Spintronic neural networks with frequency synapses

Julie Grollier et al[1*]

[1] Laboratoire Albert Fert, CNRS, Thales, Université Paris-Saclay
*Julie.grollier@cnrs-thales.fr

Spintronics introduces intrinsic memory, wave-based dynamics, and non-linearity into neuromorphic computing, offering a promising path toward energy-efficient, brain-inspired hardware. In this work, we experimentally demonstrate a compact neural network in which all computing elements—both synapses and neurons—are realized using magnetic tunnel junctions (MTJs).

The architecture employs frequency multiplexing to connect neurons and synapses: each junction's oscillation frequency acts as its unique address, enabling selective connectivity between elements sharing the same frequency. I will present two implementations of this architecture, each showcasing distinct advantages.

In the first approach, binary vortex-based synapses can be remotely switched between states without direct local access. This is achieved by globally broadcasting RF signals, enabling highly efficient control. In the second implementation, each synapse has local access and is continuously tunable across a broad frequency range via magneto-ionic effects. This tunability allows dynamic adjustment of synaptic weights and even real-time reconfiguration of network topology—mimicking dendritic plasticity observed in biological systems.

I will show that these results represent a significant step toward spintronic-enhanced neuromorphic hardware capable of on-edge learning and self-adaptation.