Quantum phase magnification

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Recent advances in the level of precision in controlling atomic and optical systems have enabled the routine generation of quantum entanglement for sensing and information processing applications. In this talk I will focus on our experiments with cold atoms highlighting some of the most recent developments in the prospect of using quantum entanglement to improve the precision of cold atom based sensor.

After briefly reviewing our recent spin squeezing experiments, I will mainly focus on the experimental demonstration of a new concept that we call quantum phase magnification (Fig. 1) [1]. To eliminate the detection-noise bottleneck in quantum metrology experiments, the particular realization of this concept utilizes optical cavity-aided interactions between atoms to magnify quantum observables to-be-measured. The technique eliminates the need for low noise detection to achieve phase sensitivities beyond the standard quantum limit (SQL). In particular we observe phase sensitivities 8dB below the SQL with a readout noise 10dB above the SQL.

Fig. 1 – Schematic illustration of quantum phase magnification. Two possible initial quantum states of a spin-half ensemble are stretched into easily measurable states via a ‘one-axis twisting’ interaction.