Sandeep Joy

Contact Information

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Employment

National High Magnetic Field Laboratory & **Florida State University**, Tallahassee, FL, USA

September 2024 - present — *Quantum Initiative Postdoctoral Fellow*
Supervisor: Cyprian Lewandowski

Education

The Ohio State University, Columbus, OH, USA

August 2019 - September 2024 — Ph.D. in Physics
Advisor: Brian Skinner

Indian Institute of Science Education and Research, Pune (IISER Pune), India

August 2014 - May 2019 — Integrated BS-MS *with Distinction* (Major - Physics)

Research Interests

Theoretical modeling of correlated quantum materials motivated by experimental observations; focusing on emergent quantum phases and phase transitions driven by Coulomb interaction, chirality, quantum geometry, and disorder.

Computational Skills

- **Computational Languages & software stacks**
  Python, Mathematica, Matlab, Qiskit and LaTeX
- **Numerical Skills**
  Transfer Matrix Methods, Exact Diagonalization, Variational wave functional methods, Numerically solving ODE's, Dynamical Mean Field Theory, Phenomenological modeling, Machine Learning

Publications

- **Theoretical Works**

1. Sandeep Joy, Leonid Levitov, Brian Skinner, Chiral Wigner crystal phases induced by Berry curvature, arXiv:2507.22121 (2025), (accepted in Phys. Rev. Lett.)
2. Sandeep Joy, Brian Skinner, Disorder-induced liquid-solid phase coexistence in 2D electron systems, arXiv:2502.11235, (under review in Phys. Rev. B (Letter))
3. Sandeep Joy, Brian Skinner, Wigner crystallization in Bernal bilayer graphene, arXiv:2310.07751
4. Sandeep Joy, Brian Skinner, Upper bound on the window of density occupied by microemulsion phases in two-dimensional electron systems, Phys. Rev. B (Letter) 108 (2023)
5. Sandeep Joy, and Brian Skinner, Wigner crystallization at large fine structure constant, Phys. Rev. B (Letter) 106 (2022)
6. Sandeep Joy, Saad Khalid, and Brian Skinner, Transparent mirror effect in twist-angle-disordered bilayer graphene, Phys. Rev. Research 2 (2020)

- **Joint Theory–Experiment Works**

1. Zhenqi Hua†, Chang Niu†, Sandeep Joy†, Pukun Tan, Gang Shi, Haoyang Liu, Jiaxing Guo, David Graf, Peide Ye, Cyprian Lewandowski, Peng Xiong, Interplay of orbital and spin magnetization in trigonal tellurium, arXiv:2507.14292(2025) (†Z.H., C.N., and S.J. contributed equally to this work, under review in Nature Communications)
2. Fangyuan Yang, Ruiheng Bai, Alexander A. Zibrov, Sandeep Joy, Takashi Taniguchi, Kenji Watanabe, Brian Skinner, Mark O. Goerbig, Andrea F. Young, Cascade of multi-electron bubble phases in monolayer graphene at high Landau level filling, Phys. Rev. Lett. 131 (2023) (*Editors' Suggestion*)

- **Commentaries/Reviews**

1. Watching electronic ice melt, Science 388 (2025) (**Perspective**) (commentary on Z. Xiang et al., Science 388 (2025).)

Selected Professional Service

- Journal Referee Services: Reviewer for *Science, Physical Review Letters, Physical Review B, Newton (Cell Press) and Phase Transitions*
- Reviewer for *French National Research Agency (ANR) grant proposal*
- Sorter for Division of Condensed Matter Physics sessions on *APS Global physics summit 2026*
- Session Chair, *APS Global physics summit 2026*

Licenses & certifications

1. Erdős Institute Summer 2025 Quantum Computing Bootcamp

Selected Awards and Fellowships

- Quantum Initiative Travel Award to attend the Boulder School 2025: Dynamics of Strongly Correlated Electrons, Florida State University, 2025
- Quantum Initiative Postdoctoral Fellowship, Florida State University/National High Magnetic Field Laboratory, 2024 - present
- Edward J. Ray Travel Award for Scholarship and Service, The Ohio State University, 2021
- German Academic Exchange - Working Internship in Science and Engineering (DAAD-WISE) Fellowship, 2017
- Indian Academy of Sciences Summer Research Fellowship, 2016
- KVPY Fellowship, Department of Science and Technology, Government of India, August 2015 - July 2019
- INSPIRE Fellowship, Department of Science and Technology, Government of India, August 2014 - July 2019

