

2531cs1105

Nonequilibrium spintronics for future AI hardware

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Project title	Nonequilibrium spintronics for future AI hardware
EPSRC theme	Physical Sciences
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Standard or collaborative project	Standard project
Restrictions for candidates applying	Only Home fees candidates can apply

Project summary

AI is transforming the world, but today's chips consume enormous energy running it. The brain does far more on about 20 watts, computing with noisy, nonlinear, interacting elements. Magnets offer strikingly similar ingredients, and this PhD will harness them.

Using spin-transfer torque from an electric current, we can hold a magnet's magnetisation at an energy maximum, pointing against a magnetic field. That is normally an unstable state. Our group recently demonstrated this in W/CoFeB films (Nature Materials, 2026). In this strongly driven, nonequilibrium regime, magnets become highly nonlinear, sensitive and tunable. These are exactly the properties neuromorphic hardware needs.

Antimagnons for signal gain. In a magnet held against the field, spin waves carry negative energy and become antimagnons. Coupled to ordinary magnons, they can amplify spin waves. This could supply the gain and sharp, threshold-like nonlinearity that artificial neurons and spin-wave neural networks need.

Probabilistic computing. At the boundary between stable and unstable, the magnetisation fluctuates strongly, and the current sets how random it is. This tunable randomness makes driven magnets natural probabilistic bits (p-bits). P-bits are building blocks for hardware that handles sampling, optimisation and generative AI, potentially at a fraction of today's energy cost.

You will fabricate nanoscale devices and measure them using high-frequency electrical techniques and magneto-optical imaging. You will model the results with micromagnetic simulations. These skills are valued in both academia and the semiconductor industry. You will join our very active and friendly research group at the London Centre for Nanotechnology, UCL (<https://www.ucl.ac.uk/spintronics>). We also run a second group at Tohoku University, Japan, and many of our PhD students make extended research visits. Our wider network includes TU Munich and the University of Leeds.

We welcome applicants from physics, engineering or materials science who want to work where fundamental physics meets the future of AI.