COMITATO NAZIONALE PER L'ENERGIA NUCLEARE
Laboratori Nazionali di Frascati

LNF-72/77
2 Ottobre 1972

G. Lucano, S. Pace, G. Parisi and G. L. Romani :
EXPERIMENTAL CHECK OF NON LINEAR EFFECTS IN Al THIN FILMS CLOSE TO T_c.

Servizio Documentazione
dei Laboratori Nazionali di Frascati del CNEN
Casella Postale 70 - Frascati (Roma)

Laboratori Nazionali di Frascati del CNEN
Servizio Documentazione

LNF-72/77
2 Ottobre 1972

G. Lucano[(x)], S. Pace[(x)], G. Parisi and G. L. Romani[(x)]: EXPERIMENTAL CHECK OF NON LINEAR EFFECTS IN Al THIN FILMS CLOSE TO T_c[(+)].

ABSTRACT. -

We refer on a first experimental verification for a theoretical predicted non linear electric field dependance of the extraconductivity in Al thin films very close to T_c.

Using a mean field approximation on the time dependent Ginsburg Landau equation (1), we derived a set of implicit equations which relate the electric field and the current in a thin film superconductor near to T_c. The solution of these equations yields an $F(J, E, T) = 0$ equation of state, which, in the zero electric field limit, becomes identical to the Aslamazov-Larkin[(2)] and Marcelja[(3)] results; for high electric fields but not too close to T_c one recovers Schmid's theory[(4)]. At non zero fields and close enough to the transition one gets more complicated relations which do not have simple expressions in terms of the elec

(x) - Istituto di Fisica dell'Università di Roma.
(+) - Work partialles supported by GNSM-CNR.

