EPSRC DTP PhD Research Project

Project Title: Neuromorphic Magnonics

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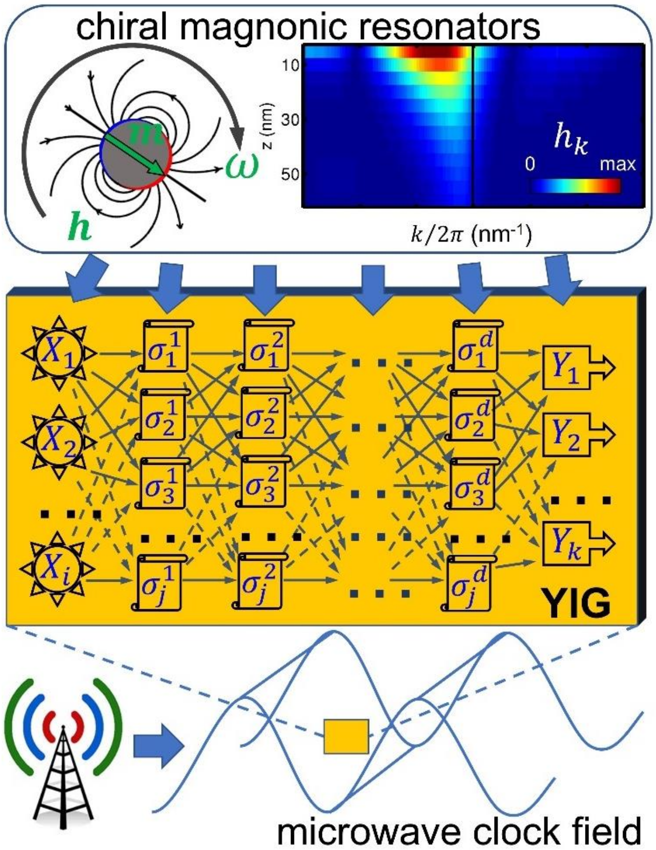
Location: Physics Building, Streatham Campus

PhD Programme: PhD in Physics

Project Description:
Both computing and thinking can be thought of as a complex nonlinear mapping of the input data to the space of answers. This mapping is defined either by the computer's architecture or by the brain's training, done using additional data ('experience'). There is also an important difference – the power consumption. Brains can implement such mappings in a very energy efficient fashion. Modern semiconductor-based computing hardware allows one to mimic the brain using algorithms of machine learning, with a steady progress in a range of tasks relevant to artificial intelligence. Yet, this success has proved disastrous in terms of the energy efficiency, making machine learning a major (and growing) consumer of energy in its own right. The search is therefore on for novel ways to power up the machine learning – those that would be free of this energy efficiency bottleneck.

In this project, you will explore building bespoke hardware for energy efficient unconventional computing using spin waves – elementary excitations of magnetically ordered materials. Spin waves boast extreme nonlinearity and modest energy dissipation while having micrometre to nanometre wavelengths at GHz frequencies. This presents unique pathways towards miniature and powerful yet energy efficient computing devices. You will combine two inherently energy-efficient technology paradigms: (i) magnonics (using spin waves to process signals and data) and (ii) neuromorphic computing (using large-scale integrated systems and analog circuits to solve data-driven problems in a brain-like manner). Going well beyond existing paradigms, you will use nanoscale chiral magnonic resonators [1] as building blocks of artificial neural networks [2]. The power of the networks will be demonstrated by creating magnonic versions of reservoir computers and recurrent neural networks.



The project allows for a bunch of practically relevant skills to be applied and / or developed, ranging from analytical theory through to numerical modelling and state-of-the-art experimentation.

1. V. V. Kruglyak "Chiral magnonic resonators: Rediscovering the basic magnetic chirality in magnonics" Appl. Phys. Lett. **119**, 200502 (2021).

2. K. G. Fripp et al "Nonlinear chiral magnonic resonators: Toward magnonic neurons" Appl. Phys. Lett. **122**, 172403 (2023).

Project specific enquiries:

Contact Prof Volodymyr Kruglyak via V.V.Kruglyak@exeter.ac.uk for more information.