Entanglement dynamics in a non-Hermitian quantum system

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Non-Hermitian quantum mechanics shows various unusual features unknown (and forbidden) in the Hermitian case even at the level of single-particle dynamics; e.g., complex spectrum, skin effect, etc. One of the interesting questions is whether such non-Hermitian peculiarities are compatible with the idea of topological insulator, especially with the notion of bulk-edge correspondence [1,2].

Here, we will also highlight the wave-packet and entanglement dynamics in non-Hermitian systems. In the many-particle case, we will focus on the time evolution of the entanglement entropy, which measures how quantum correlation spreads in the system. In the regime of weak disorder, i.e., in the extended phase, the entanglement entropy shows a characteristic non-monotonic evolution [3]. The effect of disorder is also non-monotonic with respect to the strength W of disorder; in the regime of weak disorder, it first enhances the entanglement entropy (a very unusual behavior in the mind of Hermitian quantum mechanics), while the strength W of disorder is further increased, the wave function tends to be localized; correspondingly, the entanglement entropy turns to decrease [3]. The robustness of such features against inter-particle interaction will be also discussed.

As a concrete model, we consider a 1D tight-binding model with non-reciprocal (or asymmetric) hopping and on-site disorder (the so-called Hatano-Nelson model). In the study of many-particle dynamics, we also consider on top of the above model a nearest-neighbor particle-particle interaction. We will particularly focus on the regime of weak disorder and on the case of periodic boundary condition, in which the eigenenergies exhibit a finite imaginary part. We clarify how the complex nature of the spectrum leads to unusual behaviors of the entanglement dynamics (non-monotonic temporal evolution and W-dependence, etc.).

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