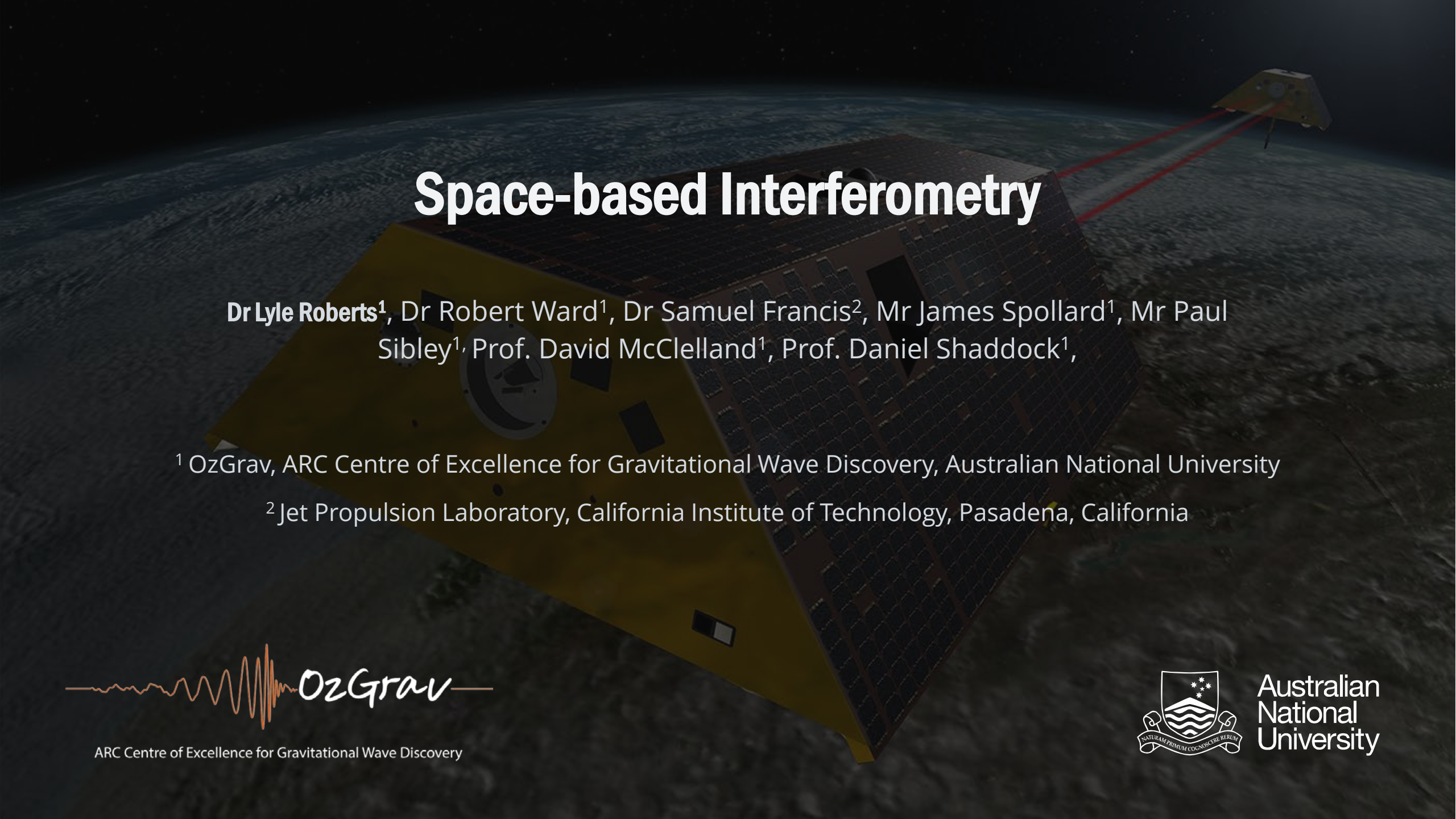


Space-based Interferometry

Dr Lyle Roberts[1], Dr Robert Ward[1], Dr Samuel Francis[2], Mr James Spollard[1], Mr Paul Sibley[1], Prof. David McClelland[1], Prof. Daniel Shaddock[1],

[1] OzGrav, ARC Centre of Excellence for Gravitational Wave Discovery, Australian National University