Outreach Activities

- Co-organizer, *FSU Quantum Discovery Day 2025*
- *Chief* quantum ambassador, FSU Quantum Initiative, 2025 - present
- Organizer and founder of biweekly *Quantum Matter Journal Club*, Condensed Matter Science Division, National High Magnetic Field Laboratory, 2025 - present
- Judge at Capital Regional Science and Engineering Fair, Tallahassee, Florida for middle school students, 2025
- Volunteer, MagLab (National High Magnetic Field Laboratory) representative at local school STEM events, 2024–present
- Trained tour guide at the MagLab (National High Magnetic Field Laboratory), 2024 - present
- Founding member and treasurer of graduate student organization "Random Interactions," 2022-2024
  Aims to foster engagement and collaboration among undergraduate students, graduate students, postdocs, and faculty working in condensed matter physics.
- Judge at State Science Day for high school and middle school students at Ohio Science Academy, 2021-2024.
- OSU Polaris Mentorship Programme 2021-2022
  Mentored an underrepresented minority undergraduate student on a research project for two semesters.
- Elected Graduate Studies Committee student representative, Physics Department, 2021 - 2022

Mentoring Experience

- Graduate Students: Joshua Scales (OSU), Reilly McDowell (OSU), Mohammed Hammam (FSU/MagLab)
- Undergraduate Students: Reese Boucher (West Virginia University, OSU CEM REU Program, 2020), Ramon Morales III (FSU UROP program 2025)
- High school students: Kai Okui (MagLab High School Externship)

Invited Talks

The story of Wigner crystallization in Bernal bilayer graphene

- Condensed Matter Sciences Seminars, National High Magnetic Field Laboratory, 2024

Transparent mirror effect in twist-angle-disordered bilayer graphene

- Indian Institute of Science Education and Research, Pune, India, 2020

Contributed Talks

Disorder is both friend and foe to melting of Wigner-Mott insulators

- APS March Meeting, American Physical Society, 2026

Disorder-induced liquid-solid phase coexistence in 2D electron systems

- APS March Meeting, American Physical Society, 2025

How prominent are microemulsion phases in 2D electron systems?

- APS March Meeting, American Physical Society, 2024

Wigner crystallization in Bernal bilayer graphene

- APS March Meeting, American Physical Society, 2023

Wigner crystallization at large fine structure constant

- APS March Meeting, American Physical Society, 2022

Transparent mirror effect in twist-angle-disordered bilayer graphene

- International Conference on Low Energy Electrodynamics in Solids (LEES), 2021
- Hayes Graduate Research Forum, The Ohio State University, 2021
- APS March Meeting, American Physical Society, 2021

Poster Presentations

The nature of the quantum liquid-solid transition for 2D electrons

- Boulder School 2025: Dynamics of Strongly Correlated Electrons
- FSU Quantum Initiative - Dirac Quantum Discussions Symposium, Florida, 2025
- Strong Correlation Across Newly Accessible Length and Energy Scales, Theory Winter School, National High Magnetic Field Laboratory, 2025

How prominent are microemulsion phases in 2D electron systems?

- Gordon Research Conference on Correlated Electron Systems: Unconventional Phenomena in Quantum Matter, Massachusetts, 2024

Wigner crystallization in Bernal bilayer graphene

- Q-PHORIA: Quantum Pennsylvania Ohio Regional Annual Conference, University of Pittsburgh, 2023
- Novel Quantum States of Matter in Moiré Materials, Aspen Center for Physics - Winter Conference, 2023
- Correlations in Flat Bands: From the FQHE to Moiré, Theory Winter School, National High Magnetic Field Laboratory, 2023
- Strongly Correlated Matter: from Quantum Criticality to Flat Bands, International Center for Theoretical Physics, Italy, 2022
- Gordon Research Conference on Correlated Electron Systems: Topology and Correlations: Long-Range Entanglement in Many-Body Systems, Massachusetts, 2022

Teaching Experience

Graduate Teaching Assistant, The Ohio State University

- Physics 5501H - Honors Quantum Mechanics 2 and Physics 5401H Honors Advanced Electricity and Magnetism 2, Spring 2021
- Physics 5500H - Honors Quantum Mechanics 1, Fall 2020
- Physics 5400 - Intermediate Electricity and Magnetism, Spring 2020
- Physics 1250 - Mechanics, Work and Energy, Thermal Physics, Fall 2019

References

1. Brian Skinner

   Associate Professor, Physics — *E-mail:* skinner.352@osu.edu
   The Ohio State University
   Columbus, OH, 43210, USA

2. Cyprian Lewandowski

   Assistant Professor, Physics — *E-mail:* clewandowski@fsu.edu
   Florida State University and National High Magnetic Field Laboratory
   Tallahassee, FL, 32301, USA

3. Vladimir Dobrosavljevic

   Professor, Physics — *E-mail:* vdobrosa@fsu.edu
   Florida State University and National High Magnetic Field Laboratory
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4. Peng Xiong

   Professor, Physics — *E-mail:* pxiong@fsu.edu
   Florida State University and National High Magnetic Field Laboratory
   Tallahassee, FL, 32301, USA

5. Leonid Levitov

   Professor, Physics — *E-mail:* levitov@mit.edu
   Massachusetts Institute of Technology
   Cambridge, MA, USA