

Can quantum physics help improve sensing and imaging?

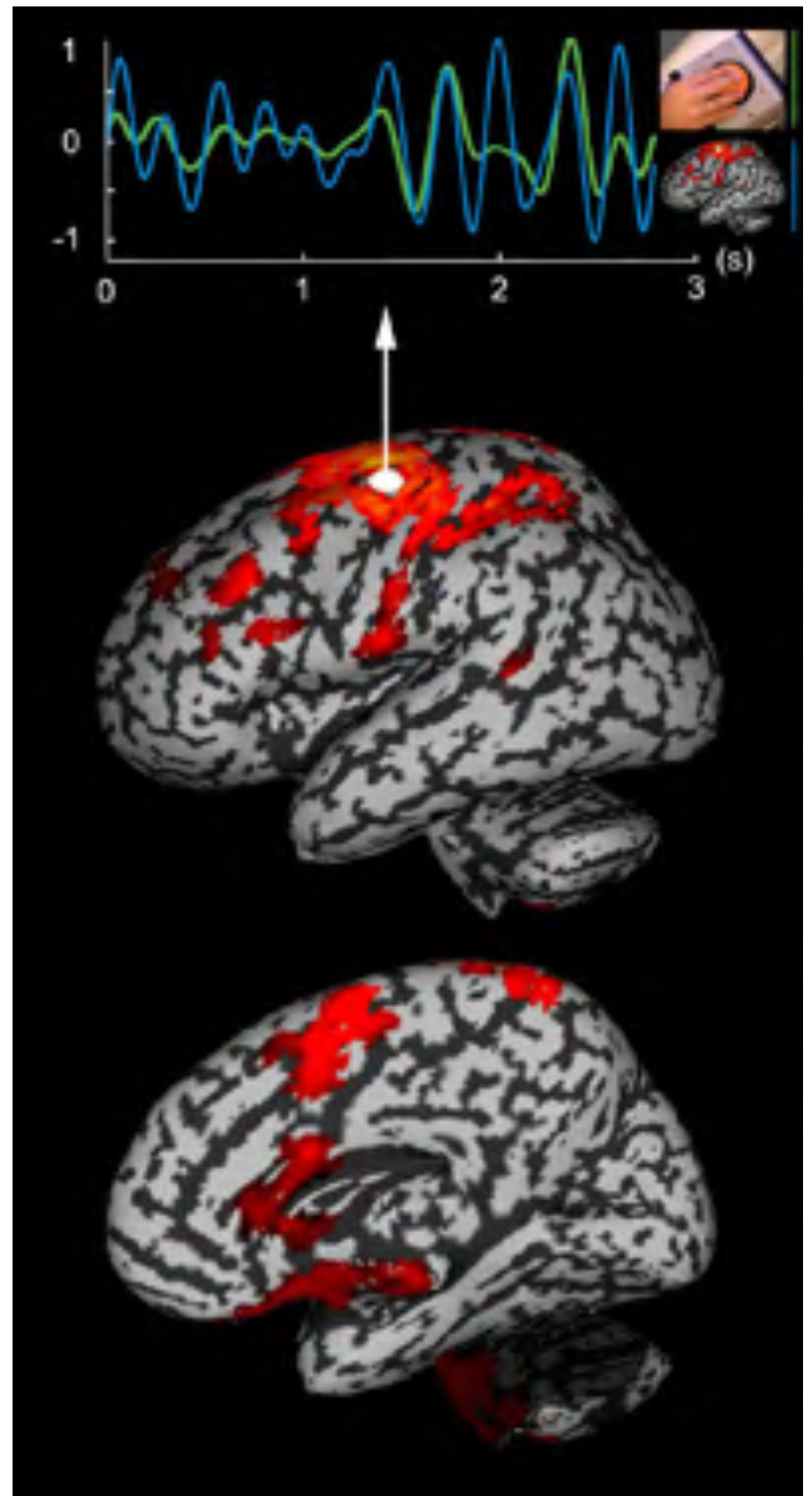
Kjetil Børkje

University of South-Eastern Norway

Tekna breakfast seminar, Oslo, 2020-03-05

Outline

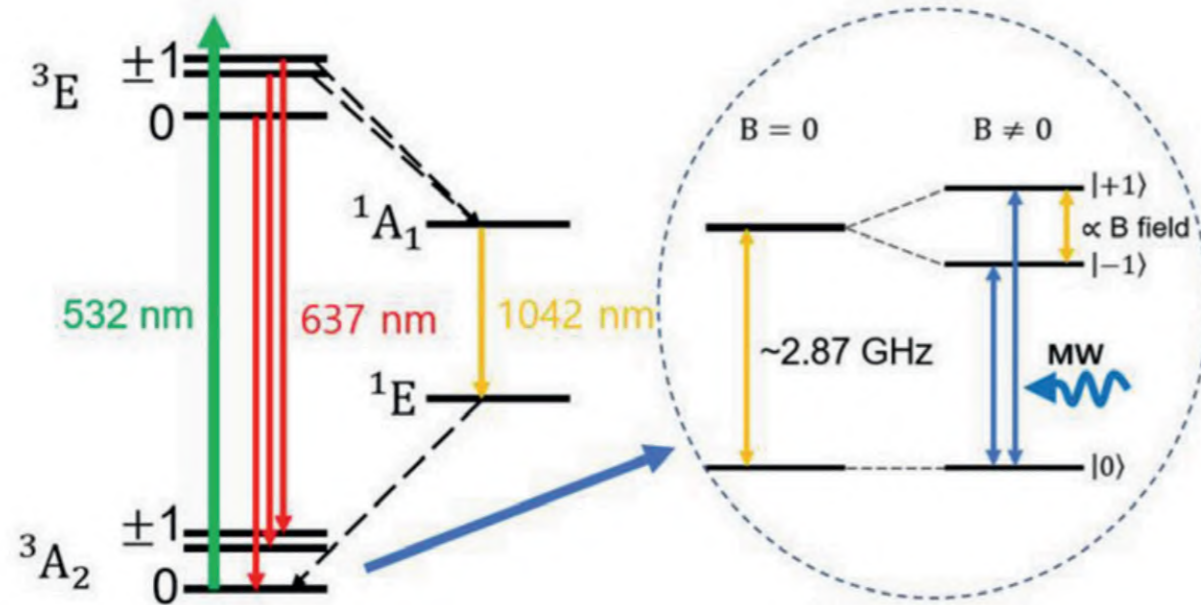
- **What is sensing?**
- **What is quantum sensing?**
- **Some promising research directions**
- **Final remarks**



Credit: National Institute of Mental Health, National Institutes of Health, Department of Health and Human Services

When is sensing «quantum» ?

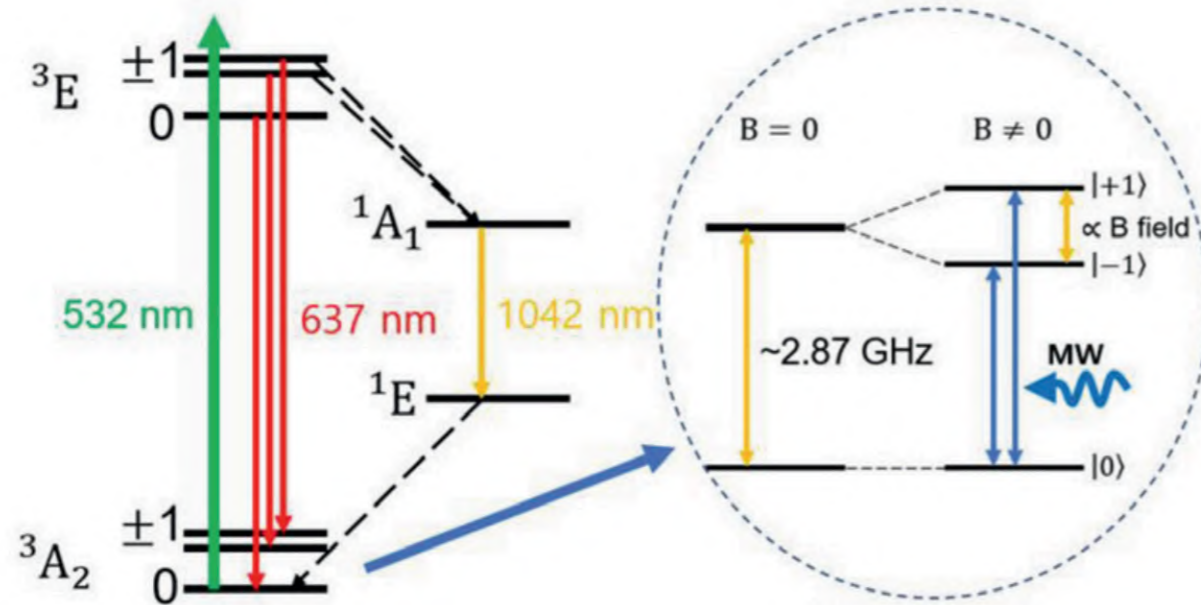
When is sensing «quantum» ?



Quantized energy levels

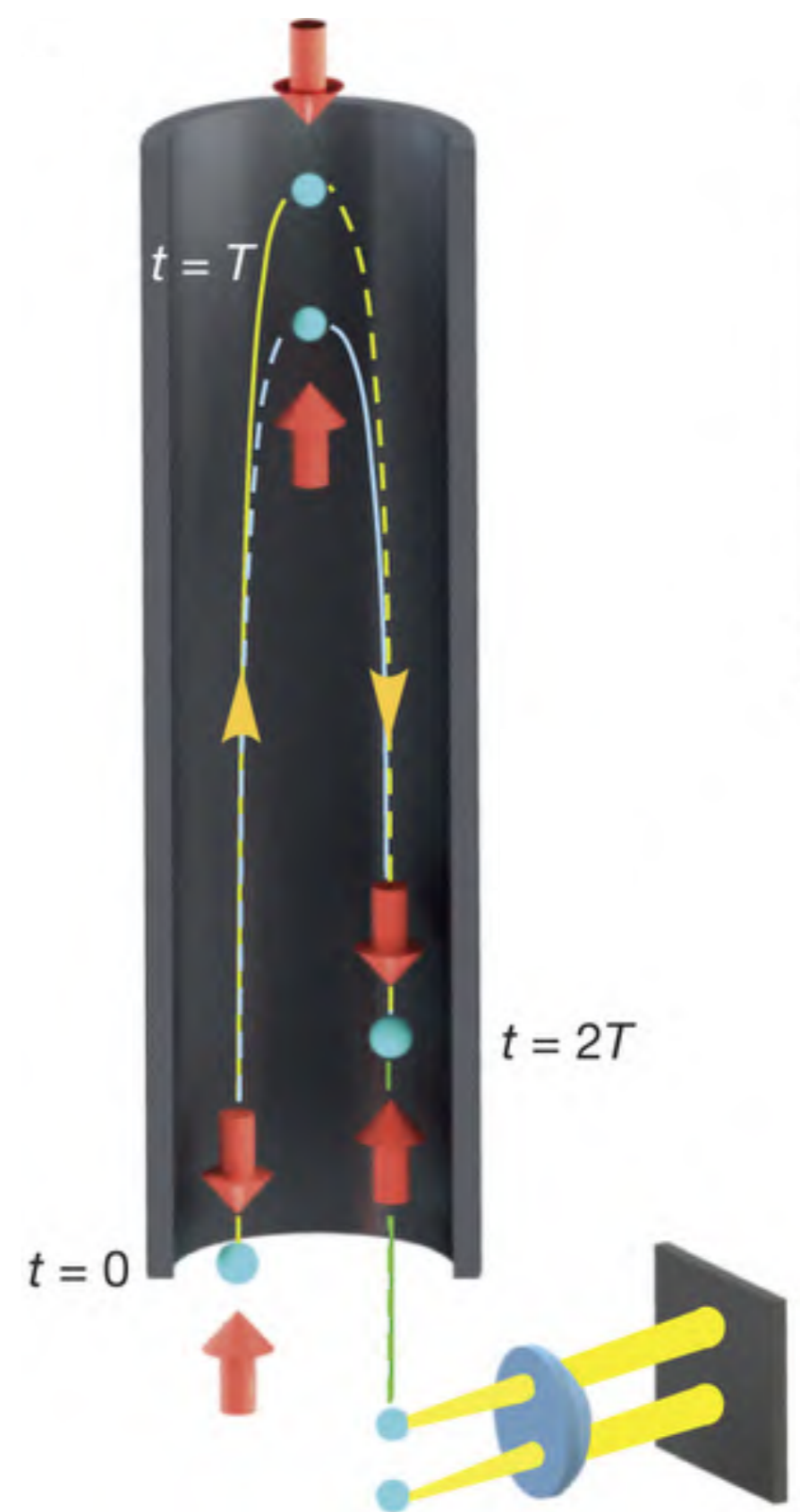
Lee et al.,
DOI: 10.5772/intechopen.84204