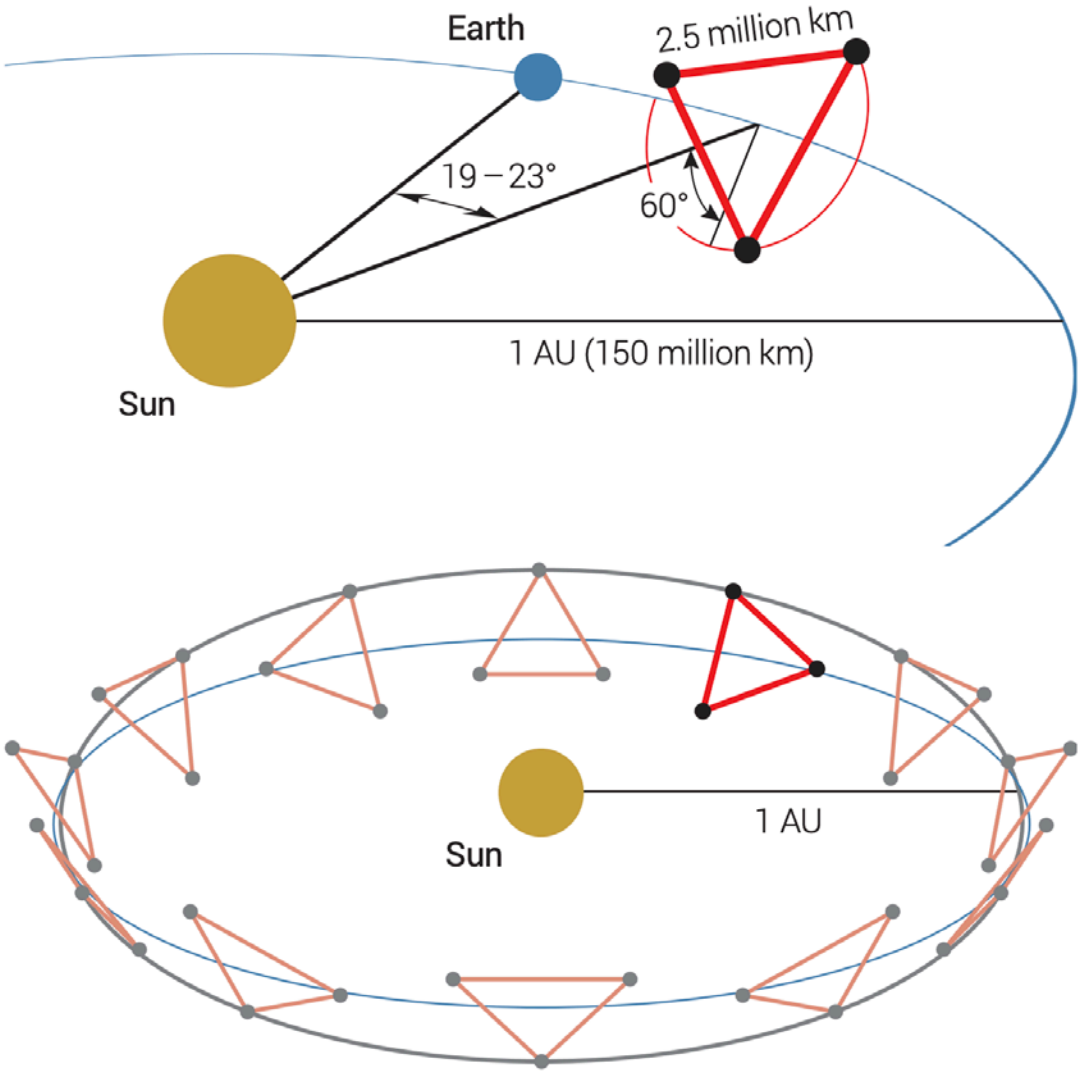
[2] Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California

OzGrav

ARC Centre of Excellence for Gravitational Wave Discovery

Australian National University

LISA is a low-frequency, *space-based* GW detector



Laser Interferometer Space Antenna (LISA)

- Three satellites
  - → Triangular formation
  - → Separated by 2.5 million km
  - → Earth-trailing heliocentric orbit
- Six active laser links
  - → Heterodyne interferometry
  - → Picometer/√Hz sensitivity
- Expected launch date in 2034
  - → Led by the European Space Agency
  - → Mission duration: 4 to 10 years

Read the full LISA mission proposal here:
https://www.elisascience.org/files/publications/LISA_L3_20170120.pdf

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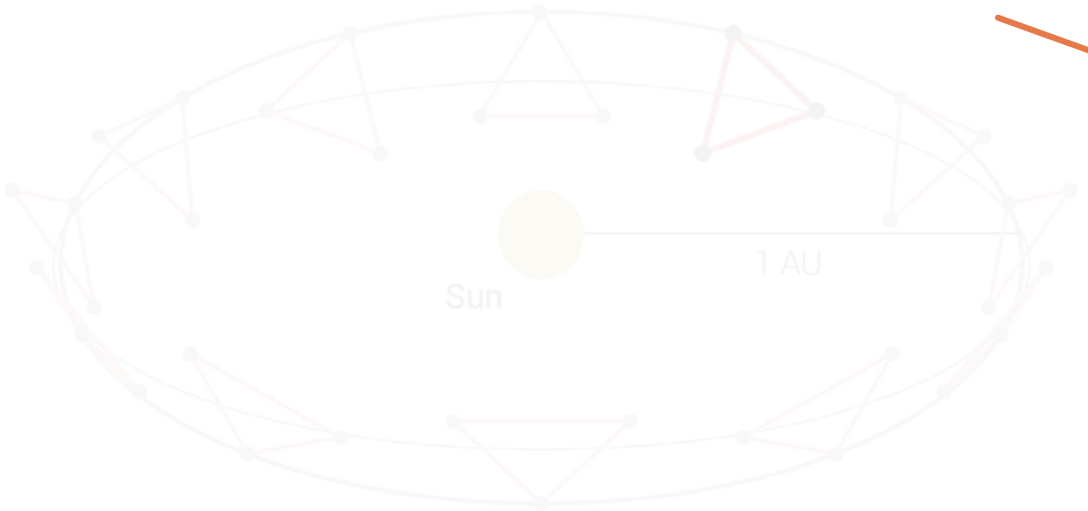
This is what we focus on



