Complex Networks of Lossy Oscillators: Multistability, Anomalies, and Loop Flows in Power Grids

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The last decades have seen a sustained effort from the complex systems community towards the analysis of synchronization phenomena in networks of coupled oscillators. Despite its high relevance, especially in the context of power grids, the case of dissipatively coupled oscillators has been overlooked, partly because of its intrinsically more challenging features. Indeed, standard mathematical methods are not applicable, due to the lack of network symmetry induced by dissipative couplings.

In this talk, we will demonstrate a close correspondence between stable synchronous states in dissipatively coupled oscillators, and the so-called winding partition of their state space. The winding partition is a geometric notion, naturally induced by the network topology, which has been shown to provide an accurate proxy for the identification of multiple stable synchronous states in lossless systems of oscillators [1]. This talk will aim at (i) comparing synchronous states in lossless and lossy oscillator networks, (ii) emphasizing the main challenges induced by the dissipativity of the couplings, and (iii) provide a framework to overcome these challenges.

The aforementioned framework will allow us to identify anomalous behaviors of lossy networked systems. Counter-intuitively, we will see that loop flows and dissipation can increase the system's transfer capacity, and that dissipation can promote multistability.

Finally, as a proof of concept and a motivation for further investigations, we will apply our geometric framework to compute power flows on the IEEE RTS-96 test system, where we identify two high voltage solutions with distinct loop flows.

References

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