DEVELOPMENT OF A PULSED NETWORK ANALYZER FOR STUDIES ON MOLECULAR MAGNETS AND ORGANIC CONDUCTORS

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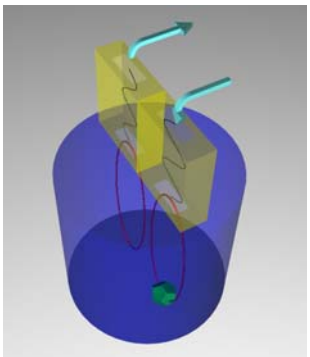
Introduction

Within the frame of the in-house research program, we propose the development of a pulsed microwave setup to explore time dependent electron spin properties in low dimensional organic magnets and conductors at mK temperatures. Molecular magnets show a relatively large magnetic moment, yet showing a clear quantum behavior, aspects that are essential for future implementations of single spin qubits (molecules can represent identical qubits that can be patterned in a well defined structure on an electronic chip). However, large magnetic moment means also stronger coupling to the environmental decoherence sources, leading to short decay times. The pulse technique that we are elaborating will give information on the effect that the environment has onto the spins quantum dynamics and will hopefully indicate ways of reducing their effect.

Experimental

The development is carried on along two directions: the pulsed network analyzer and the low temperatures. In 2006 we have accomplished most of the experimental part, as explained below. Two phase locked 20GHz synthesizers are combined to form a heterodyne detection, performed by a very fast acquisition card. One synthesizer is gated such as pulses down to nanosecond scale can be obtained and a combination of harmonic generator/mixer with multiplication factor 4 ensures the operability in the V-band (50-75GHz). Such system is equivalent to a V-band pulsed vector network analyzer. The laboratory is now equipped with a dilution refrigerator able of reaching temperatures as low as 3mK [1]. We have installed RF cabling which will supply the signal from the locked synthesizers down to the mixing chamber. We do have microwave waveguides and a Cu cavity has been designed (Fig. 1 right), to be fabricated in-house. The cavity will be 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.



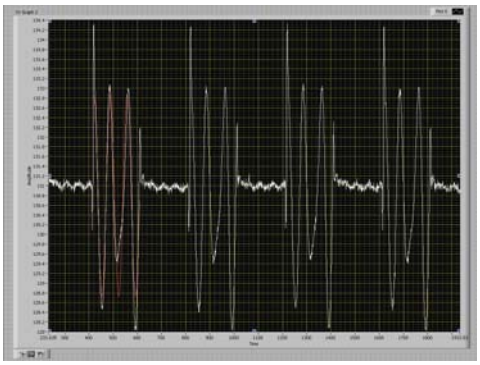


Fig.1 Right: Illustration of the designed cavity and waveguide. **Left:** Detected pulses (in white) and the obtained fit superimposed to a pulse (in red). The amplitude & phase information are given by the fit.

Results and Discussion

We performed the first tests of the pulsed setup. Fig. 1 right shows pulses detected in transmission for an empty sample holder. A “live” fit is superimposed (in red) giving the amplitude and the phase of the measured pulse. It is worth to note that the phase noise of the setup is below 1%. We will therefore be able to detect small changes in the amplitude and phase of a signal due to coherent changes in the spin orientation in a sample. Also, this setup may allow the use of electromagnetic field to implement experiments done up to now in the field of quantum optics (see [2], a perspective commentary about a recent experiment realized with superconducting qubits).

Conclusions

The development of the proposed setup is advancing as scheduled. We are currently able to excite a sample with microwave pulses with frequencies up to 75GHz and detect the changes in amplitude and phase of the transmitted signal. The setup will be adapted for mK temperatures to perform time-resolved microwave experiments in the near future.

Acknowledgements

We acknowledge support from the Sloan Research Foundation and the NHMFL-NSF In-House program.

References

[1] “Cooling power of new dilution refrigerator is world class”, NHMFL reports - winter edition, **13** (5), p. 24 (2006).
[2] I. Chiorescu, “Microwave cooling of an artificial atom” (perspective), *Science*, **314,** 1549 (2006).