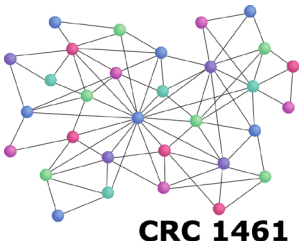

Analog computing by oscillations and waves

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The notion of analog computing stems from the idea of calculating a problem by an analogous physical system, that, is to use the laws of physics to do computation. This motivates our work to find low-power, nanoscale physical systems that naturally converge toward a computationally useful state.
One such system is a made from coupled ring oscillators. Ring oscillators are straightforwardly realizable electrical circuits, which synchronize into collective oscillatory states and can realize neural network functions. In the first half of my talk, I will show examples of ring-oscillator-based neural computation and argue that phase/frequency based analog computers can be fundamentally more power efficient than circuits that use voltage or current levels to do computation [1].
Spin waves in magnetic materials can realize rich oscillatory dynamics and do it without dissipative current flow. Recently, we engineered magnetic thin films to realize neural computing functions in the spin-wave domain [2] and the second half of my talk will show how non-linear waves in a material substrate can do analog, neuromorphic computation.

[1] Csaba, Gyorgy, and Wolfgang Porod. "Noise Immunity of Oscillatory Computing Devices." *IEEE Journal on Exploratory Solid-State Computational Devices and Circuits* 6, no. 2 (2020): 164-169.

[2] Papp, Adam, Wolfgang Porod, and Gyorgy Csaba. "Nanoscale neural network using non-linear spin-wave interference." *arXiv preprint arXiv:2012.04594* (2020).

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