Extended Abstracts of the 2017 International Conference on Solid State Devices and Materials, Sendai, 2017, pp197-198

D-4-01 (Invited)

Neuromorphic computing with spintronic nanoscale oscillators

Jacob Torrejon[1*], Mathieu Riou[1], Flavio Abreu Araujo[1], Sumito Tsunegi[2], Guru Khalsa[3], Damien Querlioz[4], Paolo Bortolotti[1], Vincent Cros[1], Akio Fukushima[2], Hitoshi Kubota[2], Shinji Yuasa[2], M. D. Stiles[3] and Julie Grollier[1]

[1] *Unité Mixte de Physique, CNRS, Thales, Univ. Paris-Sud, Université Paris-Saclay, 91767 Palaiseau, France*
[2] *National Institute of Advanced Industrial Science and Technology (AIST), Spintronics Research Center, Tsukuba, Ibaraki 305-8568, Japan*
[3] *Center for Nanoscale Science and Technology, National Institute of Standards and Technology, Gaithersburg, Maryland 20899-6202, USA*
[4] *Centre de Nanosciences et de Nanotechnologies, CNRS, Université Paris-Saclay, 91405 Orsay France*

*email: jacob.torrejondiaz@cnrs-thales.fr

The brain displays many signatures of non-linear dynamical networks, such as synchronization or complex transient behaviour [1,2]. These observations have inspired a whole class of models that harness the complex non-linear dynamical networks to perform neuro-inspired computing [3]. In this framework, neurons are modelled as non-linear oscillators, and synapses as the coupling between oscillators. These abstract models are very good at processing waveforms for pattern recognition but there are very few hardware implementations based on networks of coupled oscillators. This type of computing requires a huge number of oscillators for achieving excellent performance and nanoscale oscillators are necessary for easy integration in a microchip. However small devices tend to be noisy and to lack the stability required to process data in a reliable way. Spin torque nano-oscillators are a promising solution to over this issue because their well-controlled magnetization dynamics can lead to high signal to noise ratios. In addition, the other main advantages of spintronic oscillators compared to others existing oscillators are their exceptional ability to interact, non-linear tunability, fast time response (ns range), long lifetime and lower power consumption [4]. In this talk, I will show how to leverage the non-linear dynamics of spin-torque nano-oscillators for neuromorphic computing, and present our first experimental results of speech recognition [5]. Finally, I will give the main ingredients towards massively parallel architectures.

[1] D. R. Chialvo, Nat. Phys. **6**, 744 (2010).

[2] J. Fell and N. Axmacher, Nat. Rev. Neurosci. **12**, 105 (2011).

[3] E. M. Izhikevich, IEEE Trans. Neural Networks **15**, 1063 (2004).

[4] J. Grollier, D. Querlioz, and M. D. Stiles, Proc. IEEE **104**, 2024 (2016).

[5] J. Torrejon et al, arXiv:1701.07715 (2017).

This project is funded by European Research Council (ERC) grant, *bioSPINspired* 682955