Magnetic cooling through quantum criticality

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The proximity of a quantum critical point can significantly affect a material's thermodynamic properties even at finite temperatures. Here we demonstrate that the accumulation of entropy around a B-induced quantum critical point opens up new possibilities for realizing a very efficient low-T magnetic coolant. For the proof of principle, we focus on a simple model substance - a Cu^{2+}-containing coordination polymer $[Cu(\mu\text{-}C_2O_4)(\text{4-aminopyridine})_2(H_2O)]_n$ - a very good realization of a spin-1/2 antiferromagnetic Heisenberg chain with a weak intrachain coupling constant $J/k_B = (3.2 \pm 0.1)\,\mathrm{K}$, corresponding to a saturation field $B_s = 4.09\,\mathrm{T}$. To investigate its potential as a coolant, demagnetization experiments have been performed from $B_i > B_s$ under almost adiabatic conditions. While the cooling process is initially linear in B - such as is seen in standard paramagnets - it becomes superlinear upon approaching the QCP at B_s. In addition, the quantum critical system excels by its high efficiency $\Delta Q_c/\Delta Q_m$, which exceeds the figures found in state-of-the-art paramagnetic coolants by a factor 2-3. Here ΔQ_c is the heat the material can absorb after demagnetization to a final field B_f, and ΔQ_m the heat of magnetization released to a precooling stage held at a temperature T_i, the initial temperature of the cooling process.