

Lawrence Berkeley National Laboratory

Recent Work

Title

THE ELECTRICAL RESISTANCE OF BISMUTH FROM 25 TO 90 KELOBARS

Permalink

<https://escholarship.org/uc/item/9p24f867>

Authors

Phillips, David
Jura, George.

Publication Date

1966-10-01

University of California
Ernest O. Lawrence
Radiation Laboratory

THE ELECTRICAL RESISTANCE OF BISMUTH FROM 25 TO 90 KILOBARS

TWO-WEEK LOAN COPY

*This is a Library Circulating Copy
which may be borrowed for two weeks.
For a personal retention copy, call
Tech. Info. Division, Ext. 5545*

Berkeley, California

DISCLAIMER

This document was prepared as an account of work sponsored by the United States Government. While this document is believed to contain correct information, neither the United States Government nor any agency thereof, nor the Regents of the University of California, nor any of their employees, makes any warranty, express or implied, or assumes any legal responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by its trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or the Regents of the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof or the Regents of the University of California.

UNIVERSITY OF CALIFORNIA

Lawrence Radiation Laboratory
Berkeley, California

AEC Contract No. W-7405-eng-48

THE ELECTRICAL RESISTANCE OF BISMUTH FROM 25 TO 90 KILOBARS

David Phillips and George Jura

October 1966

THE ELECTRICAL RESISTANCE OF BISMUTH FROM 25 TO 90 KILOBARS

David Phillips* and George Jura

Inorganic Materials Research Division, Lawrence Radiation Laboratory
Department of Chemistry
University of California, Berkeley, California

October, 1966

When Bridgman¹ determined the volume-pressure relationships of bismuth to 100 kg cm^{-2} , he found two small volume discontinuities at 45 and 64 kg cm^{-2} . Probably every investigator in high pressures has determined the electrical resistivity of bismuth in this pressure range. Until Zeitlin and Brayman² reported discontinuities in the resistance of bismuth at these pressures, no one had found resistance discontinuities that corresponded to the volume discontinuities at 45 and 64 kbars. Because of this report, we undertook a more careful determination of the resistance of bismuth as a function of pressure. Our results indicate that there is no discontinuity in the resistance that is greater than 0.1%. This is much smaller than the discontinuity reported by Zeitlin and Brayman.

The Bridgman anvils, bismuth wire sample, and method of sample mounting used here have been described elsewhere.³ The resistance of the sample, which was about 2 ohms, was measured with a Leeds and Northrup Mueller bridge. The room was air conditioned, and the maximum variation in room temperature (about 3°C) was so small that it was not necessary to consider the resistance change in the bridge leads. The anvils were kept in an oil bath which was thermostated to $28.0 \pm 0.1^\circ\text{C}$. The press has a large diameter

* Presently with Department of Chemistry, Miami University, Oxford, Ohio.

ram and low pressure oil system. A strain gauge in conjunction with a Baldwin-Lima-Hamilton SR-4 bridge was used for the determination of the load. The sensitivity of the load measurement was 25 bars. The stability of the press is such that in a period of 12 hours the load would decrease by no more than 0.5%. During the day, the load was monitored and kept within 0.1% of the assigned value.

The resistance of the sample through Phase II and in Phase "VIII" were determined in the usual fashion, about two minutes after each pressure increment. In the intermediate region, the region of interest, the sample was permitted to stand until a resistance reading was obtained that was constant in the fourth decimal, a part in 20,000. This took several hours after a compression of 2 kbars. The resistance came to within 0.2% in about two minutes and then drifted downward at a very slow rate for two or three hours afterwards. When all factors are considered, the relative accuracy of the various resistances in a given experiment should be less than 0.1%.

Three complete experiments were performed. In each case the behavior before and after the region of interest agreed closely with our previous work and that of other investigators. We found no indication of a resistance discontinuity in the 40 or 60 kbar region. We can only conclude that Zeitlin and Brayman obtained spurious results for some reason that we are not in a position to determine.

We found that the most satisfactory method of showing our results was to fit a least squares quadratic expression to our data, and then show the deviation from this fit. This is shown in Fig. 1. This representation is purely empirical and is not meant to imply that this is the correct

representation of the resistance of bismuth as a function of pressure. The average deviation of a single and all three determinations is 0.06%, a figure that is reasonable with our expected error. What is more important, there appears to be no systematic deviation.

