PhD in PHYSICS – University of Trieste – XXXVIII cycle

Candidate presentation

Candidate: Žan Kokalj
Cycle: XXXVIII
Supervisor: Andrea Trombettoni
Co-supervisor:
Research Title: Precision Measurements with Ultracold Matter-Wave Devices

The Candidate has successfully accomplished the required educational activities as approved by the Teachers Board, including the Ph.D. courses, exams and the attendance of schools and conferences.

Brief description of the candidate research activity
The candidate carried out research in quantum sensing and ultracold atomic systems, focusing on matter-wave interferometry with Bose–Einstein condensates. The work investigated phase estimation and sensitivity limits in atom interferometers within the framework of open quantum systems and quantum estimation theory.

The research analyzed the effects of particle-conserving and particle non-conserving noise using Lindblad dynamics and characterized interferometric sensitivity through Fisher information and Cramér–Rao bounds. The candidate also studied the scaling of system–environment interactions, alternative interferometric protocols, and extensions of Sagnac interferometry schemes to Bose–Einstein condensates including finite-temperature effects.

Role of the Candidate and main achievements.
The candidate took an active role in all parts of the research activity, contributing to the analytical work, numerical simulations, and discussion of the physical meaning of the results. He worked with a good level of independence and was always involved in the development of the project. His work focused on the study of quantum interferometry in ultracold atomic systems in the presence of noise and environmental effects. The main results of the Ph.D. include the analysis of sensitivity limits in open quantum systems, the study of particle-conserving and particle non-conserving dissipative processes, and the investigation of different interferometric protocols for Bose–Einstein condensates, including applications to Sagnac interferometry. During the project, the candidate showed very good analytical skills and understanding of the subject, and the ability to discuss and develop new ideas in a positive and constructive way.

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General evaluation of the candidate by the supervisor:

The candidate showed very good scientific ability, commitment, and independence throughout the Ph.D. program. He developed a solid understanding of quantum many-body physics, quantum sensing, and interferometry, and approached research problems with rigor and creativity. He was constructive in scientific discussions, consistently demonstrating excellent problem-solving skills and intellectual curiosity. Overall, the candidate successfully achieved the objectives of the Ph.D. program and proved fully capable of carrying out independent research activities.

Summary: The Teachers Board agrees that the candidate fully achieved the training and scientific targets set at the beginning of the Ph.D. program

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Presentations to Conferences, workshops, and meetings

- Poster presentation at FOMO2024
- Talk at FISMAT 2025
- Poster presentation at MAWI Student Led Meeting on Quantum Technology

Publications

1) Effect of Energy Extensivity on the Performance of Open Quantum Interferometers (https://arxiv.org/abs/2511.22439)

2) Insensitivity points and performance of open quantum interferometers under number-conserving & non-conserving Lindblad dynamics (https://arxiv.org/abs/2512.10559)