

heat. The other two compounds are formed in a peritectic reaction.

3. The superconducting compound Bi_2Rb crystallizes in the cubic system with $a = 9.590 \pm 0.002$ kX and has a structure of the Cu_2Mg type.

4. An increase of the minimum interatomic spacing in Bi_2Rb relative to the isomorphic compound Bi_2K (Ref. 5) leads to an increase of the superconducting transition temperature from 3.58°K up to 4.25°K , analogous to the increase in T_c observed with increasing interatomic distances for compounds of bismuth with palladium,^{8,9} rhodium, and nickel.¹⁰

In conclusion we express our thanks to Professor N. E. Alekseevskii for valuable advice during the performance of the present research and to R. N. Kuz'min for aid in carrying out the experiments.

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STRUCTURE OF SUPERCONDUCTORS: XIII

INVESTIGATION OF BISMUTH - CESIUM ALLOYS

N. N. ZHURAVLEV

Moscow State University

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A provisional melting diagram is constructed for the Bi - Cs system. Three compounds were found: Bi_2Cs , BiCs_3 , and one which probably is BiCs_2 . The superconducting compound Bi_2Cs crystallizes in the cubic system with a lattice constant $a = 9.746 \pm 0.005\text{A}$ and is isomorphic with the superconducting compounds Bi_2K and Bi_2Rb .

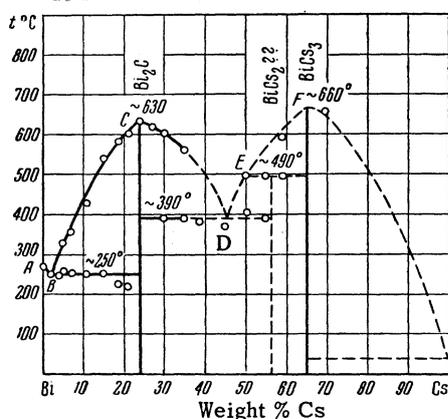
ACCORDING to experimental data,¹ certain bismuth - cesium alloys become superconductors at $T_c = 4.75^\circ\text{K}$. It is assumed that a bismuth - cesium compound which is rich in bismuth is responsible for the superconductivity of these alloys. The principal goal of the present study of bismuth - cesium alloys was to ascertain the composition and the atomic-crystalline structure of this compound.

The investigation of bismuth - cesium alloys was accompanied by certain difficulties connected with the large chemical activity of metallic cesium. Having located a small quantity of metallic cesium (~ 2 gm) we used the micromethods developed for an experimental study of bismuth - rubidium alloys² to prepare the samples and to analyze them physico-chemically.

PREPARATION AND THERMAL ANALYSIS OF THE ALLOYS

In preparing the alloys we used chemically pure bismuth and 99.99% pure cesium (the principal impurity was calcium). The melting was done in a small-gauge resistance oven. For the melting and for recording the cooling curves of the alloys with small cesium content we used quartz capsules of small volume (2–5 cm³). Samples with a large cesium content were melted in iron crucibles enclosed in the quartz capsules, just as was done for the bismuth–rubidium alloys.²

The heating and cooling curves were recorded with an electronic automatic potentiometer EPP-09 down to a temperature of 50–100°C. The weight of the alloys ranged from 0.2 to 1.0 gm. The results of the thermal analysis are presented in the figure in the form of a tentative melting diagram for the bismuth–cesium system.



Melting Diagram for the Bismuth-Cesium System

As cesium is added, the melting temperature of bismuth decreases along the line AB, reaching a minimum at about 250°C. The eutectic point lies at ~1–3% by weight Cs. From the eutectic point B the melting curve increases steadily along the line BC, reaching a maximum at about 630°C at the point C for 24.1% by weight Cs, which corresponds to the compound Bi₂Cs. An increase in the cesium content is accompanied by a falling melting curve; a eutectic stop appears on the cooling curves at ~390°C. Further increase in the cesium content of the alloy brings about a rise in the melting curve along the line DEF. At the point F the curve reaches a maximum at a temperature of about 660°C for an alloy composed of 65.6% by weight Cs, which corresponds to BiCs₃. For alloys with compositions lying in the region between the eutectic point D and the point F, temperature stops were observed at ~500°C. In our opinion these stops are related to a peritectic re-

action of formation of a compound which presumably consists of BiCs₂. Further increase of cesium in the alloy leads to a falling melting curve.

DETERMINATION OF THE STRUCTURE OF THE SUPERCONDUCTING COMPOUND Bi₂Cs

Samples of alloys with compositions close to that of Bi₂Cs were prepared for x-ray analysis in the same way as in the study of the structure of the compound Bi₂Rb,² except that as a protective liquid we used dekaline treated with cesium (maintained at a temperature of 150–170°C and stirred for 3 hours) in place of kerosene.

