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

2018 PhD Projects

Project title	Theory of Spin and Charge transport in Nanostructures
Principal supervisor	Andrey Umerski
Second supervisor	Katrine Rogers
Discipline	Applied mathematics
Research area/keywords	Theoretical Physics, Electron spin and charge transport, Spintronics
Suitable for	Full time applicants

Project background and description

Spintronics is an important scientific field which attempts to exploit the spin degree of freedom of the electron in addition to its electric charge. The field spans a huge area of scientific endeavour from theoretical physics to technology and industry. The physical quantity which describes the flow of spin through a structure is called the spin-current, and it is the spin-current which is the principal topic of this research proposal. There are a number of potential theoretical problems which could be investigated.

- Magnetic switching with spincurrents. Energy efficient manipulation of magnetic moments (magnetic switching) is required for the next generation of spintronic devices such as magnetic-random-access-memory (MRAM). To date research has focused on using a spin-polarised current, but unfortunately a high current density is required. This topic would explore the use of so-called 'static spincurrents', such as those generated in interlayer exchange coupling, to achieve magnetic switching using almost no power.
- Spin currents in graphene and topological insulators. Graphene and topological insulators are currently of great scientific interest because of their highly unusual electronic structure. The behaviour of spin-currents and spin-injection in these materials is the topic of this project.
- The behaviour of spin-current in so-called non-local geometries, where the spin current is physically separated from the charge current is of great theoretical and technological interest due to its potential application to magnetic-random-access-memory (MRAM). This topic would be explored in this project.

Other potential topics could also be explored, depending on the interests of the student. All these topics are closely allied to the research interests of the supervisor, and the program of research will explore one or more of these areas in collaboration with the principal supervisor.

Suitable students will have a strong background in theoretical physics or applied mathematics, with a knowledge of undergraduate level quantum mechanics. Some computing experience is desirable.

Background reading/references

- See Andrey Umerski's home page http://mcs.open.ac.uk/au73/, and the papers cited there.
- More general background reading can be gained from Wikipedia, by typing keywords such as: *Spintronics*, *Tunnel magnetoresistance*, *Spin-transfer torque*, and following the links.