

Macroscopic brain oscillations play a key role in cognitive and physiological processes, yet their functional role remains unclear. Communication through coherence theory proposes that rhythmic synchronization regulates information flow between neural populations by aligning periods of excitability. Theoretical studies of gamma oscillations show that when the input frequency exceeds the natural frequency of a target oscillator, phase-locking emerges, enabling effective communication. Inhibitory neurons play a crucial role in shaping these dynamics, and their diverse biophysical properties suggests distinct contributions to network synchronization.

We use exact mean-field models to investigate how multiple inhibitory populations influence cortical oscillations and synchronization. The model includes one excitatory and two distinct inhibitory populations with a network connectivity inspired in the cortical circuits. The network receives periodic input in the gamma range, mimicking inter-regional interactions. Phase-reduction techniques were applied to characterize phase-locking regimes as a function of input properties and to quantify communication efficacy. Results show that networks with a single inhibitory population support effective communication mainly for inputs faster than the intrinsic oscillation frequency, whereas the addition of a second inhibitory population with slower synaptic dynamics expands synchronization to both higher and lower frequencies. This broader phase-locking range enhances the encoding of inputs near the intrinsic gamma rhythm, improving communication. These findings highlight the role of inhibitory diversity in shaping synchronization and provide a theoretical framework for understanding how neural circuits regulate timing and support efficient information transfer.