Computation

What is the potential vision for this area?

In the next 5 years...

What's the D-Wave –simulation machine good for? Is it quantum what speed up?

Understanding what counts as non-classical

Control by engineering of decoherence
…. 4 bits or more in solid state!
….2 gates or more

Interfacing between different implementation

Improve theoretical tools for calculating specific quantum properties i.e entanglement

New algorithms

Understanding fault tolerance thresholds

Better understanding of noise models in diverse/new quantum proposals

Study broad range of technologies

Less hype more substance

Understand barriers to scaling

Identify a goal the public can buy into

Identify and produce new materials for quantum technologies →

Scaleable 2 qubit gate →

Build quantum computing architectures that can be scaled up

Scalable entanglement methods

In the longer term...

New Algorithms

Scalability is the big challenge

More general and obviously commercial applications are needed

Funding an achievable application quantum modelling of a real system and commercialise it

Mapping one strongly interacting system onto another

Discover new materials with novel properties

↓ Medical ↓ Hig Tc ↓ Thermal Mechanical

Identify 1 or 2 applications that make money

Field of quantum engineering to emerge

New material for quantum technology Graphene nanoribbon tunnel

Transistors exploiting the charge and spin of strongly confined single electrons with slow decoherence rates

Use these materials to make new qubit quantum processers

Scale it

Computation

What prevents this vision from being realised?

Research challenges to overcome...

Hybrid quantum computers [interface different type of qubit hardware]

Positioning Q spins

Engineering interactions

Process variability

Need teiller algorithms
…. More than shor?!
….higher level languages (i.e. not designing at the gate level)

Scalabilty in different systems

Double digit # of qubits pls

Realistic calculation of quantum properties [decoherence, entanglement, etc.]

Convincing industry to invest

Hot research

Integrated systems including engineering structure

Scientific / technological barriers...

DECOHERENCE – during exchange coupling

Braiding of ayons 5/2 ….

(nano) fabrication – reliable

Algorithm design for devices with big margins (“margin tolerence”) “built in redundancy”

Foundry capability

Benchmarking

Engage more computer scientists + mathematicians

Alternative implementations of adiabatic Q.C.

Can braiding be used as a universal quantum computer

Manufacturing reliability

Communication between different units within quantum hardware

Computation

What can the UK do to deliver this vision?

What we currently know...

Too early to pick a winner (technology)

Combining technologies

Build teams spanning a range of skills

(Theory experiment, fabrication…..)

World leading groups

Funding + leadership

+ Large groups + Studentships

Existing network for Q computation to bring computer scientists, mathematicians + physicists together (PI Oxford – Samson Abramsky)

CAUTION: we need to be honest and realistic about the timescales and the technological possibilities, i.e. don't oversell it to the politicians. We need to harness the skills of a wide national community of physicists, chemists, material scientists, computer and electronic engineers etc

What we need to know...

How does error correction scale in real systems

How many qubits would deliver something of value

What is the value?

How can a quantum computer be used to model quantum system?

How can you control decoherence during exchange coupling

How do you control charge noise

How do you efficiently characterise multi-qubit quantum systems?

What noise levels destroy non-classical computation?

When will quantum code breaking be feasible

Computation

What can the UK do to deliver this vision?

What should the UK do differently?

- Technology transfer improvement (R&d ⟶ r&D)
- More close look at heterotic computing
- Integrated teams (technical)
  - Eng
  - Physics
  - Chem
  - Materials
  - Computers
  - Etc
- Value in improved training (CDT's)
- Funding for international PhD students
- Yearly conference on QIP
- Creating groups to work on different problems required to be solved
- Facilitate sharing of techniques (cooling, RF, noise reduction) ⟶ has commercial value outside QIP
- Revisit PhD funding e.g. allow via responsive mode, restore DTA, delete CDT's
- More networking across academics and with industry (as with QIPRC)
- Analyse funding models in competitive countries (e.g. Japan, USA, Australia)
- Sharing and funding national "foundries"/facilities for fabrication of chips etc.
- Development of instrumentation to quantify coupling between qubits

- Provide funding for all academics irrespective of the current hot topic

- UK community funding to build interdisciplinarity: networks, yearly gatherings, IRC type activity, Virtual Institute?