Superconducting Alkaline Earth Compounds

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Intermetallic compounds between alkaline earths and noble metals have been discovered. They crystallize in the cubic Laves phase. Superconductivity is found in the rhodium and iridium systems.

IT has been established[1] earlier that no metallic systems with less than two or more than eight valence electrons per atom become superconducting above 1°K. The alkaline earths which have two valence electrons per atom are thus on the borderline and would therefore become superconducting only at very low temperatures, if at all. As also noted before, the only superconducting compounds of the alkaline earths that were known were those that formed with bismuth,[2,3] namely those given in Table I. Since bismuth itself is a superconductor,[4] many bismuth compounds are superconducting and, therefore, these alkaline earth compounds were not very informative as to the effect of the alkaline earths themselves.

For that reason we tried to find intermetallic compounds of the alkaline earth metals with other metals which would have an average valence electron per atom concentration that would fall in the range favorable for elevated superconducting transition temperatures. This implied that the average value had to be slightly below 3, 5, or 7. Those intermetallic phases were discovered by the combination of

AB_2: A = calcium, strontium, barium,
B = rhodium, palladium, iridium, platinum,

TABLE I. Superconducting alkaline earth—bismuth compounds.

	Transition temperature	Reference
$CaBi_3$	1.7°K	2
$SrBi_3$	5.62°K	3
$BaBi_3$	5.69°K	3

with the exception of $BaIr_2$. No compounds between alkaline earths and noble metals have been fully reported in the literature.* We prepared all compounds in iron crucibles under a helium atmosphere. Their crystal structure has cubic symmetry, isomorphous to $MgCu_2$, the cubic Laves phase. Five of these intermetallic systems were in fact superconductors and their transition temperatures are given in Table II. The compounds are well defined and have sharp transition temperatures. The exception is $CaIr_2$. In this system a wide homogeneity range exists with a corresponding variation of the transition temperature. When the initial composition is of stoichiometric proportions, the transition temperature is at the highest value.

TABLE II. Transition temperatures in °K of superconducting alkaline earth compounds.

	Rh_2	Ir_2
Ca	6.4°	4–6.15°
Sr	6.2°	5.7°
Ba	6.0°	...

The corresponding compounds with palladium and platinum, though isomorphous are not superconducting above 1.02°K. This is not too surprising considering their electron concentration is 7.33 electrons per atom as compared to 6.67 for the superconductors, a value much more favorable for the occurrence of superconductivity.

The crystallographic aspects of these compounds are being reported by E. A. Wood and V. B. Compton.[6]

[1] B. T. Matthias, Phys. Rev. **92**, 874 (1953).
[2] N. Alekseyevsky, J. Explt. Theoret. Phys. **20**, 863 (1950).
[3] B. T. Matthias and J. K. Hulm, Phys. Rev. **87**, 799 (1952).
[4] For a summary on superconducting bismuth, see C. J. Gorter, *Progress of Low Temperature Physics* (Interscience Publishers, Inc., New York, 1955), Vol. 1.

* After present investigation was completed, Th. Heumann and M. Kniepmeyer [Z. anorg. u. allgem. Chem. **290**, 191–204 (1957)] published a paper on the structure of the compounds of strontium with palladium, platinum, rhodium, and iridium.
[6] E. A. Wood and V. B. Compton, Acta Cryst. (to be published).