

~~Calibrating astronomical
spectrographs with drones?~~

Enabling fundamental
astrophysics with drones?

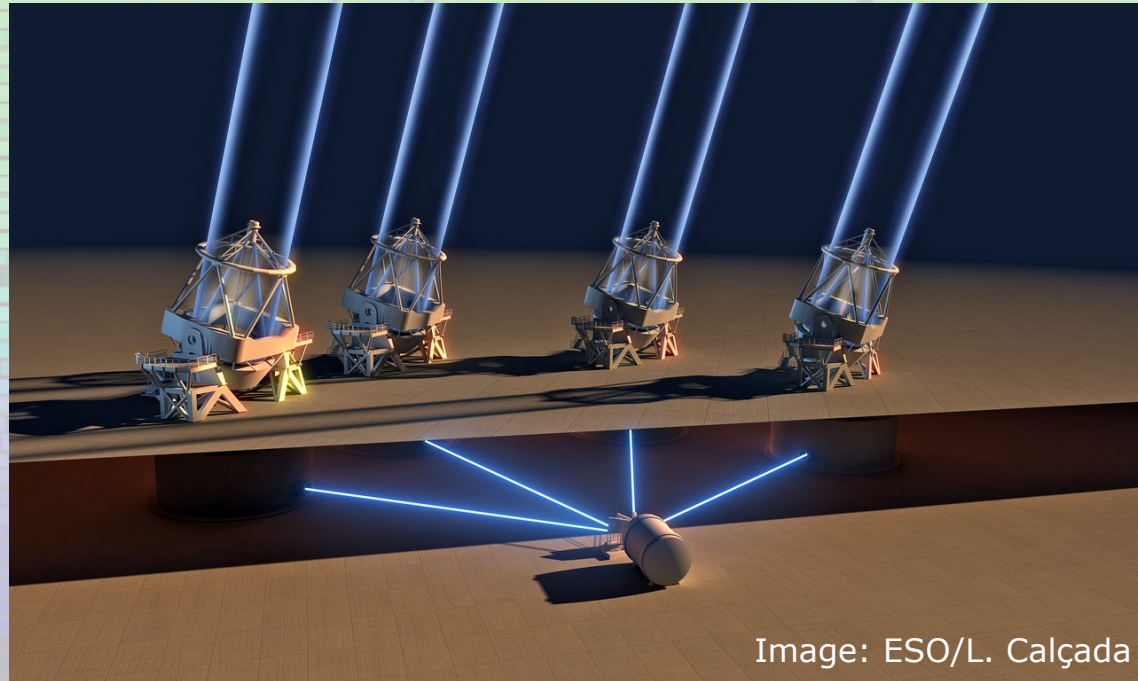
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Image: NASA/SDO & the AIA, EVE, and HMI teams

Overview

- Fundamental astrophysics with spectroscopy
- **The problem:** full-system calibration
- **Question:** Can drones help?
 - The principle idea
 - Likely challenges



Extra-solar planet discoveries:

