FY 2024 Annual Report

Unit Name

Quantum Systems Unit

Professor Thomas Busch

Research Personnel

Members

Thomás Fogarty, Staff Scientist

Wenbin He, Postdoctoral Scholar

Hao Lyu, Postdoctoral Scholar

Kritika Jain, Postdoctoral Scholar

Serhan Seyyare Aksu, Postdoctoral Scholar

Giedrius Žlabys, Postdoctoral Scholar

Muhammad Sirajul Hasan, PhD Student

Jose Carlos Pelayo, PhD Student

Raul Alejandro Hidalgo Sacoto, PhD Student

Mohamed Amine Boubakour, PhD Student

Hoshu Hiyane, PhD Student

Sarika Sasidharan Nair, PhD Student

Tuan Duc Hoang, PhD Student

Tai Duong Anh Tran, PhD Student

Keerthy Karthikeyan Menon, PhD Student

Rotation Students

Salome Catherine Hayes-Shuptar (January-April, 2024)

Kacper Nowak (January-April, 2025)

Research Interns

Felipe Gomez Lozada, National University of Colombia, *graduated (Sep 25, 2023 – May 24, 2024)

Joleen Teo, Utrecht University, Netherlands *graduated (Apr 03 – Aug 30, 2024)

Naoki Itsui, Hiroshima University, Japan (Apr 04 – Aug 02, 2024)

Huaxin He, Shanghai University, China (Apr 09 – Apr 30, 2024)

Yuanyang Zhou, Shanghai University, China (Apr 17 – Jul 31, 2024)

Fengtao Pang, Shanghai University, China (Apr 17 – Jul 31, 2024)

Brian Long, KTH Royal Institute of Technology, Sweden (May 08 – Sep 06, 2024)

Juan Bernate, National University of Colombia, Colombia (Jun 04 – Dec 03, 2024)

Kristine Grigoryan, Moscow Institute of Physics and Technology, Russia (Jul 01 – Dec 28, 2024)

Jakov Braver, Vilnius University, Lithuania (Sep 09 – Nov 29, 2024)

Ilya Volkov, ITMO University, Russia (Oct 02, 2024 – Mar 11, 2025)

Minh Khang Le, Ho Chi Minh University of Education, Viet Nam (Oct 10, 2024 – Mar 28, 2025)

Ketevan Sikharulidze, Ivane Javakhishvili Tbilisi State University, Georgia (Oct 25, 2024 – Mar 28, 2025)

Zhiyu Wang, Shanghai University, China (Dec 20, 2024 – Mar 28, 2025)

Ning Mao, Northwest University, China (Jan 14 – Mar 28, 2025)

Scholarly Contributions and Creative Productions (by Faculty)

Journal Article

1. He, W.-B.; Žlabys, G.; Hiyane, H.; Sasidharan, N., Sarika; Busch, T.

   Lieb Excitations and Topological Flat Mode of the Spectral Function of a Tonks-Girardeau Gas in a Kronig-Penney Potential. Phys. Rev. A 2025, 111, 013312.
2. Boubakour, M.; Endo, S.; Fogarty, T.; Busch, T.

   Dynamical Invariant Based Shortcut to Equilibration in Open Quantum Systems. Quantum Sci. Technol. 2025, 10, 025036.
3. Nair, S. S.; Žlabys, G.; He, W.-B.; Fogarty, T. ’as; Busch, T.

   Quench Dynamics in Topologically Nontrivial Quantum Many-Body Systems
4. Phys. Rev. A 2025, 111, 033313.
5. Pelayo, J. C.; Fogarty, T.; Busch, T.; Mistakidis, S. I.

   Phases and Dynamics of Few Fermionic Impurities Immersed in Two-Dimensional Boson Droplets. Phys. Rev. Res. 2024, 6, 033219.
6. Jain, K.; Ruks, L.; Kien, F.; Busch, T.

   Strong Dipole-Dipole Interactions via Enhanced Light-Matter Coupling in Composite Nanofiber Waveguides. Phys. Rev. Res. 2024, 6, 033311.
7. Lyu, H.; Zhang, Y.; Busch, T.

   Thouless Pumping and Trapping of Two-Component Gap Solitons. Phys. Rev. Res. 2024, 6, L042010.
8. Anh-Tai, T. D.; Fogarty, T.; María-García, S.; Busch, T.; García-March, M. A.

   Engineering Impurity Bell States through Coupling with a Quantum Bath. Phys. Rev. Res. 2024, 6, 043042.
9. Hiyane, H.; Busch, T.; Fogarty, T.

   Quantum Soliton-Trains of Strongly Correlated Impurities in Bose-Einstein Condensates. Phys. Rev. Res. 2024, 6, L032040.
10. Hasan, M. S.; Fogarty, T.; Li, J.; Ruschhaupt, A.; Busch, T.

