Science and Technology Facilities Council

RAL Space

High-accuracy[1] magnetometry[2] using quantum sensors[3]

1: ~1 nT

2: B_{earth}

3: 

Mark Bason

ETCW 2024

20th March 2024

BGS

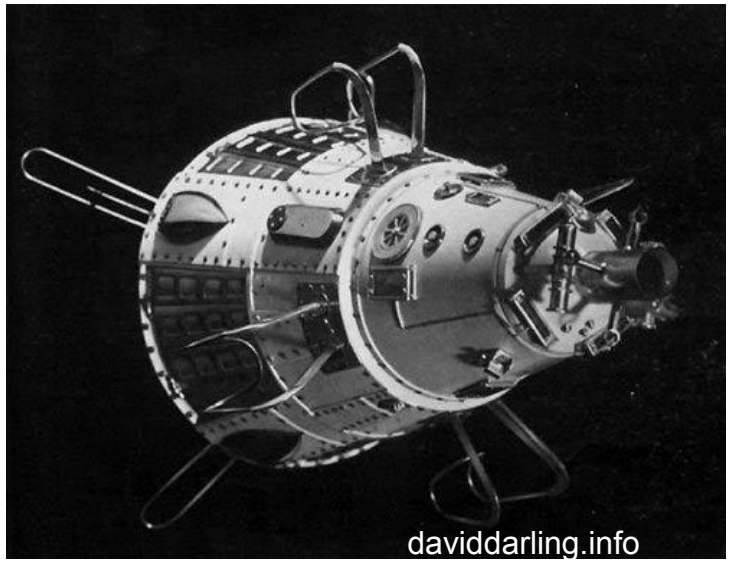
University of Strathclyde Science

iota

ThalesAlenia Space

a Thales / Leonardo company

Magnetometers in orbit

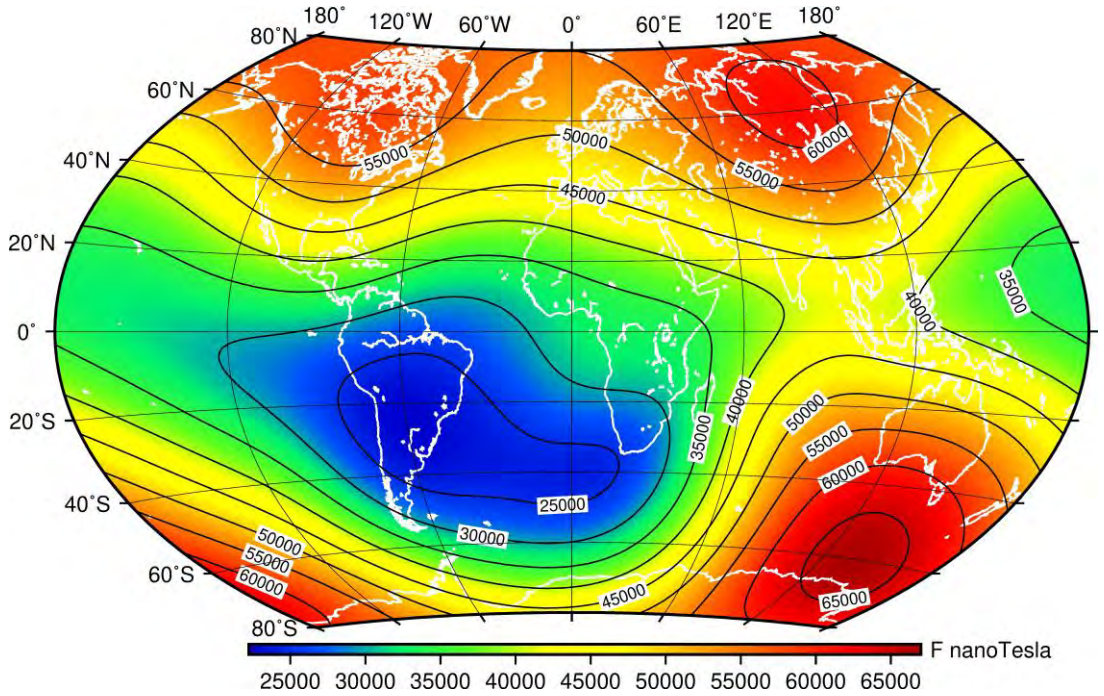


