Interaction of a current in a superconductor with Mössbauer radiation

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The behavior of the recoilless radiation of a Mössbauer source upon a change in the direction of the current between a superconducting $YBa_2Cu_3O_7$ ceramic and a Mössbauer source has been studied. It is concluded that the superconductivity current carriers in this superconductor are pairs of electrons which are coupled by a phonon exchange interaction.

The current carriers in an ordinary superconductor are generally accepted as being Cooper pairs: two electrons which are coupled by a phonon exchange interaction. As a Cooper pair goes out of a superconductor into a normal conductor, it decays into two uncoupled electrons and a phonon. If the normal conductor is a Mössbauer γ source, the appearance of additional phonons in it should lead to a decrease in the recoilless Mössbauer radiation (because of the change in the Debye–Waller factor), a decrease in the resonant absorption in a Mössbauer absorber, and an increase in the

TABLE I. Relative changes in the count for various current parameter values.

Period of the changes (s)	$((N_{sn} - N_{ns})/N_{ns})\times 10^4$	$((N_0 - N_{ns})/N_{ns})\times 10^4$
1	5.5 ∓ 3.4	0.9 ∓ 3.4
5	3.9 ∓ 2.1	− 1.2 ∓ 2.1
5	4.7 ∓ 1.8	1.5 ∓ 1.8
5	4.5 ∓ 1.6	0.3 ∓ 1.6
5	5.0 ∓ 1.5	1.2 ∓ 1.5

count in a detector behind the absorber, if the source and the absorber are at resonance. In addition to the decrease in the intensity of the Mössbauer radiation from the source (a decrease in the resonant absorption in the resonant absorber), the Mössbauer absorption spectrum may acquire satellite absorption lines at a distance $\mp n\hbar\omega$ from the fundamental line, where $\hbar\omega$ is the energy of the phonons which are formed during the decay of the Cooper pairs.

We have carried out a study aimed at verifying the model outlined above and identifying the current carriers in high-temperature superconductors.[1] We carried out experiments in the arrangement described above in the metal oxide ceramic $YBa_2Cu_3O_7$ ($T_c = 90$ K) and a Mössbauer source consisting of ^{57}Co in chromium. As an absorber we used stainless steel, in which the isomer shift of the absorption line with respect to that of the particular source which we used is close to zero. The measurements were carried out at liquid-nitrogen temperature. The superconducting state was identified on the basis of the Meissner effect. Because of the small values of the expected effect, we did not measure the complete Mössbauer spectrum; the measurements were carried out only for a zero velocity of the source and the absorber.

A current of 20 mA was passed in two directions through the assembly described above, and the pulses at a differential discriminator were counted for three cases: N_{sn}, the current of electrons out of the superconductor into the normal conductor; N_{ns}, the current in the opposite direction; and N_0, the null current. To avoid effects of a decay of the radioactive source and of instrumental drift, we varied the current parameters at a period of 1 or 5 s, and in different series of measurements we changed the order in which we used the three current parameters listed above.

If the superconductivity current in a metal oxide ceramic is carried by Cooper pairs, we should observe the following relations: $N_{sn} > N_{ns} \leqslant N_0$ (in the case of a null current, there may be a diffusion of Cooper pairs into the normal conductor).

The results are shown in Table I. They support the model outlined above and constitute serious evidence that the carriers of the superconducting current in a metal oxide ceramic are Cooper pairs, as they are in ordinary superconductors.

[1]J. G. Bednorz and K. A. Müller, Z. Phys. **B64**, 189 (1986).

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