

# Research Observatory for Atmospheric Responses to Sun-magnetosphere interactions (ROARS)

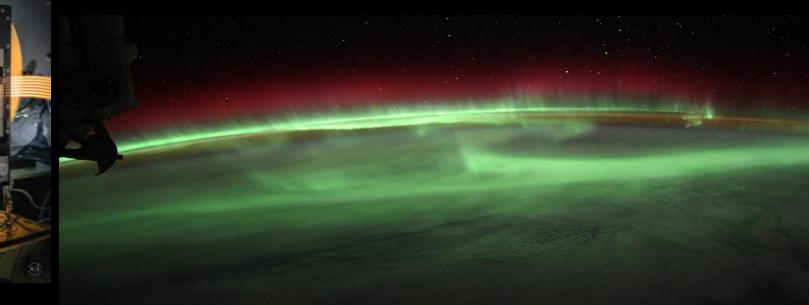
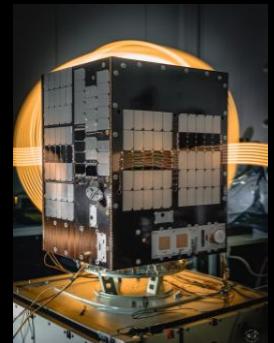
PI Ravi Desai & ROARS consortium

## The Science

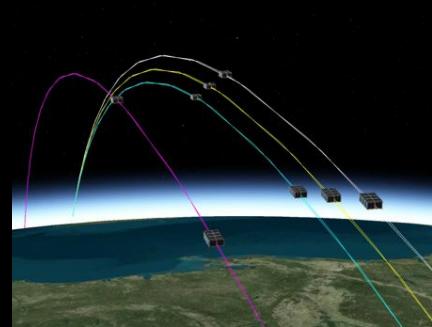
**Q1: How much energy and momentum is transported from the magnetosphere into the upper atmosphere?**

**Q2: How is energy and momentum redistributed within the ionosphere-thermosphere system?**

- Satellites:** Four identical Micro-Satellites in formation
- Orbit:** Polar, precessing, altitude 500 km - 200 km
- Lifetime:** 24-36 Months
- Mass:** Payload Mass < 20 kg, each Satellite < 100 kg



## The Mission

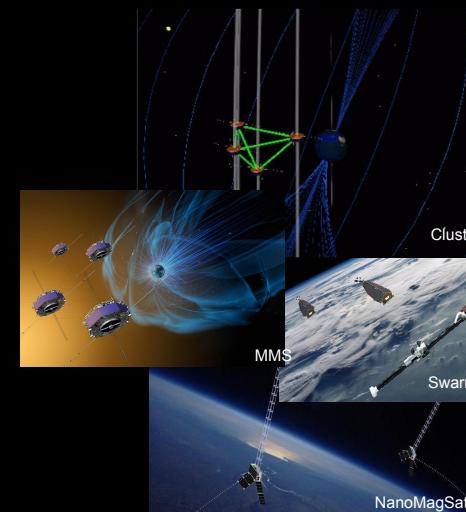


- Progressed through ESA Phase 0 study & UoPortsmouth CDF study
- Shortlisted to Stage 2 as an ESA Fast mission: F3

## The Instruments

### 1. Magnetometry

- Dual fluxgate magnetometers (IWF)
  - Quantum optically pumped magnetometer (CEA)



### 2. Energetic Particle Precipitation

- Energetic Particle (EPE) instrument (**UCLA**, RAL, Kiel, UTU)
- Low-energy Ion and Electron Analyzer (IRF)

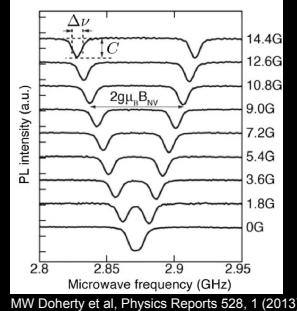
### 3. Ionosphere & Thermosphere

- Multi-Needle Langmuir Probe (EIDEL/Oslo)
- Ion Drift and Energy Analyzer (Calgary)
- Ion & Neutral Mass Spec (Bern)

