



CRC 1227
Designed Quantum States of Matter



GUEST LECTURE

Dr. Andrea Tononi

Institute of Photonic Sciences, ICFO, Castelldefels, Spain

Leibniz Universität Hannover

DQ-mat Colloquium

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Room D326, Welfengarten 1, building 1101

"Quantum gases in curved geometries"

Although condensed matter systems have been extensively studied in one- and two-dimensional configurations, the impact of spatial confinement beyond mere dimensionality has received comparatively little attention. Interestingly, research into quantum systems with curved geometries has gained significant momentum over the past decade. In the field of ultracold atoms [1], recent experiments were able to confine bosonic gases in curved setups such as thin shells [2-3]. A fundamental model, capturing the interplay between spatial curvature, quantum physics, and nontrivial topology, is a bosonic gas confined on the surface of a sphere.

Following a broad review of my previous findings [4], I will present our recent study of bosons on a sphere with zero-range attractive interactions [5]. As a main result, we observe a first-order phase transition from a weakly attractive uniform state to a solitonic state as the sphere's radius increases. We thus find an instance of a system whose few- to many-body physics can be controlled via its curved geometry. Looking ahead, the research direction of quantum gases in curved geometries could both lead to technological applications and further foundational understanding of quantum physics.

References:

- [1] A. Tononi and L. Salasnich, Low-dimensional quantum gases in curved geometries, *Nat. Rev. Phys.* 5, 398 (2023).
- [2] R. A. Carollo, et al., Observation of ultracold atomic bubbles in orbital microgravity, *Nature* 606, 281 (2022).
- [3] F. Jia, et al., Expansion Dynamics of a Shell-Shaped Bose-Einstein Condensate, *Phys. Rev. Lett.* 129, 243402 (2022).
- [4] A. Tononi and L. Salasnich, Shell-shaped atomic gases, *Phys. Rep.* 1072, 1 (2024).
- [5] A. Tononi, G. Astrakharchik, and D. S. Petrov, Gas-to-soliton transition of attractive bosons on a spherical surface, *AVS Quantum Sci.* 6, 023201 (2024).

All DQ-mat members and all interested are cordially invited to attend.