Dipolar Quantum Gases

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Theory Experiments

3 LABS and a THEORY TEAM

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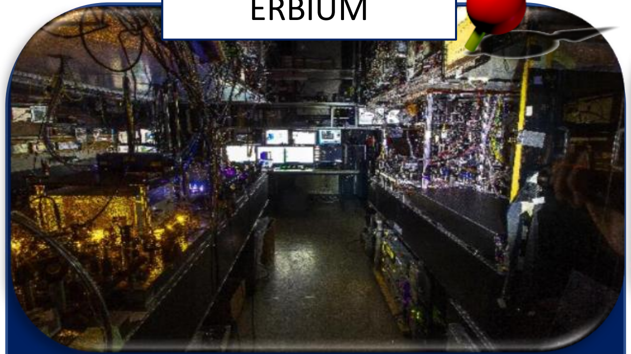
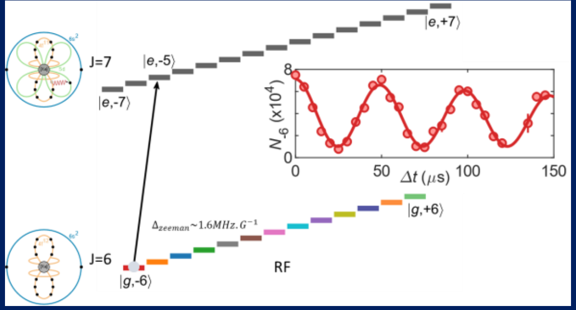
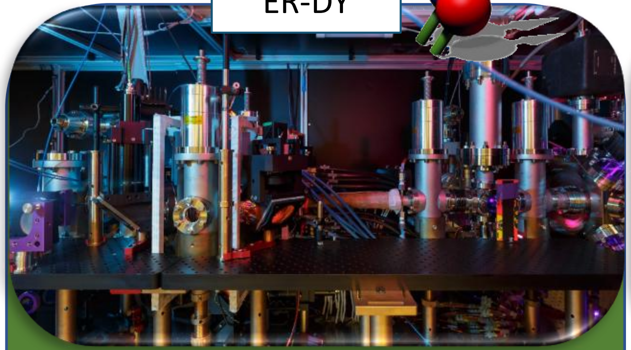


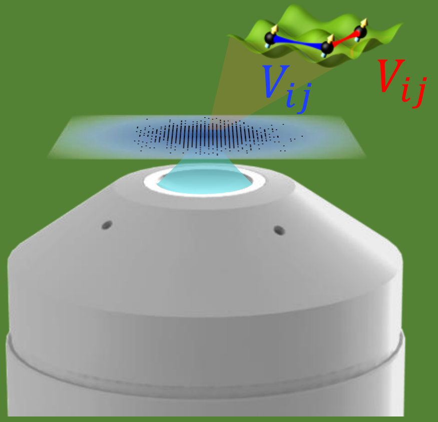
Many-body physics with large spin dipolar spinor gases



ER-DY

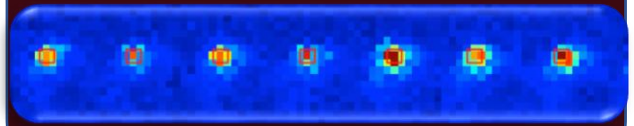


Quantum gas microscopy of lanthanides



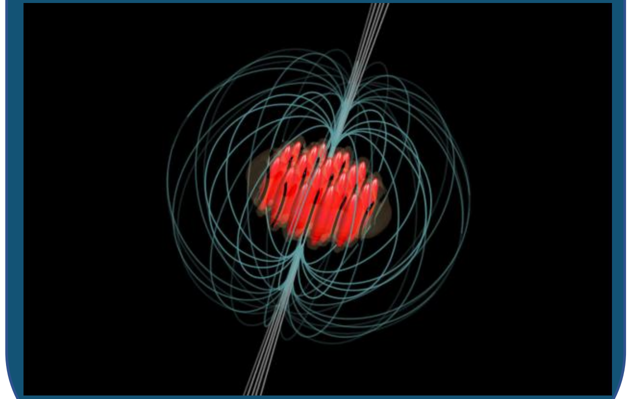
T-REQS

Single atomic magnets in an array of tweezers for quantum simulation and computation

