

APPLIED MATHEMATICS

This will cover two main areas:

- **Nanomathematics**, to support the emerging nanotechnology and nanoscience revolution; and
- **Earth systems analysis and prediction**, including sustainability and environmental impact.

a) Nanomathematics

Nanotechnology and nanoscience is giving rise to the second industrial revolution. The US Department of Energy has identified a key potential bottleneck for future development of the field—lack of development of theory, modelling and simulation tools. A collaborative effort by universities in the South West would address both of these issues by developing a coherent, yet multidisciplinary, programme in the fundamentals of theory, modelling, and simulation at the nanoscale and in the problems of linking behaviour on the small scale to behaviour on the large scale. In addition to being truly active in the world-wide scene of nanoscience and nanotechnology education and research, it can potentially have an important, and possibly crucial, impact on the development of related commercial enterprises in the South-West.

Regional relevance and business partners

The electronics industry will not risk deploying billions of devices based on molecular electronics, even when they can be built, unless they are thoroughly understood and manufacturing processes are made predictable and controllable. The practical value of theory, modelling, and simulation for industry facilitates rapid prototyping and product development. Hence, broad based tools in theory, multi-scale modelling, and simulation in nanotechnology and nanoscience are urgently needed and, indeed, crucial for the success of industrial applications. This fact has been recognized, and is currently being acted upon vigorously in the US.

Similarly the impact of nano-technologies on the fluid dynamics field is highlighted by microfluidics emergence as an enabling technology, and hence used in practical fluid dynamics problems from laminar flow control in aerospace applications to problems in medicine, thermodynamics and production engineering. Nanoscale effects are also crucially important in the development of new materials such as the complex composites used in the aerospace industry and the revolution in communications technology promised by photonic optical fibres.

Because theory, multi-scale modelling, and simulation has been identified as a great *enabler* of nanoscience and technology, it could potentially have a great impact on the development of commercial enterprises in this area in the South West. Indeed, the (at the moment) uniqueness of this proposed activity could actually encourage and attract potential start-up companies to the region. However, it is important that we act now; this is a fast moving area.

b) Earth Systems Analysis and Prediction: including Sustainability, and Environmental Impact.

Earth Systems analysis is a newly evolving discipline, which has been described as the 'second Copernican revolution'. It combines research into climate and environmental systems, how these change with time, and their impacts on industry and society in general. It is of immense importance to scientists, policy makers, industry and society as a whole. Answers to the many environmental challenges facing mankind require this 'whole systems' approach. This in turn requires research that is highly inter and multi-disciplinary, spanning mathematical and computational modelling and analysis, physical and biological science, engineering, geology and geography, economics and social science. Few universities have

research excellence across this entire range of disciplines, so it is essential to establish strong collaborations between a number of universities who between them can address the issues with authority.

Regional relevance and business partners

An obvious partner in the development of these proposed activities, and a beneficiary in terms of the availability of suitably trained staff and stronger research links with South West universities, is the UK Met Office. However, the impact of this proposal is far broader than that.

Nearly all businesses are increasingly aware of the impact of the climate and environment on their current and future activities and business strategies. Globally, some 70% of all businesses are significantly exposed to weather-related risks, and several trillion dollars of the world economy is estimated to be sensitive to fluctuations in weather conditions. Supermarkets, the food industry, water, energy, and insurance companies are among the businesses that are now actively using weather forecasts to help improve their competitiveness. The aerospace industry has long been concerned with many complex environmental issues including noise reduction, engine emissions, alternative fuels, and wake vortex prediction. The South West is well placed to become a leading centre for environment-based businesses, but this will require the expansion of the pool of relevantly qualified researchers that this programme will deliver.