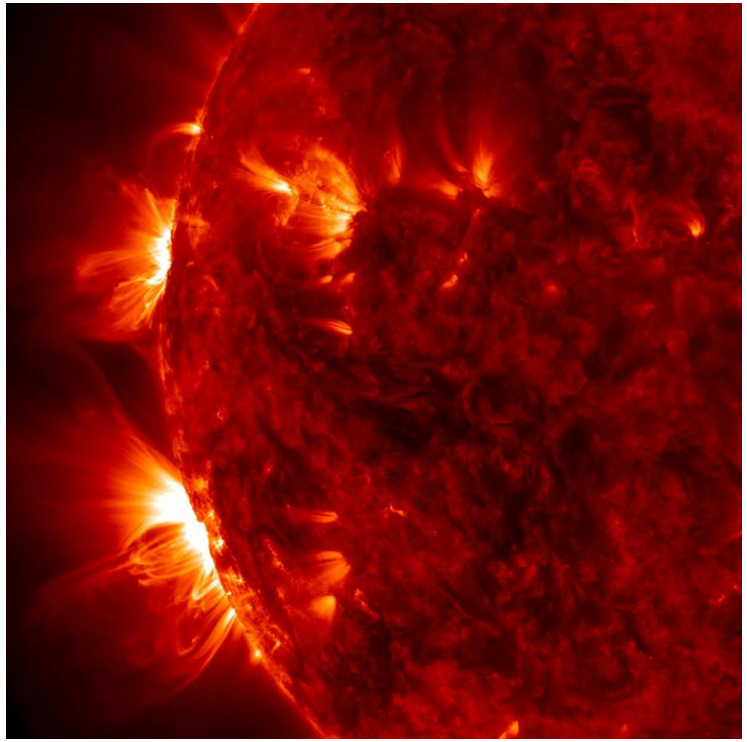
Sputnik 3: 1958

MagSat: 1979

Swarm: 2013

Science and Technology drivers





WMM/IGRF (for navigation)

Space Weather
(research & service missions)

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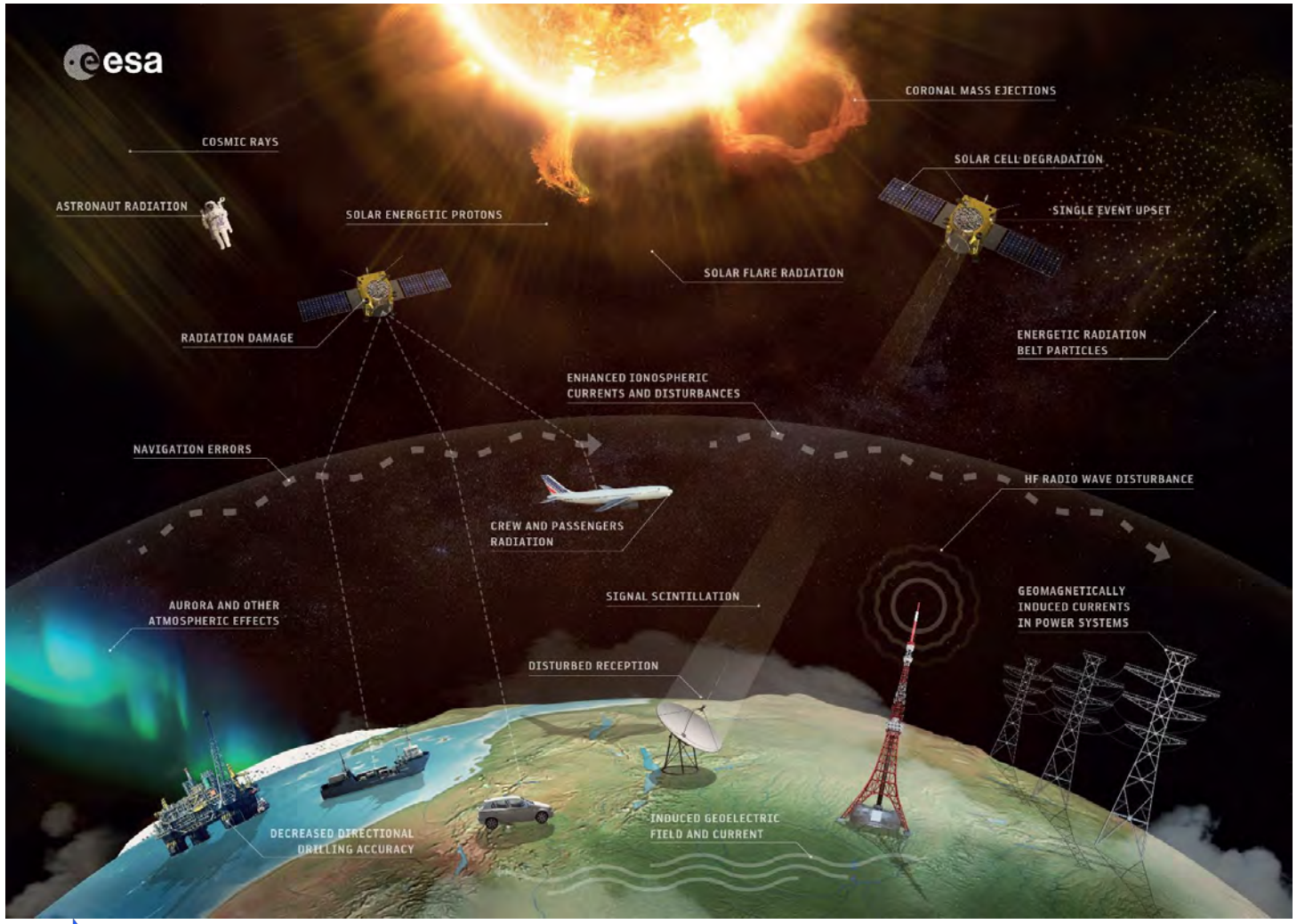
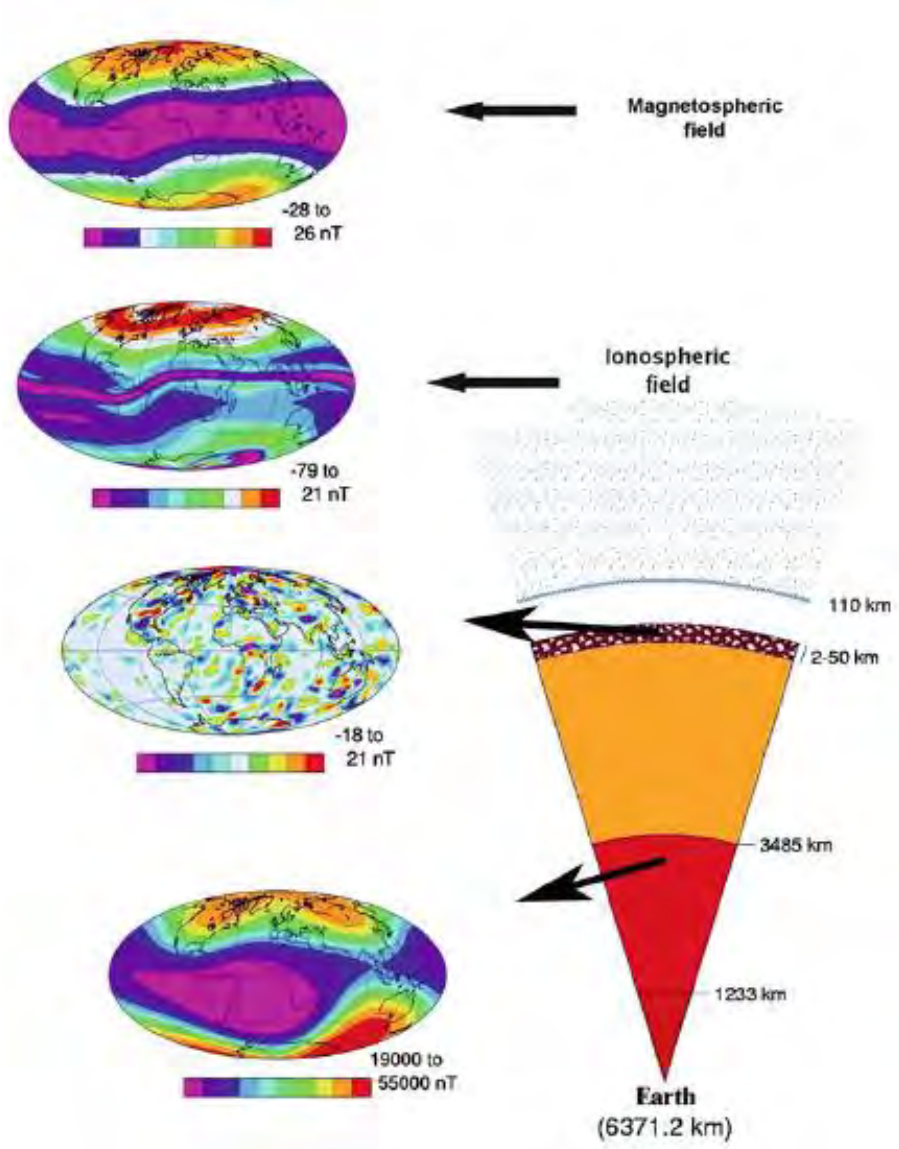
Space Weather





