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Topological phase transitions of attractive fermions with spin-orbit coupling in an optical lattice CHUNLEI QU, MING GONG, CHUANWEI ZHANG, Department of Physics, The University of Texas at Dallas — It has been shown by Zhang et al [Chuanwei Zhang et al, Phys. Rev. Lett. 101, 160401 (2008)] that an effective px + ipy order can be created from a conventional s-wave pairing with spin-orbit coupling and Zeeman field, two essential ingredients that have already been realized in experiments by Spielman's group at NIST. The same idea has been extended to semiconductor nanowires to search for the Majorana Fermions, which is a basic building block for the fault-tolerant topological quantum computation. Here we studied the the spin-orbit coupled Fermi gas in a one dimensional optical lattice with finite length in the mean field theory. In our model, the s-wave interaction induced Hartree shift term has been included. We solve the Bogoliubov-de-Gennes (BdG) equation self-consistently and find that the Hartree shift and the spin-orbit coupling can greatly enlarge the topological phase area in the $h-\mu$ phase diagram. We derive an exact expression for the topological quantum phase transition. We also show that the end of the optical lattice plays an important role in the formation of topological superfluid in our model.

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