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Temporal correlations in tunable Luttinger spin liquids

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Landau's theory of Fermi liquids, which is the cornerstone of our understanding of fermionic systems, breaks down in low dimensions. In one dimension, interacting fermions are in a quantum critical state with some fascinating universal thermodynamic properties and correlation functions. This particularly interesting case is quantitatively described by the so-called Luttinger liquid theory. The cleanest real-world realizations of this model are found in low-dimensional spin systems [1], such as in Heisenberg spin chain and ladder materials. The universal scaling relations in these Luttinger spin liquids can be tested experimentally. In this quest, neutron scattering has proven to be instrumental, as it provides direct access to spatial and temporal correlation functions. In classic previous studies [2,3], this technique has been employed to measuring finite-temperature scaling in the simplest spin chain models. The latter are described by Luttinger liquid theories with the so-called Luttinger parameter K=1/2, corresponding to a strong repulsion between particles. The new challenge is to investigate the scaling for other values of K, particularly in systems with K>1 (attractive fermions). In experiments, K and other characteristics of Luttinger spin liquids can be, in principle, tuned continuously by the application of an external magnetic field. In practice, measurements under such conditions are extremely challenging due to several unexpected technical difficulties. Nevertheless, recent advances in neutron instrumentation, particularly at pulsed neutron sources, help overcome these obstacles. In my talk I shall review the most recent results of experimental studies of Luttinger liquid properties of low dimensional quantum magnets under high magnetic fields. I will cover spin chain materials where K is continuously tunable in the range 1/2<K<1, and the strong leg spin ladder compound DIMPY where K>1 was achieved for the first time [4-6]. I will also describe how residual 3-dimensional interactions, usually considered a nuisance for low-dimensional physics, can in certain cases be exploited to accurately measure the exact field dependencies of all relevant one-dimensional Luttinger parameters.

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