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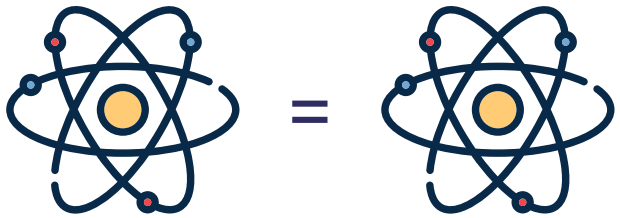
Benefits of sensing atoms

1.



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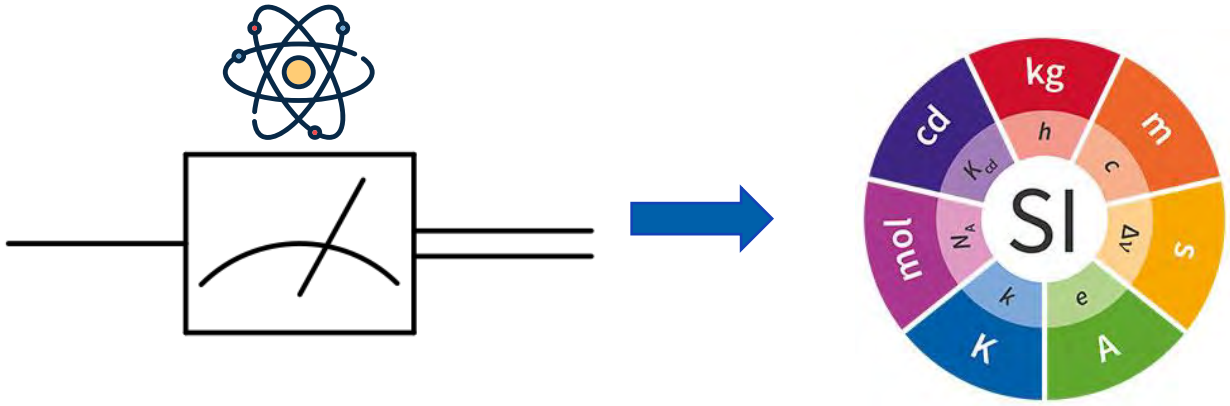

