# NAG Library Aids Spintronics in Magnetic Nanostructures at The University of Graz

Christian Ertler and Professor Walter Pötz are members of the Theoretical Solid State Physics Group at the Institute of Theoretical Physics, Karl-Franzens University Graz. Their work focusses mainly in investigating transport phenomenas in nanostructures, in particular, spin-dependent phenomenas which might be useful for future spintronic applications.

Spintronics is a hot research topic; the Nobel Prize 2007 awarded the discovery of the giant magneto resistance (a spin-dependent transport effect), which dramatically improved the data storage capabilities of hard disks used nowadays in every computer. Spintronics (= spin+electronics) tries to utilize the so-called spin of the electron (which is a quantum mechanical angular momentum, giving a magnetic moment, which can point only into two opposite directions) to store or manipulate information. It is hoped that spintronics can provide novel functionalities and drastically improve the perfomance of information technology.

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## The Challenge

Key to the project was clarifying the interplay of magnetic and transport properties in magnetic nanostructures. This structures consist of stacked layers of different materials of only a few nanometers ($10^{-9}$ m) thickness. If an external power source is plugged to the structure, particles (usually electrons) start to move through the sample. According to the small-sized dimensions of the structure the transport of this particles has to be described in terms of quantum theory.

In particular, structures are investigated, in which some of the layers are made magnetic by incorporating magnetic atoms. The electrons also possess a magnetic moment, called the *spin*, which, by oversimplfying a little bit, can only point in two opposite directions. Now, the spin of the itinerant electrons can interact with the magnetic atoms, which leads to an interesting interplay of magnetic and transport properties of the structure. The probability that an electron moves through the whole structure shows to be dependent on the electron's spin direction. This realizes a spintronic (= spin + electronic) device, which promises new functionalities and better performance than the electronic devices used today.

The project also posed some standard but complex numerical problems; solving differential equations, solving systems of nonlinear and linear equations, matrix inversion, and adaptive quadrature to name a few.

## The Solution

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Christian Ertler and Walter Pötz at the institute of Theoretical Physics, Karl-Franzens University Graz, used the NAG Library to develop a simulation tool for investigating the transport in magnetic nanostructures. By using the NAG Library they solved the quantum tranport problem very efficiently. They predict that interesting time-dependet phenomena, such as the oscillations of current and magnetization at a steady dc-bias, should occurr. The ferromagnetism in the structure can be switched on and off by the external bias. The project results were presented in a Physical Journal and at the International Workshop of Computational Electronics in October 2010 in Pisa.