

Ali Emami Kopaei

PHD STUDENT

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Profile

I am currently a Ph.D. candidate in the field of physics, pursuing my doctoral studies at Jagiellonian University in Krakow, Poland, under the guidance of [Professor Krzysztof Sacha](#). My primary area of research revolves around the fascinating concept of Time Crystals.

In our research group, we explore a diverse range of systems where we engineer the time-dependent components of the Hamiltonian to unlock unique phases and phenomena in the time domain, some part of this research is already published as a letter in [Phys. Rev. A](#) and [Phys. Rev. R](#). This exciting work has led to collaborations with esteemed researchers in the field.

During my Ph.D., I had the privilege of collaborating with [Professor Lingzhen Guo](#) from the Max Planck Institute. Together, we delved into the stability of phase space crystals, particularly in the presence of dissipation and temperature effects. Some of our findings from this collaboration were published in [Phys. Rev. B](#).

Another intriguing aspect of my research involves the creation of condensed matter phases within photonic systems. In collaboration with [Professor Almut Beige](#) from the University of Leeds, [Professor Hossein Taheri](#) from the University of California and [Professor Andrey Matsko](#) from NASA, we explored the emergence of photonic time crystals. This innovative approach harnesses periodic changes in the refractive index over both time and space dimensions, leading to the creation of a novel system with intriguing band structures. This study is available in [arXiv:2409.07885v1](#)(submitted to [Phys. Rev. L](#)). The next study we consider in the photonic system is the Anderson localization in a photonic time crystal. The study is available in [arXiv:2410.23095](#)(submitted to [Phys. Rev. L](#)).

In my master's studies, We focused on an interacting spinless fermionic system. Our investigations revealed that in our system, the weak breaking of the ergodicity leads to the formation of the scarred state, resulting in the formation of the discrete-time crystal. Some part of this work with the collaboration with [Dr. Hadi Yarloo](#) was published in [Phys. Rev. B](#).

My master's thesis prominently features the study of quantum phase transitions, with an emphasis on employing machine learning algorithms. I conducted in-depth research on the quantum Ising model in the presence of transfer fields and next-nearest neighbor interactions, utilizing a Feedforward neural network. Furthermore, we explored the phase transition from the Eigenstate Thermalization Hypothesis (ETH) to the Discrete-Time Crystal (DTC) by applying recurrent neural networks.

This multifaceted journey through the realms of quantum many-body systems, time crystals, thermalization in quantum systems, and application of neural networks in quantum systems has been a remarkable part of my academic pursuits, shaping my path as a dedicated researcher in the field of physics.

Education

Jagiellonian University

PHD, ATOMIC AND OPTIC PHYSICS

- Advisor: Prof. krzysztof Sacha
- Average Grade: **5.0/5.0**

Poland
2021 - present

Professional Experience

Reviewers **Physical Review Letters (APS),**Reviewers **Physical Review B (APS),**Reviewers **Colloid and Surface Science,**2021-2023 **Research scholarship for National Science Centre Poland**, Jagiellonian University2021-2023 **Teaching Assistant**, Dept. Physics, Jagiellonian University2018-2020 **Teaching Assistant**, Dept. Physics, Sharif University of Technology2018-2020 **Research grant for Sharif Science Centre**, Dept. Physics, Sharif University of Technology

Publications

PUBLISHED

1. **Ali Emami Kopaei**, K.S. Eswaran, A. Kosior, D. Hodgson, A. Matsko, H. Taheri, A. Beige, and Krzysztof Sacha. *Towards Timetronics with Photonic Systems*. **arXiv:2409.07885v1** (2024).
2. K.S. Eswaran, **Ali Emami Kopaei**, and Krzysztof Sacha. *Anderson Localization in Photonic Time Crystals*. **arXiv:2410.23095** (2024).
3. **Ali Emami Kopaei**, Krzysztof Giergiel, and Krzysztof Sacha. *Topologically Protected Quantized Changes of the Distance Between Atoms*. **Phys. Rev. Research 6, 043173** (2024).
4. **Ali Emami Kopaei**, Krzysztof Sacha, and Lingzhen Guo. *Classical Phase Space Crystals in an Open Environment*. **Phys. Rev. B 107, 214302** (2023).
5. **Ali Emami Kopaei**, Xuedong Tian, Krzysztof Giergiel, and Krzysztof Sacha. *Topological Molecules and Topological Localization of a Rydberg Electron on a Classical Orbit*. **Phys. Rev. A 106, Letter 031301** (2022).
6. H. Yarloo, **Ali Emami Kopaei**, and A. Langari. *Homogeneous Floquet Time Crystal from Weak Ergodicity Breaking*. **Phys. Rev. B 102, 224309** (2020).

