## Annual highlight

Emerging quantum technologies overcome the fundamental limitations for existing classical technologies by exploiting the abilities to design, fabricate, manipulate, and control Nature at its smallest scales, established through decades of fundamental research. One class of quantum technology are quantum sensors developed to measure physical properties with unprecedented sensitivity, bandwidth, or precision.

In this work, we merged the fields of optomechanics and quantum optics, and demonstrated the first micro-mechanical magnetic field sensor with quantum enhanced sensitivity and bandwidth. Optomechanics studies the interaction between light and mechanical motion and uses light as a tool to measure micromechanical displacements. Ultimately, such measurements are limited by quantum noise in the light field, which stems from an inherent unorderedness in how quanta of light (photons) arrive at the detector. Quantum optics studies such quantum noise properties of light and provides techniques for how to get around it, e.g. squeezing which reduces the noise by creating order in the photon flow.

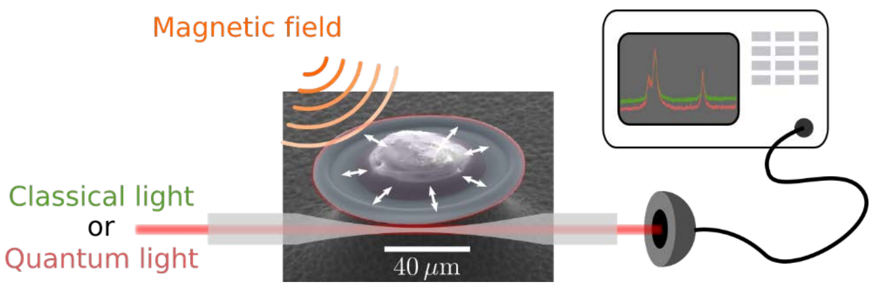


***Figure 1**: Magnetic field-induced mechanical dis-placements are measured using an optomechanical coupling seeded by either classical laser light or squeezed quantum light.*

Experimentally, an optomechanical system that couples mechanical displacements of the structure to an internal optical resonance was employed. By embedding a grain of the material terfenol-D, which expands and contracts in response to magnetic fields, a field dependent shift of the optical resonance was introduced. This in turn allowed for measurement of an applied alternating magnetic field by coupling light to the system through an optical fiber and detecting the periodic shift of the optical resonance proportional to the applied field (see figure 1). Demonstration of quantum enhanced performance was accomplished by comparing the sensor sensitivity level when operated with classical light and squeezed light input. This revealed a 20% improvement in magnetic field sensitivity when squeezed light was employed. In terms of bandwidth, a 50% increase was shown for the quantum light enhanced sensor.

<u>Publication:</u>

***"Quantum enhanced optomechanical magnetometry"***

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