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Will spin-relaxation times in molecular magnets permit quantum information processing?

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Certain computational tasks can be efficiently implemented using quantum logic, in which the information-carrying elements are permitted to exist in quantum superpositions. To achieve this in practice, a physical system that is suitable for embodying quantum bits (qubits) must be identified. Some proposed scenarios employ electron spins in the solid state, for example phosphorous donors in silicon, quantum dots, heterostructures and endohedral fullerenes, motivated by the long electron-spin relaxation times exhibited by these systems. An alternative electron-spin based proposal exploits the large number of quantum states and the non-degenerate transitions available in high spin molecular magnets. Although these advantages have stimulated vigorous research in molecular magnets, the key question of whether the intrinsic spin relaxation times are long enough has hitherto remained unaddressed. Using X-band pulsed electron spin resonance, we measure the intrinsic spin-lattice (T_1) and phase coherence (T_2) relaxation times in molecular nanomagnets for the first time. In Cr_7M heterometallic wheels, with M = Ni and Mn, phase coherence relaxation is dominated by the coupling of the electron spin to protons within the molecule. In deuterated samples T_2 reaches 3 μs at low temperatures, which is several orders of magnitude longer than the duration of spin manipulations, satisfying a prerequisite for the deployment of molecular nanomagnets in quantum information applications.