Time-optimal control of GdW30 molecular spin qudit

Marc Alsina Cowie

Guillermo Albareda Piquer, Josep Maria Bofill Villà, Ibério de Pinho Ribeiro Moreira

Universitat de Barcelona, IDEADED

marc.alsina@ideaded.com

Quantum systems with more than two levels, or qudits, can store more information and enable more efficient operations than standard qubits. Single-molecule magnets (SMMs) are promising qudit platforms thanks to their magnetic anisotropy, long spin-relaxation times, and naturally occurring multilevel spin states.

In this work, we compare two methods for driving transitions between SMM spin states: π-pulse control, which uses resonant magnetic fields, and the quantum Zermelo navigation approach, which yields the time-optimal Hamiltonian for a given state transfer. Our analysis shows that π-pulse control is constrained by strict timing requirements, while the Zermelo method, though optimal in principle, poses significant challenges for physical implementation.

References

[1] J. M. Bofill, S. Sanz, G. Albareda, I. d. P. R. Moreira, and W. Quapp, Quantum Zermelo problem for general energy resource bounds, Phys. Rev. Res. 2, 033492 (2020).

[2] S. Carretta, D. Zueco, A. Chiesa, A. Gómez-León, and F. Luis, A perspective on scaling up quantum computation with molecular spins, Appl. Phys. Lett. 118, 240501(2021)

[3] A. Castro, A. García Carrizo, S. Roca, D. Zueco, and F. Luis, Optimal Control of Molecular Spin Qudits, Phys.Rev. Appl. 17, 064028 (2022).

[4] M. D. Jenkins, Y. Duan, B. Diosdado, J. J. García-Ripoll, A. Gaita-Ariño, C. Giménez-Saiz, et al., Coherent manipulation of three-qubit states in a molecular single-ion magnet, Phys. Rev. B 95, 064423 (2017).

Figures

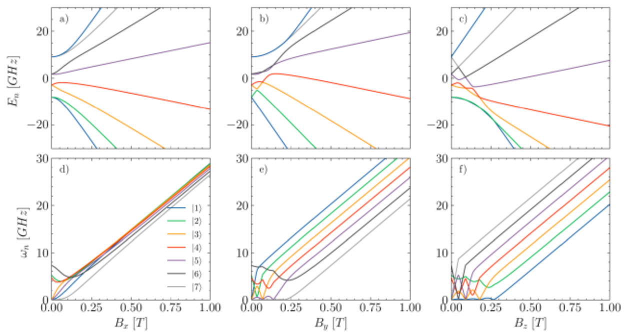

Figure 1: (a-c) Eigenenergies of the different molecule eigenstate. (d-f) Associated Bohr frequencies for adjacent eigenstate transitions.

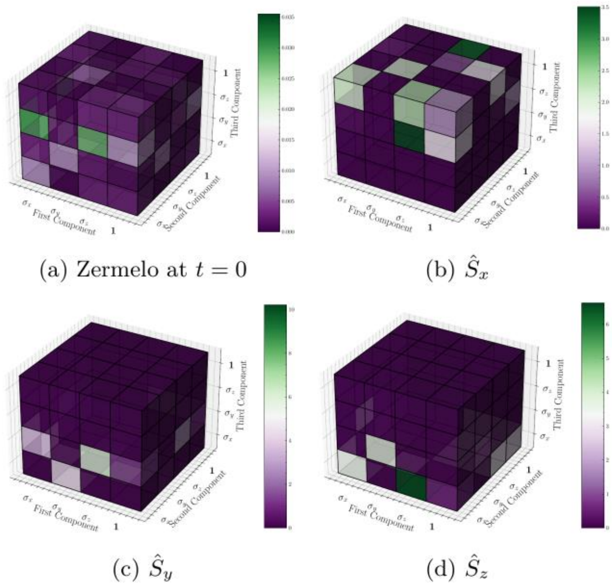

Figure 2: Orthogonal decomposition of the (a) Zermelo Hamiltonian, (b) x−component, (c) y−component and (d) z−component angular momentum operators in the Kronecker product basis.