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Theory of collective quantum effects of the nuclear spin bath in a Ge/Si core/shell nanowire quantum dot WILLIAM A. COISH, STEFANO CHESI, McGill University — We study a quantum-dot spin-valve setup with a uniform hyperfine coupling of the electron spin to the nuclear bath. We propose Ge/Si core/shell nanowire quantum dots as a promising platform in which, through engineering of the nuclear spin positions and of the radial and longitudinal electron confinement, a nearly uniform hyperfine interaction can be realized. The dynamics of this coupled system are exactly soluble in terms of collective nuclear states with fixed total angular momentum. We theoretically show that the quantum-mechanical properties of such collective states of the nuclear spins can be probed through electron transport in this spin-valve setup. The associated transport current shows an enhancement due to coupling to collective modes in the nuclear-spin system directly analogous to the problem of superradiance in quantum optics. This effect is robust to dephasing of the nuclear spins and would provide a demonstration of large-scale collective quantum effects in a nuclear-spin system.

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