows the support of the data.

INDUSTRIAL EXPERIENCE

Internship on Data Science, NLP and Automation | *Aten Ventures - Certificate* Jan - Aug 2023

- Developed and co-implemented an automated pipeline (EngageX) for corporate outreach via Twitter using personalized responses to dynamically selected posts, containing similar intentions of an user.
- Automating large database query through text to SQL and AWS Athena.
- Experimented on the automating text-based research on complex and interrelated topics using Langchain.

RESEARCH INTERESTS:

With respect to what I truly appreciate, my broad research interests include the following areas

Universal and geometric aspects of dynamical systems | *Developing a renormalization framework to demonstrate the spontaneous emergence of scale-invariance in dynamical systems.*

- How do certain Universal Behaviours emerge in classes of Dynamical Systems functioning near a Critical Point, and how to mathematically categorize and systematically study their universal behaviours?

Quantum Critical Phenomenon | *Mathematical analysis of critical phenomena in complex quantum systems*

- Deeper understanding of quantum phase transitions and critical behaviours through the information-geometric structure of the parameter space, in pursuit of the elegance of exact mathematics behind complex systems.

Topological Quantum Computation and Study of Anyons: | *Kitaev's models and emergence of quasiparticle* :

- Introduced from a course on Statistical Field Theory - Kitaev's Toric Code and Hexagonal Lattice Model, I've learnt and reproduced the calculations of the models from the Kitaev's paper.
- Got very surprised to know - that a system with anyons is a quantum computer, also wish to study further about Fusion Braid groups, and categorical formalisms therein.

Phase Transition and Scaling Laws Complex Networks: | *Abrupt changes in Macroscopic Stochastic Systems and Universal Behaviours therein*

- Inspired by various Stat. Mech contexts, as well as scalefree network of wide sorts - I would delve into extensive study of Ising-like systems but generalised for a class of different Graphs with different internal degrees, and study their peculiar behaviours

Self-Organised Criticality | *A systematics to Mathematically address Spontaneous Emergence of Scalefree Correlations in a Many-Body System:*

- Study of Systems exhibiting Scalefree distributions of its attributes without external tuning - is capable to explain strongly-correlated Emergent Structure-Formation, and ubiquitous Scaling-Laws in Nature.

Quantitative Analysis of Causation in Complex Systems using Information Geometry | *A systematics towards 'More is Different':*

- How to formalize such Emergent Irreducible Degrees of freedom in a Complex System? And study how they are interdependent within a Stochastic Environment - to formalize Anderson's 'More is Different', more systematically.

PROGRAMMING LANGUAGES AND FRAMEWORKS KNOWN:

• C • C++ • Fortran • Python • Arduino • Java • JavaScript || • Tensorflow • PyTorch • LangChain • SciPy • GeomStats

ORGANISATIONAL ACTIVITIES:

Cogito | *An Academic student-body to systematically indulge in Cognitive Science* Co-Founded

- Regularized discussion sessions on aspects at the intersection of Cognition, Philosophy and Fundamental Science, and to develop clearer perspectives about aspects of Cognition, ranging from Nature, Logic to General Perception, while documenting them coherently in a Journal Cogito

Détournement | *Literature and Philosophy Society at IACS* Co-founded

- Organised several discussion sessions on various intriguing issues around Literary perspectives, Philosophy and Modern Society, with aim towards integrity within the critical minds in my institution.

PSFI: Progressive Student Federation of India | *A Political body Towards a Scientifically Progressive Solidarity* Member

- Established strong communication between varying sociocultural perspectives among critical young minds through Public Awareness Campaigns and also collaborating with other aligned bodies.
- Established the magazine **Renegade**, and have regularly contributed therein, with dedication to the cause.

EXTRA CURRICULAR ACTIVITIES:

UNICEF and Learning Links Foundation | *Winner of SafeThon in Digital Safety Carnival* Dec 2017

- Workshop and Competition On Digital Safety and Competition on innovative solutions towards more secure virtual existence

Kolkata District Student Youth Science Fair | *1st Runner Up* Sep 2018

- IoT based affordable, Simple and compact Automation Project for all Modern-day Electric appliances

Debates and Extempores: | *Prolonged track of participating in Public discourses*

- Consistently participated in various Debate and Extempore competitions from High-School days, nurturing my ability to convince others with reason.

NASA-Artemis Student Challenge Program | *A Workshop-Project on programmable satellites for monitoring simple Lunar information*

- Mentored a team of High-School students in a long-term workshop GLEE (Great Lunar Expedition for Everyone) organised by NASA-Artemis Student Challenge Program

Music | *Started late but learnt Piano and I love to improvise on pieces*
Sports | *Badminton, Chess & Football*

DRIVING SKILLS:

Generalizability: | *A Spontaneous Drive to Bind Distant Dots*

- The pleasure of putting together a collection of distant ideas on the basis of similar principles and some imaginative frameworks, drives my urge of delving deeper into various broad and intricate aspects.

Perseverence: | *A Pursuer and not a mere Explorer*

- Following the most effective paths persistently to achieve the goals of my interests, has developed confidence over my efforts.

Autodidact: | *Once the mind is set, I believe anything remains finite steps away from understanding*

- I taught myself all the things that I find most interesting, and still in the constant process of updating the ideas every moment.

Organisability: | *To appreciate concentrated collective efforts for common causes*

- Always enjoyed the process of learning through organised discussions over various matters, and in executing collective efforts for suitable causes, be that a large scale protest or establishing a common demand in any other way.