DEVELOPMENT OF A NEW PHYSICAL LABORATORY FOR STUDIES ON QUANTUM SPIN DYNAMICS IN MOLECULAR MAGNETS

Irinel Chiorescu, Lei Chen, Nickolas Groll, Andrei Botu (NHMFL-FSU, Physics)

Introduction
Starting spring 2005, the PI has been involved in developing a new laboratory in the C-wing of NHMFL. This laboratory will allow investigation of various quantum effects on the mesoscopic scale. We aim towards a highly sensitive and time-resolved detection of the quantum dynamics of molecular spins in the presence of variable magnetic fields. The goal is to achieve coherent control of the total spin of a molecular magnet and implement quantum computing schemes in such materials. The research methods involve the use of on-chip SQUID & cavities (fabricated in MARTECH-FSU) for sensitive magnetometry and usual type of resonant cavities for pulsed EPR experiments.

Experimental
The laboratory is now equipped with a dilution refrigerator able of reaching temperatures as low as 3mK [1]. We have installed RF cabling which supply electro-magnetic fields with frequencies up to 50GHz down to the sample holder. A Cu sample holder has been designed to transfer the high frequencies to the sample placed on a Si chip. The holder was manufactured in-house. The sample holder is attached via a cold finger to the mixing chamber of the dilution and inserted in the bore of the newly acquired vector magnet, capable of 7T along Z axis and of rotating a magnetic field of 1T in XYZ. The electronic measuring scheme involves in-house equipment (low noise, rechargeable power source for amplifiers) and commercial equipment, like current pulse generator for fast SQUID measurements, acquisition card for counting switching events, amplifiers and microwave equipments.

Results and Discussion
We performed first tests of the dilution-magnet system and measured the switching probability of a micron sized Nb SQUID shown in Fig. 1(left). At 5mK, sharp current pulses are sent into the SQUID and for amplitudes higher than 90 microamps, one observes the switching behavior of the SQUID (Fig. 1 middle). The acquisition card is counting the switching events and the switching probability curve is obtained, as shown in Fig. 1 right. The two curves (red and blue) correspond to two different magnetic fluxes through the SQUID loop, proving the flux detection principle to be used in this setup. One future experiment will involve the study of magnetic hysterezis due to a tunable phonon-bottleneck effect in molecular magnets with no magnetic anisotropy. In the preparation of this experiment, we have simulated preliminary data from our external collaborators [2]. Also, this setup may allow the use of electromagnetic field to implement experiments done up to now in the field of quantum optics (see [3], a perspective commentary about a recent experiment realized with superconducting qubits).

Conclusions
The development of the laboratory is advancing as scheduled. We are currently able to reach few mK with the sample placed in a vector magnetic field. Sensitive magnetometry and pulsed microwave experiments will be performed in the near future.

Acknowledgements
We acknowledge support from the Sloan Research Foundation, the NHMFL-NSF In-House program and the Martech graduate fellowship program.

References