Coherent Spin Manipulation in Magnetic Molecules

([1]Spin-X Institute, South China University of Technology) Shang-Da JIANG[1]

Quantum information processing has been drawing massive attention for its capability to essentially overperform traditional computing in a number of vital situations. While some candidates of quantum information materials might seem much better developed at the present stage, magnetic molecules show some incomparable advantages owing to the extensive chemical toolkit at hand. their spectra can be easily engineered at energy scales ranging from radiofrequency to ultraviolet, and the dimensionality of their Hilbert spaces can be easily expanded by covalent bonding, self-assembly or simply incorporating high-spin moieties. In this talk, the importance of conducting sophisticated coherence manipulation on magnetic molecules from our group will be introduced.

After introducing the basic concepts and ideas, I will first illustrate how geometric phase gate manipulation is made possible in the molecular ground state electron spin with the help of “cage protection” of quantum coherence and energy level addressability raised by liquid crystal-induced molecular orientation.

By resolving the role of transient electric field in manipulating different terms in the molecular spin Hamiltonian, we are able to implement a wider variety of quantum state manipulations on a qubit, and potentially qudit basis, and demonstrate the Deustch-Jozsa algorithm,

To demonstrate the ability to coherently manipulate a qu*d*it’s state, I will report our work using photoexcitation of a fullerene molecule to generate a pseudo-pure qutrit state which can be a start point for arbitrary state manipulation in its whole Hilbert space. The quantum phase interference in this molecular triplet shows that multi-level molecules have richer physical behaviour than mere qubits.

Finally, we can conclude that developing novel or complexed schemes of molecular quantum state operations has the meaning of both introducing the power of chemistry to quantum information applications and helping chemists to recognize their systems from a quantum point of view.

References

[1] Hu, Z.; Dong, B.-W.; Liu, Z.; Liu, J.-J.; Yu, C.; Xiong, J.; Shi, D.-E.; Wang, Y.; Wang, B.-W.; Ardayan, A.; Shi, Z.*; Jiang, S.-D.*; Gao, S.*, *J. Am. Chem. Soc.* **2018**, 140, 1123-1130.

[2] Liu, Z.; Wang, Y.-X.; Fang, Y.-H.; Qin, S.-X.; Wang, Z.-M.; Jiang, S.-D.*; Gao, S., *Natl. Sci. Rev.* **2020**, 7, 1557-1563.

[3] Wang, Y.-X.; Liu, Z.; Fang, Y.-H.; Zhou, S.*; Jiang, S.-D.*; Gao, S., *npj Quan. Inf.* **2021**, 7, 32.

[4] Zhou, S.; Yuan, J.; Wang, Z.-Y.; Ling, K.; Fu, P.-X.; Fang, Y.-H.; Wang, Y.-X.; Liu, Z.; Porfyrakis, K.*; Briggs, A.; Gao, S.; Jiang, S.-D.*, *Angew. Chem. Int. Ed*. **2022**, 61, e202115263

[5] Fang, Y.-H.; Liu, Z.; Zhou, S.; Fu, P.-X.; Wang, Y.-X.; Wang, Z.-Y.; Wang, Z.-M.; Gao, S.; Jiang, S.-D.*, *J. Am. Chem. Soc.* **2022**, 144, 8605-8612