

4. CV of the researcher

Rajat

Theoretical physicist

Ultracold quantum gases and nonequilibrium many-body dynamics

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Department of Physics, Ben-Gurion
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Be'er Sheva, Israel

Research profile

Theoretical physicist working on ultracold Bose gases, supersolidity and nonequilibrium quantum dynamics. I develop Bogoliubov, real-time Gross-Pitaevskii, finite-temperature mean-field and exact-diagonalisation methods to connect collective modes, domain formation and coarsening with experimentally accessible observables. My first-author work established dynamic scaling in a quenched spin-orbit-coupled spin-1 condensate and predicted finite-temperature control of stripe order; my current postdoctoral research extends this toolkit to correlated lattice bosons.

Research record: 8 published peer-reviewed articles plus 1 accepted paper, including 4 first-author publications; **52 citations** and **h-index 5** (Google Scholar, accessed 21/08/2026). All publications are openly accessible through arXiv and/or the publisher.

Professional experience

ISF Postdoctoral Fellow

Oct 2025-present

Department of Physics, Ben-Gurion University of the Negev, Israel | Advisor: Prof. Doron Cohen

Research on metastability, quantum chaos and phase transitions in Bose-Hubbard rings and chains; developed exact-diagonalisation and semiclassical spectrum-tomography methods.

Visiting Researcher

Jun 2025-Oct 2025

Department of Physics, Indian Institute of Technology Ropar, India

Completed studies of collective excitations and finite-temperature dynamics in coupled ultracold gases.

Senior Research Fellow

Jan 2022-Jun 2025

Department of Physics, Indian Institute of Technology Ropar, India

Doctoral research on spin-orbit-coupled spinor condensates; co-supervised M.Sc. projects and mentored junior Ph.D. researchers in numerical method development and validation.

Junior Research Fellow

Jun 2019-Dec 2019

Department of Physics, Indian Institute of Technology Ropar, India

Lecturer

Jul 2017-May 2018

DAV College Sector-10, Panjab University, Chandigarh, India

Physics Tutor (IIT-JEE preparation)

Aug 2015-Jun 2017

Self-employed, Chandigarh, India

Education

Ph.D. in Physics

Dec 2019-Jun 2025

Indian Institute of Technology Ropar, India

Thesis: *Collective excitations and coarsening dynamics of spin-orbit-coupled spinor condensates*. Advisor: Dr. Sandeep Gautam. Defended: 13/06/2025; awarded: 16/07/2025.

M.Sc. in Physics

Jul 2013-Jun 2015

Kurukshetra University, India

First Class.

B.Sc. in Physics, Chemistry and Mathematics

Jul 2010-Jun 2013

Panjab University, Chandigarh, India

First Class.

Selected distinctions

- **Seal of Excellence**, European Commission (2026), for the MSCA-PF 2025 proposal *SuperSQF* (evaluation score: 92.6/100).
- **Best Oral Presentation Award**, PHYCON 2025, IIT Ropar (March 2025).
- **GATE Physics qualified**, Graduate Aptitude Test in Engineering, India (2017 and 2018).

Selected scientific contributions

- 1 **Nonequilibrium coarsening in a spinor quantum gas.** Demonstrated numerically that magnetic domains after a zero-momentum-to-plane-wave quench in a homogeneous quasi-two-dimensional spin-1 condensate exhibit dynamic scaling with $L(t)$ proportional to $t^{0.66}$, consistent with inertial-hydrodynamic binary-fluid coarsening. The ensemble and correlation-function workflow is the direct methodological precursor of SuperSQF. [PRA 111, 033316 (2025)]
- 2 **Finite-temperature control of stripe order.** Predicted within finite-temperature Hartree-Fock-Bogoliubov-Popov theory that, near the plane-wave-stripe boundary of a trapped quasi-one-dimensional spin-orbit-coupled gas, increasing temperature can shift the boundary and induce stripe order; a complementary homogeneous calculation finds thermal melting and phase-boundary shifts. [PRA 109, 033319 (2024); NJP 27, 043005 (2025)]
- 3 **Collective-mode diagnostics of modulated condensates.** Developed finite-difference, basis-expansion and variational Bogoliubov solvers that identify density, spin, Goldstone and roton-like responses across Raman- and angular-momentum-coupled spinor condensates. [PRA 106, 013304 (2022); PRA 108, 043310 (2023); PRA 111, 023311 (2025)]
- 4 **Many-body metastability and quantum chaos.** Combined exact diagonalisation with semiclassical phase-space analysis to connect metastable currents and mixed regular-chaotic dynamics in Bose-Hubbard rings and chains. [PRR 8, 033024 (2026)]

