Helical-pumping and hyper-SERF

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Helical-pumping: Standard optical-pumping schemes orient the atomic spins by transfer of photonic angular momentum. Generally the spins are oriented along the direction of the beam due to the selection rules of the dipole interaction. Here we experimentally demonstrate that by modulating the optical polarization, we are able to transfer angular momentum perpendicularly to the direction of the beam. This optical-pumping scheme, which has resonant features, could be beneficial to quantum metrology applications.

Hyper-SERF: Alkali spins are commonly assumed to oscillate at a constant hyperfine frequency, which for many years has been used to define the Second. Indeed, under standard experimental conditions, the spins oscillate independently, only weakly perturbed and slowly decaying due to random spin-spin collisions. Here we consider a different, unexplored regime of very dense gas, where collisions, more frequent than the hyperfine frequency, dominate the dynamics. Counter-intuitively, we find that the hyperfine oscillations become significantly longer-lived (Spin Exchange Relaxation Free of the Hyperfine coherence), and their frequency becomes dependent on the state of the ensemble, manifesting strong nonlinear dynamics. We reveal that the nonlinearity originates from a many-body interaction which synchronizes the electronic spins, driving them into a single collective mode. Finally, we identify an experimental regime where these phenomena could be realized.