From inverse-cascade to sub-diffusive dynamic scaling in driven disordered Bose fluids

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We theoretically and numerically study the dynamics of a 3D interacting Bose gas quenched across the condensation transition, in the presence of a spatial disorder and subjected to a periodic driving force. In the limit of vanishing interactions, the combination of drive and disorder leads to a new type of sub-diffusive random walk in energy space, recently demonstrated experimentally. Conversely, when both drive and disorder are absent, the dynamics across the condensation transition results in an inverse energy cascade associated with the thermalization process of the Bose gas.

Using a quantum kinetic framework, we explore the interplay between the sub-diffusive random walk and thermalization in energy space when drive, disorder and interactions are simultaneously present. This competition gives rise to three distinct dynamical regimes separated by crossovers: (i) an inverse cascade where interactions dominate the drive, (ii) a stationary regime where the sub-diffusive random walk and the inverse cascade balance each other, and (iii) a sub-diffusive spreading in energy space dominated by disorder and drive. We demonstrate that these three regimes can be described by self-similar scaling laws and discuss their universal properties.