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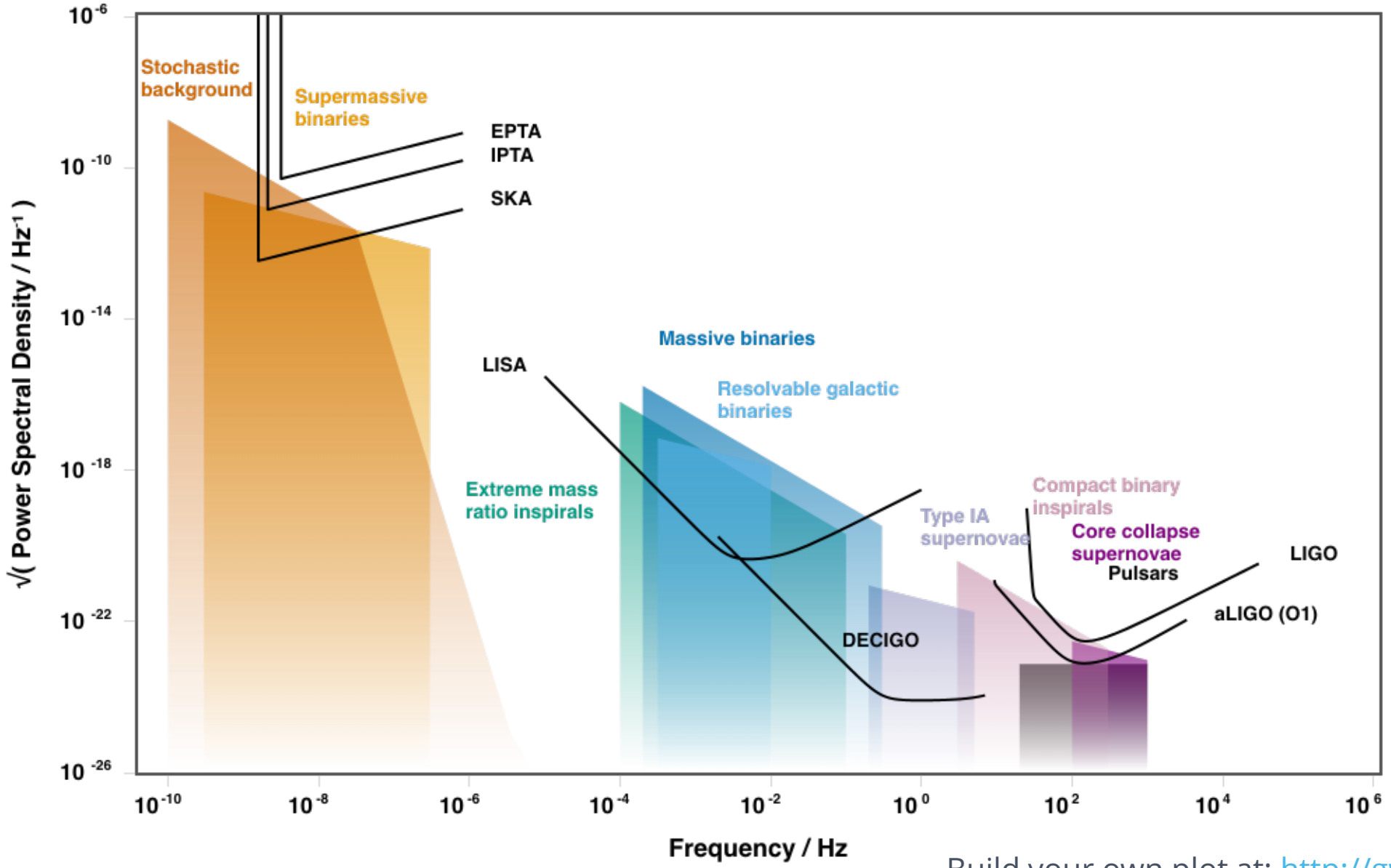
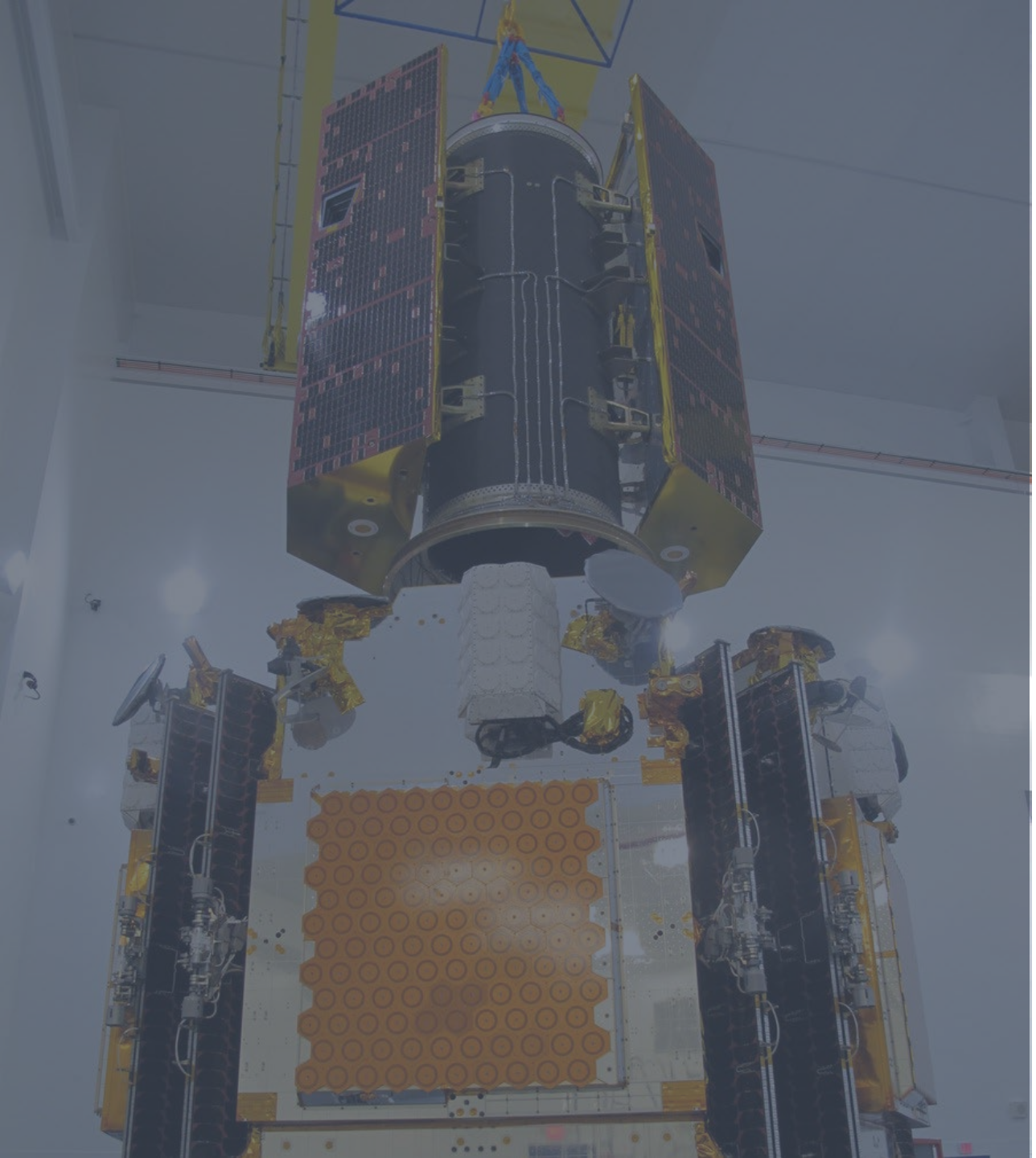


