

*Séminaire AXE 1 - Sciences et Matériaux Quantiques*



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## Olesia Dmytruk

CPHT, CNRS, École polytechnique  
[olesia.dmytruk@polytechnique.edu](mailto:olesia.dmytruk@polytechnique.edu)

### ***Majorana bound states in Kitaev chains coupled to photons***

Embedding quantum materials into photonic cavities has emerged as a promising avenue for controlling properties of materials. The Kitaev chain - a prototype model for Majorana bound states (MBSs) in topological superconductors - has attracted a lot of renewed interest. This is motivated by recent experimental realizations of two- and three-site Kitaev chains in an array of quantum dots connected by superconductors. The concept of "poor man's" MBSs arising in such platforms was introduced back in 2012, with multiple theoretical works appearing in the recent years demonstrating new insights into the model. Poor man's MBSs in a non-interacting two-site Kitaev chain emerge when the parameters of the Hamiltonian are fine-tuned to a sweet spot, such that the chemical potential is fixed to zero and the hopping equals the superconducting pairing. Moreover, the effect of particle interactions in quantum dots-based platforms is important as it leads to the hybridization between MBSs and removes the sweet spot.

In this talk, I will discuss a new way to tune "poor man's" MBS with cavity embedding [1]. I will demonstrate that coupling to photons can be used to screen electron interactions allowing for reaching the sweet spot and realizing the isolated MBS. Moreover, I will show that cavity spectroscopy could be used to probe the ground state degeneracy between even and odd parity sectors. Next, I will extend the discussion to a Kitaev chain with  $N$  sites embedded in a cavity. I will demonstrate that the photon number and the photonic field quadratures peak at values of the chemical potential corresponding to parity switching points revealing a property of a finite-length Kitaev chain in the topological phase [2]. This later finding suggests that quantum optics experiments could be employed to detect topological features of the Kitaev chain embedded into a photonic cavity.

[1] Á. Gómez-León, M. Schirò, O. Dmytruk, *Physical Review B* **111**, 155410 (2025)

[2] V. F. Becerra, O. Dmytruk, arXiv:2506.06237

### Contact

Arnaud GLOPPE ([arnaud.gloppe@ipcms.unistra.fr](mailto:arnaud.gloppe@ipcms.unistra.fr)) – David HAGENMULLER ([david.hagenmuller@ipcms.unistra.fr](mailto:david.hagenmuller@ipcms.unistra.fr))