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Collective Raising and Lowering Operations in a Spin Ensemble: State Preparation, Entanglement Detection, and Magnetic Field Gradiometer

In this talk, I will discuss topics related to the collective raising and lowering operations in a spin ensemble, which are the physical processes associated with the phenomena such as dynamical nuclear polarization by electron in semiconductor, and the collective Stokes scattering by atoms of a Lambda configuration. I will show schemes of quantum state preparation for donor nuclear spin qubits and for atomic spin qubits by the collective spin raising and lowering operations, which can realize resource of multipartite entanglement including many-body singlets and Dicke states. Realizing many-body singlets in a nuclear spin bath of an electron squeezes the fluctuations of the hyperfine field and can improve the coherence time of electron spin qubit. I will also discuss the collective Stokes scattering by a dilute atomic ensemble with size much larger than the light wavelength. The diffraction pattern of the Stokes photon can be used to detect entanglement in the atomic ensemble. The change of diffraction pattern by the evolution in a static magnetic field provides sensitive vector metrology of the field gradient.

The work was supported by the Research Grant Council of Hong Kong under Grant No. 706309P and No. 706711P.