    High Fidelity Control of a Many-Body Tonks-Girardeau Gas with an Effective Mean-Field Approach. Phys. Rev. Res. 2024, 6, 023114.
11. Meng, L.; Zhao, L.; Busch, T.; Zhang, Y.

    Controlling Dark Solitons on the Healing Length Scale. Journal of Physics B: Atomic, Molecular and Optical Physics 2024, 57.
12. Hoang, D. T.; Metz, F.; Thomasen, A.; Anh-Tai, T. D.; Busch, T.; Fogarty, T. ’as.

    Variational Quantum Algorithm for Ergotropy Estimation in Quantum Many-Body Batteries. Phys. Rev. Res. 2024, 6, 013038.

Presentation at Conference

1. Busch, T.

Topological Properties of Strongly Interacting Ultracold Few-Body Systems. Mathematical Physics - From few-body physics and droplets to turbulence 2025.

Seminars

1. Busch, T.

   Making Statistics Work: A Quantum Engine Made from Ultracold Atoms, Nils-Bohr Institute, Copenhagen University, Denmark 2025.

2. Busch, T.

   Topological Properties of Strongly Interacting Ultracold Few-Body Systems, RPTU, Kaiserslautern, Germany 2025.

3. Busch, T.

   Topological Properties of Strongly Interacting Ultracold Few-Body Systems, Forschungszentrum Juelich (Jülich Research Centre), Germany 2025.

Scholarly Contributions (For Unit Members Only)

Name of Unit Member (Author-Presenter)	Type	Title	Outlet	Publisher	Year Pub
Jacek Dobrzyniecki	Journal Article	Tunable two-species spin models with Rydberg atoms in circular and elliptical states	Phys. Rev. Research	APS	2025
Hoshu Hiyane	Journal Article	Imaging Josephson vortices on curved junctions	Phys. Rev. B	APS	2024
Hoshu Hiyane	Poster Presentation at Conference	Emergence of nonequilibrium Lieb excitations in periodically driven strongly interacting bosons	55th Conference of the European Group on Atomic Systems of the European Physical Society, Universidad de Granada, Spain		2024
Jacek Dobrzyniecki	Poster Presentation at Conference	Tunable two-species spin models with Rydberg atoms in circular and elliptical states	Global Career Workshop for Quantum Technologies, OIST, Japan		2025
Raul Hidalgo Sacoto	Poster Presentation at Conference	Two scattering 1D anyons in free space	Okinawa School in Physics: Coherent Quantum Dynamics 2024, OIST, Japan		2024
Sarika Sasidharan Nair	Poster Presentation at Conference	Emergent topological properties of Kronig-Penny-type models	YITP Workshop Quantum Simulation of Novel Phenomena with Ultracold Atoms and Molecules, Yukawa Institute for Theoretical Physics, Japan		2024
Keerthy Menon	Poster Presentation at Conference	Statistics-enhanced Quantum Engines in One Dimension	YITP Workshop Quantum Simulation of Novel Phenomena with Ultracold Atoms and Molecules, Yukawa Institute for Theoretical Physics, Japan		2024
Tai Tran	Poster Presentation at Conference	Ultracold atomic Bell-states	YITP Workshop Quantum Simulation of Novel Phenomena with Ultracold		2024

Name of Unit Member (Author-Presenter)	Type	Title	Outlet	Publisher	Year Pub
			Atoms and Molecules, Yukawa Institute for Theoretical Physics, Japan		
Raul Hidalgo Sacoto	Poster Presentation at Conference	Vanishing Chern Marker of supersymmetric partners of the topological non-trivial Kronig Penny model	Young Researchers School on Topological aspects of low-dimensional quantum physics, Ireland		2024
Thomás Fogarty	Poster Presentation at Conference	Enhancing many-body quantum batteries through symmetrization	YITP Workshop Quantum Simulation of Novel Phenomena with Ultracold Atoms and Molecules, Yukawa Institute for Theoretical Physics, Japan		2024
Wenbin He	Poster Presentation at Conference	The Lieb excitations and topological flat mode of spectral function of Tonks-Girardeau gas in Kronig-Penney potential	Atomtronics, Benasque, Spain		2024
Sarika Sasidharan Nair	Poster Presentation at Conference	Emergent topological properties in Kronig -Penney type	Atomtronics, Benasque, Spain		2024
Giedrius Žlabys	Poster Presentation at Conference	Emergent topological properties in modulated Kronig-Penney-type models	DAMOP 2024, Fort Worth, TX, USA		2024
Hoshu Hiyane	Poster Presentation at Conference	Collective excitations of a Bose-condensed gas: Fate of second sound in the crossover regime between hydrodynamic and collisionless regimes	FINESS2024: FInite temperature Non-Equilibrium Superfluid Systems, Queensland, Australia		2024
Jose Carlos Pelayo	Poster Presentation at Conference	Phases and dynamics of quantum droplets in the crossover to 2D	DAMOP 2024, Fort Worth, TX, USA		2024
Tuan Duc Hoang	Poster Presentation at Conference	Variational quantum algorithm for ergotropy estimation in quantum many-body batteries	International School of Physics Enrico Fermi Course 214: Quantum Computers and Simulators with Atoms, Varenna, Italy		2024
Kritika Jain	Poster Presentation at Conference	Loss-tolerant Mølmer Sørrnsen gates in coupled cavity systems	Okinawa School in Physics: Coherent Quantum Dynamics 2024, OIST, Japan		2024
Tuan Duc Hoang	Poster Presentation at Conference	Variational quantum algorithm for ergotropy estimation in quantum many-body batteries	Okinawa School in Physics: Coherent Quantum Dynamics 2024, OIST, Japan		2024
Jacek Dobrzyniecki	Poster Presentation at Conference	Tunable two-species spin models with Rydberg atoms in circular and elliptical states	Okinawa School in Physics: Coherent Quantum Dynamics 2024, OIST, Japan		2024