The lack of discontinuity in the resistance cannot be taken as absolute proof that the phases reported by Bridgman do not exist. There are systems which do not exhibit a discontinuity in the resistance accompanying a phase change. Lanthanum is such a case.⁴

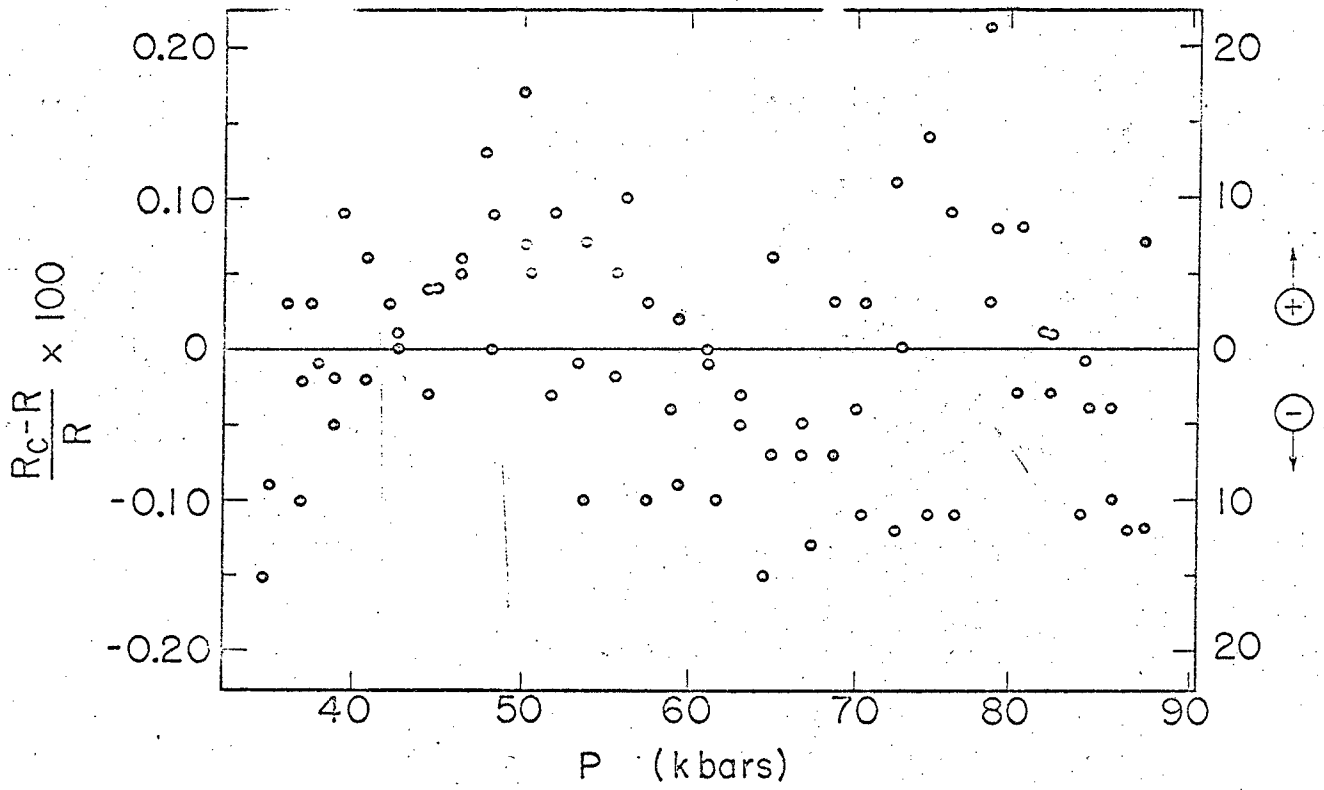
This work was performed under the auspices of the United States Atomic Energy Commission.

Footnotes

- (1) P. W. Bridgman, Proc. Am. Acad. Arts and Sci. 74, 425 (1942).
- (2) A. Zeitlin and J. Brayman, High-Pressure Measurement, A. A. Giardini and E. C. Lloyd, eds. (Butterworths, Washington, 1963), pp. 301-320.
- (3) P. W. Montgomery, H. D. Stromberg, G. H. Jura, and G. Jura, High-Pressure Measurement, A. A. Giardini and E. C. Lloyd, eds. (Butterworths, Washington, 1963), pp. 1-16.
- (4) D. McWhan, P. W. Montgomery, H. D. Stromberg, and G. Jura, J. Phys. Chem. 67, 2308 (1963).

Figure Caption

Fig. 1. Deviation of experimental points from an assumed quadratic curve fitted through the experimental points between 32 and 90 kbars. The results of three independent determinations are shown. Three points in which the deviation was greater than 0.25% are not shown. There is no indication of any transitions in the regions at 45 and 60 kbars.



MUB-4109

Fig. 1

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

- A. Makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or
- B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission, or employee of such contractor, to the extent that such employee or contractor of the Commission, or employee of such contractor prepares, disseminates, or provides access to, any information pursuant to his employment or contract with the Commission, or his employment with such contractor.