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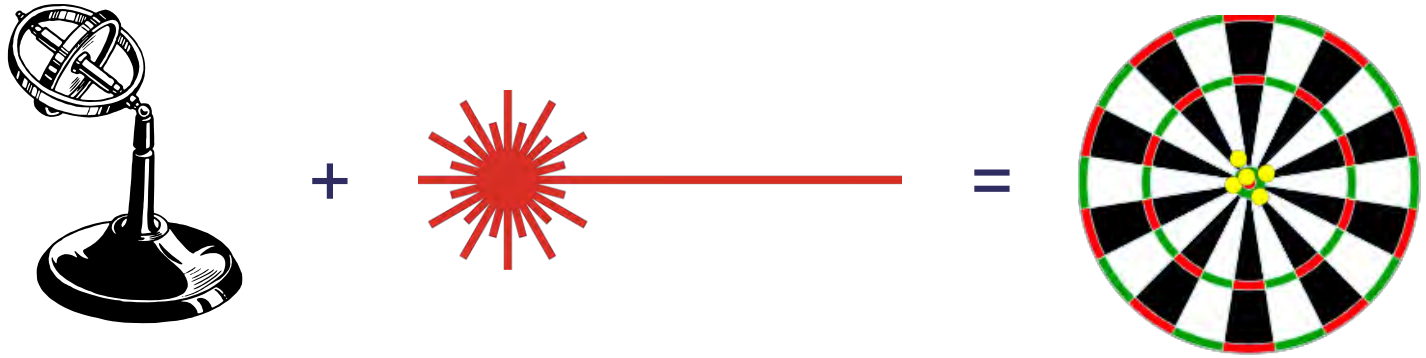

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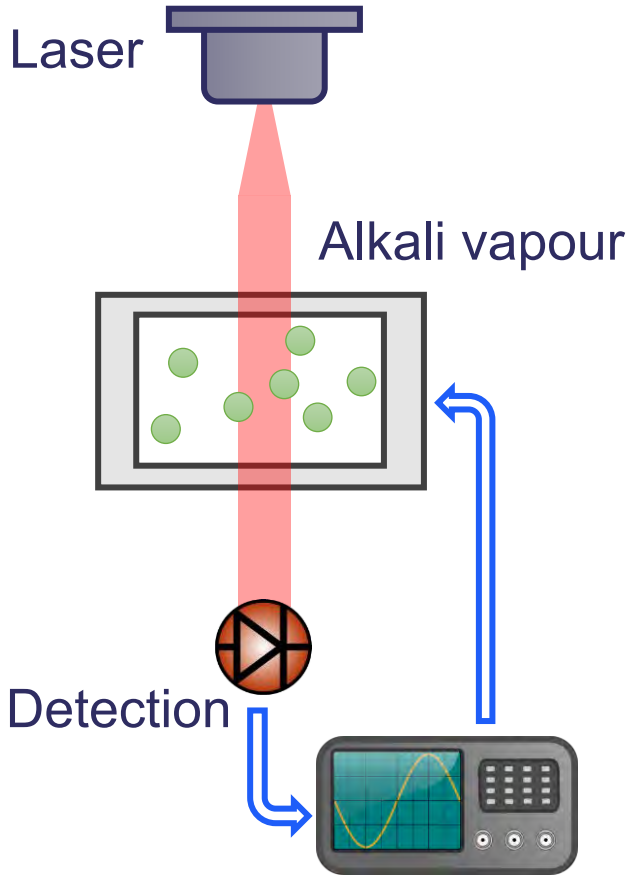
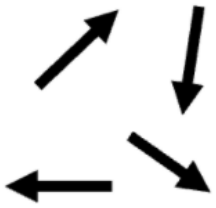
Optically-Pumped magnetometers



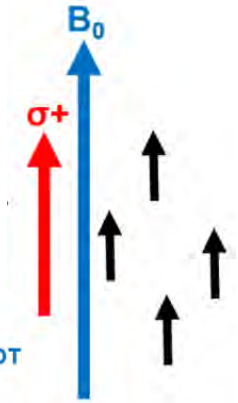
Atomic Vapour

Alkali atomic vapour confined in a cell
Atomic spins randomly distributed



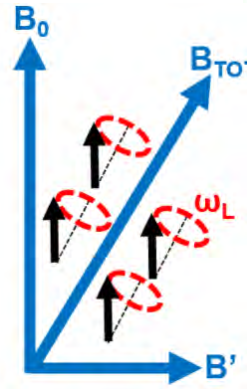
Optical Pumping

Align spins along a field with resonant laser light



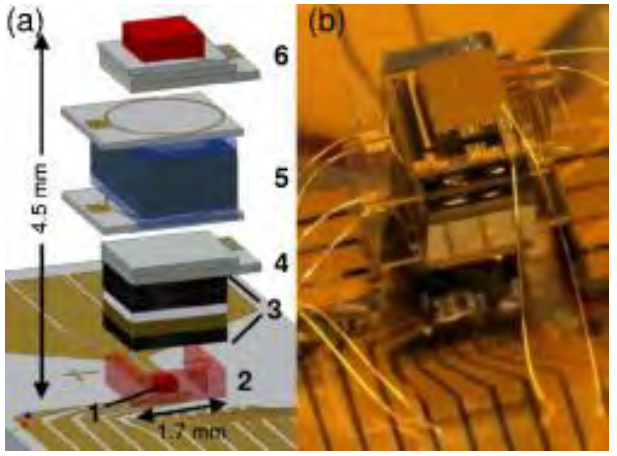
Evolution in B'

