(PS4)

Magnetic Field Induced Antiferromagnetism in a Two-Dimensional Hubbard Model: analysis of $CeRhIn_5$

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We propose the mechanism for the magnetic field induced AFM state in a two-dimensional Hubbard model in the vicinity of the antiferromagnetic (AFM) quantum critical point (QCP), using the fluctuation-exchange (FLEX) approximation by taking the Zeeman energy due to magnetic field $\mathbf{B}$ into account. In the vicinity of the QCP, we find that the AFM correlation perpendicular to $\mathbf{B}$ is enhanced, whereas that parallel to $\mathbf{B}$ is reduced. This fact means that the finite magnetic field enhances $T_{\rm N}$, with the AFM order perpendicular to $\mathbf{B}$. The obtained result naturally explains the increment of $T_{\rm N}$ in $CeRhIn_5$ and Ce_2RhIn_8 under the magnetic field. The increment of $T_{\rm N}$ can be understood in terms of the reduction of both the quantum and the thermal fluctuations due to the magnetic field, which is brought by the self-energy effect within the FLEX approximation. It is called the mode-mode coupling effect in the SCR theory.

We study the magnetic-filed dependence of the Néel temperature $T_{\rm N}$ by assuming a weak three-dimensional coupling. To simplify the analysis, we define $T_{\rm N}$ in the presence of the magnetic field under the condition that $\max_{\mathbf{q}} U\chi^0_{\uparrow,\downarrow}(\mathbf{q},0) = \alpha^0_{\rm S}$, where the left-hand side give the Stoner factor ($\chi^0_{\uparrow,\downarrow}(\mathbf{q},0)$ being the irreducible susceptibility given by the FLEX approximation), and $\alpha^0_{\rm S}$ is a constant which is slightly smaller than one. The figure shows the field dependence of $T_{\rm N}$ given by the FLEX approximation, for several choice of $\alpha^0_{\rm S}$'s. We find that the field-enhancement of the Néel temperature in nearly AFM metals in two dimensions, which has been pointed out in the present work for the first time. In the figure, $T_{\rm N}$ starts to increase in proportion to B^2, and it almost saturates around $B^* \sim 0.3$. This result also means that the system approaches to the AFM-QCP by applying the magnetic field.

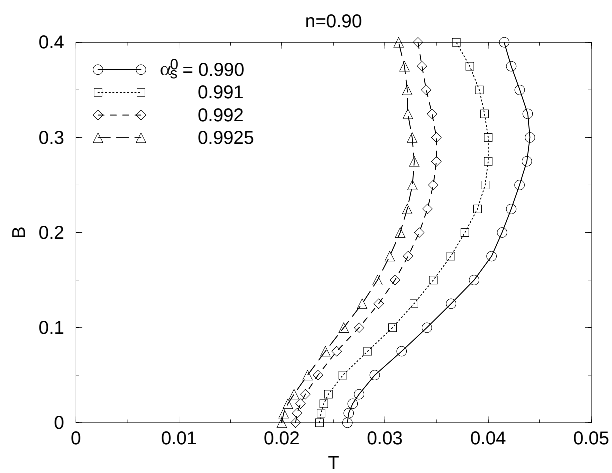

Figure 1: Obtained phase diagram for $T_{\rm N}$ versus B for various $\alpha^0_{\rm S}$'s in a square-lattice Hubbard model with $n = 0.90$, $U = 5$ and $T = 0.02$.