Non-Divergent Grüneisen Parameter in Quantum-Valence-Critical Quasicrystal

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Unconventional quantum criticality discovered in the heavy-electron quasicrystal (QC) $Yb_{15}Al_{34}Au_{51}$ has attracted much interest [1]. The criticality is common to those observed in periodic crystals β-$YbAlB_4$ [2] and α-$YbAl_{1-x}Fe_xB_4$ (x=0.014) [3], which is well explained by the theory of critical Yb-valence fluctuations (CVF) [4]. Recently, experimental evidence of the quantum valence criticality has been observed in α-$YbAl_{1-x}Fe_xB_4$ (x=0.014) [3].

Very recently, lattice-constant dependence of the Yb valence in the QC $Yb_{15}(Al, Ga)_{34}(Au, Cu)_{51}$ has been observed [5], which reveals that $Yb_{15}Al_{34}Au_{51}$ is located at just the point where the Yb valence starts to change sharply as a function of the lattice constant. This behaviour is shown to be explained by the theoretical analysis of the 1/1 approximant crystal (AC) $Yb_{14}Al_{35}Au_{51}$, which indicates that the QC $Yb_{15}Al_{34}Au_{51}$ is located at the quantum critical point (QCP) of the Yb-valence transition [6].

Recently, *non*-divergent Grüneisen parameter Γ toward the lowest temperature T =70 mK has been observed in the QC $Yb_{15}Al_{34}Au_{51}$[7]. Surprisingly, its absolute value |Γ| at T =70 mK is smaller than that in the AC $Yb_{14}Al_{35}Au_{51}$, which shows the Fermi-liquid behavior. This poses a serious challenge to the conventional understanding that |Γ| diverges at *any* QCPs [8].

To clarify the mechanism, first we construct the complete framework for calculating the specific heat C, the thermal-expansion coefficient α, and the Grüneisen parameter Γ near the magnetic QCP on the basis of the theory of spin fluctuations [9]. Then, we apply this formalism to the case of the CVF near the QCP of the valence transition. We show that the measured behaviors of C, α, and Γ in the QC $Yb_{15}Al_{34}Au_{51}$ are naturally explained, which are consistent with the robust criticality under pressure [10]. The difference in Γ at the lowest temperature between the QC and AC is shown to reflect the difference in the pressure derivative of characteristic energy scales of the CVF and the Kondo temperature [10].

In the presentation, we discuss these newly clarified aspects of the quantum critical phenomena in strongly-correlated electron systems on periodic and aperiodic crystals.

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