Atoms precess around total field at the Larmor frequency – $\omega_L = \gamma|B_{TOT}|$



Detection of ω_L

Precessing sample modifies properties of resonant laser light



Appl. Phys. Lett. 90, 081102 (2007)

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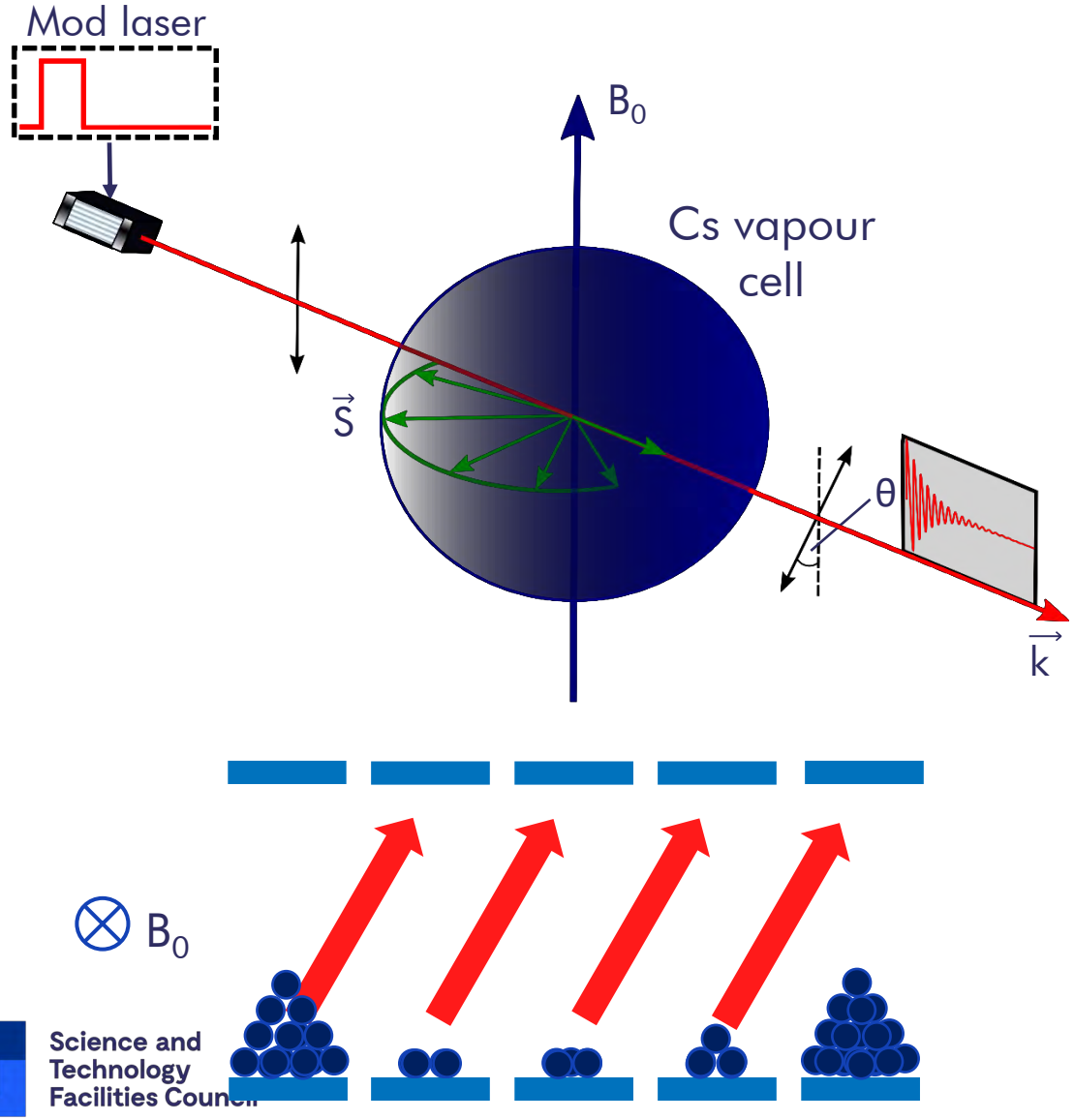
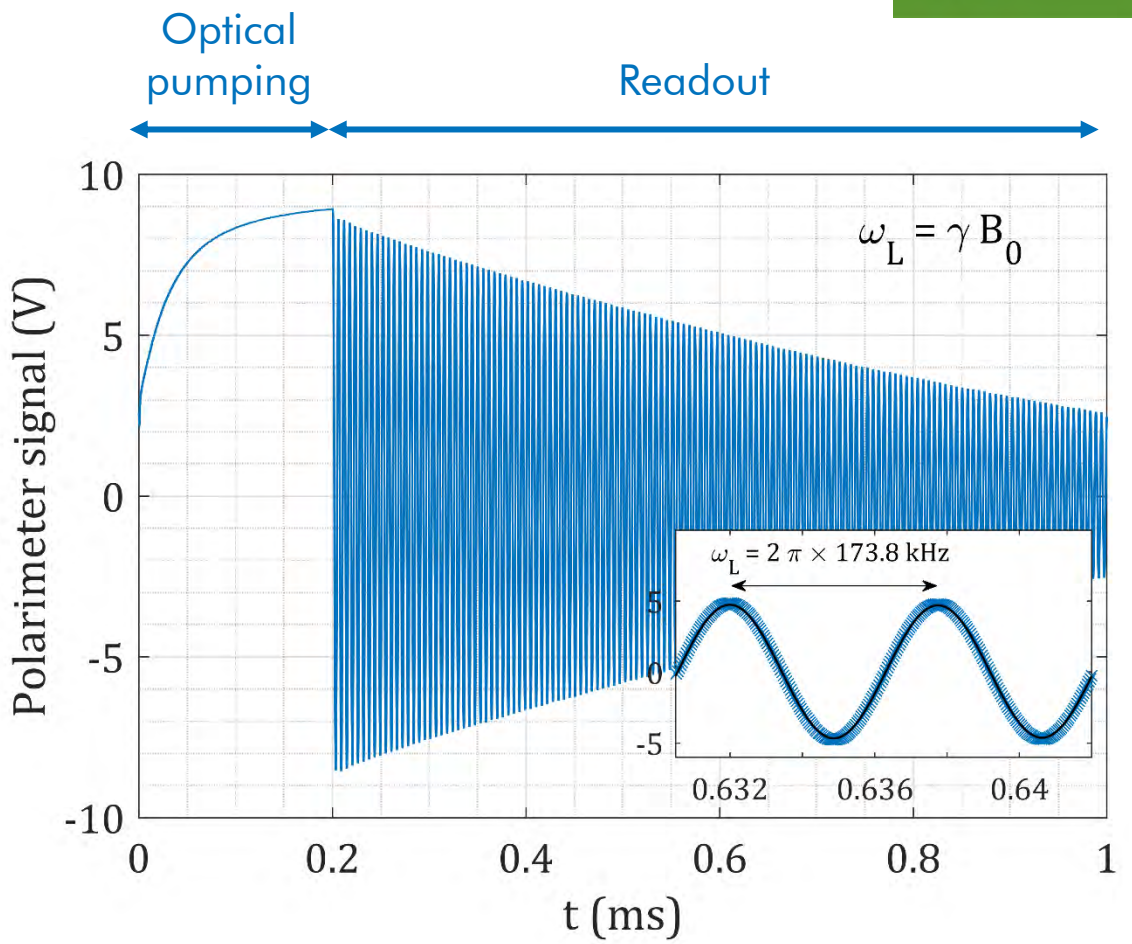
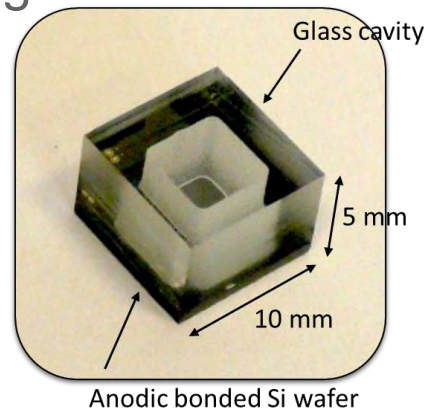
Free-induction decay

