Limit Shape Phenomena in Quantum Dynamics

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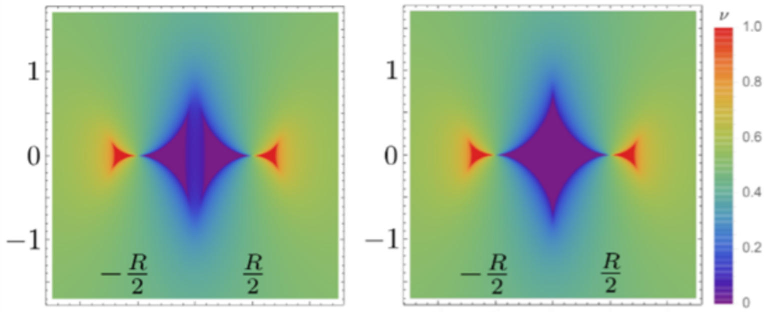

I will present a selection of examples illustrating the phenomenon of *limit shapes*, which arise as the most probable macroscopic configurations in a wide range of classical and quantum systems. These shapes emerge in the thermodynamic or large-scale limit and are characterised by sharply defined boundaries separating distinct regions: typically, "frozen" domains with rigid, ordered structure and "fluctuating" domains where microscopic degrees of freedom remain disordered and dynamic. Such phase separation phenomena have been observed in models of classical euqilibrium and out-of-equilibrium statistical physics like random tilings and growth processes.

By encoding quantum dynamics via Keldysh formalism these ideas can be transposed to quantum objects like Loschmidt Echo and Quantum Work Distribution. They can be applied to study effects of measurement on entanglement in quantum systems.

A central theme of the talk will be the special role played by analytic functions that define an associated Riemann surface. These functions encode the geometry and fluctuations of the system in a remarkably compact yet non-trivial way. In particular, the topology of the corresponding Riemann surface can undergo abrupt changes as system parameters vary, signaling the presence of phase transitions. These transitions are often reflected in qualitative changes in the limit shape, such as the emergence or disappearance of frozen regions, and can be understood through the analytic structure of the underlying functions.

Most of the examples discussed will be based on free fermionic models, where powerful analytical tools allow for an explicit characterization of limit shapes and their fluctuations in terms of explicit analytic functions. These models provide a unifying framework in which physical aspects of the problem and its space-time topology can be studied in detail .

However, I will also highlight a notable recent development that lies outside this standard non-interacting paradigm: the study of a polytropic gas with a power-law equation of state. Unlike free fermionic systems, this model exhibits interacting hydrodynamic behavior, yet still gives rise to well-defined limit shape phenomena. In this context, we investigate the Emptiness Formation Probability (EFP), a key observable that measures the likelihood of forming large empty regions. I will discuss how a hydrodynamic approach can be used to analyse the EFP in the polytropic gas and how this connects to broader questions about universality and structure in non-free systems.