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 are developing a pulsed microwave setup to explore time dependent electron spin properties in low dimensional organic magnets and conductors at mK temperatures. Our focus is on quantum dynamics of large spins in molecular magnets or diluted in non-magnetic matrices [1], 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). An efficient way to perform such studies is offered by Electron Paramagnetic Resonance (EPR) techniques to be implemented in a high cooling power dilution refrigerator. The pulse EPR technique that we are developing will give information on the lattice environment effects on the spins quantum dynamics and will hopefully indicate ways of limiting the lattice influence.

Experimental Results

The instrument developed contains two phase-locked variable frequency synthesizers working in the 2-20 GHz range, forming a heterodyne detection. The instrument can be used with standard X-band cavities for both pulsed and continuous wave studies. Though it does not offer the high microwave power currently existing in standard pulsed instruments, it offers a very accurate pulse shape and timing control. When used in a combination with harmonic generator/mixer with multiplication factor 4, the instrument can work in the V-band (50-75GHz). Such system is equivalent to a V-band pulsed vector network analyzer. The tests shown in Fig.1 left are using the newly developed heterodyne detection in conjunction with a standard X-band Bruker cavity and magnetic field control. The detection indicates the shift of the absorption dip for a test DPPH sample with a resonant field at 3428 Gauss as a function of applied field as well as the cavity absorption dip. For V-band studies we designed a cylindrical cavity in transmission geometry, placed in between the harmonic generator and the harmonic mixers. Transmission data (no field or sample) shown in Fig.1 right indicates the resonant modes of the cavity. We plan to use the TE011 mode of the cavity and place the system inside a dilution refrigerator able of reaching temperatures as low as 3mK. The Q-factor of the cavity can be tuned (not in-situ) by changing the coupling strength giving the possibility to short microwave pulses to penetrate the cavity. The dilution refrigerator is equipped with 3D superconducting coil able to rotate magnetic fields.

![Customized cylindrical cavity](image)

**Fig.1** Left: X-band tests of the instrument using Bruker cavity and magnet. The absorption dip of DPPH sample shifts with the applied field. **Right:** V-band testing of a cylindrical cavity to be placed inside the dilution refrigerator.

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References