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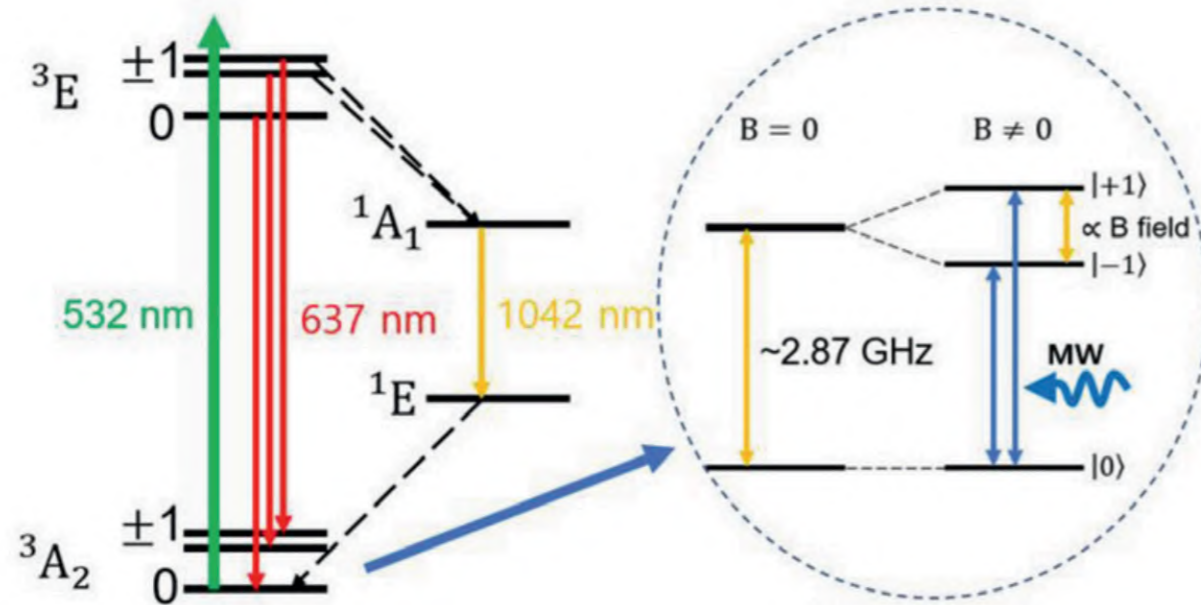
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Quantum superposition

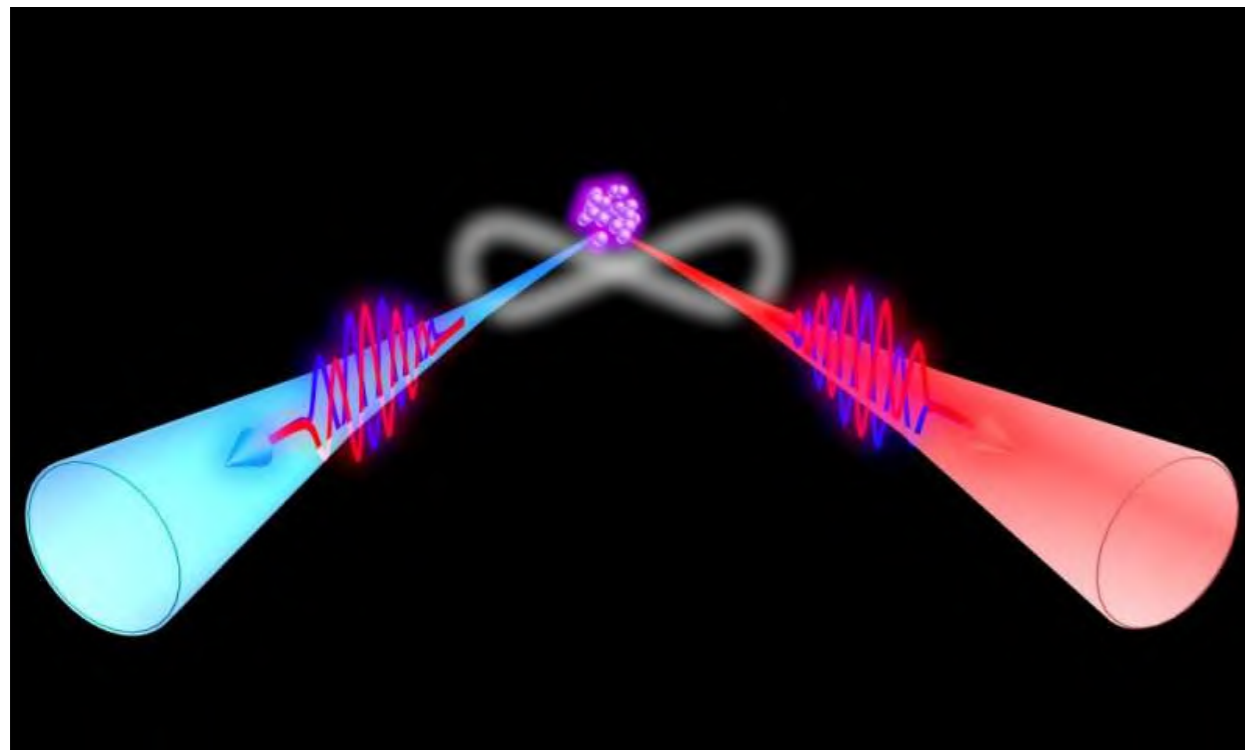
Kovachy et al.,
Nature (2015)

When is sensing «quantum» ?



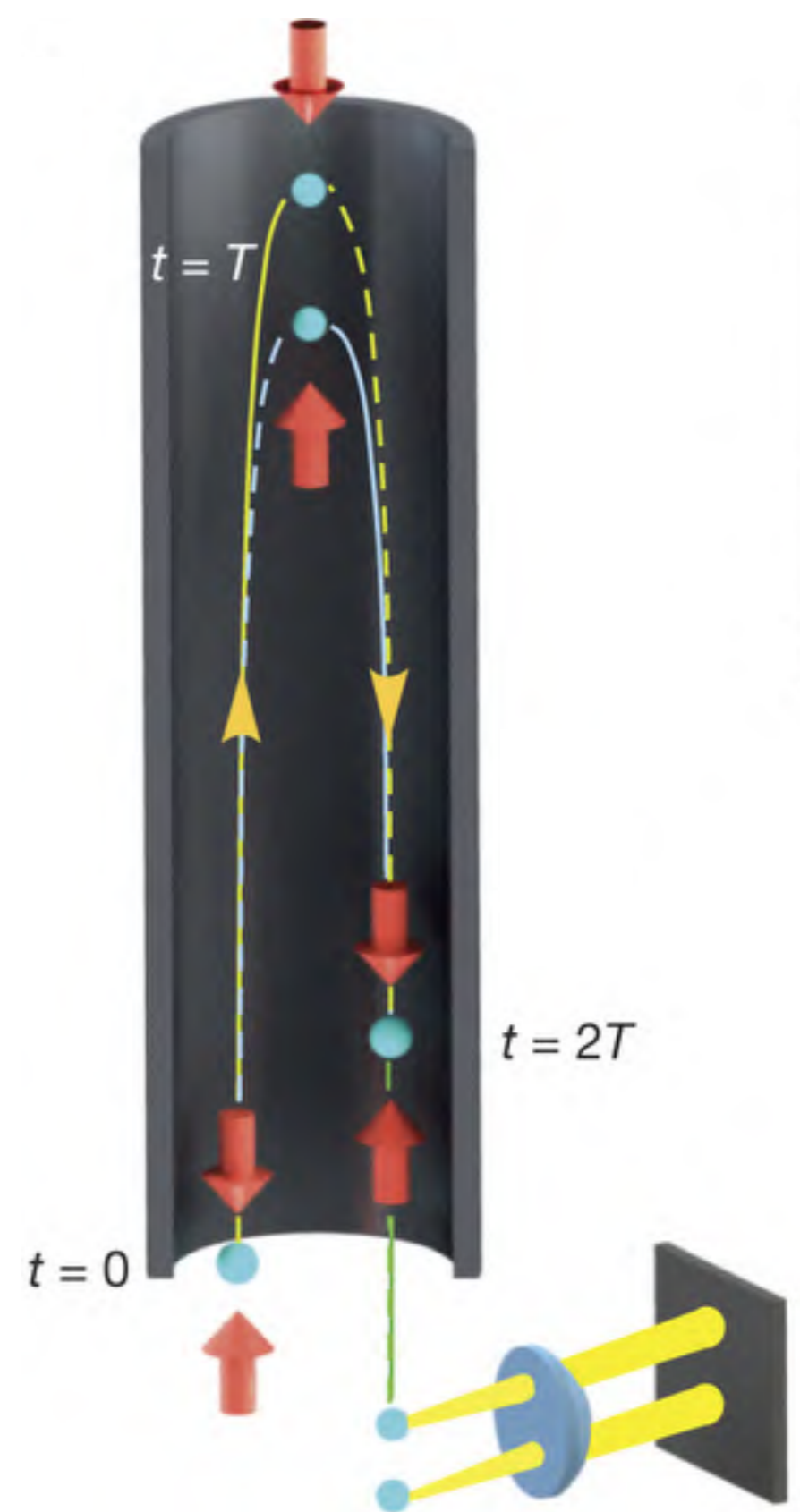
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Quantized energy levels



