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Entanglement of Impurities in Spin Chains[1] ERIK SORENSEN, McMaster, NICOLAS LAFLORENCIE, UP-sud, MING-SHYANG CHANG, IAN AFFLECK, UBC — Entanglement in $J_1 - J_2$, $S = 1/2$ quantum spin chains with an impurity is studied using analytic methods as well as large scale numerical density matrix renormalization group methods. The impurity contribution to the uniform part of the entanglement entropy, S_{imp}, is defined and analyzed in detail in both the gapless, $J_2 \leq J_2^c$, as well as the dimerized phase, $J_2 > J_2^c$, of the model. This quantum impurity model is in the universality class of the single channel Kondo model and we show that in a quite universal way the presence of the impurity in the gapless phase, $J_2 \leq J_2^c$, gives rise to a large length scale, ξ_K, associated with the screening of the impurity, the size of the Kondo screening cloud. The universality of Kondo physics then implies scaling of the form $S_{imp}(r/\xi_K, r/R)$ for a system of size R. At the critical point, J_2^c, an analytic approach based on a Fermi liquid picture, valid at distances $r \gg \xi_K$ and energy scales $T \ll T_K$, is developed and analytic results at $T = 0$ and $T \neq 0$ are obtained. In the dimerized phase an appealing picture of the entanglement is developed in terms of a *thin soliton* (TS) ansatz permitting variational calculations and the notions of impurity valence bonds (IVB) and single particle entanglement (SPE) are introduced.

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