Getting the measure of matter

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Quantum particles offer much more precise measurement than classical light.
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Peter Rohde and his collaborators develop big ideas – and a measure of corny humour – using photons, the smallest possible units of light. (Did you hear about the photon that walked into a hotel and the clerk asked for its luggage? The photon said, "I'm travelling light.")

Physics jokes aside, there's excitement about the real-world applications of using these quantum particles to make super-sensitive measurements of gravitational, magnetic and other forces. If the ideas are realised, it could lead to advances in mining, medicine and other fields.

Dr Rohde, a theoretical physicist in the Centre for Quantum Computation and Intelligent Systems at the University of Technology, Sydney (UTS), is part of a six-strong team that recently published a paper on optical quantum metrology in *Physical Review Letters*, a prestigious industry journal from the American Physical Society.

"We came up with a way of [measuring] using single photons," Dr Rohde says. "We have a simple system where you put in single photons, evolve them through a circuit we devised, then at the output it gives us a very precise measurement."

Perhaps the best part of the team's big idea is that it uses available technology, putting it a step closer to real-world implementation.

Quantum particles such as photons, says Dr Rohde, offer much more precise measurement than classical light such as lasers. "There are lots of applications where we want to be able to measure very, very small differences," he says.

One industry that could benefit is mining. "Suppose you want to measure what's under the ground – you just want to non-intrusively measure it without going to the cost of digging it up," says Dr Rohde.

"The gravitation created by a piece of rock is minuscule. If you have precise ways of measuring gravitational field … you might be able to scan an apparatus across the surface of the ground and get an idea of the different gravitational effect at different points, which would give an indication of the different types of material under the ground."

Macquarie University physicist Keith Motes collaborated on the research and is excited about the idea's possibilities. "With imaging of the body and brain in medicine, if you can measure magnetic fields more sensitively then you can image things better," he says. "Perhaps it could be used to measure magnetic fields better than a classical device. Perhaps it could be implemented in an MRI machine."

Dr Rohde is supervising Motes' PhD. Together they have published other research – as part of a team of four – on a breakthrough concept in optical quantum computing. A quantum computer, if it becomes reality (corporations such as Microsoft and IBM are investing in the notion), could crunch data in a way that makes a supercomputer look like an abacus.

"There are certain algorithms that a quantum computer can solve in a second that the supercomputers in the world currently would not be able to solve in the age of the universe," says Dr Rohde.

"RSA encryption [used for internet banking, among other things] is based on the fact that a classical computer would take billions of years to crack the encryption and therefore we assume that our information is pretty secure. A quantum computer could crack this type of encryption in no time.

"There are other applications, for example in drug design. It's complicated on a classical computer to simulate interactions – if, for example, you want to see how a human cell interacts with a molecule from a drug. A quantum computer would find that simple to do."

Dr Rohde and Motes were at a conference in Baltimore when, bored with proceedings, they sat in the lobby with pen and paper and bounced around ideas. "We came up with a way of building an optical quantum computer where, instead of requiring trillions of optical elements, it requires just three," Dr Rohde says.

"As the size of the computation gets bigger and bigger, that number doesn't change – it's always three. Instead of requiring a laboratory that would be the size of a football field, you've got something very compact. It's still challenging [to develop] – there are various technological complications – but it's much simpler than what's been previously pursued."

Dr Rohde showed an aptitude for problem-solving even as a child. "As a kid, I never bought the toys kids usually play with," he says. "For me, the best present was an old broken radio so I could pull it apart, extract the components and build something new. Then I got onto Dick Smith's kits and I think I worked through every single one he made."

The 33-year-old loves extreme sports, having climbed four of Europe's 4000-metre-plus peaks including Monte Rosa and Mont Blanc. He's also into free-diving – holding his breath under water for up to four minutes and 20 seconds. "It's funny because almost every physicist I encounter is involved in some sort of extreme sport, most commonly rock climbing," says Dr Rohde.

Motes, whose interest in physics was sparked by playing pool, is into snowboarding and yoga, which doesn't sound too extreme. "It's extreme internally," he says.

Provided by University of Technology, Sydney