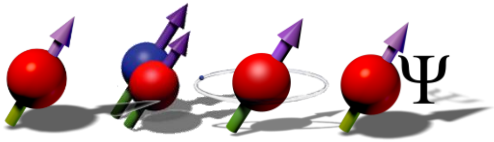


Theory

Simulation of the behavior of dipolar quantum gases



Dipolar Quantum Gases



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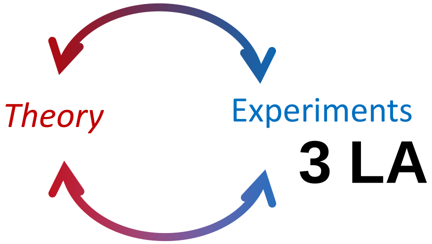

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Article | Open access | Published: 23 October 2025

Synchronization in rotating supersolids

Elena Poli, Andrea Litvinov, Eva Casotti, Clemens Ulm, Lauritz Klaus, Manfred J. Mark, Giacomo Lamporesi, Thomas Bland & Francesca Ferlaino

Nature Physics **21**, 1820–1825 (2025) | Cite this article

Article | Published: 06 November 2024

Observation of vortices in a dipolar supersolid

Eva Casotti, Elena Poli, Lauritz Klaus, Andrea Litvinov, Clemens Ulm, Claudia Politi, Manfred J. Mark, Thomas Bland & Francesca Ferlaino

Nature **635**, 327–331 (2024) | Cite this article

Glitches in Rotating Supersolids

Elena Poli[1], Thomas Bland[1], Samuel J. M. White[2,1], Manfred J. Mark[1,2], and Francesca Ferlaino[1,2,*]
Silvia Trabucco[3,4] and Massimo Mannarelli[3]

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Phys. Rev. Lett. 131, 223401 – **Published 29 November, 2023**
DOI: https://doi.org/10.1103/PhysRevLett.131.223401

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Optical Tweezer Arrays of Erbium Atoms

D. S. Grün[1,2,*], S. J. M. White[1,2,*], A. Ortu[1,2], A. Di Carli[1,2], H. Edri[1,2], M. Lepers[3], M. J. Mark[1,2] and F. Ferlaino[1,2,†]

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Phys. Rev. Lett. 133, 223402 – **Published 26 November, 2024**
DOI: https://doi.org/10.1103/PhysRevLett.133.223402

Measurement of the Excitation Spectrum of a Dipolar Gas in the Macrodroplet Regime

J. J. A. Houwman[1], D. Baillie[2], P. B. Blakie[2], G. Natale[1,3], F. Ferlaino[1,3], and M. J. Mark[1,3]

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Phys. Rev. Lett. 132, 103401 – **Published 7 March, 2024**

LETTER | OPEN ACCESS

Optical manipulation of spin states in ultracold magnetic atoms via an inner-shell hz transition

F. Claude[1], L. Lafforgue[2], J. J. A. Houwman[2], M. J. Mark[1,2], and F. Ferlaino[1,2]

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Phys. Rev. Research 6, L042016 – **Published 18 October, 2024**