Physics department, HKUST

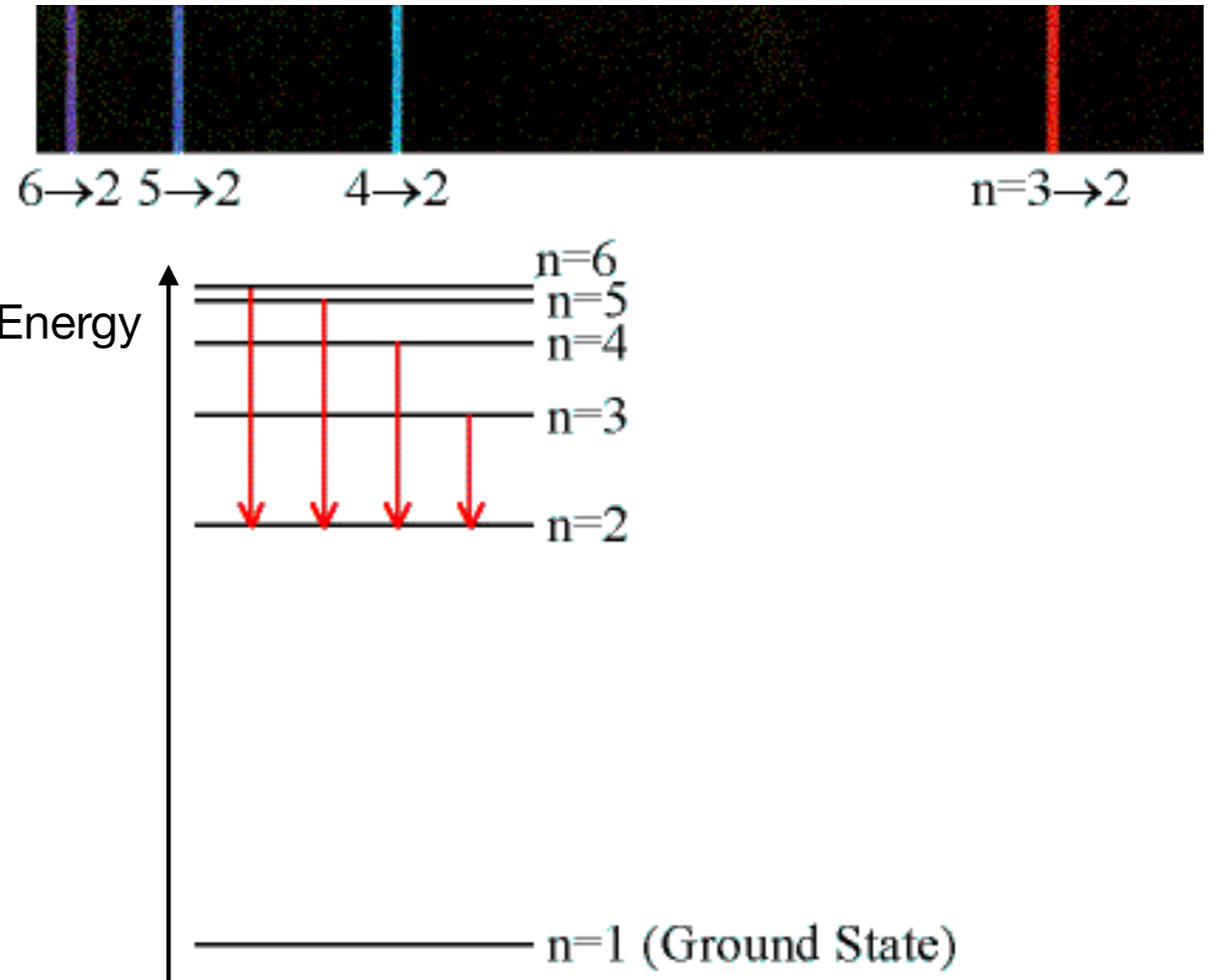
Quantum entanglement



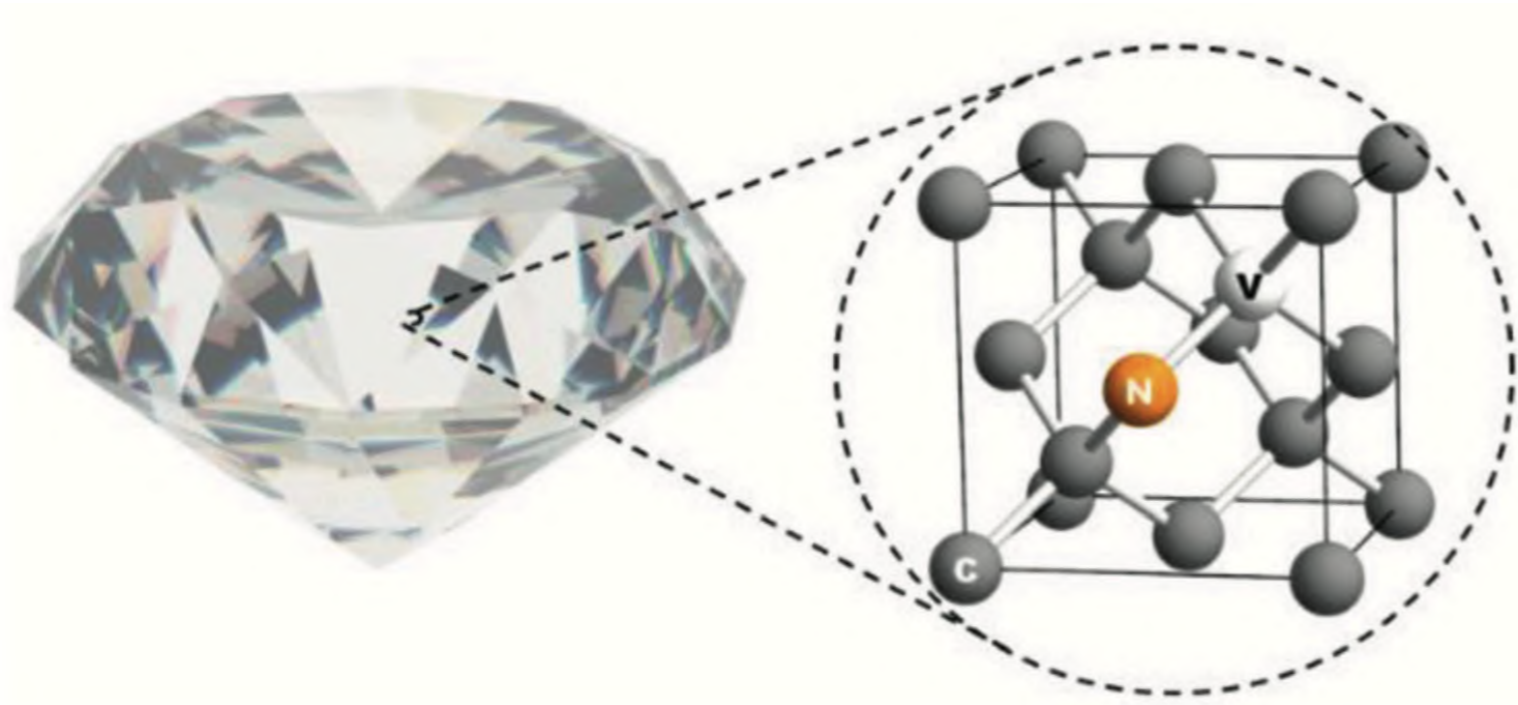
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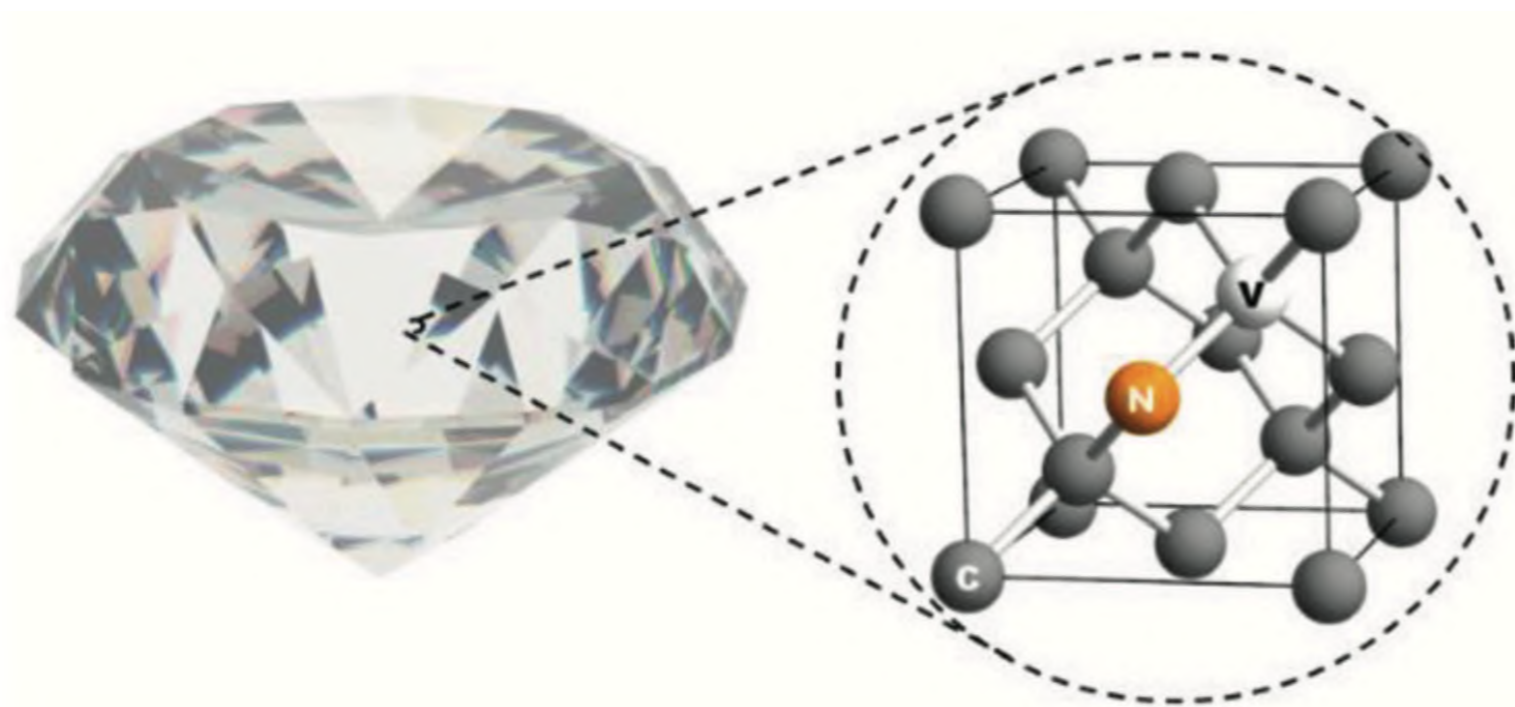


NV centers in diamond

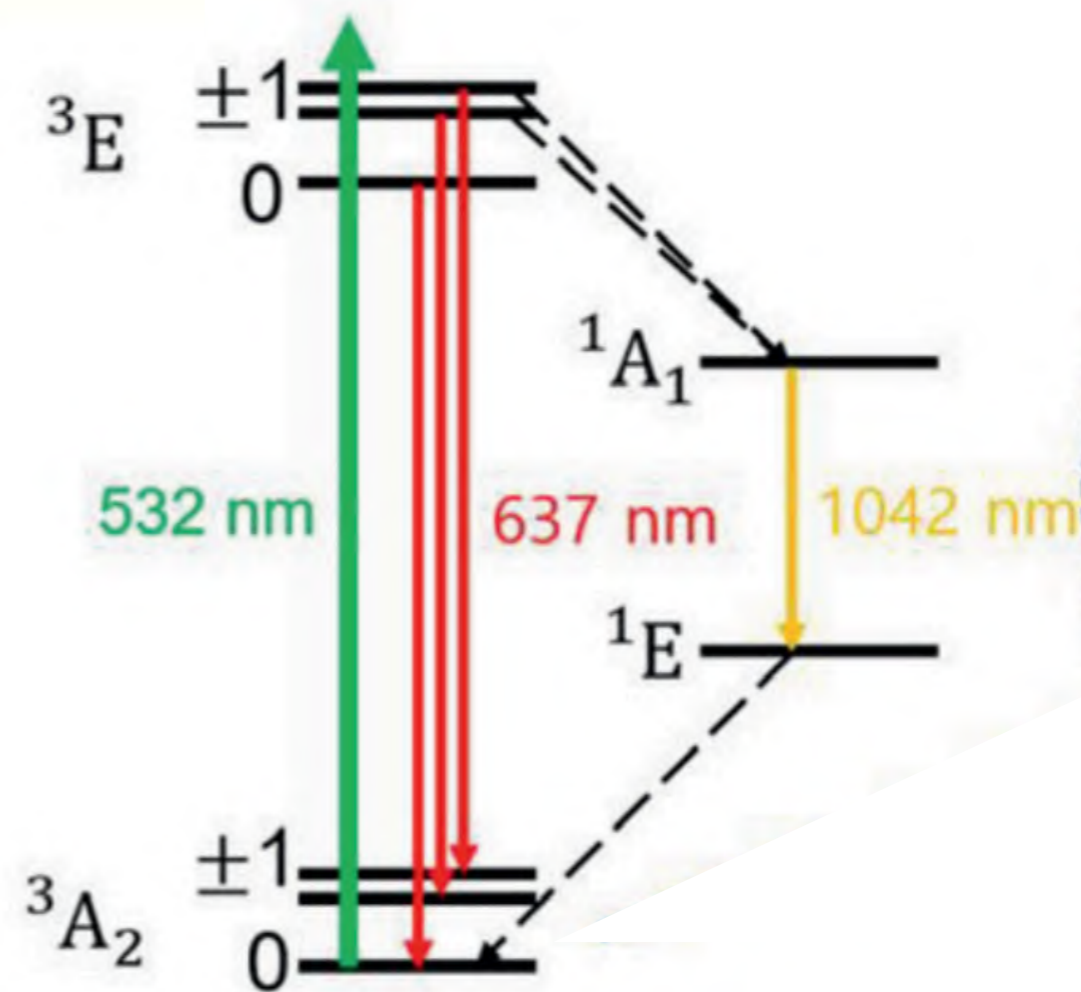


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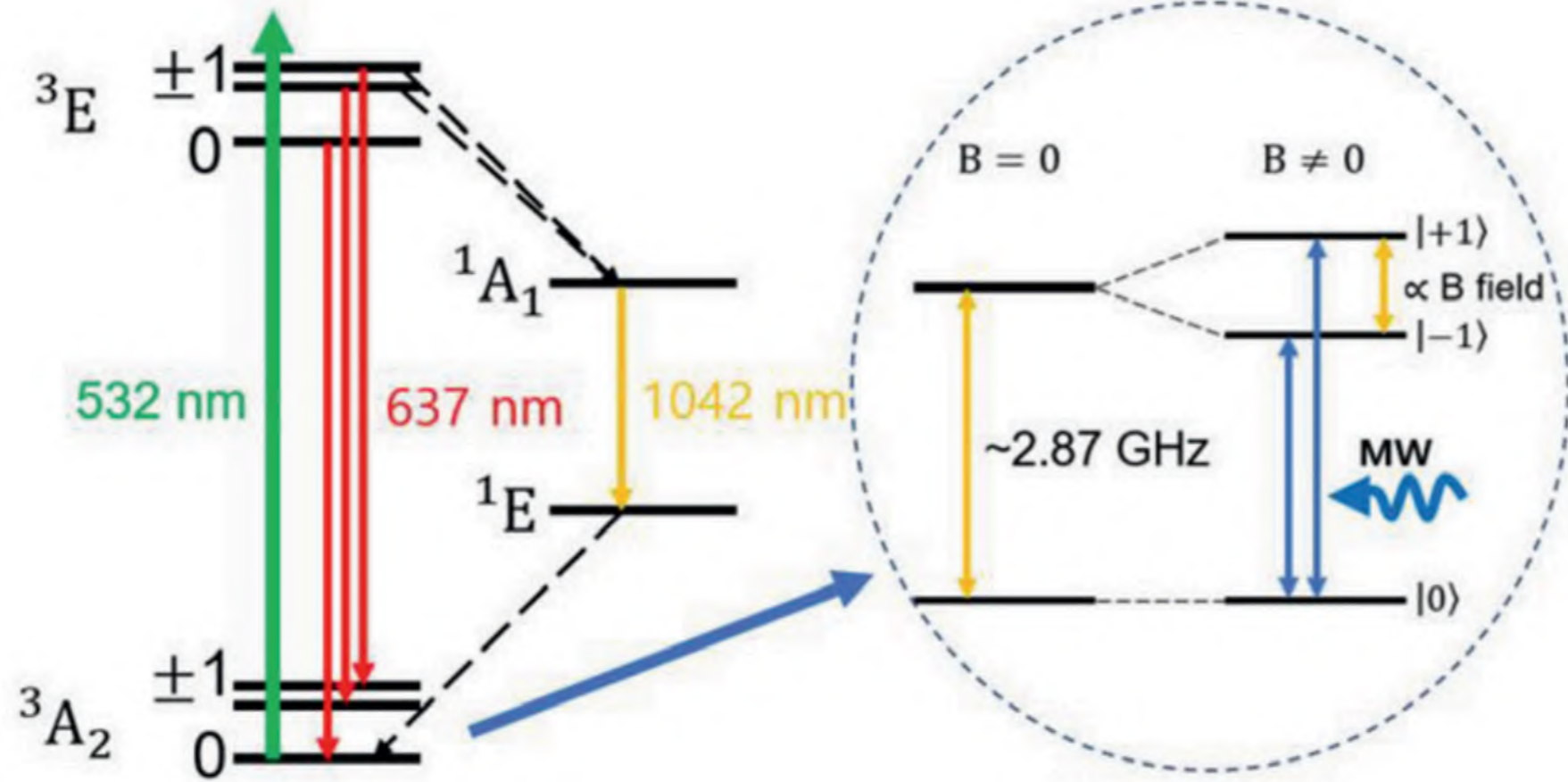
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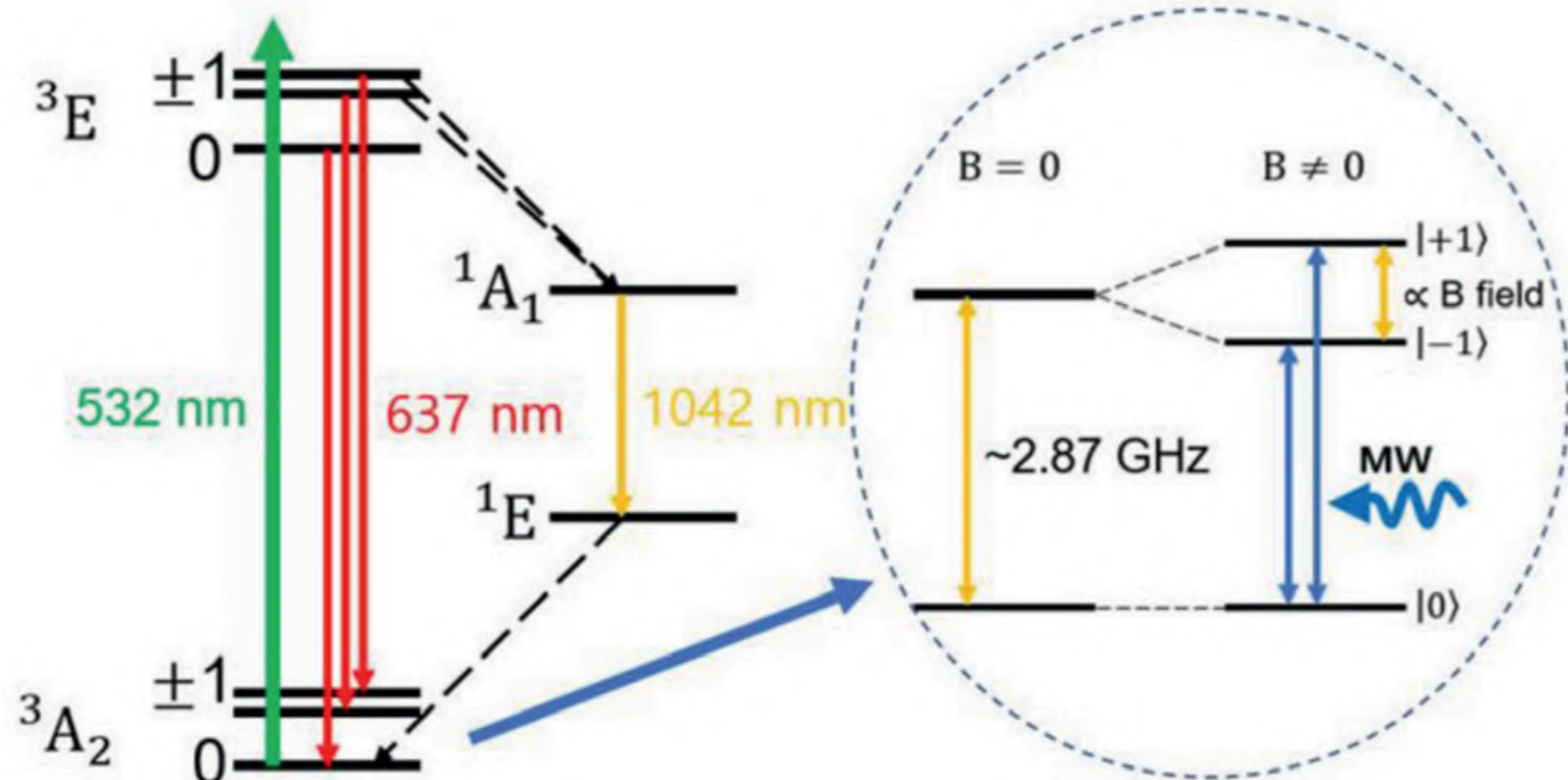


