Joy Das Bairagya, PhD

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Personal Information

Office Address: Department of Physics, Indian Institute of Technology Kanpur,
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Nationality: Indian, **Sex:** Male, **Date of birth:** 30/03/1997, **Marital status:** Single

Language: English (Read, Write, Speak), Bengali (Read, Write, Speak), Hindi (Speak)

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About Me: I am a physicist working at the interface of **physics**, **animal behavior and game theory**. My research combines **behavioral experiments** on tandem-running ants *(Diacamma indicum)*, **agent-based simulations**, and **mathematical modelling** to understand how decentralized biological systems make **collective decisions** under congestion, uncertainty, and strategic conflict. I study how **bounded (procedural) rationality** and **eco-evolutionary feedback** give rise to **cooperation**, **coordination**, and efficient transport in both animal societies and human social systems. My interdisciplinary approach enables me to address challenges across **physics**, **biology**, **ecology**, and **socio-economic systems**.

Publications

1. **J. D. Bairagya,** U. Chakraborty, S. Annagiri, S. Chakraborty, "Braess's paradox in tandem-running ants: When shortest path is not the quickest". (arXiv:2603.26226)
2. **J. D. Bairagya**, J. Newton, S. Chakraborty, "Collaboration drives phase transitions towards cooperation in prisoner's dilemma". (Under review at J. R. Soc. Interface)
3. **J. D. Bairagya**, U. Chakraborty, S. Annagiri, S. Chakraborty, "Game played by tandem-running ants: Hint of procedural rationality", Physical Review E (2026). (Selected for APS outreach to the press)
4. Manish K. Pathak, **J. D. Bairagya**, S. Chakraborty, S. Annagiri, "Traffic jams and its resolution through adaptive decisions in tandem-running ants''. (bioaRxived:2023.09.13.557316)
5. A. Patra, **J. D. Bairagya***, S. Chakraborty, "Bayesian eco-evolutionary game dynamics", Physical Review E 111 (4), 044401 (2025). (* Corresponding author)
6. **J. D. Bairagya**, S. Chakraborty, "Catalyzing coordination in stag-hunt game: Emergence of evolutionary stable procedural rationality'', Journal of Physics: Complexity 6 (3), 035004 (2025).
7. **J. D. Bairagya**, S. Chakraborty, "Hostility prevents the tragedy of the commons in metapopulation with asymmetric migration: A lesson from queenless ants", Physical Review E 108 (6), 064401 (2023).
8. **J. D. Bairagya,** S. S. Mondal, D. Chowdhury, S. Chakraborty, "Eco-evolutionary games for harvesting self-renewing common resource: effect of growing harvester population", Journal of Physics: Complexity 4 (2), 025002 (2023).

9. **J. D. Bairagya,** S. S. Mondal, D. Chowdhury, S. Chakraborty, "Game-environment feedback dynamics in growing population: Effect of finite carrying capacity", Physical Review E 104 (4), 044407 (2021).
10. **J. D. Bairagya,** K. Pal, K. Pal, T. Sarkar, "Geometry of AdS black hole thermodynamics in extended phase space", Physics Letters B 819, 136424 (2021).
11. **J. D. Bairagya,** K. Pal, K. Pal, T. Sarkar, "The geometry of RN-AdS fluids", Physics Letters B 805, 135416 (2020).

Research Interest

- **Collective Behaviour & Self-Organization** in decentralized biological systems
- **Conducting experiments** in biological system to understand **collective decision-making**
- Developing **statistical, mathematical and Agent-Based models** grounded in empirical observations
- Understanding the **emergence of social and anti-social behaviour** using the framework of **evolutionary game theory**
- Exploring the **complex systems** in biological and social contexts, using tools from **nonlinear dynamics**, **nonequilibrium statistical physics**, **network theory** and **game theory**.

Research Skills

- Experienced in designing and executing **behavioral experiments, particularly with ants**.
- Experienced in handling and interpreting a broad spectrum of data set by using different **statistical methods (Hypothesis testing, parameter estimation and statistical inferencing).**
- Experienced in building and analyzing a mathematical model to **comprehend empirical observations** using **non-linear dynamics, non-equilibrium statistical physics and game theory**.
- Experienced in building **agent-based model** and **stochastic simulation** to comprehend empirical observations.
- Experienced in building theoretical models to analyze a range of **evolutionary questions**.
- Programming Language: Python, Mathematica, Linux
- Technical Software: Origin, LaTex, Inkscape
- Agent-based model: Python

