Shihabul Haque

Integrated BS MS in Physics (2020-2025), Indian Association for the Cultivation of Science (IACS), Kolkata, India
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RESEARCH INTERESTS

I am broadly interested in **theoretical high energy physics**, specifically ***quantum field theory***, ***elementary particle physics*** and ***cosmology***. I am interested in areas of BSM phenomenology and theories - specific topics include ***ALPs***, ***Higgs sector***, ***electroweak symmetry breaking***, ***neutrinos***. My current background includes hands-on experience in some areas of astroparticle and BSM physics. In the future, I would like to get into more fundamental aspects of the field while continuing to study phenomenological models and their consequences with an emphasis on model-building.

EDUCATION

1. Indian Association for the Cultivation of Science, Kolkata, India — October 2020 – August 2025
Integrated Bachelor's - Master's in Physics — **CGPA: 9.57/10.00** (as of semester 8)

Relevant coursework: Classical and Quantum Mechanics, Statistical Mechanics, Quantum field theory, Statistical field theory, General Relativity.

2. South Point High School, Kolkata, India — April 2018 – March 2020
CBSE XII — **Final percentage: 95%** (98 in physics, 97 in maths)

3. South Point High School, Kolkata, India — April 2016 – March 2018
CBSE X — **Final percentage: 96.6%** (96 in science, 95 in maths)

SKILLS

• **Programming languages:** Julia (advanced), Python (basic), C/C++ (basic) • **Software:** LaTeX, Mathematica

PREVIOUS EXPERIENCE

Axion/photon mixing and related phenomena in astrophysical scenarios — **August 2023 – Present**
School of Physical Sciences, Indian Association for the Cultivation of Science — 2 years BS - MS project
Supervisor: *Sourov Roy, Senior Professor*

- I started on my BS MS project in August 2023 by exploring existing literature in the context of axion/photon oscillations. I focused on the astrophysical consequences of ALP/photon oscillations, specifically targeting polarisation-based studies. Following this, I extended ideas from ALP/photon mixing to graviton/photon mixing scenarios and explored ways to apply the theoretical/computational results to actual observations. Currently, I am working on the link between axions and Randall - Sundrum (RS) models of spacetime. My first semester report can be found here (link to Google drive).

Collider and GW signals of electroweak phase transition in the THDM — **July 2024 – August 2024**
Department of Physics, Osaka University, Japan — International Summer Program 2024
Supervisor: *Shinya Kanemura, Senior Professor*

- As an ISP 2024 student at Osaka University, I explored the Higgs sector in SM and BSM scenarios. Specifically, I looked into the two Higgs doublet model (THDM) and the baryon asymmetry issue. I looked into how finite temperature effects in field theory, in the context of the THDM, can be employed to explain the problem through a strong 1st order phase transition. I also considered two approaches to probing such models - loop corrections to the Higgs self-coupling using effective potentials that can be observed in colliders and detecting GWs generated due to bubble collisions during the electroweak phase transition. A report summarising the main aspects of the project can be found here.

Nonlinear oscillations and resonant behaviour in such systems — **December 2021 – January 2024**
School of Physical Sciences, Indian Association for the Cultivation of Science — Long term project
Supervisor: *Jayanta K. Bhattacharjee, Emeritus Professor*

- Under Prof. Jayanta Bhattacharjee (now at IIT, Kanpur), I learnt about different approximating techniques, perturbative techniques, diverging quantities and applied these ideas to physical systems. For my first major project, I worked on parametric resonances in a double spring pendulum, leading to some interesting and new results. I presented our work at **NODYCON, 2023**, in Rome (I personally presented online). Specifically, we derived multiple parametric resonance conditions for the system and looked into its numerical solutions.

- I also worked on the resonant forced oscillator, specifically in the context of its finite response. For smaller drives, we characterised two drive-dependent scaling laws and showed that the finiteness of the resonant response can be attributed to a destructive interference like effect. At larger drive values, we numerically showed that the oscillator undergoes a first-order transition. This work was published in a peer reviewed journal (linked below).

Weak measurements in simple quantum mechanical systems **June 2023 – July 2023**
Department of Physics, Chennai Mathematical Institute, Chennai, India Summer project
Supervisor: *H. S. Mani, Adjunct Professor*

- As a summer student at CMI, I looked at projective measurements, weak values and how our understanding evolved over time, initially working on a simple example - a spin 1 system. I explored the relation between weak measurements and interference, replicating the results in *Sokolovski et. al. (2018)* in general settings and explicitly calculating weak values in a few simple quantum systems. A brief report on some parts of the project can be accessed here.

Basic overview of the Dirac equation and related ideas **May 2022 – August 2022**
Department of Physics, Rajabazar Science College, Kolkata, India Summer project
Supervisor: *Amitava Raychaudhuri, Professor Emeritus*

- A brief summer project in which I learnt a bit about neutrinos starting from the covariant formulation of the Dirac equation and looking into SU(2), spinors and their transformation properties, and neutrino mass models.

PRESENTATIONS, PUBLICATIONS & PREPRINTS

Presentations:

- **Haque, S.**, Sasmal, N. & Bhattacharjee, J. K. (2023).“*An extensible double pendulum and multiple parametric resonances.*” NODYCON 2023, Rome (abstract available here)
- “*Testing the electroweak phase transition with future collider experiments and gravitational wave observations.*” Final presentation, ISP 2024, Osaka University (non-technical due to audience background; slides available here)

Publications/Preprints:

- **Haque, S.**, & Bhattacharjee, J. K. (2024). “Interference aided finite resonant response in an undamped forced oscillator”. *J. Phys. A: Math. Theor.* **57** 325701 (10.1088/1751-8121/ad6412)
- **Haque, S.**, Sasmal, N. & Bhattacharjee, J. K. (2024). “An extensible double pendulum and multiple parametric resonances.”, *Advances in Nonlinear Dynamics*, Volume I, ICNDA 2023, NODYCON Conference Proceedings Series, Springer, Cham. (10.1007/978-3-031-50631-4_12) (accepted after peer-review)

AWARDS

Scholarship for Super Short Term Study, Osaka University July 2024 – August 2024
I was nominated for and selected as a recipient of the *Scholarship for Super Short Term Study* at the Graduate School of Science, Osaka University, which supported my stay in Japan for the duration of the ISP, 2024.

KVPY 2019 (SX) Fellow 2020 – 2025
I am funded by the KVPY fellowship provided by the DST, Government of India, for selected students pursuing basic sciences.

OTHER RELEVANT EXPERIENCES

- Completed an astronomy course organized by the **Breakthrough Science Society, Kerala Chapter**.
- Zonal Toppers (Kolkata), **Mimamsa 2022**, a national level open book team-based science competition.

EXTRACURRICULAR EXPERIENCES

- Ranked 6^{th} in the Young Ruskin Bond competition (2019), a national level short story competition.
- Took part in public speaking and quizzing during school years along with karate and yoga. Won the gold medal in the Don Bosco Jubilee Quiz (2015). Further represented school in the Bournvita Quiz (2015). Also, a member of the activity club, learning the violin for nearly a decade.