NV centers in diamond

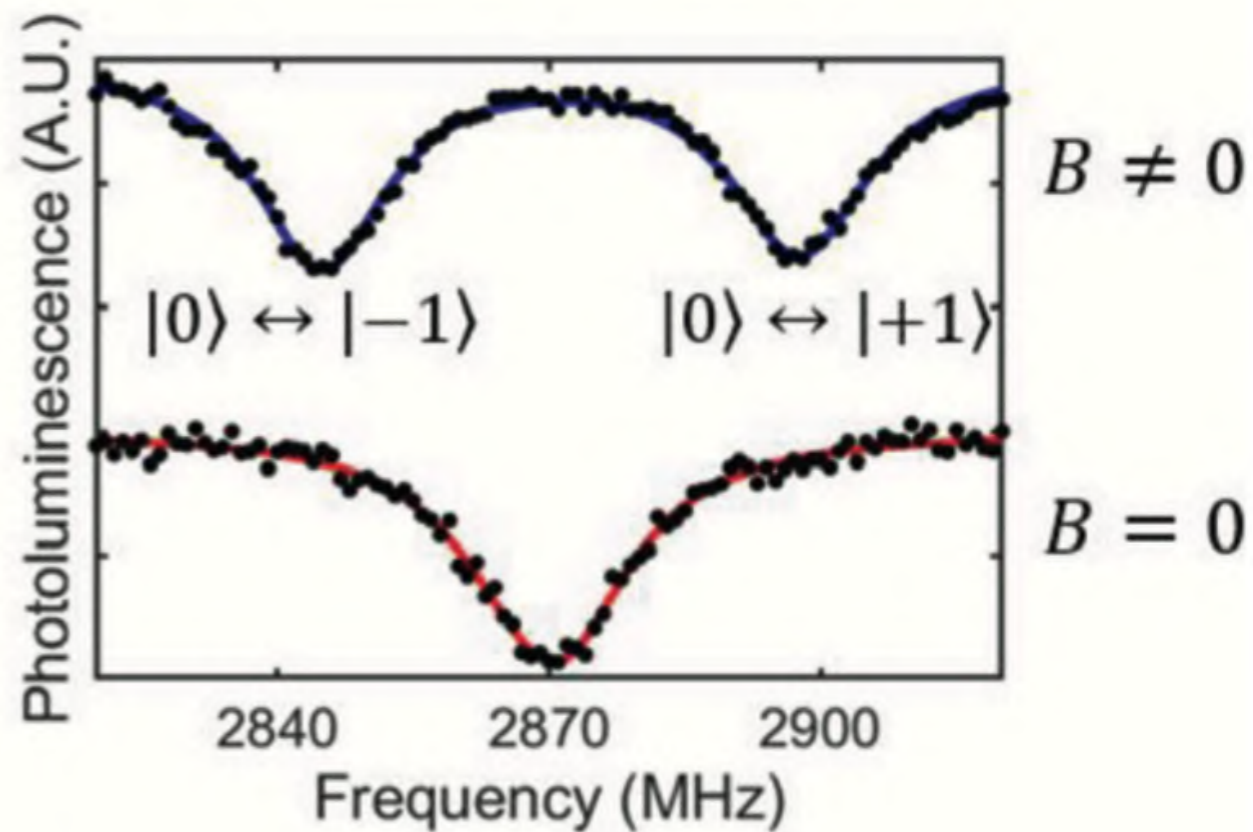


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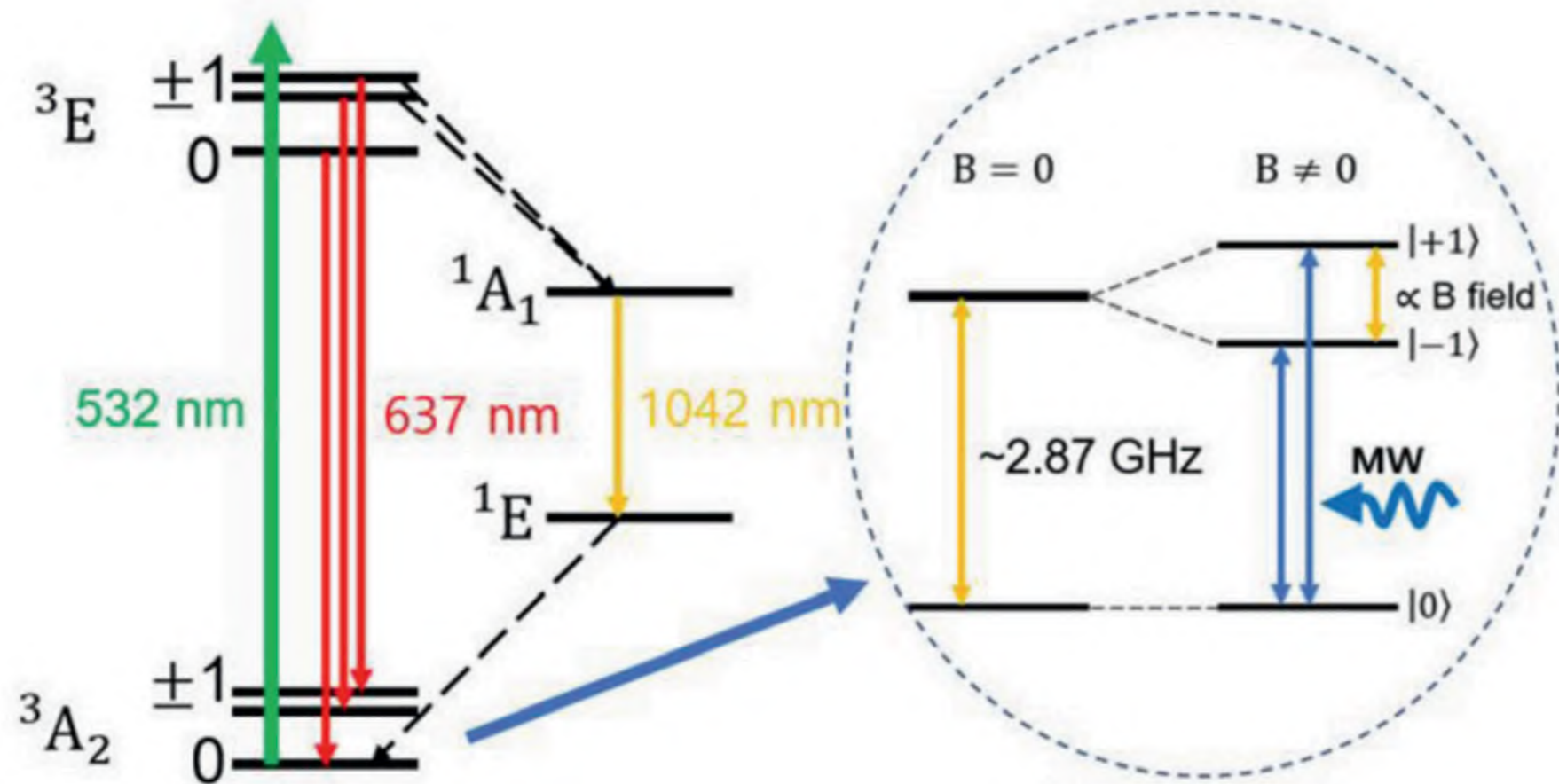
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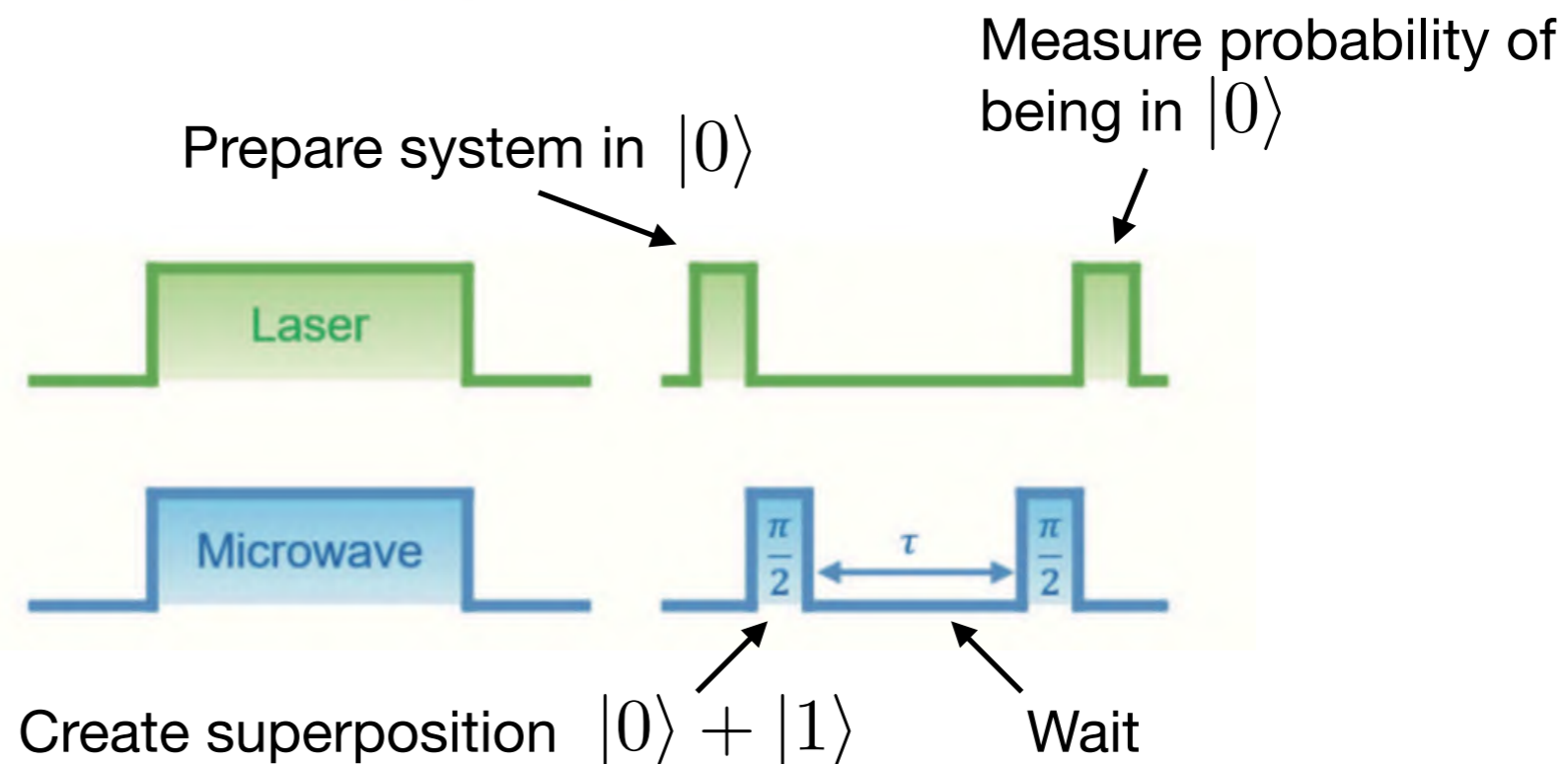
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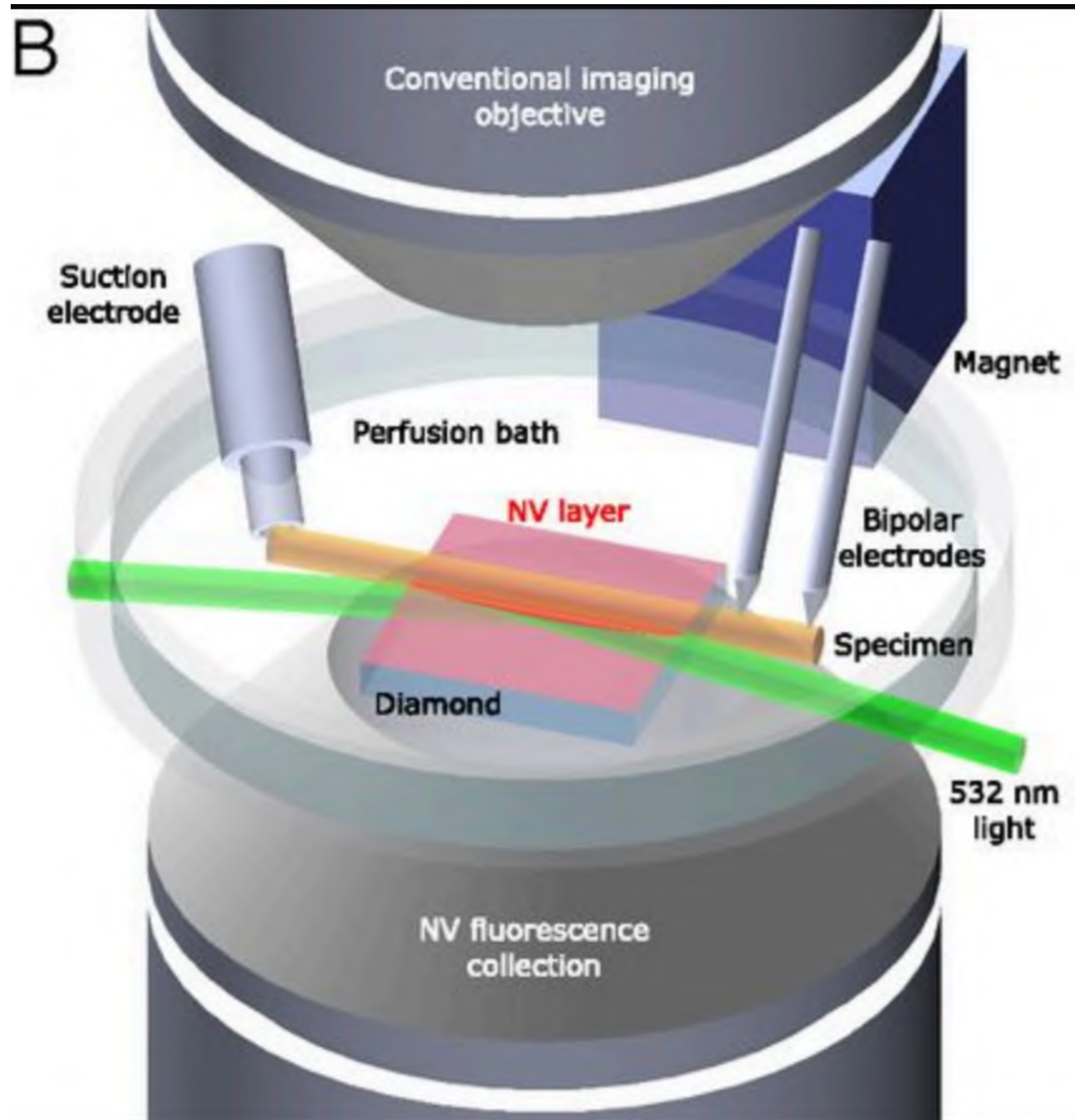
