

# Doping effect on the electronic structure and thermodynamic properties in $\text{Ce}_3\text{Ru}_4\text{Sn}_{13}$

L. Kalinowski,<sup>1</sup> J. Goraus,<sup>1</sup> P. Witas,<sup>1</sup> and A. Ślebarski<sup>1,2</sup>

<sup>1</sup>*Institute of Physics, University of Silesia,  
Uniwersytecka 4, 40-007 Katowice, Poland*

<sup>2</sup>*Centre for Advanced Materials and Smart Structures,  
Polish Academy of Sciences, Okólna 2, 50-950 Wrocław, Poland*

A comprehensive study of heat and electric transport, magnetic, and electronic structure (experiment and calculations) properties is reported for a skutterudite-related  $\text{Ce}_3\text{Ru}_4\text{Sn}_{13}$  heavy fermion system with the respective substitution of Co and Sb into Ru and Sn sites.  $\text{Ce}_3\text{Ru}_4\text{Sn}_{13}$  is obtained as a heavy fermion system with high electronic contribution to the specific heat  $C(T)/T$  of  $\approx 3\text{J}/\text{K}^2\text{mol}_{\text{Ce}}$ , and a significant Schottky anomaly below about 10 K. The complex study gives a consistent interpretation of the impact of doping on the crystal electric-field effect and Kondo temperature. For  $\text{Ce}_3\text{Ru}_4\text{Sn}_{13}$  we report a field-induced phase transition between the magnetically correlated heavy fermion phase and the single-ion Kondo impurity state, which does not depend on the type of dopant. We also demonstrate that doping does not improve the poor thermoelectric properties of  $\text{Ce}_3\text{Ru}_4\text{Sn}_{13}$ .

## References:

[1] L. Kalinowski, J. Goraus, P. Witas and A. Ślebarski, Physical Review B 94, 235151 (2016)