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Autor: Giovannella, C. / Lucchini, C. / Messi, R.

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DYNAMICS OF INTRA AND INTERGRANULAR JUNCTIONS

C. Giovannella, C. Lucchini, R. Messi, A. Giannelli, B. Lecuyer +
Dip. di Fisica, Universita' di Roma II, Via E. Carnevale, 00173 Rome, Italy
+Electronique Fondamentale, Bat. 220, 91405 Orsay, France

Abstract: We discuss the effects of a static magnetic field on the dynamics of a granular superconductor.

In recent papers [1] we have shown how a careful experimental comparison of the linear and non-linear a.c. susceptibility is needed in order to:

a) obtain information on the role played in the linear dynamics by the a.c. frequency of the probing field [2] and by the intensity of a superimposed d.c. field;

b) separate the critical region of the a.c. susceptibility curve in regions affected by: the penetration of the magnetic field into the junction network ($X' \leq - 0.8$), the intergranular critical region ($- 0.8 \leq X' \leq - 0.2$) and the intragranular critical region ($- 0.2 \leq X'$).

In this paper we describe an experiment that evidences the effects of a d.c. field on the non-linear dynamics. In fig. 1a and 1b we show the variation of the intensities of the third and second harmonics with the the temperature increase for four different experimental protocols

1) ZFC (a): the sample is cooled down to $\approx$ 40 K in zero magnetic field (terrestrial field) with the primary coil disconnected,then the probing a.c. field (900 Hz - 6 Oe) is switched on and the sample warmed up at a rate of about 0.5 K/min while the X', X" and the non-linear susceptibility (up to the 11th harmonic) are continuosly monitored and recorded.

2) ZFC/DC (b): as for 1) but with the d.c. field (16.5 Oe) switched on before the warming-up of the sample.

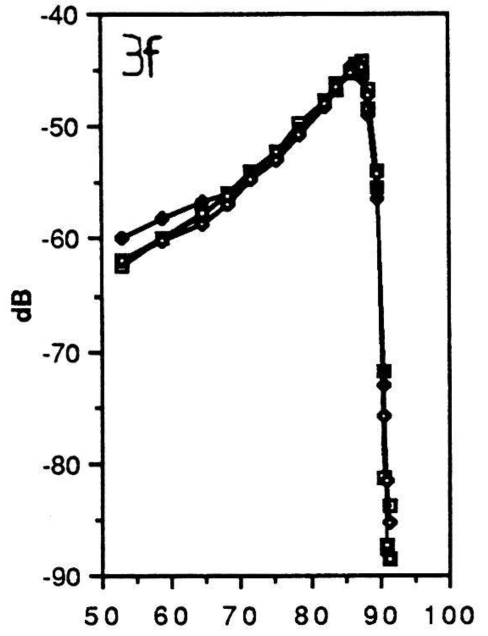
3) FC/DC (c): the sample is cooled down in a d.c. field with the primary coil disconnected, and then warmed up in the same field while the linear and the non-linear responses are recorded.

4) FC (d): as for 3) but with the d.c. field switched off before the warming-up operation.

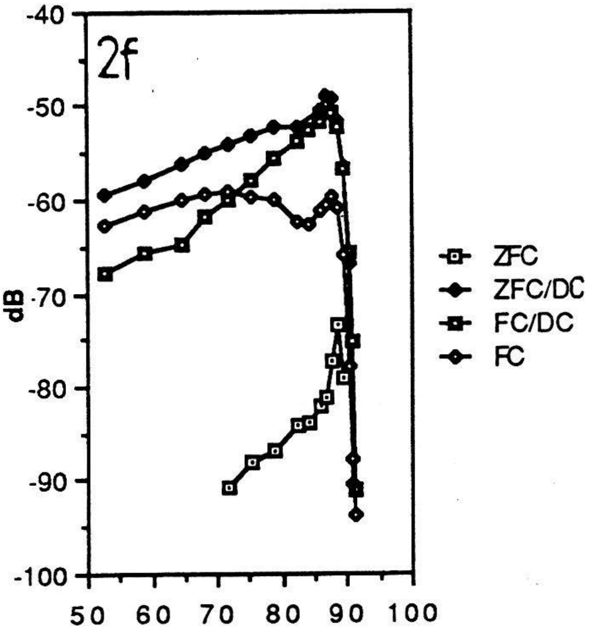
We notice that:

