Choreographing Quantum Spin Dynamics with Light: from Cavity QED to Rydberg Dressing

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I will report on recent advances in generating optically controlled long-range interactions among neutral atoms, with an eye towards applications in quantum state engineering for metrology. In one approach, we couple spin-1 atoms to an optical cavity to realize a photon-mediated spin mixing process [1] that opens prospects for fast optical generation of twin Fock states. In a second platform, we induce long-range Ising interactions among cesium atoms in their hyperfine clock states by Rydberg dressing, and observe "one-axis twisting" dynamics that promises to enable locally controlled spin squeezing. Each of these systems offers fertile new ground for engineering spatially structured entanglement and exploring its implications for quantum sensing.

[1] E. Davis, G. Bentsen, L. Homeier, T. Li, and M. Schleier-Smith. *Phys. Rev. Lett.* **122** 010405 (2019).