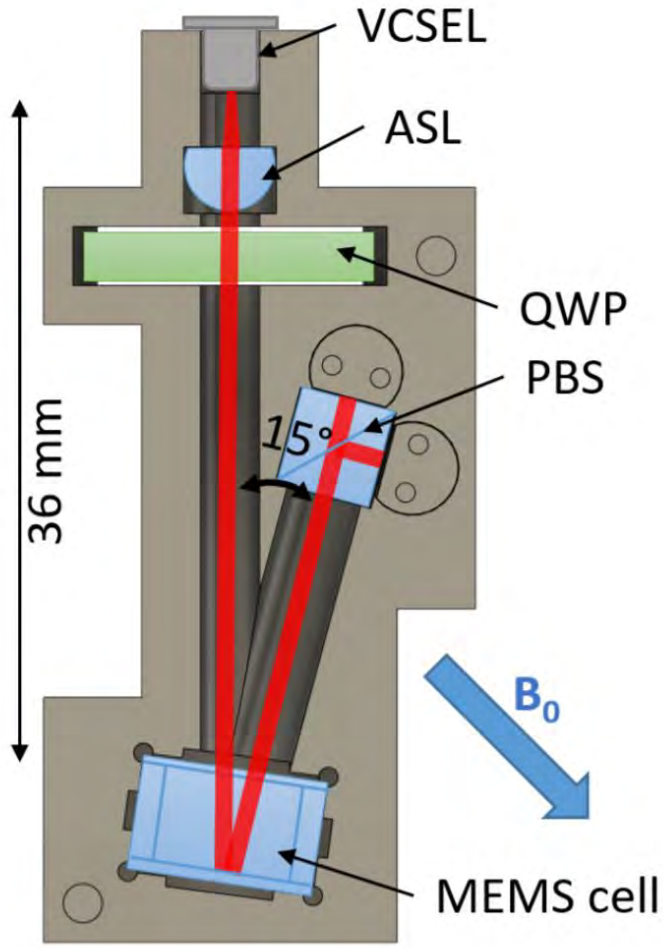


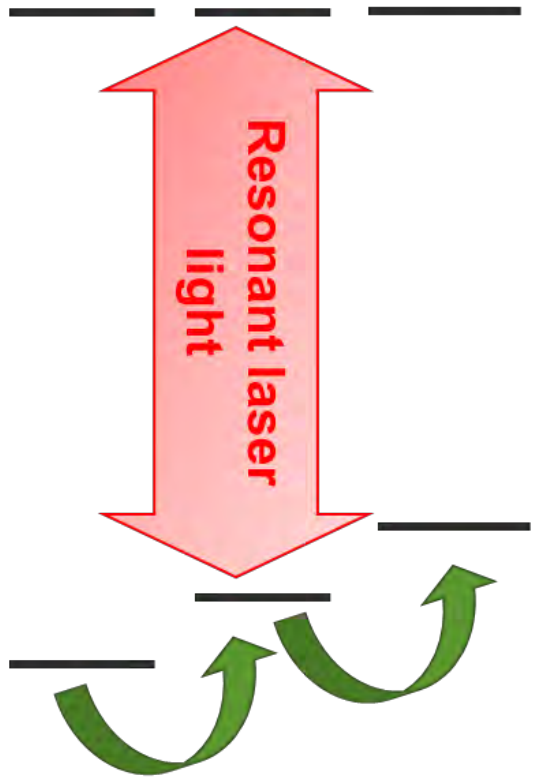


Sensor basics: double resonance

- Atomic vapour
- Resonant interaction with both light and magnetic field
- Earth's field ~50 μT → 175 kHz
