QUANTUM SIMULATION WITH TRAPPED IONS:
DRIVEN-DISSIPATIVE TOPOLOGICAL PARAMETRIC AMPLIFIERS VIA FLOQUET ENGINEERING

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Quantum simulation provides important developments in areas such as quantum sensing and metrology. In this work, we explore one crucial feature of these areas known as topological amplification. Topological phases of matter has garnered amounts of attention lately due to their robustness against disorder, being a smart way to deal with noise in open quantum systems. The goal of this project is to characterize topological amplifiers in a one dimensional array of trapped ions involving not only nearest-neighbours but long-range interactions. Furthermore, we have taken advantage of Floquet engineering in order to propose an experimental implementation accounting for parametric terms and dissipation.

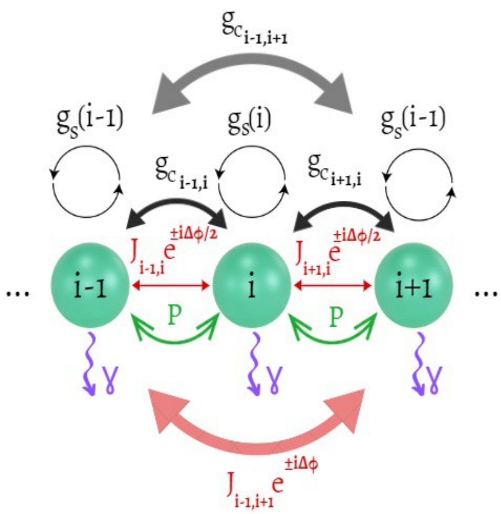

Figure 1 – Schematic of the long-range interacting couplings where the complex hopping terms are in red, parametric terms in black and dissipative terms in purple and green.

Based on previous references for nearest-neighbors regimes [1-3], we have studied numerically the steady state solution of a 1D array of N trapped ions in presence of local dissipation, pumping and driving fields via Floquet engineering. Thanks to this Floquet technique, both long-range parametric and hopping terms have been simulated, leading to topological protected phases that provide exponential amplification. All processes involved can be distinguished in Figure 1.

We observed brand new topological phases (characterized by winding number υ=2) in the long-range regime without pumping that do not have counterpart in the nearest-neighbors case (see Figure 2).

Apart from the topological classification of these systems according to their symmetries, we have given a physical characterization of realistic topological parametric amplifiers considering their robustness against disorder, stability and gain.

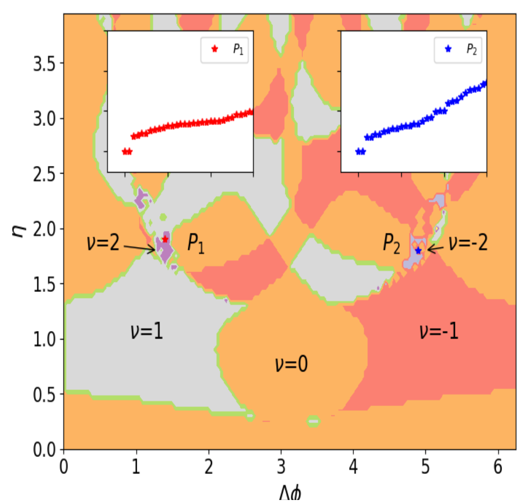

Figure 2 – Topological phases as a function of Floquet parameters Δϕ and η. Inset: Pair of degenerated zero singular values for points of the parameter space inside regions with winding number υ=±2.

REFERENCES:

[1] A. Gómez-León, T. Ramos, A. González-Tudela, D. Porras, "NonHermitian topological phases in traveling-wave parametric amplifiers", Quantum 7, 1016 (2023).

[2] T. Ramos, A. Gómez-León, J.J. García-Ripoll, A. González-Tudela, D. Porras, "Directional Josephson traveling-wave parametric amplifier via non-Hermitian topology", arXiv:2207.13728

[3] Á. Gómez-León, T. Ramos, A. González-Tudela and D. Porras. PRA 106, L011501 (2022).