Hidden string order and hole-superconducting correlations from extended correlated hopping in optical lattices

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Ultracold fermions in 1-dimensional, spin-dependent non-overlapping optical lattices are described by a non-standard Hubbard model with next-nearest-neighbor correlated hopping [PRL 116, 225303 (2016)]. We discuss the engineering of such systems in state-of-the-art experiments, where the correlated hopping can be naturally very strong and can dominate the observable physical phenomena. We discuss the ground state phase diagram and elementary excitations of our model. At a high symmetry point, exact spin-charge separation is manifest and we obtain for arbitrary filling: ground state collective order characterized by a spin gap that we ascribe to an unconventional critical hole superconductor with finite long range nonlocal string order. Away from the integrable point, both long range string order and spin gap persist for a wide range of parameters before a transition to a ferromagnetic-like state.