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Spin and charge correlations around a magnetic impurity

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We study the Kondo model —a magnetic impurity coupled to a one-dimensional wire via exchange coupling— by using Wilson's numerical renormalization group technique. By applying an approach similar to which was used to compute the two-impurity problem we managed to improve the poor spatial resolution of the numerical renormalization group method. In this way we have calculated the impurity-spin conduction-electron-spin correlation function which is a measure of the Kondo compensation cloud whose existence has been a long-standing problem in solid-state physics.

We also show that the long distance charge density oscillations in a metal induced by a weakly coupled spin-1/2 magnetic impurity exhibiting the Kondo effect are given, at zero temperature, by a universal function $F(r/\xi_K)$ where r is the distance from the impurity and ξ_K, the Kondo screening cloud size $= v_F/T_K$, where v_F is the Fermi velocity and T_K is the Kondo temperature.

In addition to those, we present results on the prototype of the underscreened models, the $S = 1$ single channel Kondo model. We demonstrate that the singular dynamics of the underscreened Kondo model modifies essentially the spin correlations as compared to the fully screened case: In contrast to the spin-$\frac{1}{2}$ model, its powerlaw decay obtains now only logarithmic corrections for $x > \xi_K$, and its long-distance tail is thus more pronounced than in the fully screened case. We demonstrate that this numerically observed tail of the "underscreening cloud" is in agreement with the expectations of an effective ferromagnetic spin-$\frac{1}{2}$ Kondo model describing the scattering off the residual magnetic moment.