University of Birmingham

Quantum Technologies

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Guest: Professor Andy Schofield
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Intro VO: *Welcome to the Ideas Lab Predictor Podcast from the University of Birmingham. In each edition we hear from an expert in a different field, who gives us insider information on key trends, upcoming events, and what they think the near future holds.*

Sam: So we're here today with Professor Andy Schofield (http://www.theory.bham.ac.uk/staff/schofield/) who is Professor of Theoretical Physics and Head of the School of Physics and Astronomy (/schools/physics/index.aspx) , here at the University of Birmingham. Hello Andy.

Andy: Hello Sam.

Sam: So we're here today to talk about quantum technology and I don't know much about quantum technology myself so why don't I start off by asking where do we see quantum technology in our daily lives?

Andy: Well quantum technology is actually something that has only just come to fruition and at the moment there are only a few examples of places where you can see quantum technology in action. Quantum mechanics on which quantum technology is founded are the laws that the way the universe works, particularly at the smallest scale, and we've understood those laws really for almost a century and quantum technology is about using, and in particular exploiting, some of the spooky properties of quantum mechanics and we hope and we have confidence actually that in the near future we will now start to see the applications of quantum mechanics into quantum technology in our daily lives.

Sam: What would be an example of something that we'd see as a result of quantum technology?

Andy: OK, well the understanding of quantum mechanics itself has already lead to technology – your smart phone for example relies on our quantum understanding of the world – but it doesn't exploit the spookiness of quantum mechanics and if I kind of explain that in terms that may be easier to visualise, we're sitting here in my office, my office peculiarly has two doors, two exit doors and when I decide to go home in the evening I have to decide which of those two doors I'm going to go out of. In the quantum world, particles don't have to make that choice and a quantum particle can actually take two routes, maybe more, to its destination and one of the ways that we can do this, use this seemingly kind of crazy non-intuitive way that the world works in the quantum domain is to exploit the fact that particles can go in more than one way to the same destination. So to give you an example of something that we're doing in Birmingham that will make use of exactly that, we're designing a device that will be very sensitive to changes in gravity and in essence, the way it works is to send an atom, both at the same time down two different routes and as the single atom explores those two routes simultaneously, it can measure very sensitively the differences in gravity between the two paths.

Sam: OK, so you can measure gravity but why would you want to do that? What applications does that actually have?

Andy: That's a very good question. You may have had the same experience that I have had of being stuck in a traffic jam because there's road works up ahead of us. One of the reasons that the roads are continually being dug up is that actually we have very little understanding of what is underneath a particular road. So if you need to fix a cable or a drain then you can be confident it might be under one part of the road but precisely where, you may not know. Moreover you also in fact have no idea what else is down there, what other important services. So it means the very act of digging up a piece of road is much more disruptive than it need be, if you could effectively remove and visualise what's underneath the tarmac. A gravity gradient censor which would be an exploit of quantum technology would effectively do that for you, allow you to look underneath the road and to be able to see all of the pipes that are out there and if you understand what's down there, then you can actually do something about it and be much more efficient in digging up the roads. And in fact the project that I've just described are measuring gravity gradients very sensitively using quantum technology is actually jointly funded with our colleagues in **civil engineering (/schools/civil-engineering/index.aspx)** and they are particularly interested in that as an application. But you can also imagine that it doesn't end there and there are archaeologists on the team. Why? Well if you want to find archaeological discoveries then it's great if they're metal, you can use a metal detector, but what if they're bone or ceramic, things that won't show up with a metal detector? How are we to look underneath the ground? Well a gravity gradient detector is exactly the way for doing that and you can quickly see that once you can see beneath the ground you can start looking for oil or gas, you can do all sorts of things that people are extremely interested in. So we're very excited about this and the quantum technology I'm describing is literally something that will impact on our lives on a sort of five year timescale.

Sam: But it's not only looking under the ground that this technology can do is it? It can do all sorts of things can't it? It's quite amazing.

Andy: Yes. I mean the potential of quantum technology to really transform our lives I think is only just being tapped. If you wanted to go to the market now and say what can I buy that exploits quantum technology, there's really only one application that's on the market commercially at the moment and that is in the form of quantum cryptography. If you want to secure sensitive information and transmit it from one place to another then although we've got good and secure means of doing that at the moment, you can actually buy a quantum cryptography kit which has no known mechanism of being broken into and that is already the first commercial application of quantum technology. I think the things we were discussing about gravity gradients are likely to be the second application of quantum technology that will hit the market. The science behind it is pretty well understood. What we're trying to do now is to go from the science to the engineering to make a device that is portable and can go where we want it. Well, you might think that you don't just want it on planet earth; you might want to put it into space. In effect you could look down and measure the volume of the Greenland ice sheets and Antarctic ice sheets and track global warming very directly from the gravity signal. Then I think as we look into the longer term, then the method by which we're going to exploit quantum technology becomes less clear and much more open for further research questions. So I described how quantum particles can be in two places at once. That allows the prospect of quantum computing where instead of having a computer that relies on zeros and ones, you can combine them together and have a quantum computer where zeros and ones co-exist simultaneously and that will speed up certain algorithms, certain methods by which a computer works, many many times over the usual computers that we rely on today. That's a great goal of quantum technology. It's a goal where we know many of the problems that are arising and we have some routes to their solution but it's not fully understood even at a research level how we're going to break through those barriers to the technology. So I think there we're looking at decades or a decade timescale before we're going to see commercial applications of that sort of quantum technology.

Sam: So obviously there's a world of research possibilities here but what is it that we're doing here at the University of Birmingham? Where are we starting with all this?

Andy: Well we have a number of projects going beyond just the quantum technology for measuring gravity gradients. We have a very active collaboration with our colleagues up in **Nottingham (http://www.nottingham.ac.uk/)** as part of the **Midlands UltraCold Atom Research Centre (http://mpa.ac.uk/muarc/)** and the whole idea behind that centre is using the quantum properties of atoms, particularly cooled to billionths of a Kelvin above absolute zero, so very near absolute zero, where those quantum properties become much more manifest and much more sensitive to the environment and that's how you can use them for measuring things. Our colleagues in Nottingham for example are making detectors that will measure the tiny currents in the brain and again, allow us to see into the brain by very sensitive measurements and this of course is set in the contexts of a worldwide effort of physicists and technologists around the world, grappling with how to turn the science of quantum mechanics into the technology of quantum mechanics.

Sam: Fantastic. Well that's very exciting stuff. So Professor Andy Schofield, thank you very much.

Andy: Thank you, Sam.

Outro VO: *This podcast and others in the series are available on the Ideas Lab website:* ***www.ideaslabuk.com (http://www.ideaslabuk.com)*** *. There's also information on the free support Ideas Lab has to offer to TV and radio producers, new media producers and journalists. The interviewer and producer for the Ideas Lab Predictor Podcast* *was Sam Walter.*