Build your own plot at: http://gwplotter.com/



GRACE Follow-On

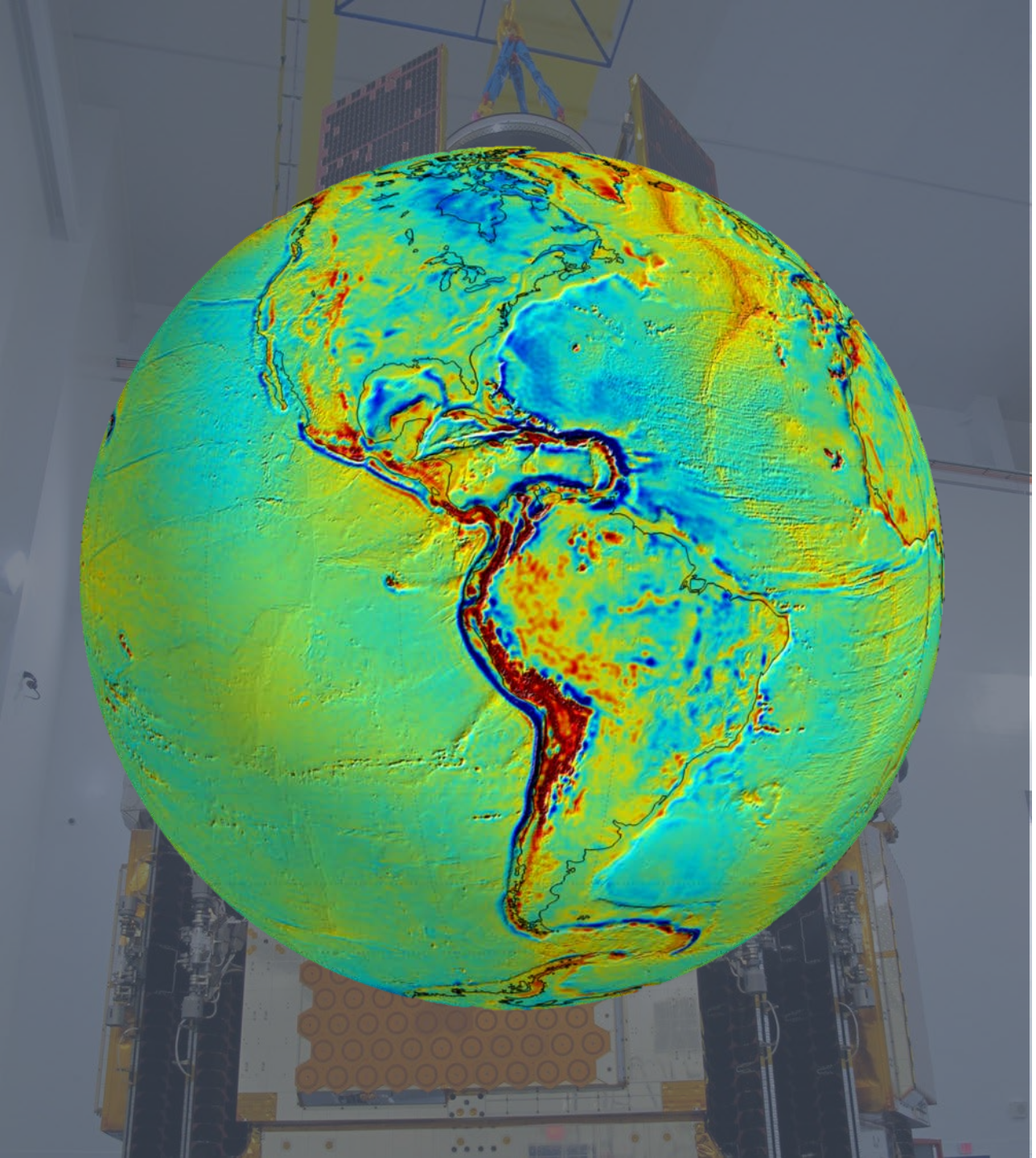
- Gravity Recovery and Climate Experiment Follow-On Mission

→ Launched on May 22, 2018
  - Vandenberg Air Force base
  - SpaceX Falcon 9 rocket

→ Continues the work of the hugely successful GRACE mission
  - Launched in 2002, retired in 2017

→ Measures Earth's gravity gradient
  - Monitors changing distribution of mass, including melting ice-sheets, ground-water movement

→ First intersatellite laser ranging interferometer
  - This is kind of like a mini LISA



