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Thermal fading of the $1/k^4$-tail of the momentum distribution induced by the hole anomaly

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I present our anomaly in the temperature dependence of the thermodynamics of a one-dimensional Bose gas. The anomaly exists for any contact repulsive interaction strength and is a reminiscence of a superfluid-normal phase transition. It signals unpopulated states below the hole branch in the excitation spectrum. The anomaly temperature is of the order of the hole-branch maximal energy. The dynamic structure factor is computed with the ab-initio Path Integral Monte Carlo (PIMC) method and indicates the breakdown of the quasiparticle description for the excitations at the anomaly temperature. We provide indications for observations and how the hole anomaly can be employed for in-situ thermometry and as a simulator of anomalies in atomic, solid-state, electronic, spin-chain and ladder systems.

PIMC calculation of the momentum distribution shows that, at large momentum k and temperature above the anomaly threshold, the tail $\mathcal{C}/k^4$ (where $\mathcal{C}$ is the contact) is screened due to a dramatic thermal increase of the internal energy. The same fading is revealed in the short-distance one-body density matrix where the cubic dependence disappears. We obtain a general analytic tail for the distribution and a minimum momentum fixing its validity range, both calculated with Bethe-Ansatz and valid for any interaction and temperature.

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