S5-9: Entanglement generation through non-linear spin dynamics in atomic magnetometers

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Abstract: Atomic magnetometers are a versatile platform for magnetic field measurement with applications ranging from fundamental physics, navigation, and chemical analysis to security and medical screening. Their operation is based on monitoring the evolution of ground state coherences of alkali-metal atoms located within the external magnetic field, and hence the performance relies on both high signal to noise and long coherence lifetime. Significant progress has been achieved in magnetometry through the design and implementation of various protocols that prolong this lifetime.

It is generally accepted that either an optical probe or spin-exchange collisions, through so-called quantum back-action and decoherence respectively, will introduce perturbations to the atomic system. Usually these have a detrimental effect on the performance of the quantum measurement. We show that non-linearities introduced by an optical probe (i.e. the tensor light shift) or by spin-exchange collisions generate novel non-linear atomic spin dynamics that can lead to the generation of entanglement. In the case of an optical probe we will demonstrated this in the context of the so-called spin maser. Non-linear dynamics induced by an optical probe can also lead to increased coherence times, making them particularly interesting for magnetometry applications. We will discuss the case of non-linear spin dynamics mediated by spin exchange collisions in context of the Bell-Bloom pumping process – where the atomic coherences are created by a train of optical excitation pulses.