# Nitrogen Vacancy in Diamond Magnetometers

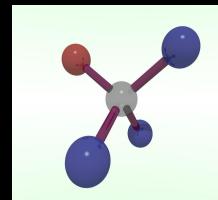
Ravi Desai, Gavin Morley, Colin Stephen, Patrick Brown, Stuart Graham, Alex Newman, Irene Ruiz-Rodriguez

IMPERIAL

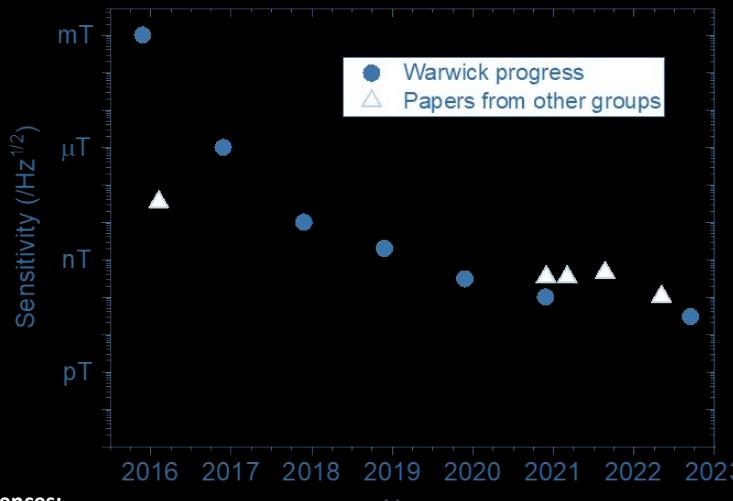


## Green excitation □

1. Spin polarization
2. Spin-dependent photoluminescence



- Optically detected magnetic resonance (ODMR) used to measure magnetic fields at NV centres
- Returns field projection along each four orientations of the NV point defect



## References:

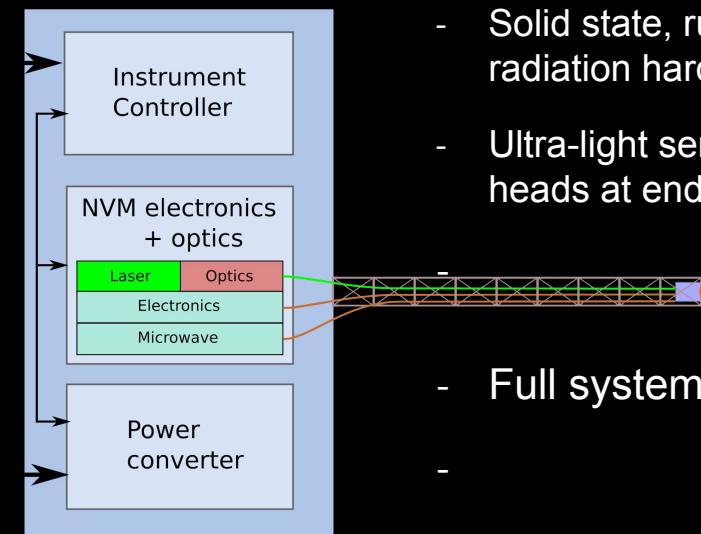
[1] S. M. Graham, et al., *Fiber-Coupled Diamond Magnetometry with an Unshielded Sensitivity of 30 pT/√Hz*, Phys. Rev. Applied 19, 044042 (2023).  
[2] R. Kashtiban et al., *Nitrogen Vacancy Center in Diamond-Based Faraday Magnetometer*, arXiv:2411.10437, (2025).

