PROVINCIA AUTONOMA DI TRENTO

TRENTINO

Full title: Accordo di Programma per la realizzazione di attività di ricerca scientifica da parte del Centro BEC per il periodo 01 luglio 2021 – 30 giugno 2024
Project: ***Ricerche sui gas quantistici al Centro BEC***

Duration: from 2021, July 1st to 2024, June 30th

Total cost: 750.000,00 Euro

PAT contribution: 450.000,00 Euro

Host Organization: Istituto Nazionale di Ottica (INO), Consiglio Nazionale delle Ricerche (CNR), Unità Operativa di Supporto (U.O.S.) di Trento, Centro BEC

Project leader: dr. Iacopo Carusotto

Any other participants: Department of Physics, University of Trento

Scientific or technological area: Material sciences: inorganic and hybrid micro- and nano-technologies

Keywords: Ultracold atoms; quantum gases and fluids; quantum science and technologies

Web-page:
Updated informations on the activities of the BEC Center are available on the homepage:
https://bec.science.unitn.it/
Given the limited space available in this document, we refer the interested readers to the full report, available on the web-page of the BEC Center at the address:
https://bec.science.unitn.it/BEC/3_Publication/Reports.html

Background and Objectives

The general goal of the project was to advance our understanding of the fundamental physics of quantum systems displaying macroscopic coherence effects, and to develop innovative techniques of potential interest for applications to quantum science and technology. In particular, our experimental activities aimed at exploiting the unique features of our ultracold atom apparatus to carry out pioneering investigations on spinor Bose-Einstein condensates and on their applications to quantum simulations of magnetic and/or quantum vacuum fluctuation phenomena. In addition to providing regular support to the experiments, the theoretical activity aimed at developing a unitary conceptual framework that includes an interdisciplinary way cold atom systems traditionally studied at the BEC Center as well as new hybrid quantum systems such as photonic, super- and semi-conductor-based, and nanomechanical devices, and explore their potential applications to quantum communication, information, and simulation.

State of the art and innovation potential (i.e. ground-breaking nature of the objectives, concepts

involved, issues and problems to be addressed and achievements foreseen beyond state-of-the-art)

In the previous periods, we implemented a novel experimental apparatus displaying unprecedented features, whose unique magnetic stability has allowed us to address unexplored regimes where spinor condensates preserve their coherence for macroscopically long times and can thus be used for quantum simulation. The hiring campaign carried out by the BEC Center in 2020 has extended the spectrum of the available theoretical expertise and has opened the way to the development of fruitful synergies between initially distinct research fields.

Organization of work

The working group consists of an experimental and a theoretical team, both involving CNR-INO and UniTN staff members. On top of these, the BEC Center involves more than 40 young researchers such as MSc and PhD students, PostDoc fellows, as well as international exchange students. Close collaborations are active with prestigious international institutions and with industrial groups like Google-AI. At the local level, strong synergies are in place with other members of the Q@TN consortium, in particular with FBK on the development of superconducting quantum devices.

Results obtained

The close collaboration between theory and experiments has allowed to implement at the BEC Center an experimental platform for the quantum simulation of many-body magnetic and relaxation phenomena, closely related to the so-called false vacuum decay of particle physics and cosmology. The strong synergy between our traditional cold atom research and the new lines has led to formulate far-reaching interdisciplinary links and conceive new experiments presently in the course of being built by our local and international partners, for instance on fluids of light in semi- and super-conducting platforms.

Impact

The remarkable impact of our research at the academic level is witnessed by the prestige of the journals and the bibliometric index of our numerous publications, which confirms the leading role of the BEC Center within the international community. The successful training activity makes the BEC Center an attractive environment for young national and international students pursuing their MSc and PhD . Our collaborations with the Q@TN colleagues will facilitate the transfer of our know-how in fundamental science towards potential applications, in particular to quantum technologies.