Synthetic Helical Liquids with Ultracold Atoms in Optical Lattices

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We discuss a platform for the synthetic realization of helical Tomonaga Luttinger liquid (HTLL) physics with ultracold fermionic atoms in one-dimensional optical lattices. The HTLL is a strongly correlated metallic state where spin polarization and propagation direction of the itinerant particles are locked to each other. We propose an unconventional one-dimensional Fermi-Hubbard model which, at quarter filling, resembles the HTLL in the long wavelength limit, as we demonstrate with a combination of analytical (bosonization) and numerical (density matrix renormalization group) methods. An experimentally feasible scheme is presented for the realization of this model with ultracold fermionic atoms in optical lattices. Finally, we discuss how the robustness of the HTLL against back-scattering and imperfections, well known from its realization at the edge of two-dimensional topological insulators, is reflected in our synthetic one-dimensional scenario.