Name of Unit Member (Author-Presenter)	Type	Title	Outlet	Publisher	Year Pub
Thomás Fogarty	Presentation at Conference	Making Statistics Work: A quantum engine in the BEC-BCS crossover	ICAP 2024, Imperial College London, UK.		2024
Thomás Fogarty	Presentation at Conference	Making Statistics Work: A quantum engine in the BEC-BCS crossover	Recent trends in quantum computing and quantum technologies, ICPT, Italy		2024
Chinmayee Mishra	Presentation at Conference	Shortcuts to Adiabaticity for Bose-Einstein Condensates in Anisotropic Traps	Atomtronics, Benasque, Spain		2024
Giedrius Žlabys	Presentation at Conference	Topological properties of height modulated subwavelength barrier lattices	The Third Taiwan-Latvia-Lithuania Workshop on Coherent Optical Control of Atomic Systems, National Sun Yat-sen University, Taiwan		2024
Chinmayee Mishra	Presentation at Conference	Shortcuts to Adiabaticity for Bose-Einstein Condensates in Anisotropic Traps	Okinawa School in Physics: Coherent Quantum Dynamics 2024. OIST, Japan		2024
Mohamed Boubakour	Presentation at Conference	Dynamical Invariant based shortcut to equilibration in open quantums systems	Ultracold Atoms Japan 2024, OIST, Japan		2024

Outreach Activities (For Unit Members Only)

2025-02-25	Sarika Sasidharan Nair, Okidens' Science exhibition
2025-02-01	Chinmayee Mishra, OIST Science Festival

Workshops and Seminars (Organized and Hosted by Faculty/Units)

Speaker Name(s)	Title	Location	Co-Organizers	Date
Abhijit Pendse, previously at MPI-PKS, Germany	A Rydberg atom interacting with ultracold atoms	Seminar Room L4E01		2024-12-02
Juliette Huynh, INPHYNI & Université Côte d'Azur, France	Critical Velocity for Superfluidity in Reduced Dimensions	Seminar Room L4E01		2024-11-26
Domantas Burba, Student, Vilnius University, Lithuania	Strong long-range interactions and geometrical frustration in subwavelength Raman lattices	Seminar Room C209		2024-11-21
Abel Rojo Francàs, Student, University of Barcelona, Spain	Charging interacting quantum batteries using SAP	Seminar Room C700		2024-11-18

Speaker Name(s)	Title	Location	Co-Organizers	Date
Sagarika Basak, University of Oklahoma, USA	Quantum Phases and Dynamics of Strongly Interacting Spinor Gases in One-Dimensiona Optical Lattices	Seminar Room L4E01		2024-10-25
	Okinawa School in Physics 2024: Coherent Quantum Dynamics	OIST Seaside House	Síle Nic Chormaic, OIST Graduate University Kae Nemoto, OIST Graduate University	2024-09-24
Matthias Huls, Forschungszentrum Jülich GmbH, Austria	Optimal pulses for Rydberg atom circularization	Seminar Room C209		2024-09-20
Doerte Blume, Professor, University of Oklahoma, USA		Seminar Room C209		2024-09-12
Le Bin Ho, Assistant Professor, Tohoku University, Japan	Variational Quantum Algorithms for Optimal Resources and Applications in Quantum Metrology	Seminar Room C700		2024-08-05
	Ultracold Atoms Japan 2024	OIST Main Campus, OIST Seaside House	Shin Inouye, Osaka Metropolitan University Yuki Kawaguchi, Nagoya University Munekazu Horikoshi, Osaka Metropolitan University Takeshi Fukuhara, Riken Hiroki Takahashi, OIST Graduate University	2024-04-09