Abstract Submitted
for the DAMOP17 Meeting of
The American Physical Society

Exactly solvable interacting number-conserving models with Majorana-like ground states ZHIYUAN WANG, YOUJIANG XU, HAN PU, KADEN HAZZARD, Rice University — Majorana fermions have sparked interest in condensed matter and cold atoms as emergent quasiparticles with fundamentally new properties, in particular non-Abelian statistics. However, most theoretical calculations start with a Bogoliubov mean-field approximation from which it is shown that the resulting model supports Majorana states. It then remains an open question whether and when this mean-field approximation is valid. We make progress towards this question in two ways. First, we demonstrate a model in which mean-field theory incorrectly predicts a gapped phase with Majorana ground states, whereas an unbiased DMRG calculation predicts a gapless phase instead. Second, we construct new families of exactly solvable interacting models, including a one-dimensional double wire lattice model and a two dimensional p+ip superconducting model. Significantly, these models are number-conserving but nevertheless can be shown to host robust Majorana-like degenerate ground states in the presence of edges and vortices. These results give a deeper conceptual understanding of how Majorana fermions can be realized in practice.

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Date submitted: 25 Jan 2017 Electronic form version 1.4