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Abstract for an Invited Paper
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Momentum space entanglement in quantum spin chains

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I will discuss work performed in collaboration with R. Thomale and A. Bernevig (*Phys. Rev. Lett.* **105**, 116805 (2010)) on entanglement spectra in spin chains. Typically, bipartite entanglement entropy and spectra have been studied in the case of spatial partitions, *i.e.* A denotes the left half of a spin chain, B the right half, $\rho_{\mathrm{A}} = \mathrm{Tr}_{\mathrm{B}}|\Psi_0\rangle\langle\Psi_0|$ is the reduced density matrix, and $\mathrm{spec}(\rho_{\mathrm{A}})$ is the entanglement spectrum (ES). We find for the $S = \frac{1}{2}$ Heisenberg model that a remarkable structure in the ES is revealed if the partition is performed in momentum space, *i.e.* A = left-movers and B = right-movers. Further classifying the entanglement eigenstates by total crystal momentum, we observe a universal low-lying portion of the ES with specific multiplicities separated from a higher-lying nonuniversal set of levels by an *entanglement gap*, similar to what was observed by Li and Haldane (*Phys. Rev. Lett.* **101**, 010504 (2008)) for the fractional quantum Hall effect. Indeed, the momentum space ES for the Heisenberg chain is understood in terms of the proximity of the Haldane-Shastry model, which corresponds to a fixed point with no nonuniversal corrections, and whose ground state wavefunction is related to that for the $\nu = \frac{1}{2}$ Laughlin state. We further explore the behavior of the ES as one tunes through the spin-Peierls transition in a model with next-nearest- neighbor exchange. We also discuss entanglement gap scaling and applications to other systems.