Pronounced superconducting dome and phonon softening at a structural quantum critical point: $Lu(Pt_{1-x}Pd_x)_2In$

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Puzzling out cause and effect of novel phase transitions is one of the most appealing tasks in modern solid state physics. We recently discovered Lu(Pt1-xPdx)2In to present a very rare case of strongly enhanced superconductivity at a structural quantum critical point (QCP). This system provides an exceptional opportunity to study the connection between a structural QCP, phonon softening and superconductivity.

We synthesized the new Lu(Pt1-xPdx)2In series with a large number of intermediate concentrations to study their structural and electronic properties. We found that at high temperatures all compounds crystallize in the simple cubic Heusler structure. In LuPt2In susceptibility χ(T), resistivity ρ(T), temperature-dependent powder X-ray diffraction and neutron data evidence a charge density wave (CDW) type phase transition at about 490 K to a new cubic superstructure. The temperature dependence of the anomalies in χ(T) and ρ(T) indicate a 2nd order type transition. Substituting Pd for Pt in Lu(Pt1-xPdx)2In results in a continuous suppression of the transition temperature, indicating a structural QCP at xc ≈ 0.58. For concentrations higher than 0.58 all compounds retain in the Heusler structure down to lowest temperature.

Most interestingly, we observed bulk superconductivity in the whole alloy series, with a clear maximum of the SC transition temperature at xc. Furthermore, low temperature specific heat measurements and inelastic neutron scattering give evidence to critical phonon softening at xc. These results provide new insight into structural QCPs.