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Understanding the role of spin–motion coupling in Ramsey spectroscopy[1] ANDREW KOLLER, JILA/CU, MICHAEL BEVERLAND, Caltech/IQIM, JOSHUA MUNDINGER, JILA, ALEXEY GORSHKOV, JQI/NIST/UMD, ANA MARIA REY, JILA/NIST/CU — Ramsey spectroscopy has become a powerful technique for probing non-equilibrium dynamics of internal (pseudospin) degrees of freedom of interacting systems. In many theoretical treatments, the key to understanding the dynamics has been to assume the external (motional) degrees of freedom are decoupled from the pseudospin degrees of freedom. Determining the validity of this approximation – known as the spin model approximation – has not been addressed in detail. We shed light in this direction by calculating Ramsey dynamics exactly for two interacting spin-1/2 particles in a harmonic trap. We find that in 1D the spin model assumption works well over a wide range of experimentally-relevant conditions, but can fail at time scales longer than those set by the mean interaction energy. Surprisingly, in 2D a modified version of the spin model is exact to first order in the interaction strength. This analysis is important for a correct interpretation of Ramsey spectroscopy and has broad applications ranging from precision measurements to quantum information and to fundamental probes of many-body systems.

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