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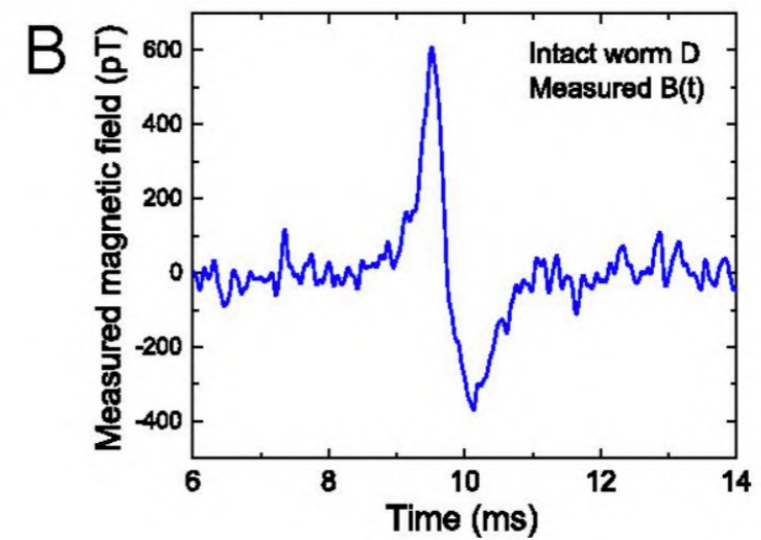
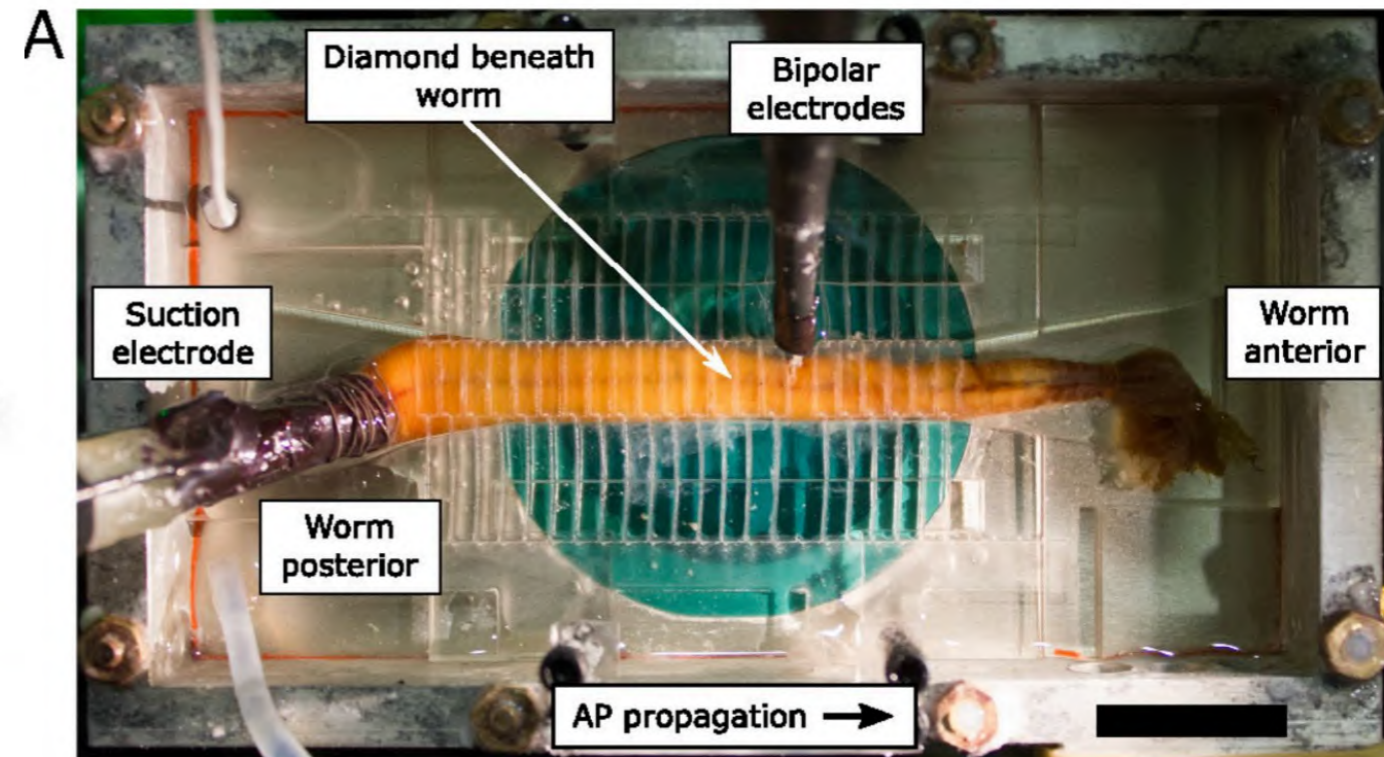
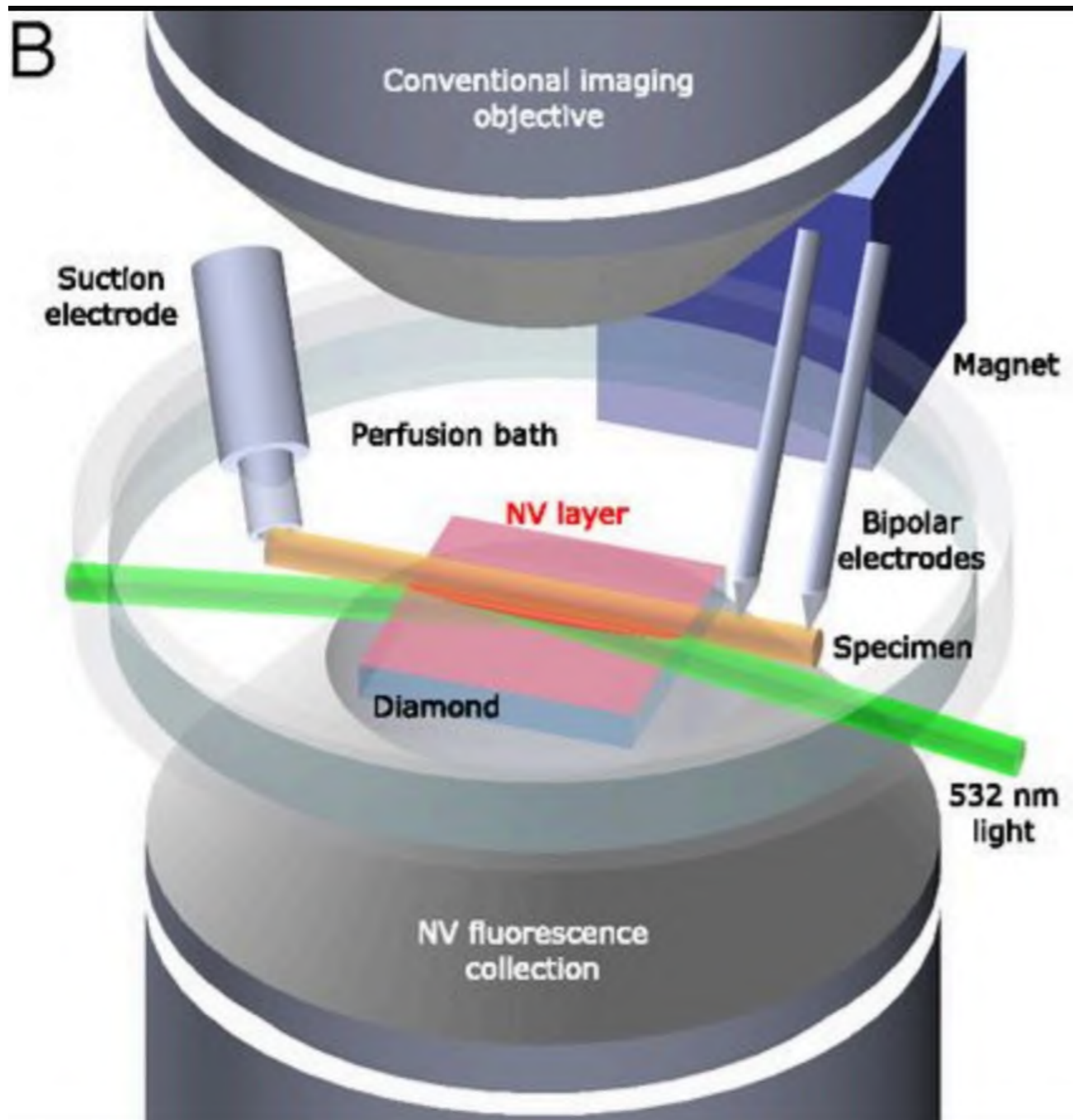
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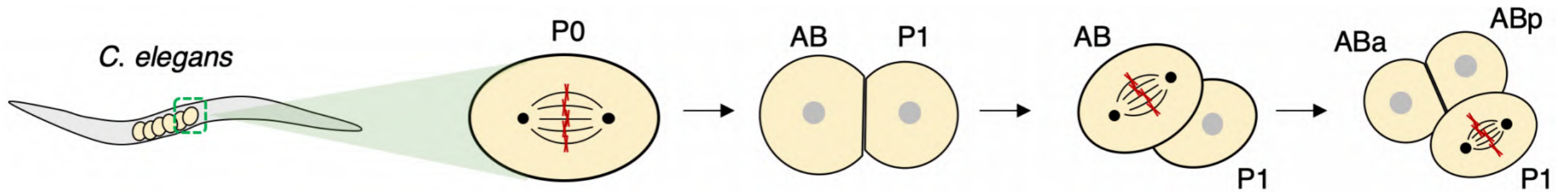
Single-neuron sensitivity



