Magnetothermal transport in spin chain materials

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Properties of materials in the vicinity of quantum phase transitions have recently attracted considerable attention. Of particular interest are transitions between various gapless and gapped states, induced in low-dimensional magnetic systems by an external magnetic field. We present and discuss experiments on the magnetic field dependent thermal transport in several one-dimensional spin S=1/2 and S=1 systems. In the S=1/2 Heisenberg chain material $Cu(C_4H_4N_2)(NO_3)_2$, a magnetic field induces a transition between the gapless Luttinger liquid (LL) state and the gapped fully spin-polarized state. The S=1/2 spin-ladder system $(C_5H_{12}N)_2CuBr_4$ has a finite gap in zero field. With increasing magnetic field the spin gap is first closed, leading to either the LL state or the ordered AFM state, and then reopens at higher fields. In the S=1 Haldane chains in $Ni(C_2H_8N_2)_2NO_2(ClO_4)$, the size of the energy gap can be greatly reduced by applying an external magnetic field. Finally, the S=1 chain system with strong easy-plane anisotropy $NiCl_2$-$4SC(NH_2)_2$ undergoes a transition from a gapped state to an XY-like AFM state. The thermal conductivity κ of all these materials is found to be strongly affected by the respective transitions. We discuss differences and similarities in the observed $\kappa(T, B)$ dependences aiming at establishing the transport mechanisms responsible for the observed behavior. In some cases, it is possible to clearly distinguish the magnetic and the phononic contributions to the total conductivity and to successfully analyze the spin contribution in terms of quasiparticle models. For example, the model of heat transport by Jordan-Wigner spinless fermions seems suitable for the case of the S=1/2 Heisenberg chain. However, some features of the observed $\kappa(T, B)$ dependences, especially those likely related to the interactions between the spin and lattice excitations, remain to be explained.