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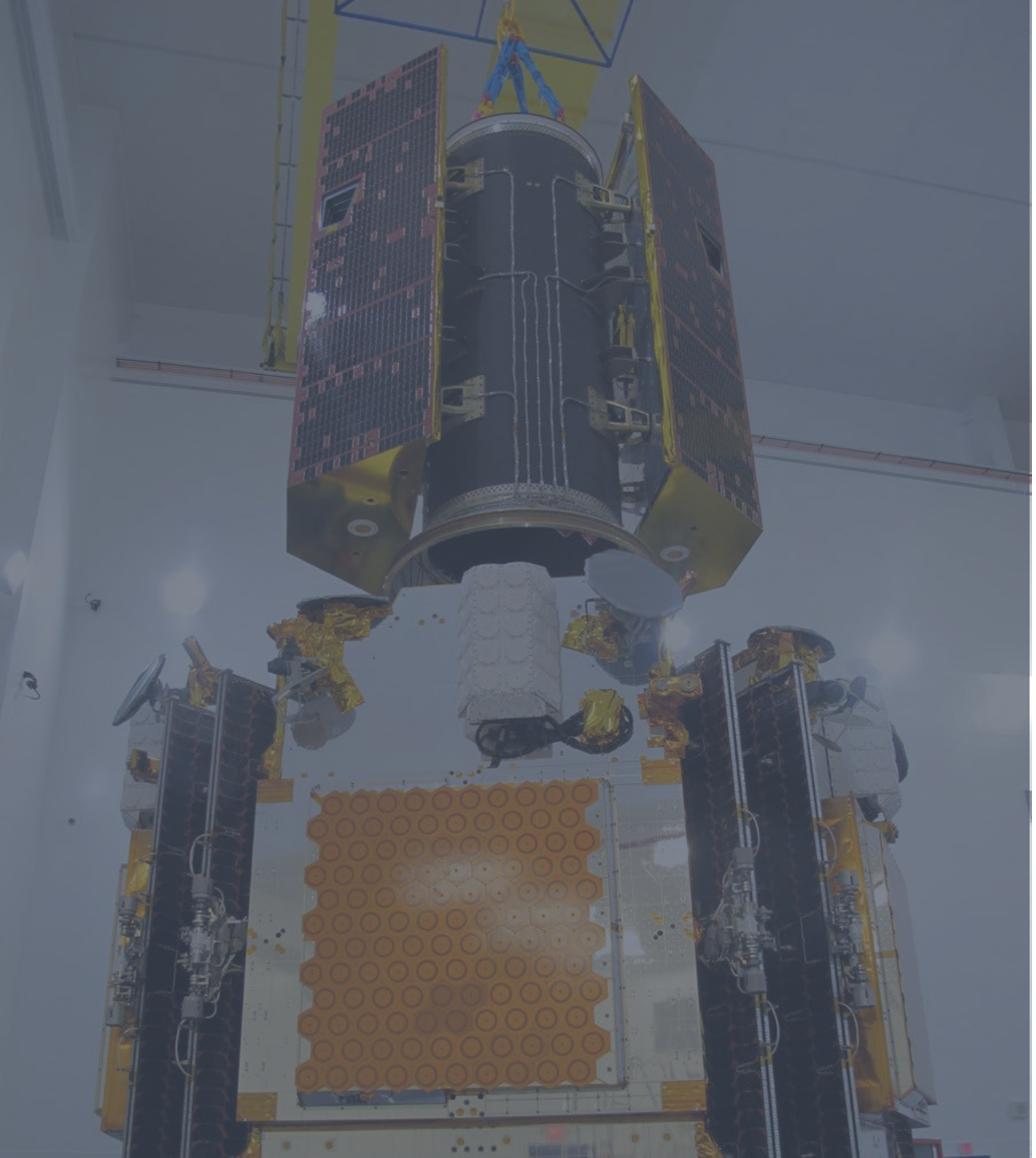


