Experimental Determination of the
Temperature Dependence of Metallic
Work Functions at Low Temperatures

Progress Report

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ABSTRACT

The progress made under AEC Contract No. AT(11-1)-2314(Mod 1) is described. This progress includes a theoretical study of a superconducting loop containing a Josephson junction with a temperature gradient across it, initiation of experiments to measure the temperature dependence of metallic work functions at low temperatures and the design and construction of a variable temperature cryostat for use in experiments on the effects of temperature gradients on superconductors.

The progress made in the past year under AEC Contract No. AT(11-1)-2314 (Mod 1) has been in three particular areas, 1) the theoretical study of a superconducting loop containing a Josephson junction with a temperature gradient across it, 2) completion of the system for measuring the temperature dependence of metallic work functions at low temperature and gathering of preliminary data on Nb, and 3) the design and construction of a variable temperature cryostat which can be inserted in a helium storage dewar for experiments on the effects of temperature gradients on superconductors. The detailed progress in these three areas is as follows:

1) A theoretical study of a superconducting loop containing a Josephson junction with a temperature gradient across it has been carried out and is described in detail in the attached preprint (Report no. C00-2314-3). This work was a direct result of preliminary calculations being done for the superconducting microbridge experiments which were initiated last year. The major result of these calculations is that a magnetic flux will be induced through a superconducting loop containing a Josephson junction across which a temperature difference is maintained. This flux is similar to that predicted by Garland and van Harlingen.¹

2) The cryostat for measuring the temperature dependence of work functions in metals has been finished and some data on Nb have been taken. In the initial runs the low temperature preamplifier described in report no. C00-2314-2 was installed, however there were problems with the gain calibration. It was decided to measure the gain in separate dip experiments and also to determine the gain stability after repeated thermal cycling. Thus at present a room temperature electrometer preamplifier is being used.

The shakedown runs with this cryostat have mainly been involved with isolating and eliminating noise sources. In addition to the noise sources enumerated in the original proposal for these experiments we have had to deal with such problems as inadequate building grounds and a rather strong RF interference from local radio stations. The grounding problem has been solved by arranging to float the entire cryostat and the electrometer preamplifier.

The present noise level of the system is about $5\mu\text{V}$ referred to the preamplifier input. We have hard evidence that a major portion of this is due to the odd harmonic response of the particular lock in detector we are using (PAR 128). Since we typically operate at 1Hz a large number of odd harmonics occur in a narrow band. A detailed comparison of our present system with the same system using a PAR 124A lock in detector borrowed from Princeton Applied Research has just been completed. This comparison shows that at least a factor of 10 can be gained by better harmonic rejection at the front end of the lock in detector.

As was stated earlier some preliminary data has been taken on Nb both at 77K and at 4.2K. The signal to noise was too low for these measurements to be used as anything more than an indication that a signal is visible. (These data were taken before the solution to the grounding problem was found.)

3) The third area in which progress has been made is related to the measurement of thermally induced supercurrents in superconducting microbridges. Early measurements of I-V characteristics of microbridges were hampered by interference from the local College radio station. It was decided to construct

a cryostat for these experiments that could be conveniently used in a screened room located in the Dartmouth Plasma Physics Laboratory.

A cryostat capable of operating between 1K and 300K has been designed and is in the final stages of assembly. We are taking advantage of the fact that our 25 liter helium storage dewar has a 1-1/2" diameter neck tube. Thus the cryostat can be inserted in this storage dewar after being precooled in liquid nitrogen. This will not only keep liquid helium and nitrogen consumption to a minimum but gives excellent RF shielding and makes the cryostat completely portable. RF filters are inserted in all the wiring in this cryostat. Measurements on the microbridges using this cryostat should begin in the next month or so.

The principal investigator devoted about 25% of his time to this project during the months of March-May, 1974 and September-November, 1974. During the months of June, July and August, 1974 the principal investigator worked on this project essentially full time. It is anticipated that he will devote about 25% of his time to the project between now and the end of the contract year.

REFERENCES

1. J.C. Garland and D.J. van Harlingen, Physics Letters 47A, 423 (1974)

ARTICLES PREPARED FOR PUBLICATION

1. U.J. Gibson and P.B. Pipes (submitted to Physical Review)
AEC Technical Report No. C00-2314-3