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Exactly solvable Majorana-like ground states in number-conserving models 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 they show that the resulting model possesses 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, in contrast to the gapless phase that we find from numerically exact DMRG calculations. Secondly, we construct new families of interacting models where the mean field treatment happens to be exact. Significantly, these exactly solvable models are number-conserving but nevertheless can be shown to host robust Majorana-like degenerate ground states and exhibit non-abelian statistics. These results give a deeper conceptual understanding of how Majorana fermions can be realized in nature.

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