GRACE Follow-On

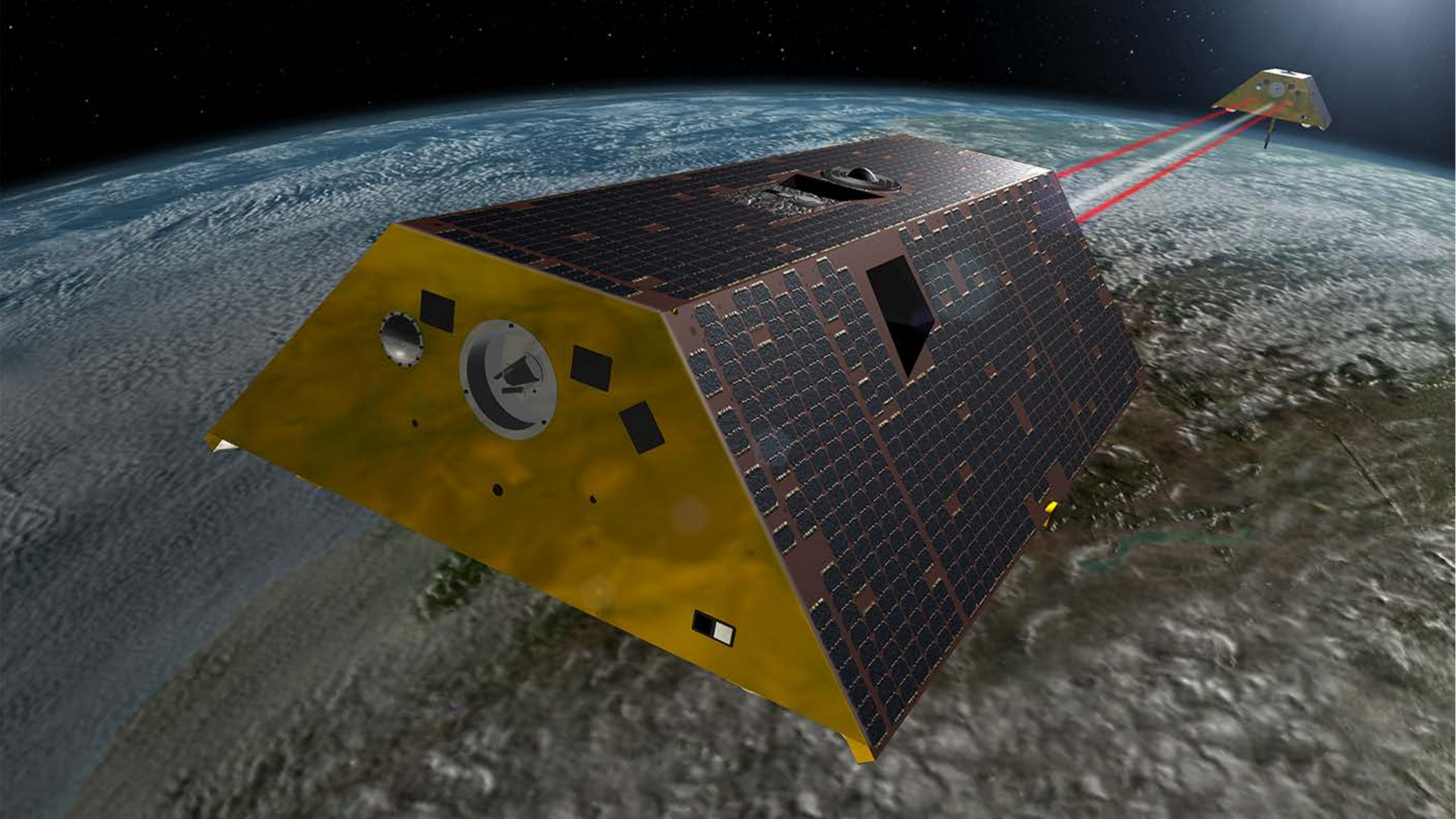
- Laser Ranging Instrument

  → “First light” operation began on June 13
    - Worked first time