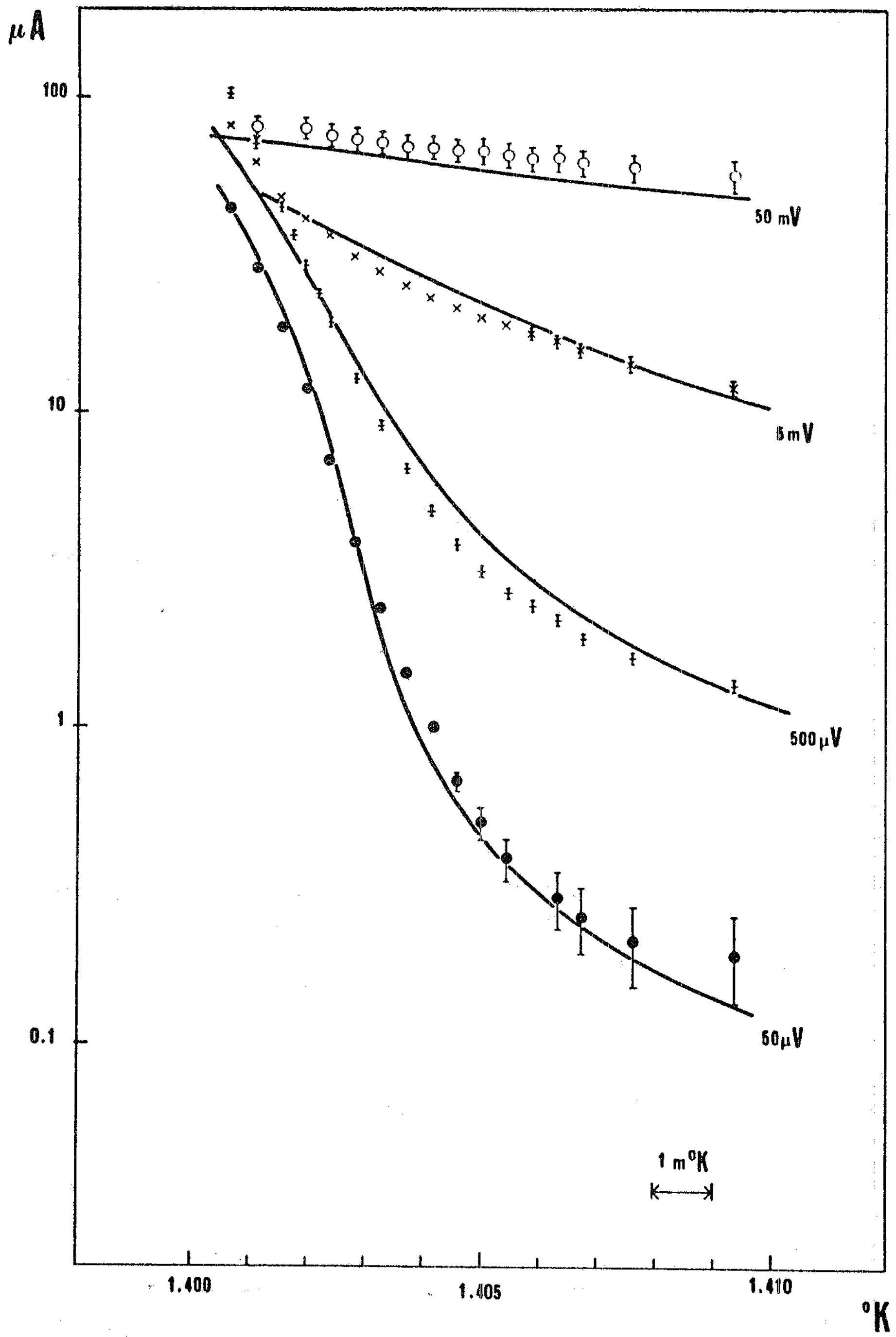

FIG. 1 - Excess current versus temperature at various constant electric field for a 220 Å Al cylindrical film. Dimensions: Diameter 3 mm, lengh 40 mm normal resistance $R_{\square} = 1.2\ \Omega_{\square}$, $T_{c_{Al}} = 1.404\ ^{o}K$, curves plotted correspond to the theoretical predictions (ref. 1).

tric field E.

We got a first experimental verification of this theoretical result studying a set of Al samples. The sample were obtained by standard vacuum evaporation techniques on cylindrical glasses.

Cylindrical shape was used to avoid every possi ble edge effect; geometrical dimensions of our films were: lenght 40 mm, diameter 3 mm, thickness ranging around 250 Å.

Electric measurement proved that the films were quite clean and homogeneous since they all had resistance per square ranging between 1 $\Omega_{\square}$ and 2 $\Omega_{\square}$ and, on the other hand, their transition region did never extend over more than 30 m°K.

During the experiment the earth magnetic field was reduced by means of a triple mu-metal shield and the sample was in termal contact with a liquid helium bath. The resistance measurements were made using a four terminal low noise d.c. technique. The temperature dependance of the normal conductivity was found to be smooth in the interesting range.

In fig. 1 results are shown, concerning one of our sample. In the same sample small current resistance measurements showed the existence of an Aslamazov Larkin like, region, which was 10 m°K wide; this data implies a transition temperature of 1.404°K and a film thickness of 220 Å which is in agreement with our previous rough evaluation. In the figure dots and crosses represent experimental values of the excess current versus temperature at four different electric field intensities.

The curves plotted represent a fit of the theoretical prediction(1) for all the four curves we used the same value of the microscopic fitting parameters. They were evaluated using a manual approssimation; a better fit may be obtained by a computer analysis.

As one can see our data are more close to the transition than earlier results(5, 6) and they do agree quite well with the theoretical predictions(1), not only above, but also a few m°K below the extrapolated Aslamozov Larkin transition temperature, where other theories(4, 6) becomes compleately useless.

Acknowledgements are due to M. Berardo for his technical assistance.

REFERENCES -

(1) - G. Parisi, Phys. Letters A, to be published.
(2) - L.G. Aslamozov and A.I. Larkin, Sov. Phys. - Solid State 10, 875 (1968); Phys. Letters 26 A, 238 (1968).
(3) - S. Marcelja, Phys. Letters 28 A, 180 (1968); S. Marcelja, W. E. Masker and R.D. Parks, Phys. Rev. Letters 22, 124 (1969).
(4) - A. Schmid, Phys. Rev. 180, 527 (1969).
(5) - R.O. Schmid, B. Serin and E. Abrahams, Phys. Letters 28 A, 224 (1968); G.A. Thomas and R.D. Park in Proc. Intern. Conf. on the Science of Superconductivity, Stanford University (1969); K. Kaijmura and N. Mitoshiba, Phys. Rev. Letters 26, 1233 (1971).
(6) - T. Tsuzuki, Prog. Theor. Phys. 43, 286 (1969).