Single-neuron sensitivity

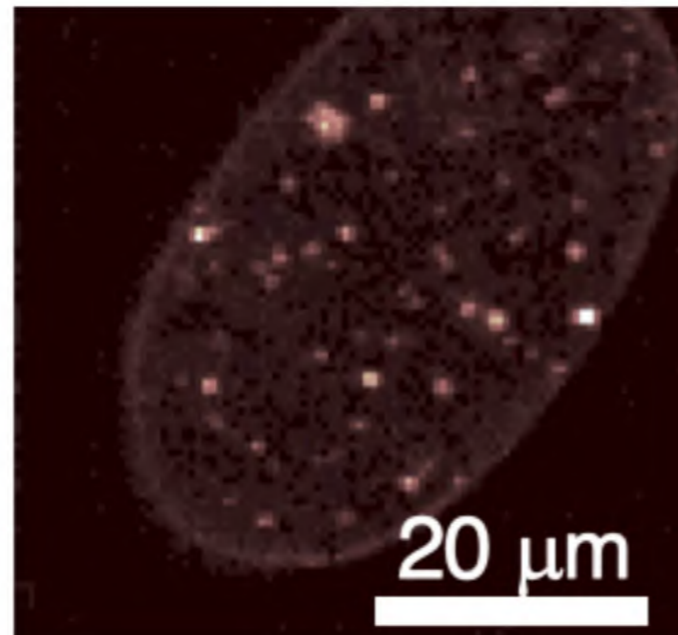
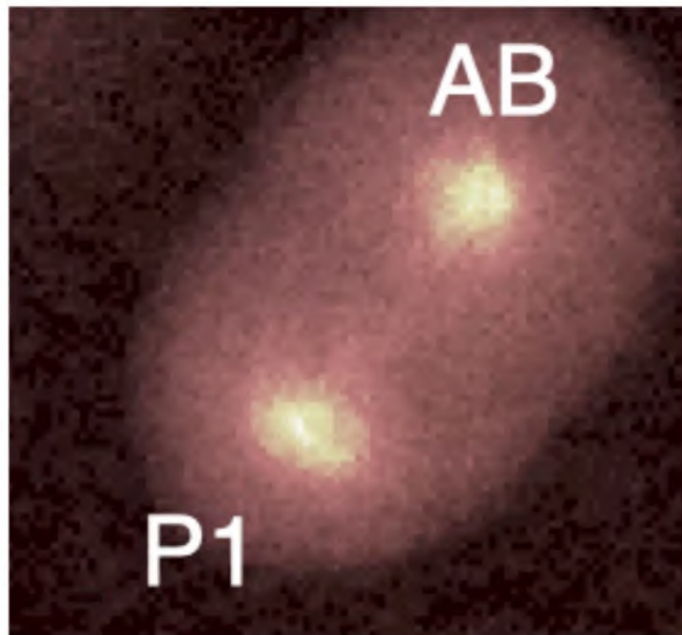


Thermometers inside cells

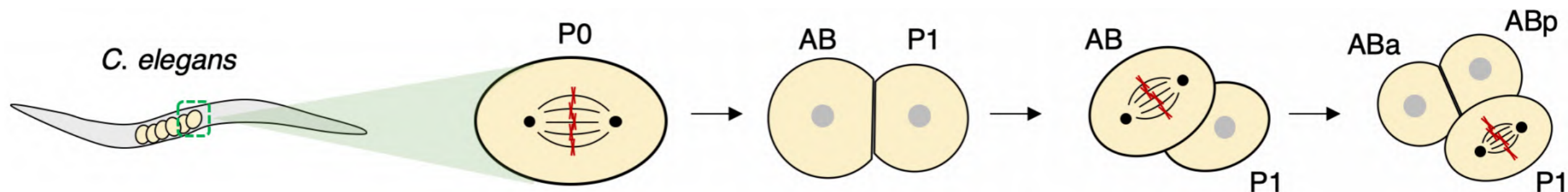


GFP

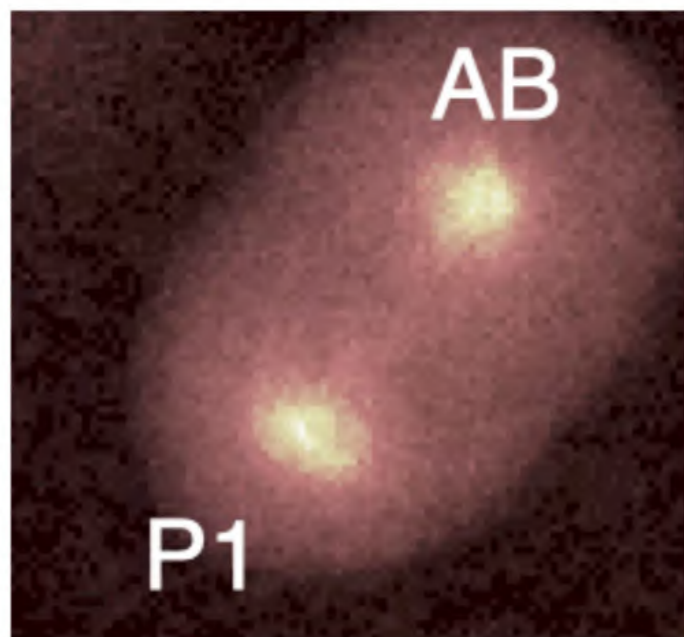
NV



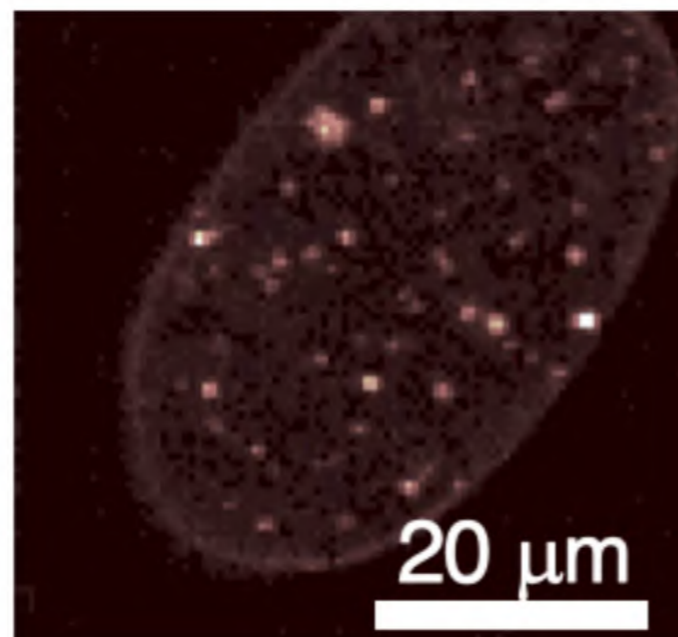
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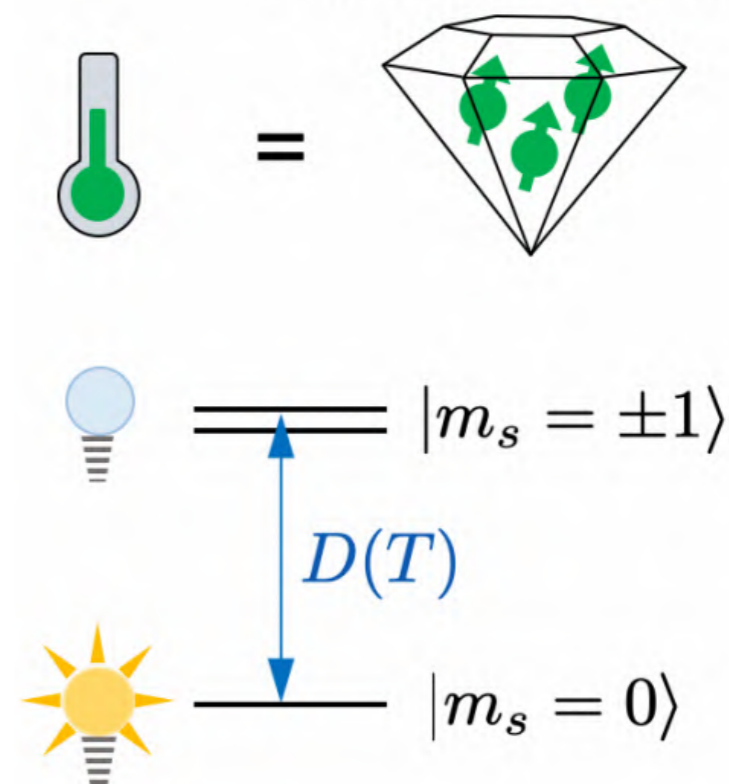
GFP



NV



NVs in a nanodiamond



Choi et al., arXiv (2020)
Fujiwara et al., arXiv (2020)

Commercialization?

Quantum Diamond Technologies

USA



Switzerland



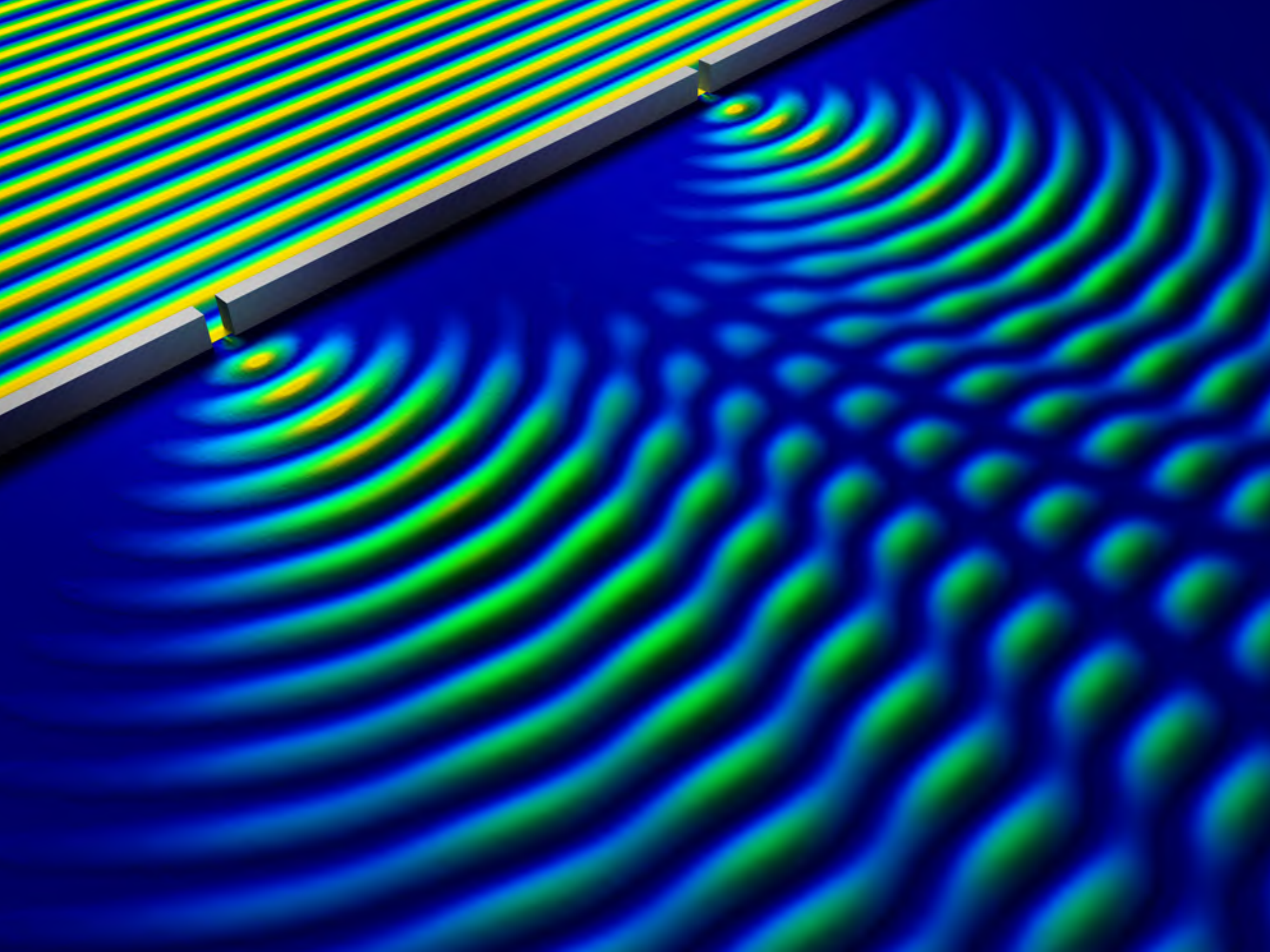
Germany



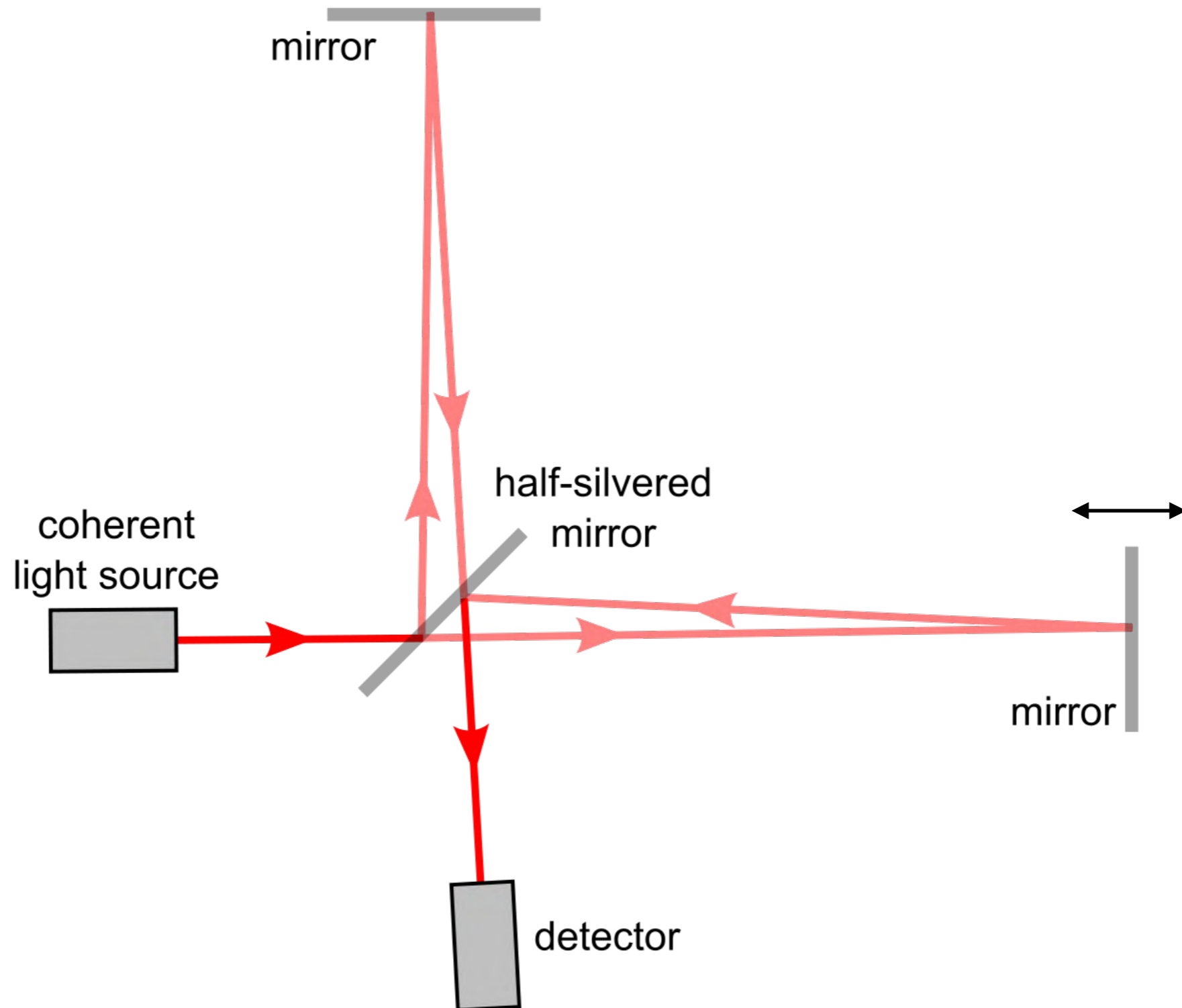
Switzerland

etc...