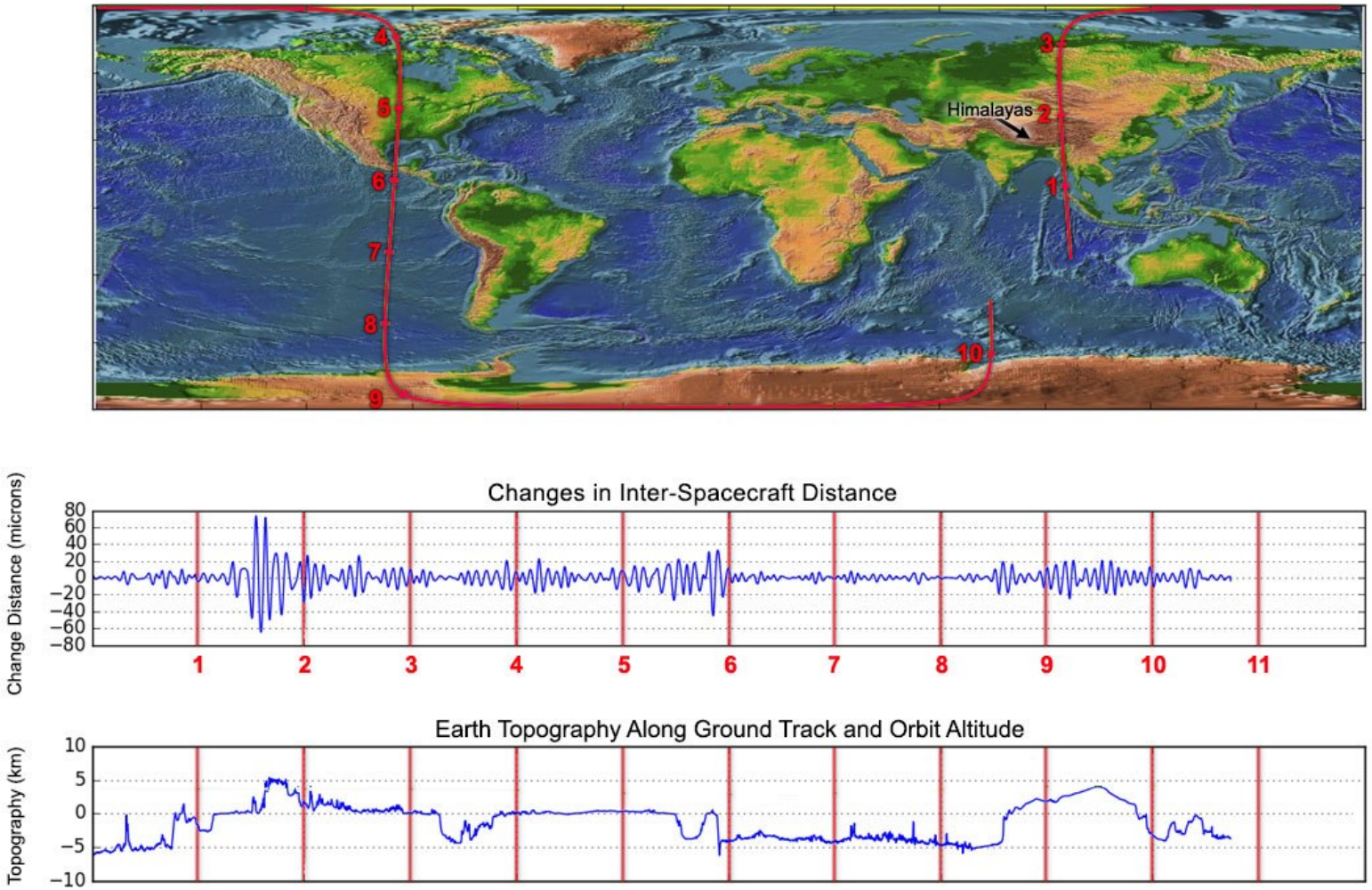
  → ANU contributions:
    - Link-acquisition system
    - Triple-mirror assembly (TMA)
    - Phasemeter

