New Frontiers

Quantum Technology

Despite a number of successful demonstrations, quantum technologies are still in a very early phase of development. An inducement prize in this area could help further incentivise research communities to advance the demonstration and commercialisation of quantum technologies.

Our vision

The role of an inducement prize in this area would be to accelerate innovations in the field by encouraging existing academic groups and partnerships to actively compete towards building concrete applications of quantum technologies for a range of useful purposes. Most of the research groups working in this area seem to be well funded, thus this would limit the common challenge of participants needing to attract funding in order to work towards a solution. A prize in this area could also help familiarise a broader audience with the concepts and opportunities offered by quantum technology.

The challenges and their context

The field of quantum information science and technology is a growing one. In the past decades, significant advancements have taken place in quantum cryptography, with around 100 groups around the world working on technologies such as quantum key distribution. Other areas such as quantum communications and quantum computing are still at a more fundamental level of development.

The two main advantages often highlighted when discussing quantum technologies are significantly increased computing power and increased security.

The challenges in each of these areas of quantum technologies research are varied. For example, for quantum key distribution, researchers are currently looking at the use of satellites to help transmit quantum signals across large distances. However, one of the limitations to this approach is the fact that satellite trajectories cannot be predicted over long periods of time to the precision required.

In the field of quantum communications, researchers are looking at developing technologies to help transmit quantum information over long distances. Because of the additional complexity of the data to be transmitted, different technologies to those used in quantum cryptography need to be developed. Potential solutions could include the development of quantum repeaters (which do not distort the quantum data) or atomic memories able to appropriately store quantum-specific information. However, these technologies are still at an early stage of development.

The purpose of developing an inducement prize in this area would be to overcome significant technological barriers and accelerate change in order to allow for additional innovations to take place. For example, in the area of quantum communications, the challenge could be that of developing technologies that can support the transmission of quantum information over long distances.

Current innovation

Research in the field of quantum technologies is steadily advancing; while some areas such as quantum computing or quantum communications are still at an earlier development phase, researchers in quantum cryptography are working towards building existing demonstrations into commercial solutions.

Latest research in the field of quantum communications has managed to transmit quantum signals over a distance of 100km using 'dark fibres'[1]; for longer distances researchers are looking into the use of 'node points', atomic memory and satellites. Such technologies are required when transmitting over long distances as quantum data can't be amplified like traditional electronic data encoded on laser light and transmitted through optical fibre.

Using 'lit' fibres to transmit telecommunications data poses a different challenge as conventional data streams are usually about a million times stronger than quantum streams and the quantum data are drowned out. Recent breakthroughs have reduced the noise level of detectors while increasing their efficiency in detecting photons from just 15% to 50%[2].

In quantum cryptography, vast improvements have also been made in the rate at which detectors can 'count' photon pulses — this is crucial in determining the rate at which quantum keys can be sent, and thus the speed of the network. Counting rates have been raised 1,000-fold, to about 2 gigahertz[3].

The potential for challenge prizes

- Long distance quantum cryptography: Existing approaches using fibre-optic cables offer a reliable and secure solution for individuals and organisations interested in exchanging encrypted information across relatively distances of less than 100km. However, in order to fully exploit the capabilities offered by QKD, innovations are needed to increase the distance over which quantum keys can be sent.
- Quantum communication: There are a variety of barriers to achieving deep space travel, one of them being our limited communications systems. Currently we can only send messages at the speed of light, which is too slow for deep space travel. Quantum mechanics offers the potential for ultra-secure and instant communication.

Prepared for the Nesta Challenge Prize Centre by Anna Williams. Last updated 12/02/2016.

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[1] C. Gobby, Z. L. Yuan and A. J. Shields (2004). 'Quantum key distribution over 122 km of standard telecom fiber'. Appl. Phys. Lett. 84, 3762.
[2] Qiu, J (2014) "Quantum communications leap out of the lab" Nature New. [Online] Available at: http://www.nature.com/news/quantum-communications-leap-out-of-the-lab-1.15093?WT.mc_id=TWT_NatureNews
[3] ibid