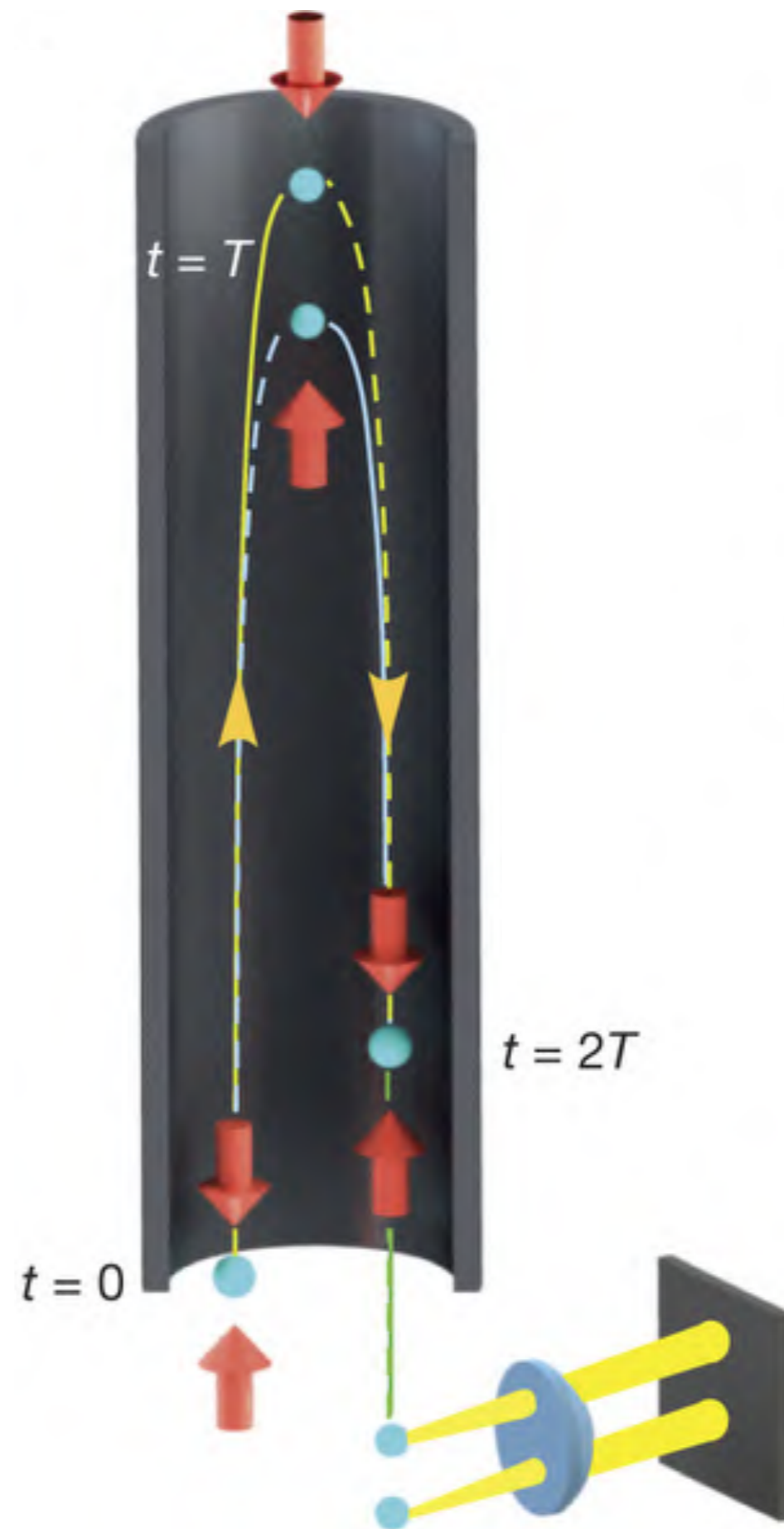
Quantum superpositions




Optical interferometry

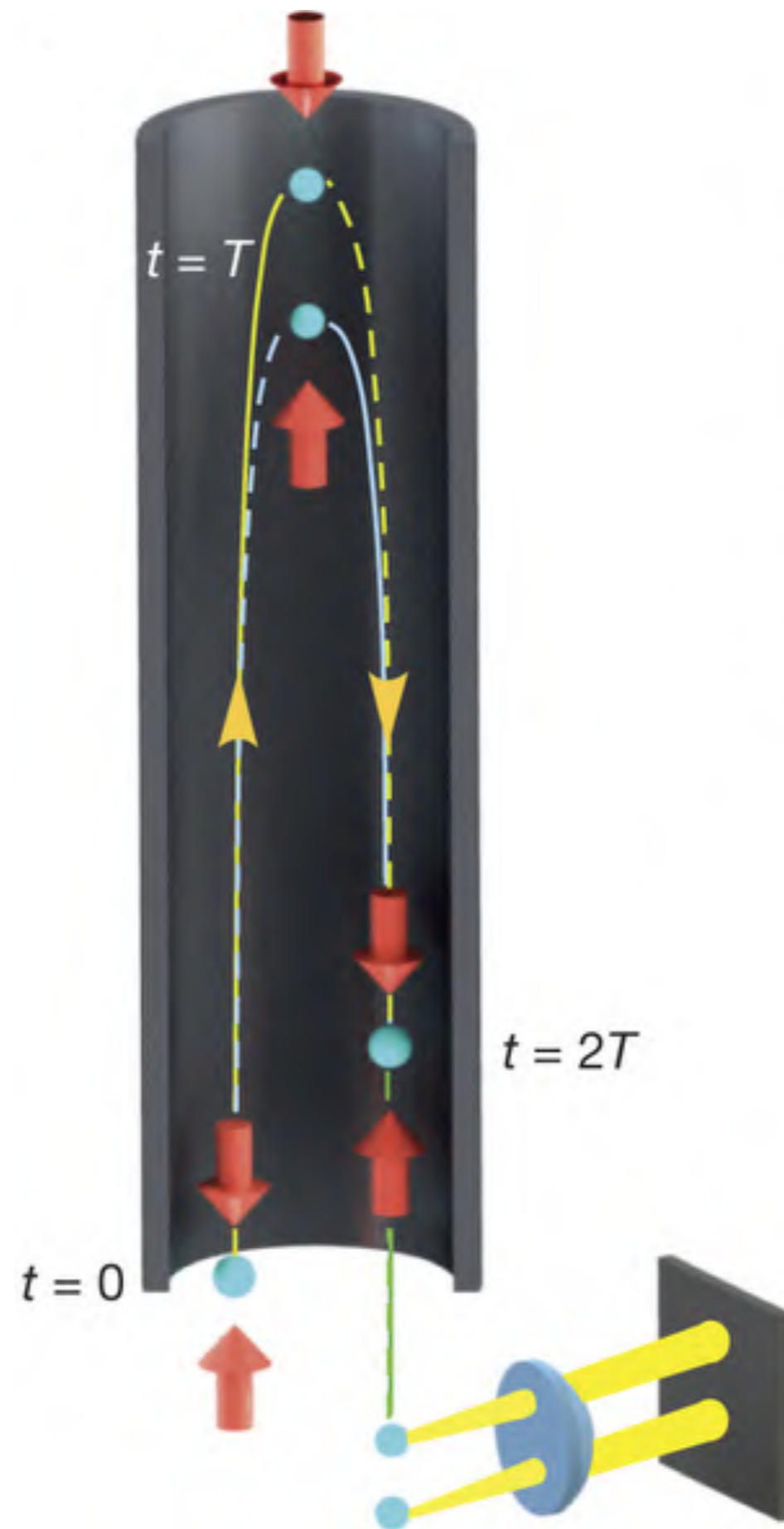


Atom clouds as waves



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$$g = 9.8 \text{ m/s}^2$$




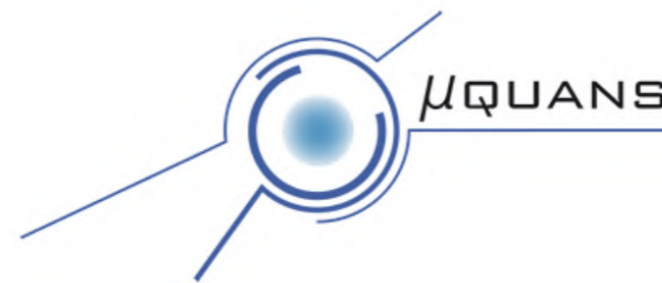
What is underground?



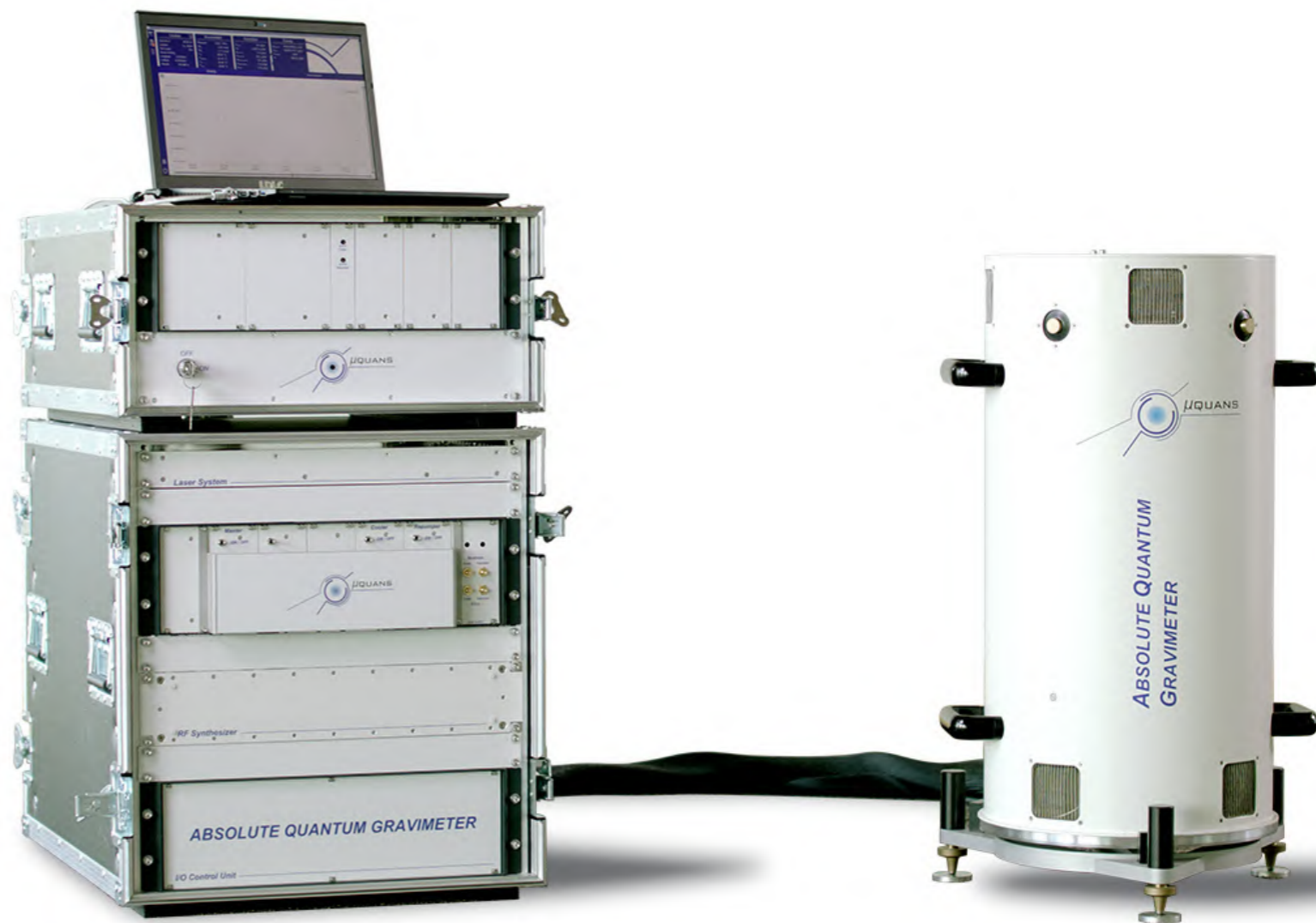
Quantum accelerometer



Commercialization?



