School of Mathematics and Statistics
Faculty of Science, Technology, Engineering and Mathematics

2022 PhD Projects

The Open University

Project title

Theory of Spintronics

Principal supervisor

Andrey Umerski

Second supervisor

Marc Pradas

Discipline	Applied mathematics
Research area/keywords	Applied Mathematics, Theoretical Physics, Quantum Mechanics, Spin Transport
Suitable for	Full-time or part-time applicants

Project background and description

Spintronics is a hugely important scientific field which attempts to exploit the spin of the electron in addition to its electric charge [1]. As such it can be thought of as a generalisation of traditional electronics which only ever utilises the charge of the electron. The field spans a large area of scientific endeavour from theoretical physics to engineering and is a sub-discipline of nanotechnology. It has applications to magnetic field sensors, data storage, as well as quantum and neuromorphic computing.

The modern day hard-disk read-head was the first commercial spintronic device to utilise the spin of an electron rather than its electric charge [2]. Other spintronic devices currently being developed include, novel types of ultra-fast non-volatile memory and spin-based transistors and logic gates that use electron spin for information processing. Such devices may work with virtually no applied current, superseding present-day traditional electronic technology.

This project will focus on various fundamental aspects of a phenomenon called ”interlayer exchange coupling” in ”out-of-equilibrium” systems. This has application to a new form of non-volatile memory called MRAM (magnetic random access memory) [3], which promises to eventually surpass all other computer memory including RAM becoming a ”universal memory”. The project will use a mixture of traditional pencil and paper applied mathematics, computer algebra and high performance numerical computing. The project applicant should have a sound knowledge of undergraduate quantum mechanics and applied mathematics. The ability to program in a numerical computer language such as C or FORTRAN would be of benefit, but could be learned during the studentship.

Background reading/references

1 D.D. Awschalom, M.E. Flatte and N. Samarth, Scientific American, pp66-73, June 2002.

2 J. Mathon and A. Umerski, 'Theory of Tunneling Magnetoresistance and its Application to Hard Disk Technology', in 'UK Success Stories in Industrial Mathematics', (2016), Springer, pp. 179-204, ISBN-10: 3319254529

3 Akerman, J. (2005). "APPLIED PHYSICS: Toward a Universal Memory". Science. 308 (5721): 508510. doi:10.1126/science.1110549.