IN PREP

1. A. Aramthottil, **Ali Emami Kopaei**, Piotr Sierant, Lev Vidmar, and Jakub Zakrzewski. *Apparent Signatures of Non-ETH Behavior in Interacting Spin Chains*.
2. Xuedong Tian, Weronika Golletz, **Ali Emami Kopaei**, and Krzysztof Sacha. *Optical Tweezer Platform to Detect Many-Body System Phenomena*.
3. K.S. Eswaran, **Ali Emami Kopaei**, and Krzysztof Sacha. *Condensed Matter in Photonic Time Crystals*.
4. **Ali Emami Kopaei**, Arkadiusz Kosior, Hossein Taheri, Krzysztof Sacha, Gin Jose, and Almut Beige. *(Under Preparation)*.

Presentations

AND ORGANIZING CONFERENCE

ORGANIZING CONFERENCE

Summer 2023. **Time Crystals** . more information at www.time-crystals.org

VISITING UNIVERSITY AND INSTITUTE

- **Summer 2022** – *International Centre for Theoretical Physics (ICTP), Trieste, Italy*

- **Summer 2022** – *Max Planck Institute, Erlangen, Germany*
- **Winter 2024** – *University of Leeds, Leeds, UK*

INVITED TALKS

- **Winter 2024** – *Towards Timetronics in Photonic Systems, Atomic Physics 24, Max Planck Institute, Dresden, Germany*
- **Autumn 2024** – *Timetronics in Condensed Matter, Future of Ultracold and Ultrafast Dynamics, Max Planck Institute, Dresden, Germany*
- **Autumn 2023** – *Topological Molecules and Topological Localization of a Rydberg Electron on a Classical Orbit, BEC Seminar, CTP PAS, Warsaw, Poland*
- **Summer 2023** – *Classical Phase Space Crystals in an Open Environment, Max Planck Institute, Erlangen, Germany*
- **Summer 2023** – *Topology in Atomic Systems, Zakład Fotoniki, Jagiellonian University, Kraków, Poland*
- **Winter 2022** – *Topological Molecules, ZOA, Jagiellonian University, Kraków, Poland*
- **Winter 2021** – *Floquet Time Crystal from Weak Ergodicity Breaking, ZOA, Jagiellonian University, Kraków, Poland*

Teaching Experience

Course	Role	Institution
Physics of Ultra-Cold Atoms	Teaching Assistant	Jagiellonian University (Fall 2023)
Selected Topics in Theoretical Physics II	Teaching Assistant	Jagiellonian University (Fall 2023)
Selected Topics in Theoretical Physics II	Teaching Assistant	Jagiellonian University (Fall 2022)
Introduction to Electrodynamics	Teaching Assistant	Sharif University of Technology (Fall 2019)
Fundamentals of Statistical Physics	Teaching Assistant	Sharif University of Technology (Fall 2019)

Expertise in Computational Physics

- Artificial Neural Network based Machine Learning
- Tensor Network Methods
- Exact Diagonalization
- Density matrix renormalization group (DMRG)
- Time-Evolving Block Decimation (TEBD)
- Quantum Monte Carlo

Skill

Programming Languages:

- Python: ***** (Expert)
- Julia: **** (Experienced)
- Fortran: **** (Experienced)
- LaTeX: ***** (Expert)
- Mathematica: ***** (Expert)

Libraries and Frameworks:

- Tenpy: ***** (Expert)
- SLEPc, PETSc, MUMPS Packages: ***** (Expert)
- TensorFlow: ***** (Expert)
- ITensor Libraries: ***** (Expert)
- SciKit-Learn: ***** (Expert)
- Qutip: **** (Experienced)
- Theano: ***** (Expert)
- QuSpin and QuTiP Packages: ***** (Expert)