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Spin Seebeck Effect of Triangular-lattice Spin Supersolid

Using the developed thermal tensor-network approach, we investigate the spin Seebeck effect (SSE) of the triangular-lattice quantum antiferromagnet hosting spin supersolid phase. We focus on the low-temperature scaling behaviors of the normalized spin current across the interface. Using the 1D Heisenberg chain as a benchmark system, we observe a negative spinon spin current exhibiting algebraic scaling T^α, with exponent α, in the Tomonaga-Luttinger liquid phase. On the triangular lattice, spin frustration dramatically enhances the low-temperature SSE, with distinct spin-current signatures - particularly the sign reversal and characteristic temperature dependence - distinguishing different spin states. Remarkably, we discover a persistent, negative spin current in the spin supersolid phase. It saturates to a non-zero value in the low-temperature limit, and can be ascribed to the Goldstone-mode-mediated spin supercurrents. Moreover, a universal scaling $T^{d/z}$ is found at the U(1)-symmetric polarization quantum critical points. These distinct quantum spin transport traits provide sensitive probes for spin-supersolid compounds such as $Na_2BaCo(PO_4)_2$. Furthermore, our results establish spin supersolids as a tunable quantum platform for spin caloritronics in the ultralow-temperature regime.

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