- PPB sensitivity to changes
- Sensor head: 200g







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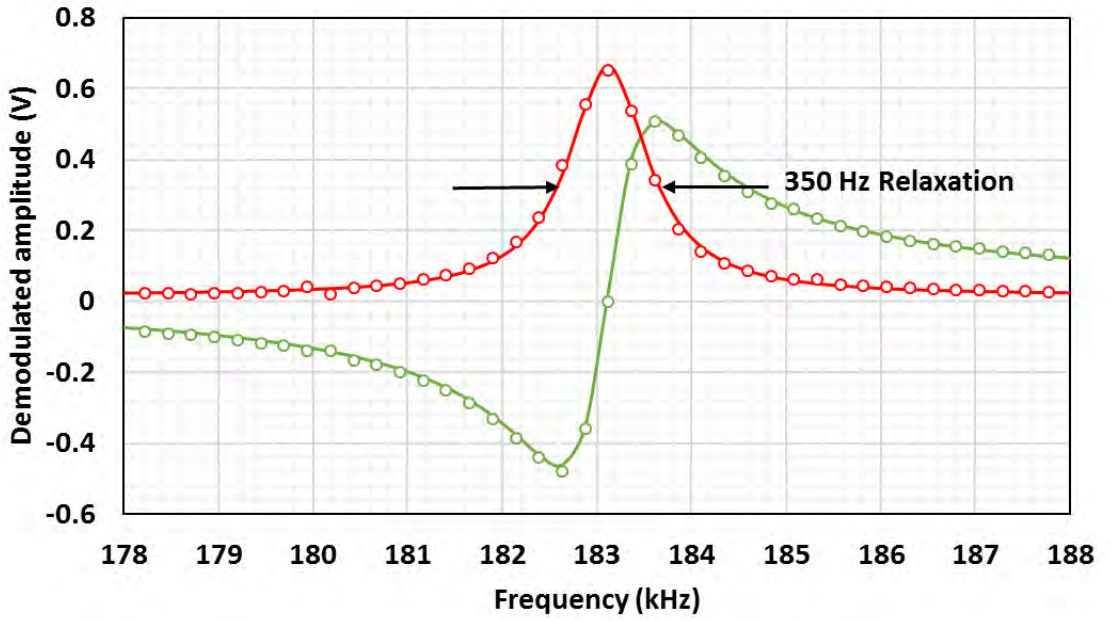
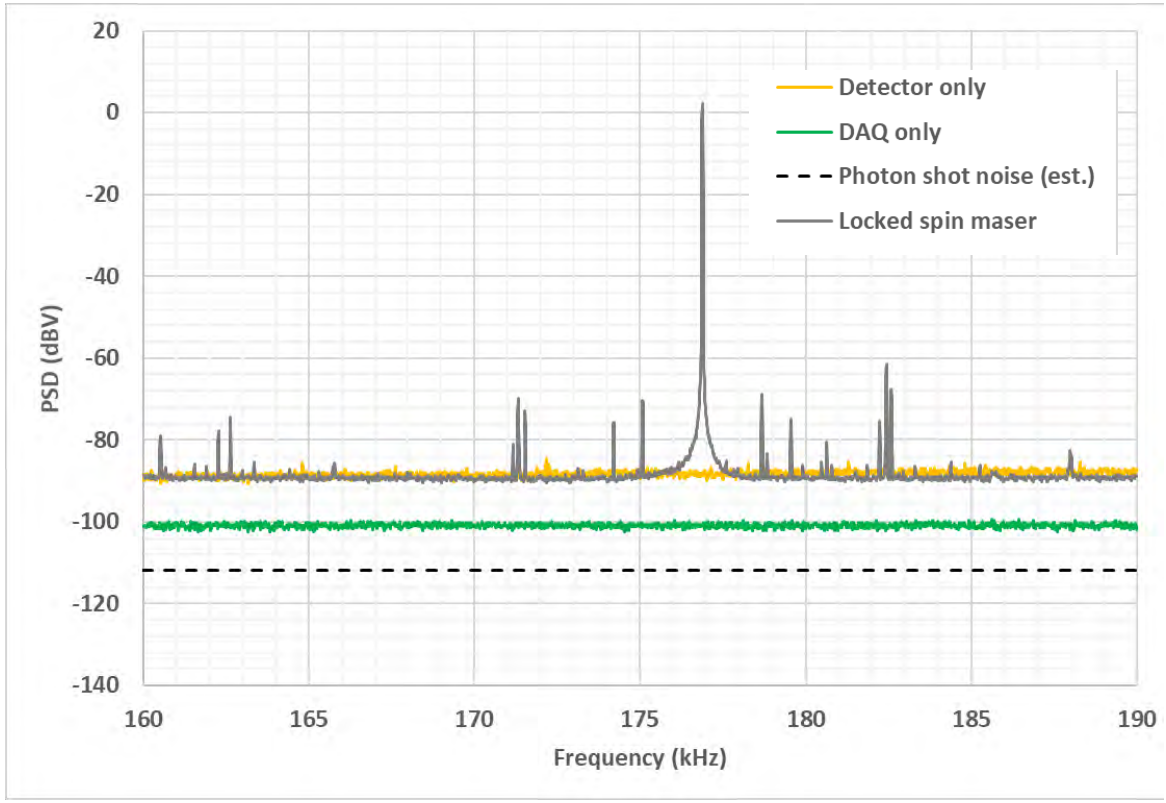
TRL raising activities: sensor



