

Charge density wave of $A_3T_4Sn_{13}$

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In the field of solid-state physics, the relationship between superconductivity and charge density wave (CDW) is one of the central research topics. Superconductivity is a phenomenon in which a material exhibits zero electrical resistance below a certain critical temperature. In contrast, a CDW is a state in which the electron density periodically modulates, forming a wave-like pattern. Traditionally, superconductivity and CDW have been considered competing phenomena, since the formation of a CDW opens a gap in the electronic band structure, potentially suppressing superconductivity. However, recent studies have suggested that under certain conditions, these two phenomena may coexist.

Particularly in the $A_3T_4Sn_{13}$ family of compounds, the coexistence of CDW and superconductivity has been reported, drawing significant attention in recent years [1]. Understanding how these two phenomena coexist could lead to the discovery of novel physical phenomena and open up new possibilities for technological applications. The wave vector of the CDW reflects the interaction between the electronic states and the lattice structure within the material, making it a crucial parameter in exploring the coexistence of superconductivity and CDW. By clearly identifying the CDW wave vector, it is expected that the underlying mechanism of this coexistence can be clarified, offering new insights into unresolved issues in solid-state physics. The aim of this study is to identify the CDW wave vector in $A_3T_4Sn_{13}$ compounds and to investigate in depth its physical characteristics and its relationship with superconductivity. The objective of this study is to precisely determine the wave vector of the CDW observed in $A_3T_4Sn_{13}$ compounds by analyzing superlattice reflections and to elucidate its characteristics. Superlattice reflections originating from the CDW have

previously been reported, through powder X-ray diffraction (XRD) experiments, and are therefore expected to be observable in this study as well. The samples investigated in this study were $La_3Ru_4Sn_{13}$, $La_3Co_4Sn_{13}$, $Pr_3Ru_4Sn_{13}$, and $Pr_3Co_4Sn_{13}$, all of which belong to the $A_3T_4Sn_{13}$ family and are potential candidates for exhibiting CDW behavior. Figure 1 shows a representative powder neutron diffraction pattern of $La_3Ru_4Sn_{13}$. At 3 K, no superlattice reflections were observed. The same result was obtained for $Pr_3Ru_4Sn_{13}$. These findings suggest that the superlattice reflections observed in the Co-based compounds are suppressed by the choice of transition metal. Superlattice reflections, which are present in the Co-based compounds, were not observed in either $La_3Ru_4Sn_{13}$ or $Pr_3Ru_4Sn_{13}$ at 3 K, as shown in the diffraction pattern of $La_3Ru_4Sn_{13}$ in Fig. 1. This indicates that the presence of superlattice reflections is suppressed by the type of transition metal, in this case Ru.

[1] Y. J. Hu et al., Phys. Rev. B, 95, 155142 (2017).

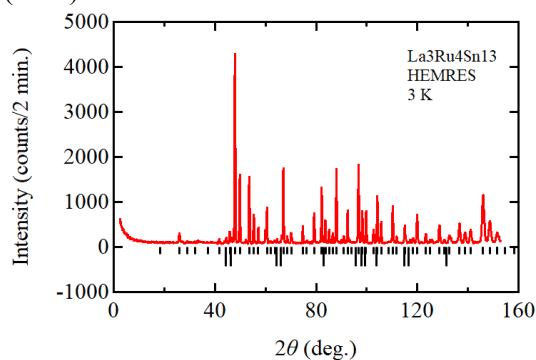


Fig. 1. Neutron diffraction patterns of $La_3Ru_4Sn_{13}$. Bragg bars represents the Bragg position of $La_3Ru_4Sn_{13}$ and Sn (flux)