X-ray powder patterns were obtained with a RKU-86 camera by CuK α radiation of samples consisting of ~23% by weight Cs. According to microscopic data, such a sample contains mostly crystals of the compound Bi₂Cs and a small quantity of the eutectic Bi + Bi₂Cs. In order that the bismuth lines could be separated from the lines of the compound in the x-ray photograph, the sample was viewed with a slow rotation (one or two revolutions during the time of exposure), just as for the x-ray study of Bi₂Rb crystals.

From the x-ray photographs, the intensities I and the displacements of the lines were measured, and values of the interplanar distances d were calculated. All the lines of the x-ray photographs of Bi₂Cs crystals are indexed in the cubic system. A value of $a = 9.726 \pm 0.005$ kX was obtained for the period of the elementary cell of Bi₂Cs. The interplanar distances calculated from these data agree well with the measured values. As a result of the indexing and of a comparison of x-ray photographs of Bi₂Cs, Bi₂K, and Bi₂Rb, it is established that these three compounds are isomorphs. A comparison of the calculated and measured intensities shows good agreement and supports the assignment to Bi₂Cs crystals of a structure of the Cu₂Mg type. Below are given the minimum interatomic distances for crystals of Bi₂Cs:

Compound	Bi—Bi, Å	Bi—Cs, Å	Cs—Cs, Å
Bi ₂ Cs	3.44	4.04	4.22

The research which has been carried out permits us to perform a crystallochemical analysis of the group of superconducting compounds established as isomorphs: Bi₂K, Bi₂Rb, and Bi₂Cs. Considering the change of the period of the unit cell and the minimum interatomic spacings in these compounds as the atomic number of the alkali metal increases, it can be noted that an increase in the atomic number (atomic radius) of the alkali metal leads to an increase in the period of the unit cell of the compound and is accompa-

nied by an increase in T_c . This fact supports the correlation, mentioned in reference 3, between the temperatures at which the superconducting transition occurs and the position in the Mendeleev table of the metal forming the compound with the bismuth.

It is probable that the other group of compounds BiK_3 , BiRb_3 , and BiCs_3 are also isomorphs and have a structure of the Na_3As type.⁴ A series of compounds of arsenic, antimony, and bismuth with the alkali metals crystallizes in this type of structure: Li_3As , Na_3As , K_3As , $\alpha\text{-Li}_3\text{Sb}$, Na_3Sb , K_3Sb , Na_3Bi , and K_3Bi .

According to one author,⁶ the compound BiCs_3 , obtained by the method of successive precipitation of layers of bismuth and cesium by vacuum sublimation, can serve as a photo-cathode like the compound SbCs_3 , but among the group of compounds SbCs_3 , SbRb_3 , SbK_3 , and BiCs_3 it is the one least sensitive to light.

CONCLUSIONS

1. A tentative melting diagram has been constructed for the bismuth - cesium system.

2. Three compounds crystallize in the bismuth - cesium system: Bi_2Cs , BiCs_2 , and a compound which presumably consists of BiCs_2 . The compounds Bi_2Cs and BiCs_3 correspond to maxima on the melting diagram; the third compound is formed in a peritectic reaction.

3. The superconducting compound Bi_2Cs crystallizes in a cubic lattice with $a = 9.726 \pm 0.005$ kX and has a structure of the Cu_2Mg type.

4. Crystallochemical analysis shows that for the isomorphous group Bi_2K , Bi_2Rb , and Bi_2Cs , an increase in the period of the unit cell is accompanied by an increase in T_c .

We take this opportunity to express our deep gratitude to Professor G. S. Zhdanov and to Professor N. E. Alekseevskii for valuable discussions and for guidance during the performance of the present research, and to V. A. Smirnov for assistance in conducting the experiments.

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ANGULAR CORRELATIONS OF $\pi^+ - \mu^+ - e^+$ -DECAYS IN A PROPANE BUBBLE CHAMBER

V. V. BARMIN, V. P. KANAVETS, B. V. MOROZOV, and I. I. PERSHIN

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The result of projective treatment of 6760 $\pi^+ - \mu^+ - e^+$ -decay events photographed in a two liter propane bubble chamber is discussed. Assuming the angular distribution of decay positrons to be described by the formula $1 + a \cos\theta$, it is found that $a_{\text{prop}} = -0.19 \pm 0.03$. This result confirms the hypothesis of Lee and Yang of nonconservation of parity in weak interactions.

1. INTRODUCTION

THE hypothesis of Lee and Yang^{1,2} of non-conservation of parity and charge conjugation in weak interactions has been confirmed by a series of ex-

periments on β -decay and angular correlations in $\pi^+ - \mu^+ - e^+$ -decay. If parity is not conserved in the consecutive stages of the $\pi^+ - \mu^+ - e^+$ -decay, the angular distribution of the positrons will be given by the formula