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Unconventional superfluidity in higher bands of an optical lattice

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Atoms trapped in optical lattices have been used successfully to study many-body phenomena. However, the shape that bosonic ground-state wavefunctions can take is limited, apparently compromising the usefulness of this approach. Such limitations, however, do not apply to excited states of bosons. The study of atomic superfluids realized in higher Bloch bands, where orbital degrees of freedom are essential, can bring the world of optical lattices closer to relevant condensed matter systems. I will discuss our observations of long coherence times, chiral superfluid order and topological features in higher bands in a square optical lattice.