Cavity Resonant Modes, On-chip and Off-chip Studies

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(work done in the Quantum Spin Dynamics group at NHMFL, under the supervision of Dr. I. Chiorescu)

Introduction

We worked within the Quantum Spin Dynamics and Nanoelectronics group at NHMFL. This lab specializes in quantum effects on a nanoscopic scale, with applications in quantum computing. In this project, we investigate the behavior of magnetic materials and their interaction with electromagnetic fields at low temperatures.

Motivation

The ultimate goal is to test the effects of microwave pulses on magnetic materials at low temperatures, specifically looking at the resonant modes of the electromagnetic field in a cavity. We are interested in understanding how these modes change with temperature and how they can be controlled.

Experimental Setup

A schematic of our experimental setup is shown in Figure 1. We used a dilution refrigerator to cool the sample down to cryogenic temperatures. The sample was held in a cavity, which was connected to a microwave source through an microwave probe. The cavity was excited at different frequencies, and the response was measured using a lock-in amplifier.

Resonant Cavities and Resonant Modes

A resonant cavity is a hollow conductor blocked at both ends and containing an electromagnetic wave. The cavity resonates at specific frequencies, called resonant modes. The resonant modes of a cavity are determined by its geometry and the electromagnetic properties of the materials it contains.

Ongoing Projects in the Lab

We conducted experiments to study the resonant modes of a cavity. In one experiment, we measured the response of the cavity to microwave pulses at different temperatures. We observed a significant change in the resonant modes as the temperature was varied. This result suggests that the resonant modes are sensitive to temperature.

Design Trials of the Cell Phone Resonance Cavity

The cell phone resonance cavity is a resonant cavity with a specific geometry. We designed and fabricated several cavity prototypes to optimize the resonant modes for different applications. The cavity was fabricated using a combination of laser cutting and 3D printing. We tested the cavity response to a range of frequencies and observed a high-quality factor, indicating good optical confinement.

Conclusions

The results of our experiments were promising. We observed significant changes in the resonant modes of the cavity as a function of temperature. These results suggest that the resonant modes can be controlled by temperature, which could have applications in quantum computing and other fields.

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References