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When repulsive coupling promotes synchronization of bursting neurons

Synchrony has been broadly observed in pathological brain states, especially during epilepsy and Parkinson's tremors. The neuronal mechanisms that generate such abnormal synchronous states are far from being fully understood. In this talk, we discuss the emergence of synchronization in networks of bursting neurons as highly non-trivial, synergistic effects when (i) the addition of pairwise repulsive inhibition to excitatory networks can promote in-phase synchronization and (ii) combined electrical and inhibitory coupling can induce synchronization even though each coupling alone promotes an antiphase rhythm. In particular, we reveal the underlying mechanism, which uses a balance between hidden properties of electrical and inhibitory coupling to act together to synchronize neuronal bursting. We show that this balance is controlled by the duty cycle of the self-coupled system which governs the synchronized bursting rhythm. Our studies of neuronal synchronization form a basis for understanding the counterintuitive dynamics of bursting networks, which may yield meaningful insight into the phenomenon of pathological synchrony in epileptic networks. Our results suggest that promoting normally repulsive inhibition in an attempt to prevent seizures can have an unintended effect of inducing pathological synchrony.