Two-dimensional higher-order topological superconductor with electron-electron interactions

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In this report, we will present the results of an analytical and numerical study of the Coulomb interaction problem in one of the standard models of a higher-order topological superconductor, which describes a 2D topological insulator on a square lattice with $s_{\pm}$-superconducting pairing. In particular, attention is paid to both limiting cases: weak and strong charge correlations [1,2].

In the first situation, it is shown that the boundaries of the topologically nontrivial phase are extended due to the many-body interaction. For a system with open boundary conditions, a crossover of the ground state was found with increasing repulsion intensity. Before the crossover, the charge density distribution has C_4 symmetry and does not depend on spin, and the energy of the Majorana corner state is determined by the overlap of the wave functions localized in different corners. After the crossover, the concentration correlator depends on the spin projection and has a spontaneously broken symmetry. In turn, the energy of the corner state ceases to depend on the size of the system. The dependence of this crossover on the shape of the boundary of the 2D system is discussed.

The possibility to realize the Majorana corner states in the limit of the infinitely strong repulsion is demonstrated based on the analysis of the Dirac mass of edge states of Hubbard fermions induced by the superconducting pairing. It is shown that the boundaries of the topologically nontrivial phase become strongly renormalized due to the Hubbard corrections. In the regime of strong but finite Coulomb repulsion, the effective Hamiltonian of the higher-order topological superconductor is obtained.

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[1] S. V. Aksenov, A. D. Fedoseev, M. S. Shustin, and A. O. Zlotnikov, Phys. Rev. B 107, 125401 (2023).

[2] S. V. Aksenov, A. D. Fedoseev, M. S. Shustin, and A. O. Zlotnikov, Phys. Sol. St., in press (2023).