Clarification of Quantum Criticality by Spin-echo decay method

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In order to diagnose the nature of quantum criticality, we have used the nuclear spin-echo decay rate $1/T_{2G}$, which is related to the static magnetic susceptibility at $q = Q$: $\mathrm{Re}\chi(Q,0)$, in combination with the spin-lattice relaxation rate $1/T_1T \propto [\mathrm{Im}\chi(Q,\omega)/\omega]_{\omega\sim 0}$. Based on the dynamical scaling law, the magnetic spin-spin correlation length ξ may be expressed as $1/(T_1T) \sim \xi^{z-1-\eta} \sim \xi^{z-1}$ and $(1/T_{2G})^2 \sim \xi^{1-2\eta} \sim \xi$ for the $d = 3, \eta = 0$ case. In the $d = 3$ antiferromagnetic heavy fermion compound USn_3, which is near a QCP, data for $(1/T_{2G})^2$ show that $\xi \propto T^{-3/4}$ above 100 K, as is expected for the quantum critical regime of a spin density wave (SDW) magnetic instability [1]. Observation that $T_1T/T_{2G}^2 \sim \xi^{2-z}$ remains T-independent at low temperatures leads to categorisation of the heavy fermion state of USn_3 in the overdamped regime with a dynamical critical exponent $z = 2$. We discuss the origin of the difference between the standard SDW and Kondo-breakdown type of quantum criticality in terms of new T_{2G} results in $YbRh_2Si_2$.

[1] S. Kambe, H. Sakai, Y. Tokunaga, T.D Matsuda, Y. Haga, H. Chudo and R.E. Walstedt, Phys. Rev. Lett. **102**, 037208 (2009).