Identifying the hidden multiplex architecture of complex systems
(or a new decomposition theory of non-Markovian dynamics)

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Only in a few cases can a multi-layered architecture be empirically observed, as one usually only has experimental access to such structure from an aggregated projection. A fundamental challenge is thus to determine whether the hidden underlying architecture of complex systems is better modelled as a single interaction layer or results from the aggregation of multiple layers. I will present a method that, using local information provided by a random walker navigating the aggregated network, is able to determine whether these dynamics can be more accurately represented by a single layer or by a (hidden) multiplex structure. In the latter case, I will also provide a Bayesian method to estimate the most probable number of hidden layers and the model parameters. The method enables to decipher the underlying multiplex architecture of complex systems by exploiting the non-Markovian signatures of a single random walk on the aggregated network. In fact, the mathematical formalism presented here provides a principled solution for the optimal decomposition and projection of complex, non-Markovian dynamics into a Markov switching combination of diffusive modes. I will validate the methodology with numerical simulations of (i) random walks navigating hidden multiplex networks and (ii) Markovian and non-Markovian continuous stochastic processes. Finally I will apply the methodology to understand the dynamics of RNA polymerases at the single-molecule level.

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