JOHANNES KEPLER UNIVERSITÄT LINZ

PHYSIKKOLLOQUIUM

Fachbereich für Physik

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über

Room Temperature Superfluorescence in Lead Halide Perovskites and its Implications for Quantum Materials

Abstract:

The increasing demand for advancements in computing, communication, and cryptology underscores the critical need for the discovery of novel "quantum materials." Despite the known properties required for most applications, clear guidelines for synthesizing and processing these materials remain elusive. Particularly intriguing are materials demonstrating macroscopic quantum effects, although achieving these at room temperature presents a significant challenge due to the short lifetime of quantum coherent states.

A fundamental question arises: Are thermal processes an insurmountable obstacle to designing materials with extended quantum coherence? Our recent discovery involving room temperature superfluorescence in hybrid perovskites suggests a promising avenue.[1,2] Superfluorescence, an optical quantum effect, emerges from the macroscopic coherence of electronic dipoles. Here, an initially incoherent ensemble of dipoles spontaneously synchronizes, forming a giant dipole that emits a burst of photons (Fig.1). Our exploration of the kinetics of a dipole ensemble transitioning from an incoherent to a coherent state provides compelling evidence for an intrinsic vibration isolation mechanism. This mechanism shields the quantum system from ambient thermal noise, facilitating superfluorescence. In this presentation, we will delve into the room temperature superfluorescence observed in lead-halide perovskites and discuss the Quantum Analog of Vibration Isolation (QAVI) model. QAVI model holds potential for guiding the design and development of high-temperature quantum materials across diverse quantum applications.

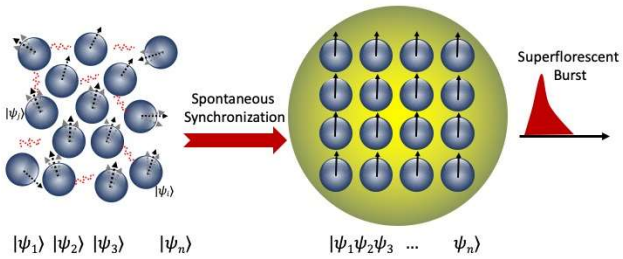

Figure 1. Superfluoresence formation: An incoherently prepared system of excited dipoles spontaneously develops macroscopic coherence from vacuum fluctuations and produces a delayed pulse of coherent light

[1] Melike Biliroglu, Gamze Findik, Juliana Mendes, Dovletgeldi Seyitliyev, Lei Lei, Qi Dong, Yash Mehta, Vasily V Temnov, Franky So, Kenan Gundogdu, Nature Photonics, **16** (4), 324 (2022)

[2] Gamze Findik, Melike Biliroglu, Dovletgeldi Seyitliyev, Juliana Mendes, Andrew Barrette, Hossein Ardekani, Lei Lei, Qi Dong, Franky So, Kenan Gundogdu, Nature Photonics, **15** (9), 676 (2021)

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