Detection of Quantum Spin Dynamics Using Mesoscopic Devices

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Introduction

The research activities of the "Quantum Spin Dynamics" group are focusing on the 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 or of diluted spins (see [1]) 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

Using the clean room facilities of the MARTECH institute on campus, graduate students are fabricating mainly two types of devices: on-chip SQUIDs and on-chip cavities. The devices are installed in a dilution refrigerator either directly on the mixing chamber or on a top loading probe developed in our group with the support of the NHMFL mechanical workshop (the work involved one REU project as well). The probe allows to quickly and efficiently exchange samples. We have installed RF cabling which supply electro-magnetic fields with frequencies up to 50GHz down to the sample holder. The head of the probe holder has a cold finger inserting 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

The Nb SQUIDs fabricated at MARTECH are of type "weak-link", that is the two Josephson junctions are constrictions on a larger superconducting loop (see Fig.1 left). The Fig.1 middle shows the SQUID modulation curve of such a device. The asymmetry of the curve is due to an unbalance between the two junctions, to be corrected in future devices. We have also tested Nb SQUIDs of type "tunnel junctions" fabricated at Lincoln Lab. Fig.1 right shows the modulation curves of such device, much closer to the theoretical abs(cos) function. The use of both type of devices as flux detectors of nano-sized magnetic samples will be investigated. Another type of detector is constituted by an on-chip Nb cavity, as shown in fig.2. The length of the meandering central line defines the resonant frequency and magnetic samples will be placed in areas of maximum B-field (middle of the device). We are currently fabricating and testing such devices.

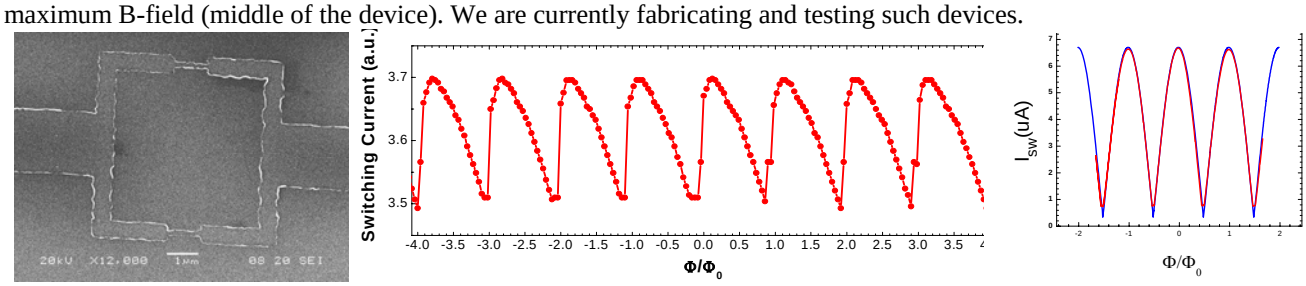

Fig.1 left: SEM of a test Nb-SQUID. SQUID voltage (**middle**) and switching probability (**right**) as a function of current.

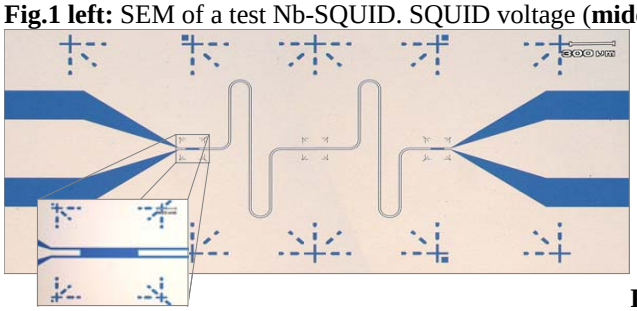

Fig. 2 On-chip cavity fabricated at MARTECH-FSU

Acknowledgements

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References

[1] Nellutla, S.; Choi, K.-Y.; Pati, M.; van Tol, J.; Chiorescu, I. and Dalal, N.S., Coherent Manipulation of Electron Spins up to Ambient Temperatures in Cr5+ (S=1/2) doped K3NbO8, *Phys. Rev. Lett.* **99**, 137601 (2007) /cond-mat 0710.5199