Properties near magnetic instability of heavy-electron compounds $Ce_3M_4Sn_{13}$ and $La_3M_4Sn_{13}$, with M = Co, Rh, and Ru

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In $Ce_3M_4Sn_{13}$ filled cage Kondo systems, where M = Co, Rh, or Ru, thermoelectricity can be strongly enhanced at the low temperatures as a result of sharp features in the electronic density of states at the Fermi energy and the *rattling* effects. Therefore these materials are considered as candidate for low-temperature thermoelectric cooling applications. $Ce_3M_4Sn_{13}$ and $La_3M_4Sn_{13}$ have also generated much interest due to their wide physical properties including quantum criticallity and superconductivity. $Ce_3M_4Sn_{13}$ show a cross-over from a magnetically correlated heavy fermion state to a single impurity state in applied magnetic fields. In order to study the proximity of $Ce_3M_4Sn_{13}$ to the possible magnetic quantum critical point, we investigated the system of $Ce_{3-x}La_xM_4Sn_{13}$ alloys and found a critical behaviour near $x \sim 0.6$. The low-temperature thermodynamic properties of $Ce_3Ru_4Sn_{13}$ are determined by crystal field and Kondo effects. Specific heat and resistivity data show that $La_3M_4Sn_{13}$ are typical BCS superconductors below T_c, however, $La_3Rh_4Sn_{13}$ and $La_3Ru_4Sn_{13}$ exhibit a second superconducting phase between T_c and $T_c^\star$ ($T_c < T_c^\star$), characteristic of inhomogeneous superconductors.