MA 19: PhD Focus Session: Symposium on "Magnetism - A Potential Platform for Big Data?" (joint session MA/O/AKjDPG)

As pointed out in a recent Nature editorial article titled "Big data needs a hardware revolution", new technologies and hardware architectures are necessary in order to cope with the ever increasing amount of information. Google's AlphaGo's success apprised of the potential of parallel computing, yet energy efficiency remained as a major challenge. Hardware developers came up with mimicking the human brain as the most efficient processor, leading to the field of neuromorphic computing. An immense amount of research is deployed in different fields to screen for fast, low energy consuming and scalable solutions. In this focus session we elucidate on the potential role of magnetism in the development of non-Von Neumann hardware platforms to fulfill the current needs of AI and Big Data. An introduction to neuromorphic computing is followed by implementations of magnetic devices for processing and data storage in the information age. We finalise with a panel conversation with the speakers, where we aim to discuss the potential of magnetic-based devices in helping solve current challenges in the field of brain-inspired computing.

Organizers: Mauricio Bejarano and Tobias Hula (Helmholtz-Zentrum Dresden Rossendorf), Luis Flacke (Walther-Meissner Institute and TU Munich)

Time: Friday 13:30–16:30 Location: H5

Invited Talk MA 19.1 Fri 13:30 H5

"Neuromorphic Computing": A Productive Contradiction in Terms — •Herbert Jaeger — Rijksuniversiteit Groningen (NL) Faculty of Science and Engineering - CogniGron

The term "computing" has a specific, firm, powerful, traditional meaning – condensed in the paradigm of Turing computability (TC). A core aspect of TC is the perfectly reliable composition of perfectly identifiable symbolic tokens into complex, hierarchical symbolic structures. But all which is novel and promising and original in "neuromorphic" information processing leads away from such perfect symbolic compositionality. Apparently new formal conceptions of "computing" would be most welcome (and a new term for it, too). In my talk I will carve out a number of concrete aspects that separate neuromorphic information processing from symbolic computing - some of them being classical topics in the philosophy of AI, others having more recently emerged from technological progress in non-digital hardware.

Invited Talk MA 19.2 Fri 14:00 H5

Neuromorphic computing with radiofrequency spintronic devices — •Alice Mizrahi[1], Nathan Leroux[1], Danijela Markovic[1], Dedalo Sanz Hernandez[1], Juan Trastoy[1], Paolo Bortolotti[1], Leandro Martins[2], Alex Jenkins[2], Ricardo Ferreira[2], and Julie Grollier[1] — [1]Unité Mixte de Physique CNRS, Thales, Université Paris-Saclay, 91767 Palaiseau, France — [2]International Iberian Nanotechnology Laboratory (INL), 4715-31 Braga, Portugal

The need for energy efficient artificial intelligence has motivated research on the implementation of neural networks in hardware, using emerging technology. In particular, spintronic nano-oscillators have emerged as promising candidates to emulate neurons due to their nonlinear behavior. However, in order to scale such systems to deep neural network capable of performing state of the art artificial intelligence tasks, it is necessary to have physical synapses – which weights can be tuned –connecting the neurons. Here we propose a scalable architecture for neural networks using spintronic RF oscillators as neurons and spintronic RF resonators as synapses. First, we show how individual spintronic resonators, and in particular magnetic tunnel junctions, can multiply RF signals by a tunable weight, thus emulating synapses. Then, we show how to assemble these devices into chains performing the multiply and accumulate function, which is at the core of neural network. Finally, we show how to assemble a full neural network and perform classification tasks. These results open the path for compact and energy efficient deep neural networks.

10 min. break.

Invited Talk MA 19.3 Fri 14:40 H5

Data Storage and Processing in the Cognitive Era — •Giovanni Cherubini — IBM Research - Zurich

In this talk, I will present the emerging vision of cognitive data systems. A data system comprises physical devices that provide means to acquire, store and modify data for analytics and communications tasks, with the goal of obtaining high-value information. With the need to deal with exponentially growing amounts of data, however, the system size and complexity present major challenges for data storage and processing. In addition, with the approaching end of Moore's law, there is a dire need to significantly improve the energy efficiency of data systems. To address these challenges, cognitive data systems will require novel learning algorithms and computing paradigms. The talk will be divided into two parts, focusing on data storage and processing aspects. First, I will present advanced technologies for big data storage systems, with focus on magnetic tape drives of future generations, targeting areal densities of several hundred gigabits per square inch on a flexible medium. Next, I will introduce novel in-memory computing techniques and devices that are based on non-von Neumann architectures and aim at achieving the efficiency of the human brain.

Invited Talk MA 19.4 Fri 15:10 H5

Brain-inspired approaches and ultrafast magnetism for Green ICT — •Theo Rasing — Radboud University, Institute for Molecules and Materials, Heijendaalseweg 135, 6525AJ Nijmegen, the Netherlands

The explosive growth of digital data use and storage has led to an enormous rise in global energy consumption of Information and Communication Technology (ICT), which already stands at 7% of the world electricity consumption. New ICT technologies, such as Artificial Intelligence push this exponentially increasing energy requirement even more, though the underlying hardware paradigm is utterly inefficient: tasks like pattern recognition can be performed by the human brain with only 20W, while conventional (super)computers require 10 MW. Therefore, the development of radically new physical principles that combine energy-efficiency with high speeds and high densities is crucial for a sustainable future. One of those is the use of non-thermodynamic routes that promises orders of magnitude faster and more energy efficient manipulation of bits. Another one is neuromorphic computing, that is inspired by the notion that our brain uses a million times less energy than a supercomputer while, at least for some tasks, it even outperforms the latter. In this talk, I will discuss the state of the art in ultrafast manipulation of magnetic bits and present some first results to implement brain-inspired computing concepts in magnetic materials that operate close to these ultimate limits.

10 min. break.

Discussion MA 19.5 Fri 15:50 H5

Panel discussion PhD Focus Session — •Tobias Hula[1], Mauricio Bejarano[1], and Luis Flacke[2] — [1]Helmholtz-Zentrum Dresden Rossendorf — [2]Walther-Meissner Institute and TU Munich

Panel discussion for PhD Focus Session:"Magnetism - A Potential Platform for Big Data?"