Electronic States near Quantum Critical Points of Valence Transition

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Recently, Mott transition attracts much attention since new universality class has been identified as the marginal critical point at which the first-order metal-insulator transition terminates at zero temperature [1,2]. Valence transition provides a prototype of a metal-to-metal first-order transition with the critical end point (CEP), which is known to be realized as α-γ transition in Ce metal [3]. When the CEP is suppressed toward zero temperature, enhanced valence fluctuation coupled with the Fermi surface instability is considered to be a key mechanism to cause electronic instability. Actually, in some Ce compounds as $CeCu_2Ge_2$ [4] and $CeCu_2Si_2$ [5], the superconducting transition temperature increases remarkably in the pressure range where the valence of Ce changes drastically.

To get insight into the nature of the CEP in the quantum degeneracy regime, the quantum valence transition is studied on the basis of the periodic Anderson model as a minimal model for the Ce systems [6]. The density matrix renormalization group calculation for the ground state shows that the first-order valence transition emerges with the quantum critical point with diverging valence susceptibility. Instead of the phase separation shown by the mean-field theory, quantum fluctuations generate a wide region of crossover between the Kondo and mixed valence states. It is found that the superconducting correlation is developed in the Kondo regime near the quantum critical point of the valence transition. The origin is ascribed to the enhanced coherent motion of electrons with valence fluctuation, but not to the enhancement of the charge compressibility. Remarks on the valence transition are also given in connection with Ce compounds and Ce metal.

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