Bachelor Project

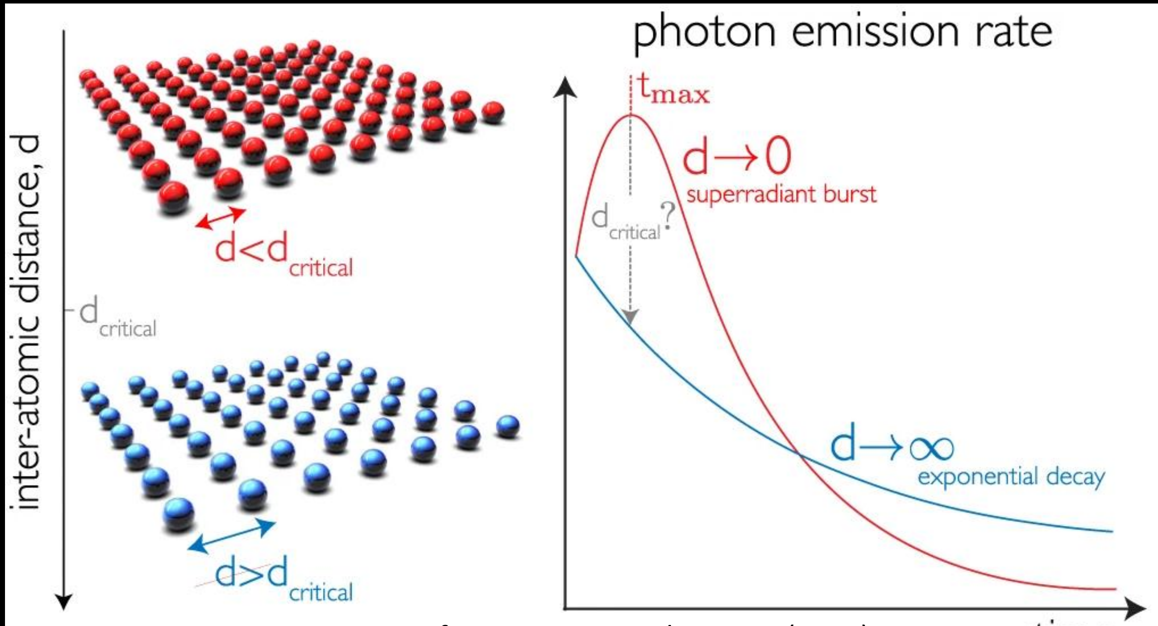
1. Super- and Subradiance in ordered atomic arrays

Closely spaced **light emitters** can show collective behavior due to a photon-mediated coupling, leading to either an enhancement or suppression of **spontaneous emission**. This so-called **super-** and **subradiance** has been studied for almost 70 years now since the seminal works by Dicke and Lehmberg. The goal of this project is to learn and understand how spontaneous emission is modified in **atomic arrays** with spacings below the wavelength of the emitted photons.

You will:

- Review core concepts of light-matter interactions, seminal work on super- and subradiance and the latest experimental advances
- Optional: Perform numerical calculations of the effects of inhomogeneities and long-range interactions on the resulting emission dynamics with Julia

This project combines **theoretical exploration** with **numerical simulations** with the ultimate goal of understanding how interactions can build up correlations and how such systems can be engineered and studied in modern atomic quantum simulators.



Picture from Masson et al. Nature (2022)

