Universal and measurable entanglement in the spin-boson model
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HUR, Department of Physics, Yale University; Departement de Physique, Universite de Sherbrooke — We study the entanglement between a qubit and its envi-
ronment by calculating the von Neumann entropy of the spin in the delocalized
phase of the spin-boson model. Using a well-known mapping between the spin-
boson model with Ohmic dissipation and the anisotropic Kondo model, we obtain
exact results for the entanglement entropy $E$ at arbitrary dissipation strength $\alpha$ and
level asymmetry $h$. We show that the Kondo energy scale $T_K$ controls the entan-
glement between the qubit and the bosonic environment. For $h \ll T_K$, we find that
$E = E(h = 0) - \frac{2\alpha^{b/(2-2\alpha)}\Gamma[1+1/(2-2\alpha)]}{\pi\ln 2\Gamma[1+\alpha/(2-2\alpha)]} (\frac{h}{T_K})^2$, where $b = \alpha \ln \alpha + (1 - \alpha) \ln(1 - \alpha)$.
The universal $(h/T_K)^2$ scaling reflects the Fermi liquid nature of the Kondo ground
state. In the limit $h \gg T_K$, $E$ vanishes as $(T_K/h)^{2-2\alpha}$, up to a logarithmic cor-
rection. We thoroughly explore the phase space $(\alpha, h)$; for a given $h$, the maximal
entanglement occurs in the crossover regime $h \sim T_K$. We also emphasize the possi-
bility of measuring this entanglement using charge qubits subject to electromagnetic
noise.

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