

## MEASURING TEMPORAL ENTROPIES IN EXPERIMENTS

Aleix Bou-Comas, Affiliation  
 Institute of Fundamental Physics IFF-CSIC, Calle Serrano 113b, Madrid 28006, Spain  
 T: +34 689432607, aleix.bou@iff.csic.es  
 Carlos Ramos Marimon, UB  
 Jan T. Schneider, CSIC  
 Stefano Carignano, BSC  
 Luca Tagliacozzo, CSIC

We propose a novel experimental protocol to measure generalized temporal entropies in many-body quantum systems. Our approach involves using local operators as probes to characterize the out-of-equilibrium dynamics induced by a geometric double quench on a replicated system. Such protocol mimics the path-integral on the corresponding Riemann surface encoding generalized temporal entanglement. We present the results of tensor network simulations of one-dimensional systems which validate the protocol and demonstrate the experimental feasibility of measuring generalized temporal entropies, and we outline the experimental requirements for implementing these quenches using state-of-the-art quantum simulators. Therefore, our results provide a physical interpretation of the meaning of generalized temporal entropies. Furthermore, they reveal that the dynamics induced on two replicas of the Ising model in a transverse field differ qualitatively from the ones of its non-integrable extension, suggesting that generalized temporal entropies can be used as a tool for identifying different dynamical classes in quantum systems.

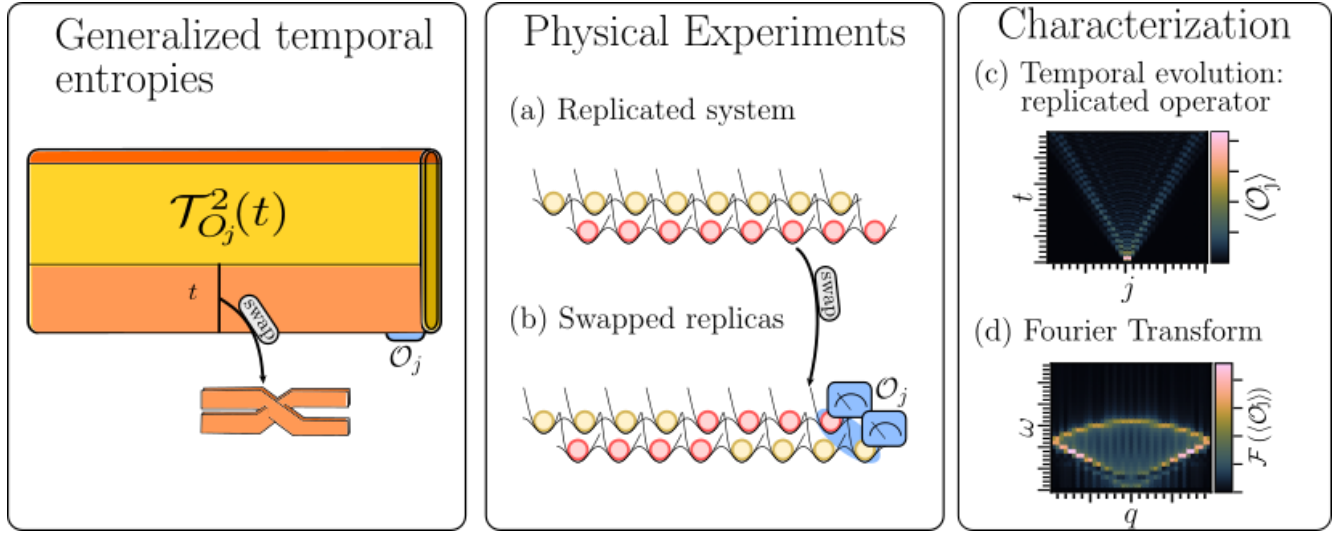


Figure 1: The path integral formulation leading to the generalized temporal purities (left) can be mapped explicitly to a double-quench experimental setup (center). We exemplify the idea by using atoms trapped in optical lattices. (a): we start with two replicas with a deep super-lattice in the  $y$ -direction to keep them separated. The two copies start evolving separately under the same Hamiltonian. At a given time, dynamics is frozen by raising the potential in the  $x$ -direction and a swap is performed by lowering the lattice, in the region we want to swap, in the  $y$ -direction for the time needed to obtain full transfer of atoms between the two wells. (b) shows the configuration after the swap, leading to subsequent independent evolution of the partially swapped replicas. We finally measure any local observable jointly on the two copies. By repeating several experiments, varying both the time after swap and the position where the observable is measured we can access a full space-time picture (c) and its Fourier transform (d) that reveals spectral properties of the system regimes on a Riemann surface.