Bachelor Project

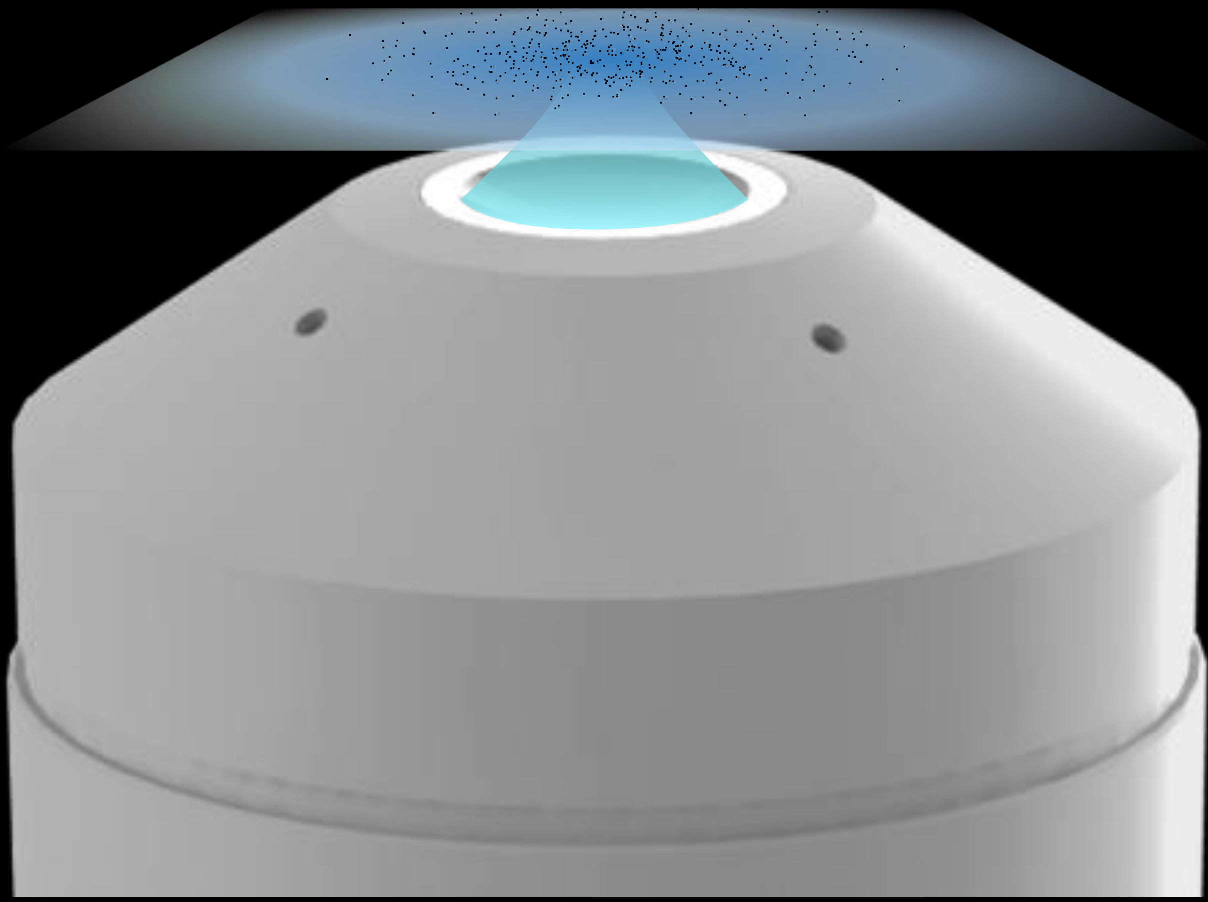
2. Quantum gas magnification

Recent technological progress in observation and detection methods led to the development of **quantum gas microscopes**, where **sub-wavelength** spatial resolution and **single photon** sensitivity allow the study of interacting quantum systems in unexplored regimes. The goal of this project is to study the **quantum gas magnification** technique and its application to quantum gas microscopes.

You will:

- Learn the basic principle of how to magnify and image an atomic wavefunction with a resolution beyond the optical limit.
- Optional: Perform numerical simulations on the influence of long-range interactions and possible mitigation strategies for it.

This project combines **literature exploration** with **numerical simulations** with the ultimate goal of understanding how to image single atoms beyond the resolution limit using modern quantum gas techniques.



Bachelor Project

3. **Emergent Spin Textures**: Frustrated Spin Physics with Magnetic Atoms and Rydberg Platforms

The aim of this project is to investigate the physics of **frustrated spin systems** in triangular-lattice ladders with **magnetic atoms** (Erbium and Dysprosium) and **Rydberg tweezer arrays**. The main goal is to investigate key theoretical models related to frustration, low-dimensional magnetism, and **symmetry-protected topological phases**. This includes studying the **Su–Schrieffer–Heeger (SSH) model** and its topological features, as well as **Heisenberg-type spin-1/2 models**, which are essential for understanding emergent spin textures and competing interactions in frustrated geometries.

You will:

- Review core papers on frustrated spin systems, topological phases, and dipolar interactions.
- Optional: Perform simulations of relevant Hamiltonians to investigate ground-state properties using tools like **TeNPy**.

This project combines **theoretical exploration**, **numerical simulations**, and **practical skills development** in quantum simulation and scientific coding, with the ultimate goal of understanding how frustration and topology can be engineered and studied in modern atomic quantum simulators.