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Quantum phase transition to a twisted superfluid phase in hexagonal optical lattices DIRK-SOEREN LUEHMANN, PARVIS SOLTAN-PANAHI, JULIAN STRUCK, PATRICK WINDPASSINGER, KLAUS SENGSTOCK, University of Hamburg — We report on the observation of a novel superfluid phase with complex superfluid order parameters in binary spin mixtures. In this novel phase, the local phase angle of the complex order parameter is continuously twisted between the neighboring sites of the hexagonal optical lattice. Commonly, superfluids in the ground-state can be described on a mean-field level by a real s-band order parameter. In contrast, the observed twisted superfluid quantum phase occurs due to an interaction-induced admixture of the p-orbital. The strong coupling with the p-orbital is induced by the combination of the graphene-like band structure and the state-dependency of the optical potential. We observe a second-order quantum phase transition between the normal and the twisted superfluid being triggered by the competition of inter- and intraspecies interactions. The phase transition is accompanied by the breaking of the six-fold rotational symmetry in momentum space. This allows for a sensitive detection of the novel superfluid phase using time-of-flight imaging. We present experimental results and calculated phase diagrams for different binary mixtures. These results pave the way towards a deeper understanding of orbital aspects in superfluidity.

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