## Critical Gap:

- Reliable absolute measurements of the magnetic field: *dual sensor designs*

## NV magnetometers:

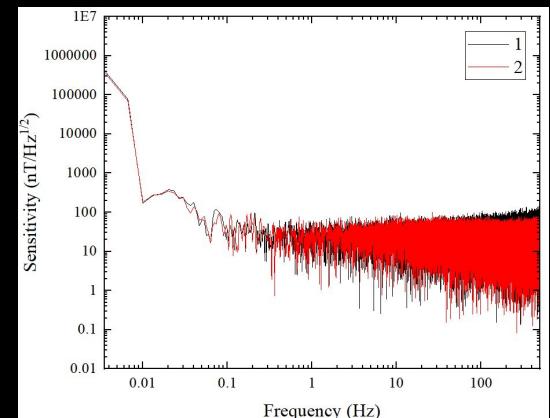
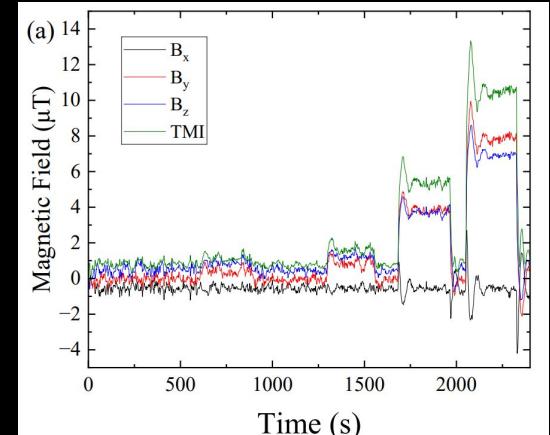
- Absolute vector measurement
- Large dynamics range (e.g. Earth field mapping through to ISM)
- Temperature insensitive



- Solid state, rugged, radiation hard
- Ultra-light sensor heads at end of boom

- Full system: <1 litre

## Preliminary Results



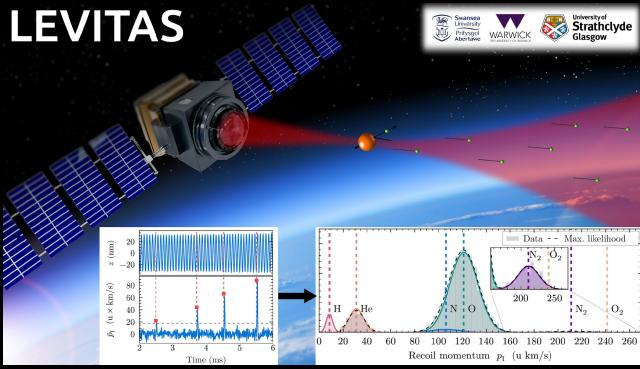
[3] A. J. Newman et al., *Endoscopic diamond magnetometer for cancer surgery*, Phys. Rev. Applied 24, 024029 (2025).  
[4] A. J. Newman et al., *Tensor gradiometry with a diamond magnetometer*, Phys. Rev. Applied 21, 014003 (2024).  
[5] S. M. Graham et al., *On the road with a diamond magnetometer*, Diamond and Related Materials 152, 111945 (2025)

# LEVITAS: Levitodynamics for Individual Particle Sensing in Space

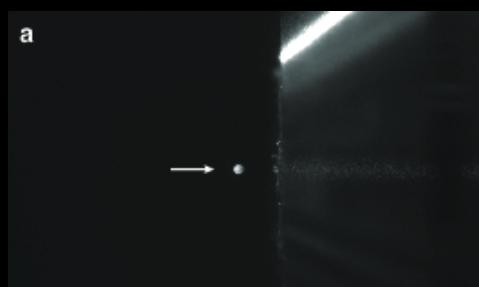
Ravi Desai, Animesh Datta, James Bateman, Daniel Oi, Bengt Eliason, Rafal Gajewski