Peer-reviewed publications

- 1 Ritu, **Rajat**, M. Singh, R. K. Gupta and S. Gautam, "Spin and density excitations of one-dimensional self-bound Bose-Bose droplets," accepted for publication in *Phys. Rev. A* (07/08/2026). DOI | arXiv
- 2 **Rajat** and D. Cohen, "Metastability, chaos, and spectrum tomography for Bose-Hubbard rings and chains," *Phys. Rev. Research* **8**, 033024 (2026). DOI
- 3 Sunilkumar V, **Rajat**, S. Gautam and A. Roy, "Finite-temperature phase diagram and collective modes of coherently coupled Bose mixtures," *Phys. Rev. A* **113**, 043310 (2026). DOI
- 4 Ritu, **Rajat**, A. Roy and S. Gautam, "Thermal amplification and melting of phases in spin-orbit-coupled spin-1 Bose-Einstein condensates," *New J. Phys.* **27**, 043005 (2025). DOI

- 5 **Rajat**, P. Banger and S. Gautam, "Collective excitations and universal coarsening dynamics of a spin-orbit-coupled spin-1 Bose-Einstein condensate," *Phys. Rev. A* **111**, 033316 (2025). DOI
- 6 P. Banger, **Rajat** and S. Gautam, "Excitations of a supersolid annular stripe phase in a spin-orbital-angular-momentum-coupled spin-1 Bose-Einstein condensate," *Phys. Rev. A* **111**, 023311 (2025). DOI
- 7 **Rajat**, Ritu, A. Roy and S. Gautam, "Temperature-induced supersolidity in spin-orbit-coupled Bose gases," *Phys. Rev. A* **109**, 033319 (2024). DOI
- 8 P. Banger, **Rajat**, A. Roy and S. Gautam, "Quantum phases and the spectrum of collective modes in a spin-1 Bose-Einstein condensate with spin-orbital-angular-momentum coupling," *Phys. Rev. A* **108**, 043310 (2023). DOI
- 9 **Rajat**, A. Roy and S. Gautam, "Collective excitations in cigar-shaped spin-orbit-coupled spin-1 Bose-Einstein condensates," *Phys. Rev. A* **106**, 013304 (2022). DOI

Journal Impact Factors are intentionally omitted; the qualitative significance of the most relevant outputs is stated above.

Research methods and software

- **Collective modes and stability:** finite-difference and harmonic-oscillator-basis Bogoliubov-de Gennes solvers; time-dependent variational models; linear-instability and roton-gap analysis.
- **Real-time fields and domains:** Fourier-pseudospectral Gross-Pitaevskii solvers for spinor and coherently coupled condensates; homogeneous quench ensembles; structure factors, correlation lengths and domain tracking.
- **Finite-temperature and ensemble methods:** self-consistent Hartree-Fock-Bogoliubov-Popov/Bogoliubov calculations for equilibrium properties, together with noise-seeded Hamiltonian GPE ensembles for quench dynamics.
- **Correlated lattice bosons:** many-body Lanczos exact diagonalisation, spectral analysis and semiclassical phase-space tomography for Bose-Hubbard rings and chains.
- **Computing and reproducibility:** advanced Fortran; proficient Mathematica; Python and MATLAB; OpenMP/OpenACC, Slurm, LAPACK, ARPACK, BLAS and FFTW; version-controlled inputs, recorded seeds and convergence tests.

Supervision, teaching and knowledge transfer

- Co-supervised M.Sc. project students and mentored junior Ph.D. researchers at IIT Ropar (2022-2025), with emphasis on numerical implementation, testing and interpretation.
- Teaching assistant for Quantum Mechanics I (M.Sc.), Physics for Engineering and undergraduate laboratories at IIT Ropar (2021-2023); delivered tutorials, problem-solving sessions and assessment.
- Lecturer in undergraduate physics at DAV College Sector-10, Panjab University (2017-2018); earlier provided advanced physics instruction for national engineering-entrance preparation (2015-2017).

Selected presentations and professional development

- **Contributed oral:** *Collective excitations and universal coarsening dynamics in spin-orbit-coupled spin-1 condensates*, PHYCON 2025, IIT Ropar (Best Oral Presentation Award); *Temperature-induced supersolidity in spin-orbit-coupled Bose gases*, QMAT 2024, IIT Guwahati.
- **Poster:** *Metastability, chaos and spectrum tomography for Bose-Hubbard rings and chains*, Atomtronics 2026, Benasque, Spain; *Temperature-induced supersolidity in spin-orbit-coupled Bose gases*, Ultracold Atoms Japan 2024, OIST, Japan.
- **Advanced training:** Ultracold Molecules and Controlled Chemistry, IIT Ropar (2019); TAMIONs school, ICTS Bengaluru (2021).