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Title: Hydrodynamic theory of interacting spinon liquid in quantum spin chains.

Quasiparticles of the Heisenberg spin-1/2 chain — spinons — represent the best experimentally accessible example of fractionalized excitations known to date. Dynamic spin response of the spin chain is typically dominated by the broad multi-spinon continuum that often masks subtle features, such as continuum edge singularities, induced by the interaction between spinons. This, however, is not the case in the small momentum region of the magnetized spin chain where strong interaction between spinons leads to qualitative changes in the response.

We present hydrodynamic theory of the dynamic spin susceptibility of the antiferromagnetic spin-1/2 XXZ Heisenberg chain with a uniform Dzyaloshinskii-Moriya (DM) interaction and an external magnetic field. The theory is based on equations of motion for magnetization densities and currents that follow from Kac-Moody algebra of spin current operators. We find that backscattering interaction between spinons strongly affects dynamic response and produces finite energy splitting between optical branches of excitations at small momenta [1]. Our approximate analytical calculations are in good agreement with numerical DMRG results.

We also report experimental verification [2] of this approach by the electron spin resonance (ESR) experiments on a model material $K_2CuSO_4Br_2$. We exploit the unique feature of the material — the uniform DM interaction between chain spins — in order to access the small momentum regime of the dynamic spin susceptibility. By measuring interaction-induced splitting between the two components of the ESR doublet we directly determine the magnitude of the marginally irrelevant backscattering interaction between spinons for the first time. We find it to be in excellent agreement with the predictions of the field theory.

[1] Ren-Bo Wang, Anna Keselman, Oleg A. Starykh, Phys. Rev. B **105**, 184429 (2022).
[2] Kirill Yu. Povarov, Timofei A. Soldatov, Ren-Bo Wang, Andrey Zheludev, Alexander I. Smirnov, Oleg A. Starykh, Phys. Rev. Lett. **128**, 187202 (2022).