## Optomechanics

### LEVITAS

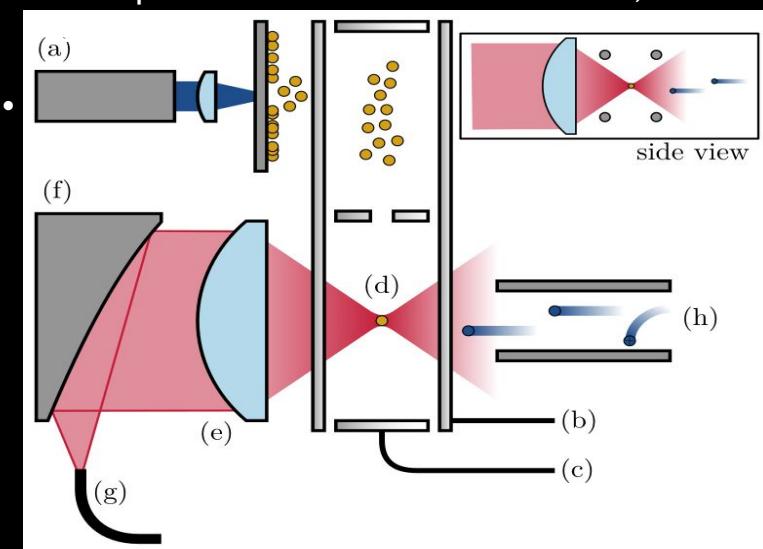


- MAQRO was proposed to probe quantum collapse [1]
- Here, a dielectric nanoparticle is exposed to the ambient medium outside the spacecraft.



Photograph of a nanoparticle held at the focus of a high NA objective lens [2]

→ \*

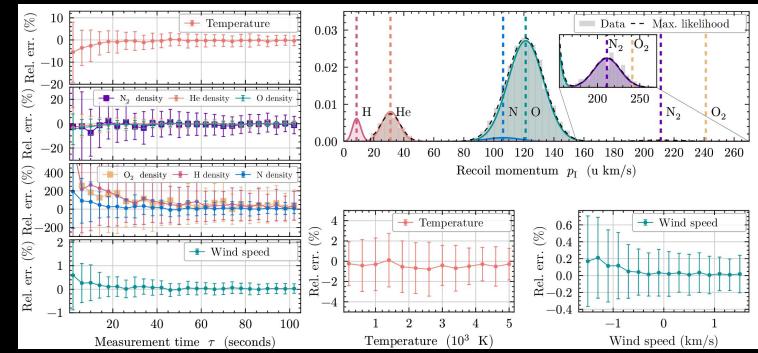


LEVITAS sensor head: Nanoparticles are ejected from a metallic substrate using a pulsed laser via laser-induced acoustic desorption

## Critical Gap

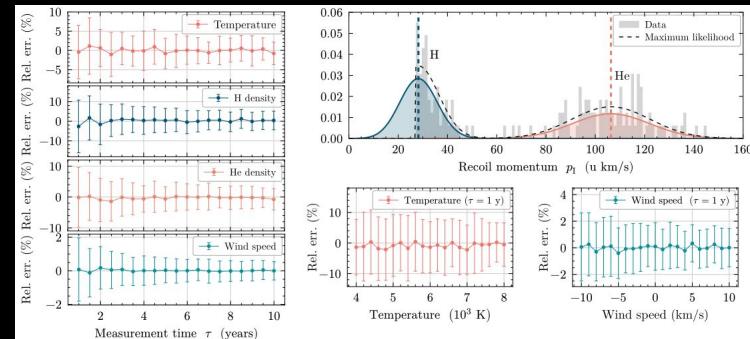
- Current instruments use indirect methods to detect neutrals & extensive calibration
- LEVITAS provides a highly sensitive solution to directly measure particles in space
- Compact sensor head less than 2u, TRL

## Thermosphere @ 600 km



Inference of parameters in LEO at 600 km altitude

## Interstellar neutrals @L2



Inference of parameters of the interstellar medium observed at L2