Cortical networks show collective dynamics that are remarkably complex, even though they are built upon simple motifs of excitatory-inhibitory interactions. Furthermore, it is known that cortical networks maintain their excitatory-inhibitory (E-I) balance through multiple modes of homeostatic plasticity, ensuring the proper function of cortical neurons and populations. However, it is not clear how strongly the functional benefits of E-I homeostasis extravasate the population level, shaping macroscale dynamics.

Using tools from dynamical systems, we derive analytically the solution of the Wilson-Cowan model under diverse modes of homeostasis in line with the literature. With this exercise, we demonstrate how cortical networks can regulate the bifurcation between damped and sustained oscillations through E-I homeostasis and how conjugating multiple modes of homeostasis is a robust method to ensure stable activity while minimizing disruptions to node dynamics.

We then apply our framework to large-scale models of the human cortex with local E-I balance. Our results demonstrate that networks relying on multiple modes of homeostasis are not only more stable, but they better reproduce functional connectivity (FC), FC dynamics (FCD), and empirical levels of metastability and complexity. Not only that, but model performance is optimal in a regime of maximal metastability and complexity, potentiated by heterogeneities in the position of nodes relative to the bifurcation, which naturally emerge with specific modes of homeostasis.

Altogether, our results agree with the edge-of-bifurcation theory for large-scale brain dynamics, suggesting that it can be a consequence of local E-I balance, particularly when relying on multiple modes of homeostasis.