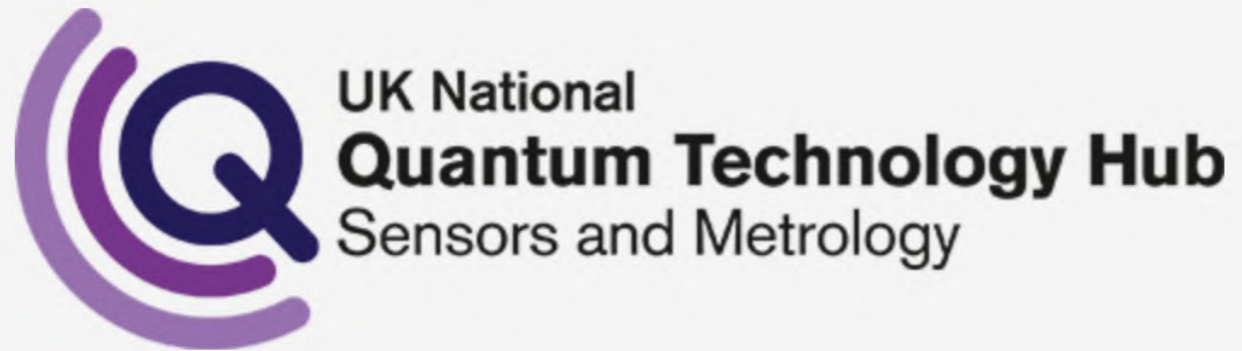
France



Singapore

etc...

Commercialization?



DEFENCE



TRANSPORT



MANUFACTURING



OIL AND GAS

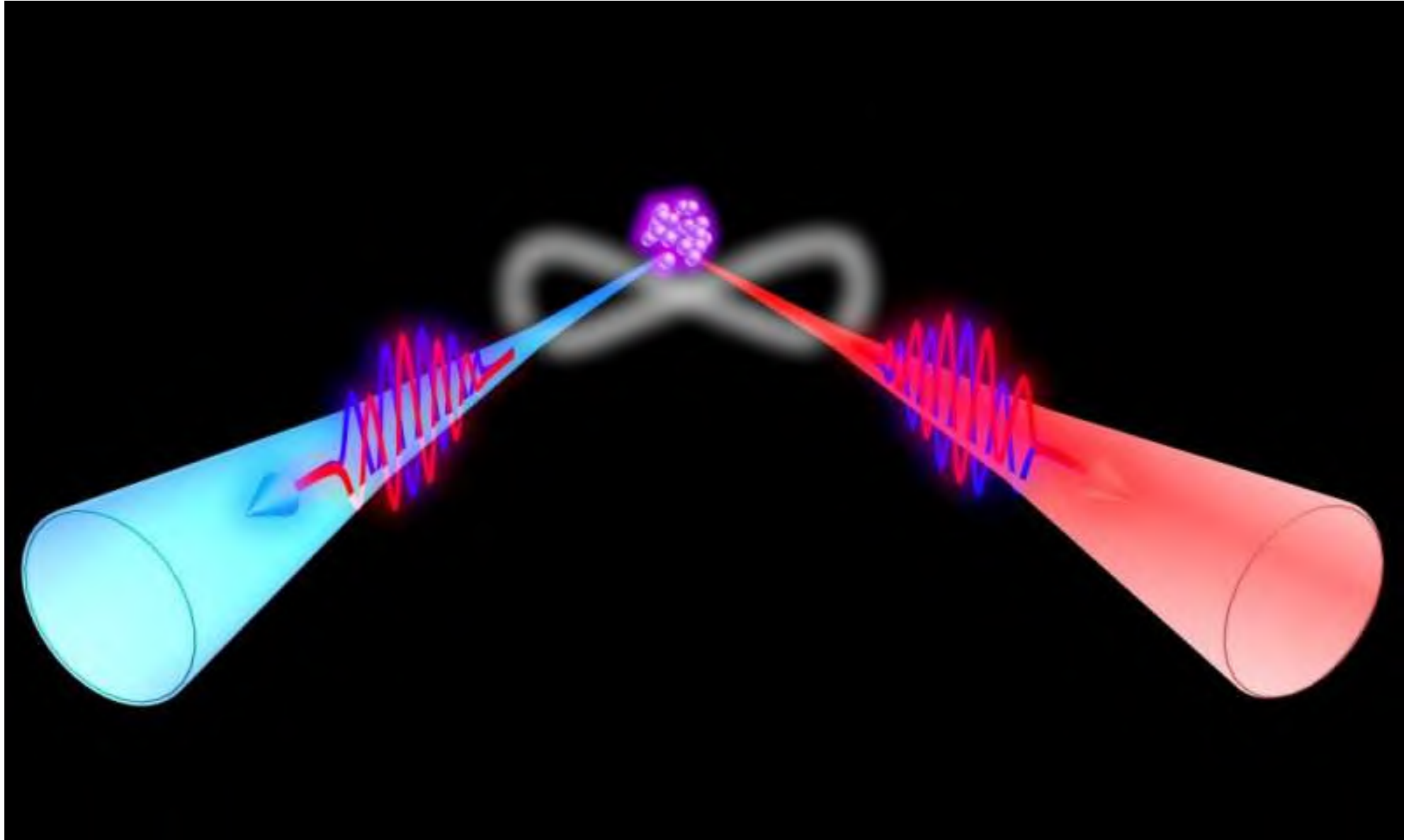


CIVIL ENGINEERING



HEALTHCARE

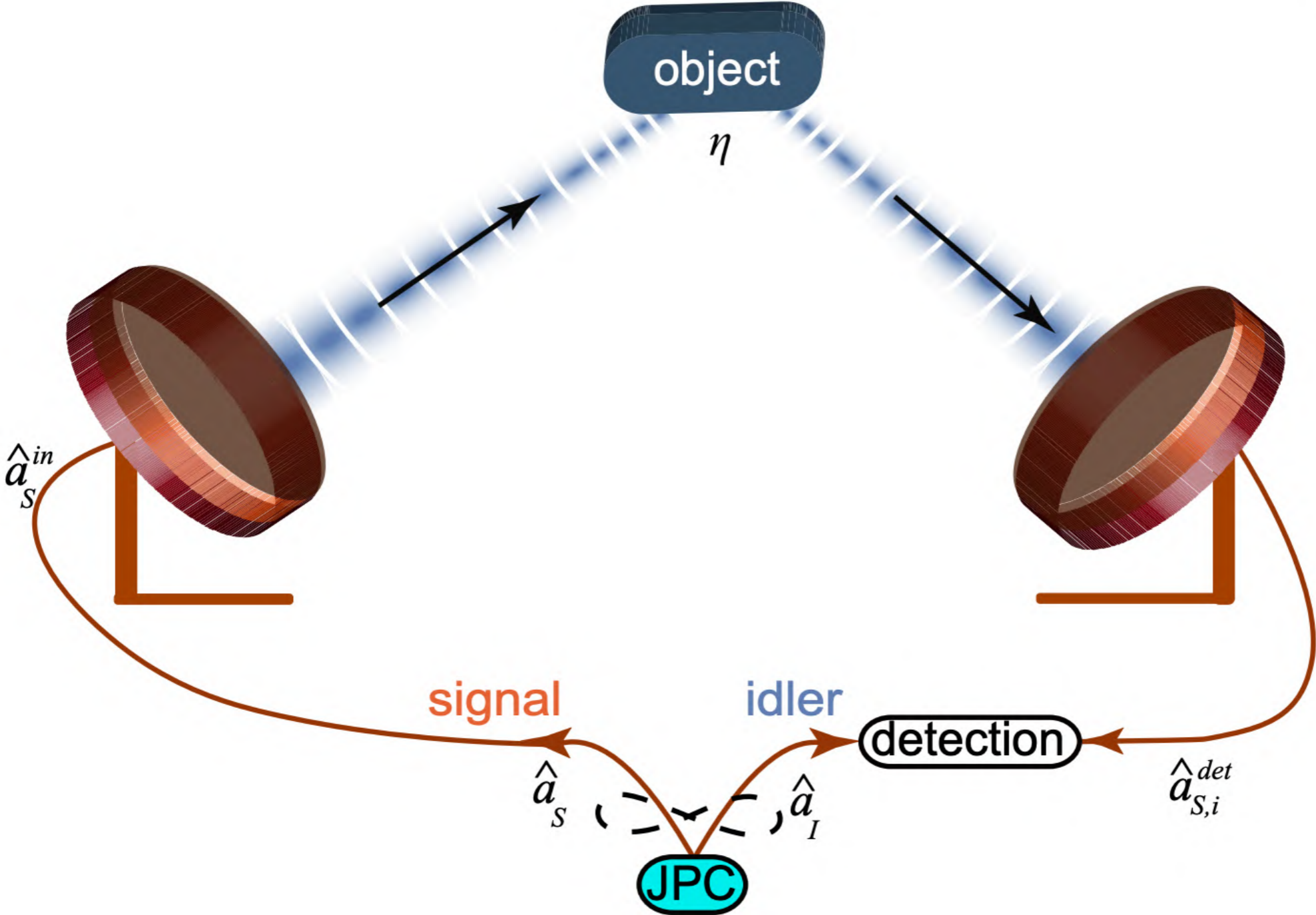
Quantum entanglement



Physics department, HKUST

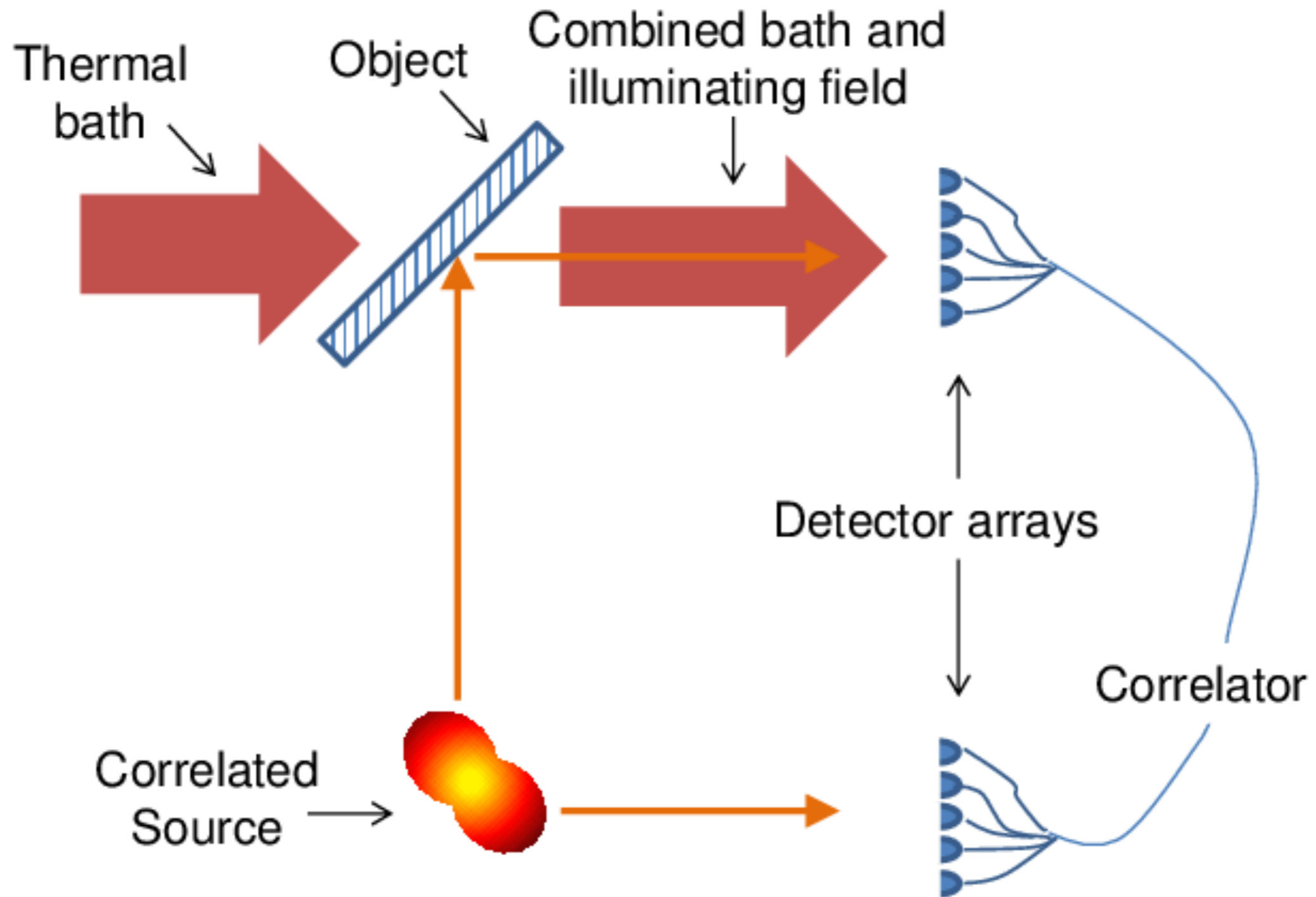


Quantum illumination



Barzanjeh et al., arXiv (2019)

Quantum advantage even with noise



Investments

The US and China are in a quantum arms race that will transform warfare



Canada developing quantum radar to detect stealth aircraft

UK QUANTUM TECHNOLOGY HUB IN QUANTUM ENHANCED IMAGING

etc...

Final remarks

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hammer looking for a nail

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- **The end user might not care about «quantum»**
«classical» spin-off technologies are OK!

Final remarks

- **Quantum technology enabled by pushing boundaries in academic research**
hammer looking for a nail
- **Lots of hype**
apply healthy dose of scepticism
- **The end user might not care about «quantum»**
«classical» spin-off technologies are OK!
- **Promise for new technology**
medical field, civil engineering, navigation...