Frustration and glassiness in spin models with cavity-mediated interactions

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The effective spin-spin interaction between three-level atoms confined in a multimode optical cavity is long-ranged and sign-changing, like the RKKY interaction; therefore, ensembles of such atoms subject to frozen-in positional randomness can realize spin systems having disordered and frustrated interactions [1]. We argue via a mapping to the Hopfield neural network model that, whenever the atoms couple to sufficiently many cavity modes, the cavity-mediated interactions give rise to a spin glass. In addition, we show that the quantum dynamics of cavity-confined spin systems is that of a Bose-Hubbard model with strongly disordered hopping but no on-site disorder; this model exhibits a random-singlet glass phase, absent in conventional optical-lattice realizations. We briefly discuss experimental signatures of the realizable phases.