"It’s the first inter-spacecraft laser interferometer and the culmination of about a decade of NASA- and German-funded research and development.” – *Dr Kirk McKenzie, JPL*


iABG



GRACE-FO Single-Orbit Ground Track (June 14, 2018)



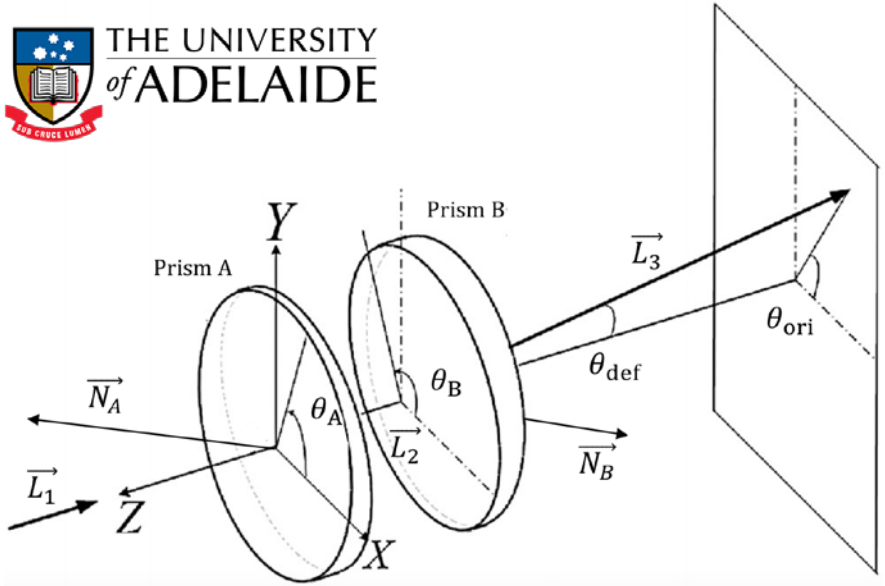
Learn more:
https://gracefo.jpl.nasa.gov/news/138/first-laser-light-for-grace-follow-on/

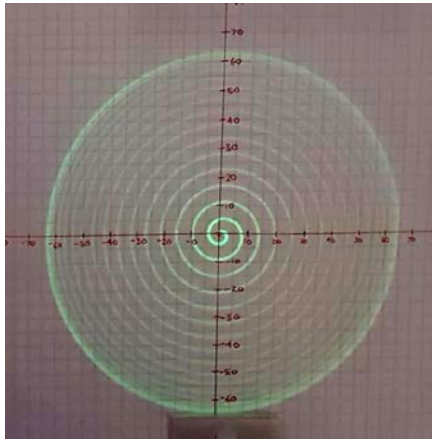
Internode Collaboration

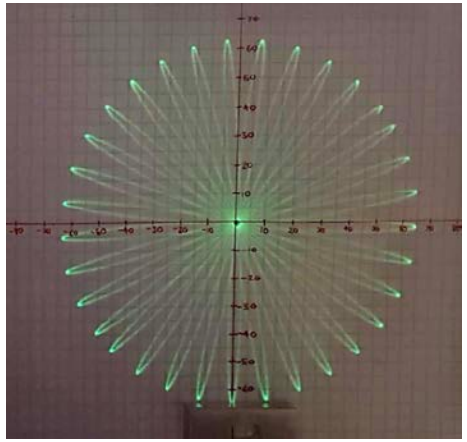
- In 2018, we worked with students from the University of Adelaide to explore alternative techniques for inter-satellite link acquisition and tracking
  - → Dynamic beam-deflection using motorized Dual Risley Prisms
  - → Experimentally demonstrated robust link-acquisition and target tracking

- Nathaniel Shearer will continue this work in 2019
  - → Investigate the use of his team's beam-steering system for more general applications of free-space link acquisition
    - E.g., free-space laser communications, light detection and ranging (LiDAR)

THE UNIVERSITY of ADELAIDE







What's happening in 2019?

- Prof. Daniel Shaddock is leaving
  → We have a plan.
- Push the limits of weak-light phase detection
  → Future intersatellite laser ranging systems can expect to receive less than 10 fW of optical power.
  → Track the phase of a 10 fW optical carrier whilst maintaining picometer/√Hz sensitivity. This is very difficult.
- Explore new architectures for future space-based laser interferometers
  → Link acquisition for LISA and other space-based GW detectors
- LISA Experience of GRACE Optical Payload (LEGOP)
  → Test LISA concepts using GRACE-FO platform
- Light Detection and Ranging (LiDAR)
  → Applied for OzGrav Seed Translation Fund in November
  → Pathway to commercialisation