Quantum information processing using magnets

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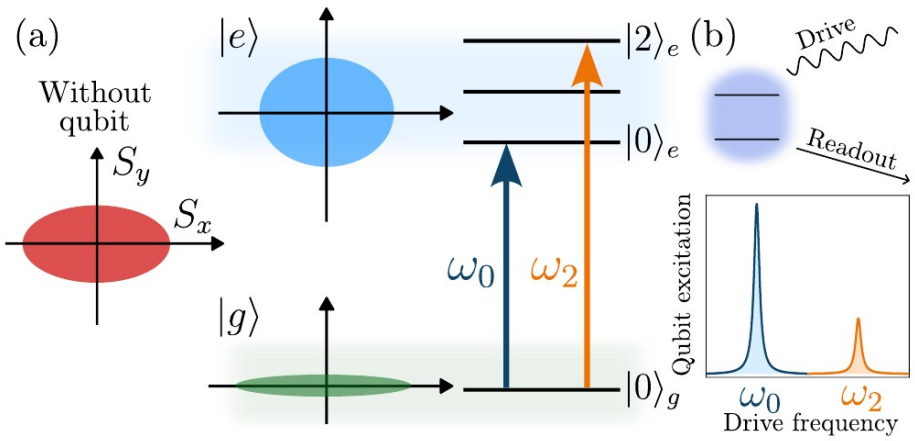
This theoretical project aims at understanding the quantum features, such as entanglement, harbored by magnets and exploiting these insights in developing quantum technologies, such as computing and high-precision sensing. There is a sharp contrast between the description and understanding of magnets in the scientific world. On the one hand, it is known that magnets, especially antiferromagnets, form quantum spin liquids harboring long-range entanglement and topological spin excitations. At the same time, a classical phenomenological description of magnets in terms of magnons has enabled them to underlie multiple technological breakthroughs, such as magnetic sensors in hard-disk drives. The goal of our overall research is to bridge these two theories and develop an understanding which will bring the quantum features harbored by magnets to the realm of devices. The feasibility of such a theory and potential have been demonstrated by recent works on entanglement entropy by our research group. Hence, we will capitalize on the head-start due to our unique insights into a challenging problem.

The exact problem to be investigated will be decided in consultation with the student as per his/her aptitude and interests. For an example of recent research coming out of our group, please see the figure below. The language of communication will be English. Please contact the supervisor for a discussion if you are interested.



An example demonstrating how a qubit can be used for controlling, detecting, and utilizing the quantum ground state of a ferromagnet is depicted in the figure taken from the article: A. E. Römling, A. Vivas-Viaña, C. Sánchez Muñoz, and A. Kamra. Resolving nonclassical magnon composition of a magnetic ground state via a qubit. arXiv:2306.05065 (to appear in Phys. Rev. Lett.).