The impact of community structure on network dynamics: The case of synchronization

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Determining how the network structure affects its function remains one of the great challenges of Network Science. Among the numerous network functions studied so far, synchronization has attracted much attention over the last two decades, partly due to its simplicity—as an observable phenomenon—and to its fundamental significance in many fields of applications, including neuroscience, ecology, and sociology. For instance, in neuroscience, synchronization of neurons plays a crucial role in many brain functions such as memory and consciousness. In ecology, flocks with tens of thousands of birds have been observed to fly in unison at high speeds and execute collectively complex maneuvers.

Studies have revealed that the relationship between the structure of a network and its capacity to synchronize is rich and subtle. For instance, networks sharing the same degree distribution can have very different synchronization behaviours. Despite recent advances showing that significant changes in the network structure may result in the incapacity of a global synchronization, much has to be done to further understand how structure—especially at the mesoscale (communities)—affects synchronization.

We study the synchronization of dynamics in networks with clear community structures, such as those generated by the stochastic block model (SBM). We find new regions in the structural parameter space where exist chimeras, which are dynamical states characterized by a simultaneous cohabitation of full synchronization in certain communities and partial synchronization in others. We also measure the effect of structure on the chaotic behavior of chimeras. Finally, we use structural information to successfully predict the critical coupling above which the synchronization of the whole network can occur.