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Superfluorescence from rubidium vapor
~ Results with heated gas cells and prospects for experiments with cold atoms~

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Superfluorescence (SF) is a spontaneous synchronization phenomenon of quantum radiators such as atoms. When an ensemble of atoms is prepared in their excited state, a radiative decay occurs through the spontaneous emission process. Due to the indistinguishability of which atom emitted the photon, atoms are dynamically entangled with each other during the radiative decay process. This entanglement causes the atomic ensemble to synchronize in oscillation. As a result, an intense coherent pulse called SF is emitted. SF is a fundamental quantum optical phenomenon occurring in many-body systems. However, in almost all cases of previous studies over a half-century, only the classical properties of SF have been investigated. Those are an intensity or a pulse shape of SF. On the other hand, quantum properties of light such as photon statistics or entanglement have never been investigated except in a recent few studies [1,2]. This is because to observe the quantum properties of SF, it is necessary to achieve SF with low photon flux, which is experimentally extremely difficult.

Our ultimate goal is to develop a variety of quantum optical devices that exploit the unique feature of quantum signal amplification in SF. As a first step, we have investigated the classical properties of SF in various physical systems of rubidium (Rb) atoms, including the temporal properties of SF pulses [3] and the polarization correlation between two radiation modes [4]. These experiments have been conducted on Rb atoms in heated gas cells. Based on these results, we plan to investigate the quantum properties of SF realized in cold Rb atoms using Magneto-optical trap.

References

[1] Justin G. Bohnet *et. al*., Nature **484**, 78 (2012).
[2] F. Jahnke *et. al*., Nat. Commun. **7**, 11540 (2016).
[3] K. Kitano and H. Maeda, Opt. Lett. **48**, 69 (2023).
[4] K. Kitano, H. Tomida, D. Takei, and H. Maeda, Opt. Lett. **46**, 5055 (2021).