A characteristic of spin reversal in the presence of phonon-bottleneck is the deviation of the magnetization cycle from a reversible function into an opened hysteresis cycle. In recent experiments on molecular magnets (e.g. V15 and Ru2), the zero-field level repulsion was sufficiently large to ensure an otherwise adiabatic passage through zero-field and the magnetization curves can be described by using only a phonon-bottleneck model. Here, we generalize the phonon-bottleneck model into a model able to blend the non-adiabatic dynamics of spins with the presence of a non-equilibrium phonon bath. In this simple phenomenological model, Bloch equations are written in the eigenbasis of the effective spin Hamiltonian, considered to be a two-level system at low temperatures. The relaxation term is given by the phonon-bottleneck mechanism. To the expense of calculus time, the method can be generalized to multi-level systems, where the notion of Bloch sphere does not apply but the density matrix formalism is still applicable.

Results obtained by this simple phenomenological model are presented below, in the case of a spin $\frac{1}{2}$ having a zero-bias energy level repulsion $\Delta$.

![Graph of magnetic field vs. magnetization](image1.png)

**Fig. 1 left** (a) Half hysteresis cycles (field ramped up) for two values of $\Delta$ corresponding to almost adiabatic (thick line) and non-adiabatic (thin line) spin reversal. Due to the PB effect the spin is far from thermal equilibrium. (b) and (c) Spin dynamics in the two situations: adiabatic reversal almost contained in the $xz$ plane and large spin oscillations due to the LZ effect. The $<S_z>$ increases gradually from -1 (black) to +1 (white). The zoom shows coherent oscillations induced by the LZ mechanism.

These results give more insight on the way phonons can influence the dynamics of a quantum spin under the drive of a variable magnetic field. Quenching the lattice at lower temperatures using a phonon-bottleneck mechanism could provide an additional knob to improve the active cooling of qubits or of any other quasi-spin system.

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**References**