Narrow resonance → High sensitivity



Large SNR

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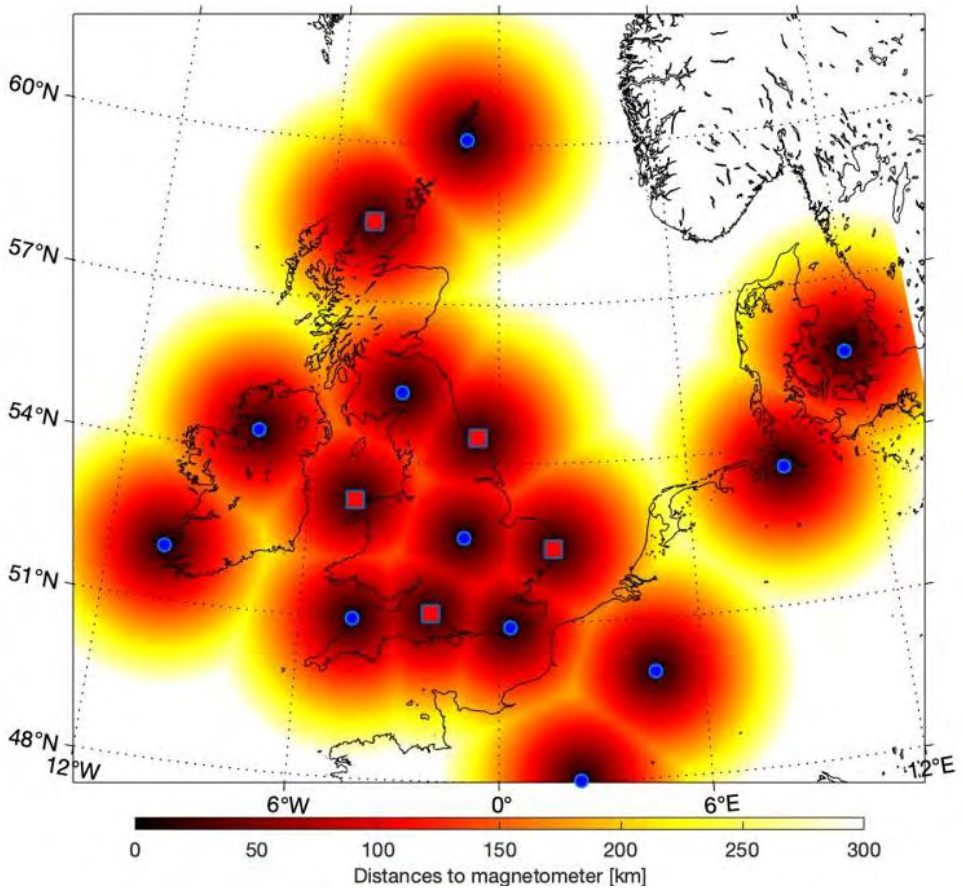
Quantum Magnetometers: Ground



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British Geological Survey

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Engineering and Physical Sciences Research Council

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