Low Field Microwave Absorption and Magnetic Flux Quantization in Granular Rb$_3$C$_{60}$: Observation of Nonperiodic Sharp Line Microwave Absorption

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Received March 2, 1993; revised July 27, 1993

Abstract. The low field microwave absorption (LFMA) of granular samples of superconducting Rb$_3$C$_{60}$ has been studied as a function of the microwave power, magnetic field modulation amplitude and temperature at dc magnetic fields less than 0.5 G. Nonperiodic sharp lines are observed for the first time in these new alkali-metal doped fullerenes. An interpretation is advanced based on a spin-glass model of a set of superconducting current loops with random orientations but uniform areas.

1. Introduction

Low field microwave absorption (LFMA) has become a sensitive technique to characterize the superconducting state [1]. For cuprate-based superconductors, a series of equally spaced lines [1-4] is observed in good single crystals. For ceramic or powder samples, typically an intense, broad, unresolved signal is reported [5, 6].

LFMA has also been used to investigate the new alkali-metal doped C$_{60}$ superconductors [7-10]. As for ceramic cuprate superconductors only a broad signal is observed.

Here, we report a series of sharp lines for the first time in a sample of superconducting Rb$_3$C$_{60}$. The effects of field modulation amplitude, microwave power and temperature are reported.

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2. Experimental

Alkali metal azides as a source of alkali metal are heated with $C_{60}$ in a 3:1 stoichiometric ratio [10]. Right after alkali metal azide decomposition around 500°C, the mixture is quenched to room temperature. The whole operation lasts less than 10 minutes. Details of this preparation have been published [10].

LFMA is carried out using a Bruker ESP 300 X-band spectrometer with a field modulation frequency of 100 kHz. This spectrometer has a 60 dB variable attenuator plus a 30 dB step attenuator for the microwave power. An external pair of coils on the magnet pole faces allow a magnetic field sweep from $-40$ to $+40$ G through zero field. The temperature is varied by an Oxford ESR 900 cryostat.

3. Results

As already reported [10], right after doping only a very weak LFMA signal is observed. After 15 h this signal increases by more than a hundredfold and reaches a plateau. All data reported were performed at least two days after the end of doping.

Displayed in Fig. 1 is the LFMA signal of $Rb_3C_{60}$ for different magnetic field modulation amplitudes at 4 K. These observed lines are similar to the sharp lines observed for single crystal superconducting cuprates. A change in the LFMA signal starts around 10 mG and the resolved sharp lines are masked when the modulation exceeds 50 mG (see the arrows in Fig. 1).

The LFMA signal versus microwave power (Fig. 2) reveals no microwave power threshold down to $2 \times 10^{-7}$ mW. However from Fig. 2, as indicated by the arrows, a change in these resolved LFMA signals is seen above $1 \times 10^{-4}$ mW.

A continuous decrease of the LFMA signal magnitude with increasing temperature is shown in Fig. 3. Above the superconducting transition temperature of $\sim 35$ K the LFMA signal disappears.

4. Discussion

Several models have been introduced to account for the nonresonant microwave absorption of type II superconductor materials. A model of Silver and Zimmerman [11] is based on the magnetic field response of a superconducting ring of inductance $L$ with a weak link which limits the supercurrent in