1) the variation of the intensity of the third harmonics (as well that of the higher odd harmonics) as a function of the temperature is only slightly affected by the experimental procedure. Odd harmonics are strictly related to the fluxons sweeping in and out;

2) the even harmonics are observable only if the d.c. field is switched on, in agreement with the results of reference [3], but the variation of their intensity with the temperature is strongly dependent on the experimental protocol used. In the ZFC procedure we observe a small second harmonics signal only for very high temperatures, when the residual field is sufficiently strong to penetrate the sample permanently. The second harmonic intensity is peaked in the intragranular critical region. In the FC/DC protocol, fluxons are pinned in the whole sample during the cooling down procedure, so that we observe their non-linear response in the whole critical range. The intensity of the non-linear response is even higher in the case of the ZFC/DC protocol is very interesting. The reason is not completely clear. The case of the FC protocol. In this case the switching off of the d.c. field induces a situation of non equilibrium. With the increase of the temperature, first we observe an increase of the dissipation as expected, but for higher temperatures the fluxons come out of the sample untill the equilibrium is reached again and a new penetration in the intragranular region does occur. It is very interesting to observe that the temperature at which is situated the deep is 83.1 K, see fig. 2a. From this we deduce that the intergranular region should had been completely penetrated much before the occurence of the peak in the X" curve, see fig. 2b, and around the value of - 0.8 / - 0.7 of the X' curve, see also ref. [1]. As a consequence, the interpretation of the X" peak as a sign of the flux penetration up to geometrical center of the sample is rather doubtful [4]. Correspondences between the X" peak and the flux penetration up to the center of the grains, or the critical transition of the intergranular junction network are also not immediate[5].The latter can be better studied [1] by monitoring the temperature dependence of the odd harmonics intensities in the ZFC procedure.



T (K) Fig. 1a



T(K) Fig. 1b

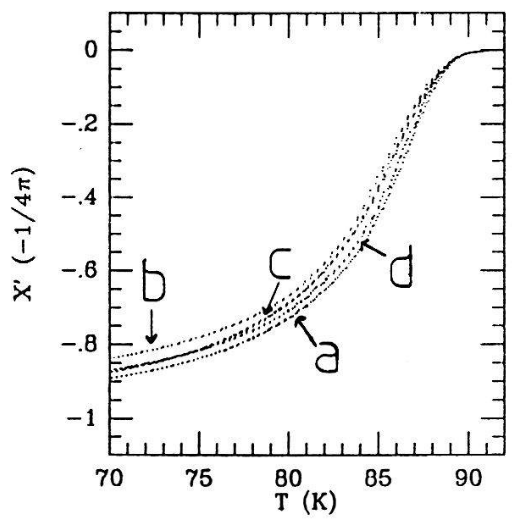


Fig. 2a

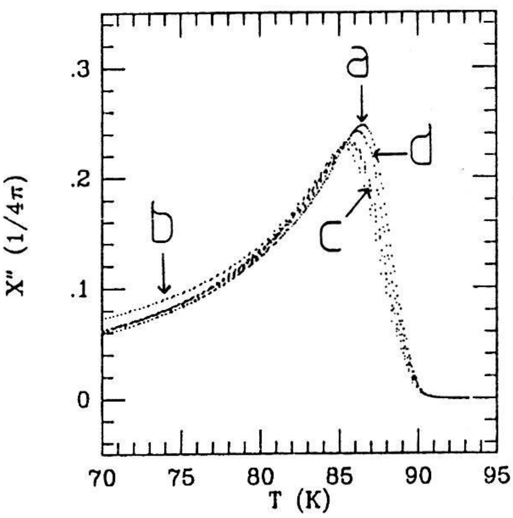


Fig. 2b

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