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Gigahertz dynamics of a strongly-driven single spin in diamond[1]

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Fast quantum control is critical to quantum information processing due to the practical need for fault tolerance. Resonant quantum manipulation is typically performed under the rotating wave approximation (RWA) which assumes that the oscillating driving field can be approximated by a rotating field. Here we present experiments probing the spin dynamics of single nitrogen vacancy (NV) centers in diamond driven by a large amplitude oscillating field where this approximation is no longer valid[3]. Using lithographic coplanar waveguides on diamond substrates we generate oscillating magnetic fields large enough to produce spin rotations on the same timescale as Larmor precession. In this regime the Rabi oscillations become highly anharmonic due to the influence of both the co- and counter-rotating components of the magnetic driving field. Surprisingly, we find that coherent spin flips can still occur under these conditions. Moreover, they occur on sub-nanosecond timescales – faster than expected from the RWA. Our results in combination with the recent demonstration of millisecond coherence times in this system suggest that over one million coherent operations can be performed on an NV center at room temperature. Finally, we present ion implantation experiments demonstrating the ability to place NV centers in the diamond lattice near the high-field region of our waveguides with sub-100nm spatial accuracy. This technique is applicable to other experiments requiring precise positioning of NV centers within the diamond host.

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[3]G. D. Fuchs, V. V. Dobrovitski, D. M. Toyli, F. J. Heremans, D. D. Awschalom, *Science*, 19 November 2009 (10.1126/science.1181193).