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Geometric Frustration with Negative Temperature States

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Negative absolute temperature entails a situation where the entropy of a closed system reduces as the internal energy increases, and this leads to the peculiar situation that atoms in a band dominantly occupy the highest energy states in the band. Here we report the observation of negative absolute temperatures in a triangular optical lattice—a non-bipartite lattice where geometric frustration leads to two inequivalent maxima in the lowest band. The geometric frustration leads to strikingly different critical interaction strengths for the bosonic superfluid to Mott insulator transition at negative absolute temperatures (frustrated), compared to the positive (unfrustrated) temperature state. We furthermore show, for both cases, how coherence emerges dynamically, and experimentally reveal the order of phase transition in the frustrated case. Finally, we will also give an overview of our work towards loading bosons into the flat band of the kagome lattice and implementing a quantum gas microscope for single-site-resolved imaging.

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