Name of Quantum Technology

Quantum metrology

What is the potential vision for this area?

In the next 5 years…

- Improve miniaturisation of atomic clocks using QM to minimise noise.
- Magnetic field sensing at nm scale. In difficult environments.

In the longer term…

- Will be a key part of the wider quantum technologies. (Manufacture, testing, etc)

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What prevents this vision from being realised?

Research challenges to overcome...

- Feasible architectures.
- Understand unwanted tunnelling events.
- Significant progress below the shot noise limit.
- Interaction/decoherent balance
- Realistic calculation of quantum properties.

Scientific / technological barriers...

- Low loss sources
- Devices
- Efficient measurements
- Decoherence
- Lack of theoretical tools for many-body problems.

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What can the UK do to deliver this vision?

What we currently know...

- Loss is a killer
- Entanglement can be helpful
- Design and strategies are application dependent
- There are few applications.

<u>Applications</u>

- Enhanced resolution magnetometry
- Reduced measurement time
- Quantum current standard
- Mass standard
- Gravitational field strength time standards.

What we need to know...

- Work on loss resistance.
- How to work within real world constraints
- Need to understand what the real world looks like.
- What are the problems? Who is interested?
- How do we get quantum measurements into the real world?
- Access to industry/defence roadmaps.
- Community roadmap.

- What can sophisticated engineers achieve?
- How do we get them engaged?
- A figure of merit for what good measurement is.
- How perturbed is the system.
- Comparisons with classical limit?
- How do we filter R->D in this area?
- Manufacturers?

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What can the UK do to deliver this vision?

(Might?)

What should the UK do differently?

- On the tech side – need careful assessment of how limited resources should be used to enable key advances.
- Appropriately collaborate across disciplines – Training approach?
- Vertical integration?
- Explore gap between discovery and development. Big research labs?
- Visible presence to interface with big international activities.
- Careful assessment of balance between R and D with limited resources.
- More direct grant based PhD funding.

<u>International competition</u>

- Time standards -> NIST/Jila
- Simulation -> Germany
- Australia (e.g. Simmons)
- German model – Max Planck
- Stanford + spin out
- Gravity sensors & clocks
- Harvard – NV magnetometers
- France – Inertial sensors (Bordeaux)
- Hannover – Microgravity – Quantum absorption
- Multidisciplinary – with engineers
- Network
- Co-location Balance

Quantum metrology

<u>Other Points</u>

- Metrology leads 10 years beyond what industry needs
- Portable quantum Standard
- Measuring small changes in absorption or length.

- Need to ask the customers Is there a high value measurement

- More engineers and Industrialists

- Improving classical systems for commercial exploitation

- Magnetometry for research applications

- Potential to reduce measurement time with entanglement

- Diamond NV Centres (enhanced resolution)

- Quantum Current Standard

- Superpositions -> correlations