QuanTalks

IISc Quantum Technology Initiative (IQTI) Seminar Series

Title: Towards quantum simulations with ultracold thulium atoms at an optical lattice formed by 1064 nm laser light.

Tuesday, 6th June 2023
at 4.00 PM (IST)
Physics Department Auditorium, IISc

Speaker

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Meeting Link

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Abstract: Bose-Einstein condensation (BEC) is a powerful tool for a wide range of research activities, a large fraction of which is related to quantum simulations. Various problems may benefit from different atomic species. Thulium atoms possess a dipole moment of 4 Bohr magneton in the ground state, allowing long-term interactions. It also has a number of non-chaotic low-field Feshbach resonances, allowing fine control of the near-field interactions. It also has a relatively simple level structure compared to the other magnetic lanthanoids and thus is a quite promising subject for applications in quantum simulations.

Nevertheless, cooling down novel species interesting for quantum simulations to BEC temperatures requires a substantial amount of optimization and is usually considered to be a difficult experimental task. Specifically, previous attempts of cooling thulium atoms to Bose-Einstein condensation temperature at a 532 nm dipole trap were not successful.

Here we report on the implementation of the Bayesian machine learning technique to optimize the evaporative cooling of thulium atoms and achieved BEC in an optical dipole trap. The developed approach could be used to cool down other novel atomic species to quantum degeneracy without additional studies of their properties. We also analyzed the atomic loss mechanism for the 532 nm optical trap, used in the Bose-condensation experiment, and compares it with the alternative and more traditional micron-range optical dipole trap.

While the condensate of the thulium atom has a lot of applications in quantum simulations and other areas of physics, it can also serve as a unique diagnostic tool for many atomic experiments. In the present study, the Bose-Einstein condensate of the thulium atom was successfully utilized to diagnose an optical lattice and detect unwanted reflections in the experiments with the 1064 nm optical lattice, which will further be used in a quantum gas microscope experiment.

Biography: Alexey received his BS, MS, and Ph.D. degrees from Moscow Institute for Physics and Technology in 1998, 2000, and 2003, respectively. In 1997 he started working in the Laboratory for Active Media at the Lebedev Physical Institute of the Russian Academy of Sciences. His research was focused on the narrow optical resonances in hot and laser-cooled atoms and their applications to metrology. From 2006-2012 he was a visiting scholar in Misha Lukin's group in the Physics Department of Harvard University, where he worked on a number of research projects related to surface plasmons, quantum dots, and NV color centers in diamonds. The main focus of this activity was light-spin interfaces and solid-state nanophotonic. From 2010-2012 he was the acting director of the Russian Quantum Center (RQC), supported by the Skolkovo Foundation. He then accepted a Principal Investigator position at the RQC and conducted research in the fields of cold atoms and solid-state spin systems. In October 2015 he joined the Physics Department of Texas A&M University as an Assistant Professor. Hi got his tenure in 2021, but in 2022 returned to Russia where he is now Principal Investigator at the Russian quantum center. Currently, his research is covering the application of color centers in diamonds in quantum information science, as well as the utilization of ultra-cold atoms for quantum simulations.