Fluctuation-dissipation of the Kuramoto model on fruit-fly connectomes

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We investigate the distance from equilibrium using the Kuramoto model via the degree of fluctuation–dissipation violation as the consequence of different levels of edge weight anisotropies. This is achieved by solving the synchronization equations on the raw, homeostatic weighted and a random inhibitory edge variant of a real full fly (FF) connectome, containing $\sim 10^5$ neuron cell nodes. We investigate these systems close to their synchronization transition critical points. While the topological (graph) dimension is high: $d \sim 6$ the spectral dimensions of the variants, relevant in describing the synchronization behavior, are lower than the upper critical dimension: $d_s \sim 2 < d_c = 4$, suggesting relevant fluctuation effects and non mean-field scaling behavior. By measuring the auto-correlations and the auto-response functions for small perturbations we calculate the fluctuation–dissipation ratios (FDR) for the different variants of different anisotropy levels of the FF connectome. Numerical evidence is presented that the FDRs follow the level of anisotropy of these non-equilibrium systems in agreement with the expectations. We also compare these results with those on a symmetric random graph of similar size. We provide a detailed network analysis of the FF connectome and calculate the level of hierarchy, also related to the anisotropy. Finally, we provide some partial results for the periodically forced Kuramoto, the Shinomoto–Kuramoto model.