Introduction to Quantum Phase Transitions

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An introduction to the basic concepts of quantum phase transitions will be presented [1,2]. We start with a general discussion of the scaling hypothesis, the phase diagram, its crossovers and the quantum critical thermodynamics. Afterwards we introduce various specific examples of quantum critical systems. First, we introduce the superfluid-insulator transition and the dilute Bose gas. Second, quantum phase transitions in magnetic insulators will be discussed with a particular focus on low-dimensional spin systems like chains and ladders. Third, we review quantum phase transition in metals. We introduce the Hertz-Millis model and discuss its successes and shortcomings.

[1] S. Sachdev, *Quantum phase transitions*, 2nd Edition (Cambridge University Press, 2011)

[2] M. Vojta, *Thermal and Quantum Phase transitions*, Lectures given at the Les Houches Doctoral Training School in Statistical Physics 2015, `http://statphys15.inln.cnrs.fr`

[3] Ch. Rüegg et al., Phys. Rev. Lett. **101**, 247202 (2008)

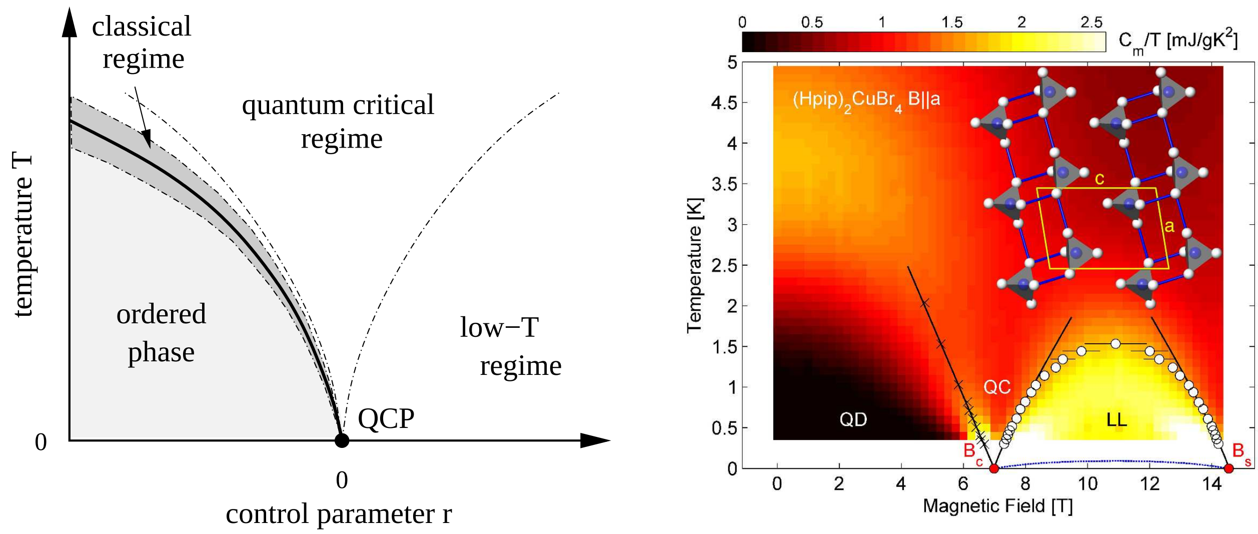

Figure 1: Left: Generic phase diagram with a quantum critical point (QCP) at temperature $T = 0$ between a disordered and an ordered phase as a function of a control parameter r. Here, the ordered phase extends to finite temperatures giving rise to a line of classical transitions emanating from the QCP. Right: Phase diagram of the spin-ladder material $(Hpip)_2CuBr_4$ which shows two quantum phase transitions as a function of magnetic field [3]. In the regime between the two critical fields the spin excitations are described by the Luttinger liquid (LL) theory.