UNIVERSITY OF BIRMINGHAM

RESEARCH THAT MATTERS

QUANTUM TECHNOLOGIES

From identifying underground infrastructure to mapping brain waves in people with dementia, researchers at the University of Birmingham are at the forefront of work to exploit the laws of quantum physics to turn research in quantum technologies (QT) into practical applications which we can take into the outside world.

The principles of quantum physics, the laws that govern nature at the smallest scale, have been understood for the last 100 years.

By exploiting the extreme sensitivity of quantum sensors, physicists at Birmingham are working to bring to the market place technology that will enable them to look accurately and non-destructively at many scenarios, including mapping pipework and cabling under the road surface before digging takes place, reducing disruption and traffic delays; monitoring water levels in aquifers in drought-prone areas; understanding the archaeological history of the landscape beneath us and providing a non-invasive way of measuring brain activity to further research into dementia.

Key messages

- The University received funding of £80 million to host a national research hub to progress work in quantum sensors across four UK universities. This was announced by Greg Clark MP in November 2014.
- The Birmingham hub, one of four nationally, focuses on Quantum Sensing and Metrology.
- Our understanding of Quantum Mechanics is already responsible for advances that make modern life possible. Without it there would be no computers, lasers, magnetic resonance imaging or electron microscopes. The new Quantum Technology initiative will allow us to also harness the more involved features of quantum, such as superposition and entanglement, where we can expect applications with similar economic impact.
- The Birmingham hub has already drawn engagement from more than 70 industrial partners, and will nurture many more.

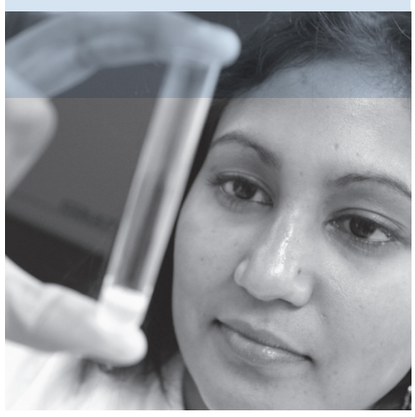
What is quantum technology?

Super-cold atoms can be in two places at once. Described by scientists as a 'spooky effect', a single atom can travel in two directions at the same time, creating an interference pattern. This enables it to explore two routes simultaneously. The atom will be very sensitive to changes in gravity and can measure very accurately the differences in gravity between the two paths.

Background

OUR £80 MILLION INVESTMENT IN QUANTUM TECHNOLOGIES (QT) HAS THE POTENTIAL TO BRING GAME-CHANGING ADVANTAGES TO FUTURE TIMING, SENSING AND NAVIGATION CAPABILITIES THAT COULD SUPPORT MULTI-BILLION-POUND MARKETS IN THE UK AND GLOBALLY.

- This funding demonstrates the government's recognition of the UK's science base and its critical contribution to sustained economic growth.
- The 15–20 year vision for this project is to trigger a multi-billion-pound QT industry in the UK, which accordingly would translate into up to 50,000 jobs.



QUANTUM TECHNOLOGIES

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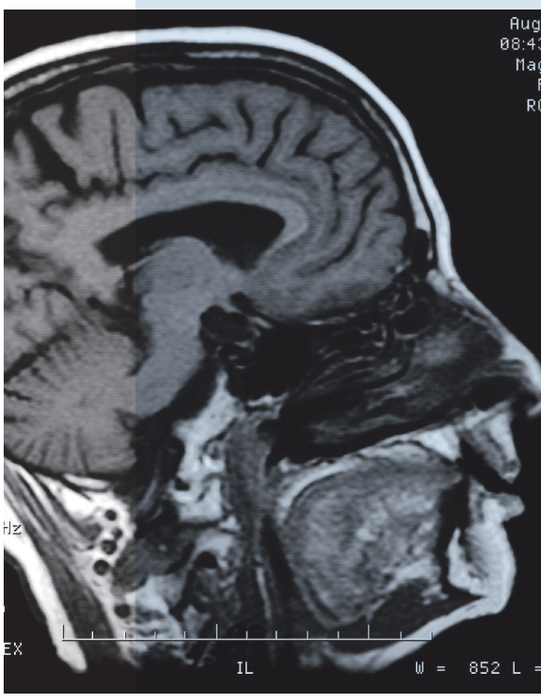
Key applications

DEMENTIA:
Dementia cost the UK £26 billion in 2015. Quantum technology magnetic sensors offer the potential to see brain waves and monitor when communication channels in the brain get disrupted (which seems to be the underlying problem in dementia). The current research is done with MEG systems, which are costly and require liquid helium to operate. Quantum technology atomic magnetometers could provide monitoring outside the clinical environment (ie, in the natural environment of the patient) at a fraction of the cost. This could enable a significant push in drug development, or even active feedback systems with electric stimulus of communication channels to mediate the effects of dementia.



The evidence

- The University received funding of £80 million to host one of four national hubs.
- The team has established strong links with industry to progress the research.
- The School of Physics and Astronomy at Birmingham focuses on three research areas: particle and nuclear physics; quantum matter and nanoscale science; and astronomy. Its annual research income is more than £8 million and more than 250 research publications are produced each year.

INFRASTRUCTURE PROJECTS:
There is a one-trillion-dollar world market for infrastructure projects. Gravity sensors based on quantum technology promise to open a new window to see under ground and help infrastructure projects in several ways:

- Roadworks: the cost to the UK of digging holes for infrastructure is about £5 billion, a year (this includes secondary costs, eg, due to traffic congestion), and three out of five holes are in the wrong place as there are no precise records of where the infrastructure lies. Quantum technology gravity sensors offer a new way of seeing under ground, which promises to reduce these costs.
- Street/rail infrastructure: gravity sensors offer the unique potential to identify sinkholes (large voids relatively deep under ground, ie, deeper than can be seen by ground-penetrating radar) and to assess railway track beds for their integrity. These are rare events, but when they occur they have multi-million-pound implications, the most recent example being a landslide close to Banbury, which closed the rail line between Birmingham and Oxford/London Marylebone for several weeks.
- Assessment of water pipes: quantum sensors could be used to assess water losses in the UK's distribution infrastructure. In addition to small leaks, there are the occasional big bursts (some years ago a hospital close to London was flooded resulting in £10 million damage). Water seeping into the ground will cause density/gravity changes, which are in principle detectable by QT gravity sensors, ie, they have substantial potential to reduce the cost of regularly renewing water infrastructure.

$1 TRILLION WORLD MARKET FOR INFRASTRUCTURE PROJECTS

GRAVITY SENSORS BASED ON QUANTUM TECHNOLOGY PROMISE TO OPEN A NEW WINDOW TO SEE UNDER GROUND.