Education

- **Fellowship for Academic and Research Excellence**, Indian Institute of Technology Kanpur (ongoing), Joining Date: 01/12/2025
- **Ph. D in Physics**, Indian Institute of Technology Kanpur (2026)
- Thesis defense date: 22/04/2026
  Thesis title: "Conflict and cooperation among queenless ants: A game dynamical view"
  Thesis Supervisor: Prof. Sagar Chakraborty
- **M. Sc in Physics**, Indian Institute of Technology Kanpur (2020)
- **B. Sc in Physics**, Burdwan Raj College, University of Burdwan (2017)

Grants and Fellowships

I. Fellowship for Academic and Research Excellence, Indian Institute of Technology Kanpur (2025 - Ongoing)

II. Prime Minister's Research Fellowship and Grants (2021-2025)

III. Institute Research Fellowship of IIT Kanpur (2020-2021)

IV. Department of Science & Technology, Innovation in Science Pursuit for Inspired Research (INSPIRE) (2014-2017)

V. Swami Vivekananda Merit-cum-Means Scholarship (2012, 2014)

Academic Achievements

Secured top ranks in national entrance examinations:

I. TIFR GS-2018 (AIR-13)
II. JEST-2018 (AIR-96), JEST-2020 (AIR-157)
III. JAM-2018 (AIR-48)
IV. NET-2019 (AIR-47, LS)
V. GATE-2020 (AIR-1610)

Teaching Experiences

As a **Prime Minister's Research Fellow (PMRF),** I am required to complete **50 hours of teaching** per year outside my home institute. To fulfill this obligation, I have served as an **instructor** for the following course:

I. Introduction to equilibrium concepts of game theory (at Institute of Smart Structures and Systems)
II. Solving textbook problem of Quantum Mechanics (Online)
III. Short introduction to Statistical Hypothesis Testing (at Institute of Smart Structures and Systems)
IV. Mathematical introduction to Chaos and Fractals (at Institute of Smart Structures and Systems)
V. Introduction to LaTex (Department of Information Technology, Chhatrapati Shahu Ji Maharaj University, Kanpur)
VI. Evolutionary Game Theory (at Institute of Smart Structures and Systems)
VII. Equilibrium concepts in game theory (at Institute of Smart Structures and Systems)

In addition to role as an instructor, I have also worked as a teaching assistant for the following courses

I. Statistical Mechanics [Instructor: Prof. Sagar Chakraborty, IIT Kanpur]
II. Non-equilibrium Statistical Mechanics [Instructor: Debashish Chowdhury, IIT Kanpur]
III. Statistical Mechanics [Instructor: Prof. Girish S. Setlur, NPTEL]
IV. Probability and Statistics [Instructor: Prof. Andrew Thangaraj, NPTEL]

Talks and Conferences

I. Presented "Collaboration drives phase transitions towards cooperation in prisoner's dilemma" at International conference on Complex dynamical systems and applications **CDSA 2026, Gandhinagar, Gujrat, India** (January 2026)
II. Presented "A game played by tandem-running ants: Hint of procedural rationality" at XXXVIII International Ethological congress **Behaviour 2025**, **in Kolkata, India** (August 2025)
III. Presented "Catalysing coordination in stag-hunt game: Emergence of evolutionary stable procedural rationality'' at Decision, Games, and Evolution at **ICTS Bangaluru, India** (March 2025)
IV. Presented "Hostility prevents the tragedy of the commons in metapopulation with asym-metric migration: A lesson from queenless ants" at **Statphys28, University of Tokyo, Japan** (August 2023).

V. Presented at Conference on Nonlinear Systems and Dynamics, **IISER Pune, India** (December 2022).
VI. Participated in **Bangalore School on Statistical Physics XII** (June - July 2021).

Academic Referees

Referee (Thesis supervisor):

Name: Prof. Sagar Chakraborty

Designation: Professor

Department: Department of Physics

Institute: Indian Institute of Technology Kanpur (IIT Kanpur)

Country: India

Mail: sagarc@iitk.ac.in

Referee:

Name: Prof. Debashish Chowdhury

Designation: Professor

Department: Department of Physics

Institute: DIT University, Dehradun

Country: India

Mail: debchg@gmail.com

Referee:

Name: Prof. Sumana Annagiri

Designation: Professor

Department: Department of Biological Sciences

Institute: Indian Institute of Science Education and Research Kolkata (IISER Kolkata)

Country: India

Mail: sumana@iiserkol.ac.in