SEMINARIO

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Ergodicity and the emergence of the hydrodynamic scale in quantum spin chains

Abstract: How do the laws of large-scale physics emerge from the microscopic dynamics of particles, spins, etc? This is one of the most important questions in theoretical physics, but there are few general and rigorous results, especially in many-body quantum systems. I will discuss our recent results where we establish in quite some generality aspects of emergence in quantum spin lattices (restricting for simplicity to spin chains): the phenomenon of ergodicity, and, most importantly, the emergence of the equations linearised hydrodynamics at the Euler scale. Ergodicity says that upon time averaging over long enough times, one recovers the ensemble description of statistical mechanics. In classical mechanics, this is because, under some conditions, the trajectory essentially covers the full phase space. But in many-body systems, with infinitely-many degrees of freedom, this notion is more subtle. I will explain how it works, and general results including our ``almost everywhere ergodicity". I will then discuss how this connects to the emergence of the Euler (or ballistic) scale of hydrodynamics. Specifically, we have shown that under ballistic scaling, the asymptotic form of two-point correlation functions in spacetime is obtained by projections onto appropriate ``sound modes" — related to the extensive conserved quantities of the model — whose propagation is described by a linearised Euler-type equation. The latter results are meaningful especially in spin chains which have the property of integrability, such as the Heisenberg chain, as these admit infinitely-many extensive conserved quantities.

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