Synthesis, Structure and Physical Properties of the $REIr_3$ and RE_2Ir_7 Binary Iridates

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The family of compounds characterized by the general formula $RE_{2m+n}T_{4m+5n}$, where RE is a rare earth element and T is a transition metal, is of significance due to its structural complexity and wide range of observed physical properties. The m and n parameters determine the number of $MgCu_2$-type and $CaCu_5$-type structural blocks, respectively, thereby providing a systematic framework for understanding structural variations and their influence on the properties. The $REIr_3$ system (m = 1 and n = 1) is known to form in different crystal structure types, depending on the choice of the RE element and the post-synthesize annealing temperature.

In this lecture we will present synthesis, structural and physical studies of the rhombohedral ($PuNi_3$ type) $CeIr_3$, $PrIr_3$, $NdIr_3$ and $ThIr_3$. The key element in this family, which affects the physical properties, is the rare earth metal. While $LaIr_3$, $CeIr_3$ and $ThIr_3$ are superconductors with T_c = 3.5 K [1], 2.5 K [2] and 4.4 K [3], respectively. In contrast, the remaining two are classified as ferromagnets, with the Curie temperature T_{Curie} = 7.5 K ($PrIr_3$) [4] and 10.6 K ($NdIr_3$) [5]. Interestingly, at around 70 K, the both magnetic compounds reveal a structural phase transition. The rhombohedral R-3m crystal structure undergoes a transformation to a monoclinic C2/m structure upon cooling, and further cooling reveals temperature-independent behaviour of the unit cell volume.

We also report on the synthesis and study of the m = 1, n = 2 variant of this family, i.e. La_2Ir_7 and Ce_2Ir_7, which also form the in the rhombohedral crystal structure (Gd_2Co_7–type). Superconductivity was revealed through electrical resistivity and heat capacity measurements, with transition temperatures of T_c = 1.4 K and 1.6 K for La_2Ir_7 and Ce_2Ir_7, respectively. Thermodynamic and transport measurements demonstrate that both compounds are type-II superconductors, exhibiting a fully opened superconducting gap and weak electron-phonon coupling. The experimental results will be analyzed alongside the theoretical calculations.

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