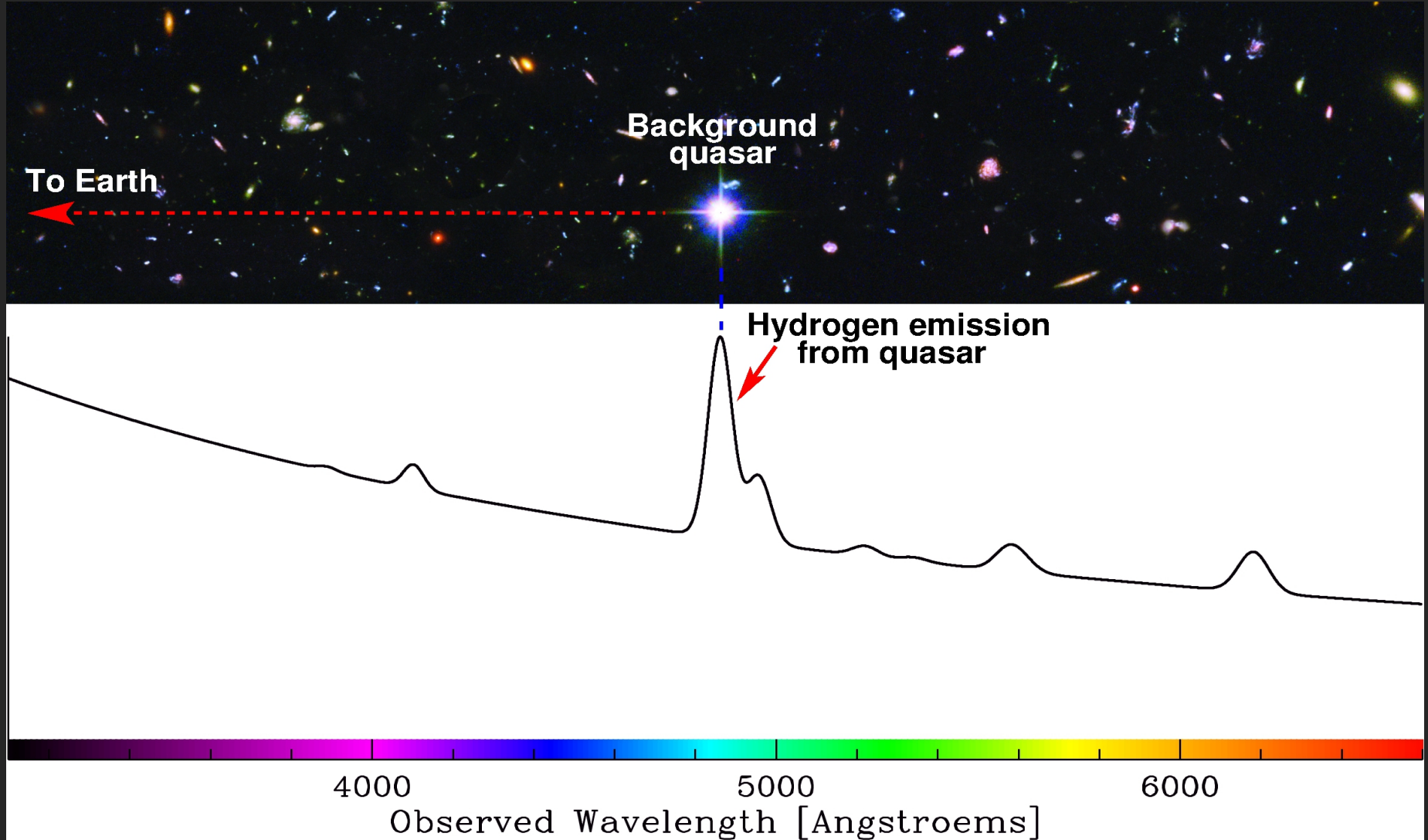


10 cm s^{-1}

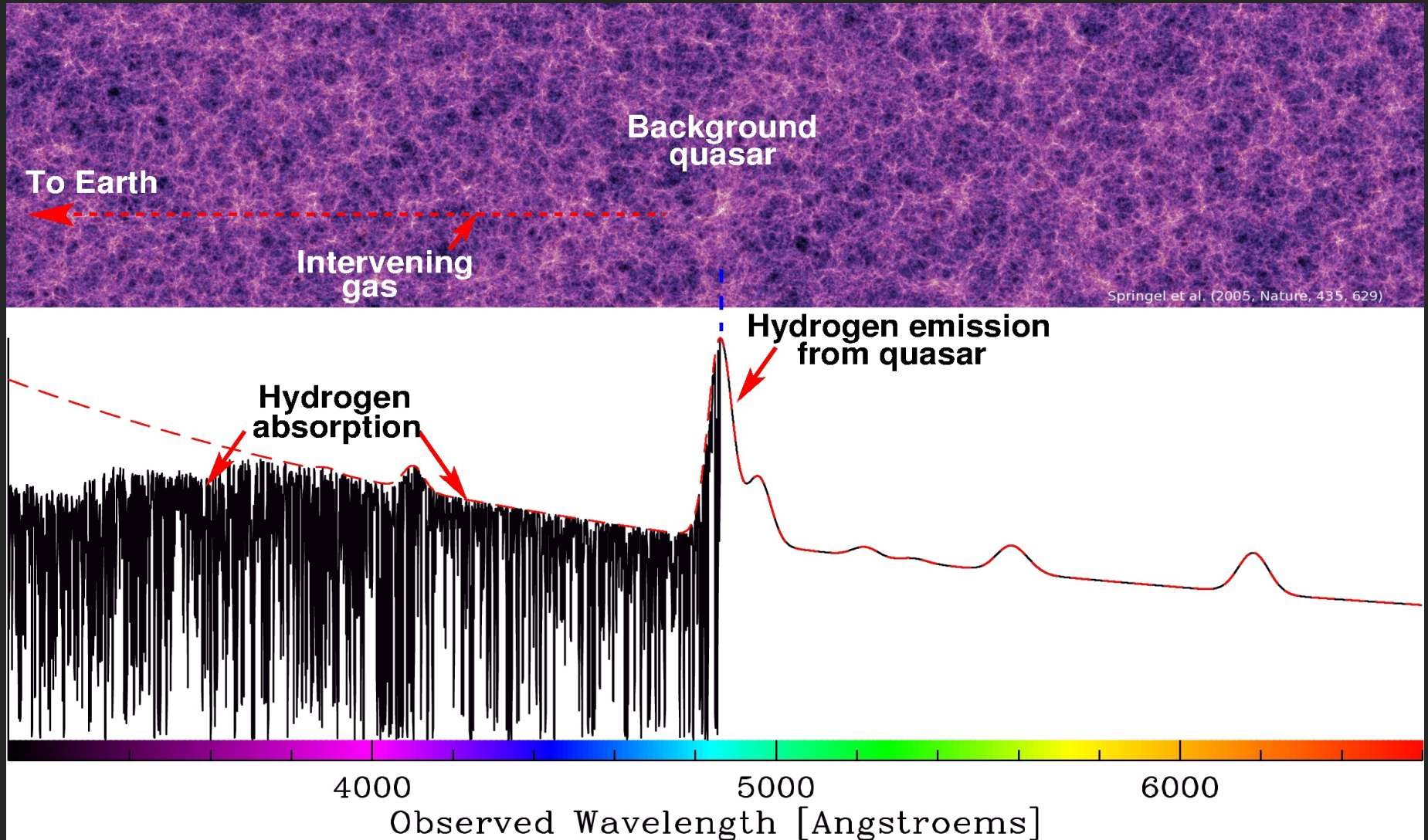
Sun's reflex motion due to Earth

Video: ESO/L. Calçada

Quasar spectroscopy



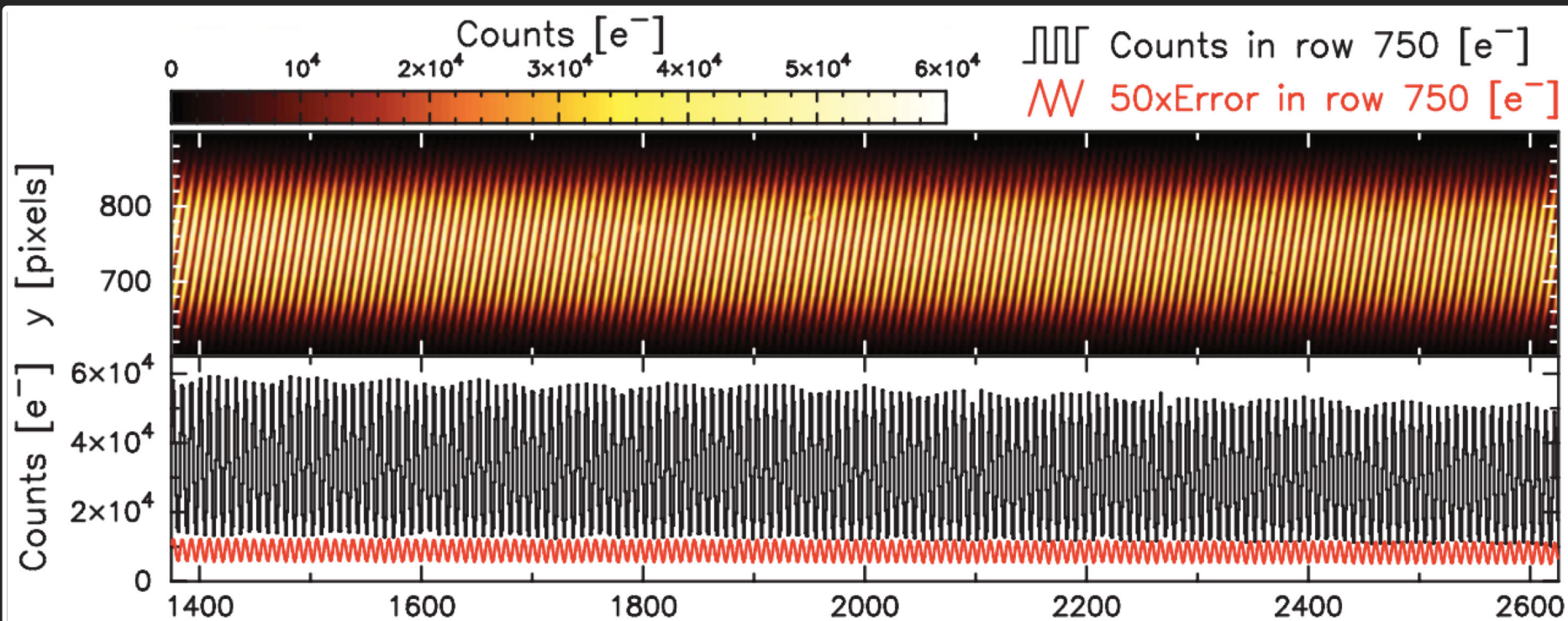
Sandage test



6 cm s^{-1} Decadal drift in intergalactic H lines

Laser frequency combs

- Nobel Prize in Physics 2005 (Hänsch & Hall)
- Dense comb of equally spaced, unresolved lines
- Every line **absolutely** calibrated
- 'Astrocombs': cm s^{-1} precision possible (Murphy+07)



Full-system calibration required

- Telescope optics not currently included
 - High-precision calibrators are within spectrographs
 - Atmospheric lines: few lines, too sparse, not all wavelengths
 - Laser guide-star: few lines, narrow wavelength region



Image: ESO/P. Horálek

Proposal

Observe a drone-mounted frequency comb high over the telescope with the astronomical spectrograph you want to calibrate

● Benefits:

- Absolute calibration entire telescope + spectrograph optics
- Point source
- Repeatable

● Disadvantages:

- Not simultaneous with astronomical observations
- Not always available
- Different telescope focus – drone not “at infinity”

Likely challenges

Drone

- **Weight?** Frequency comb may weigh $\sim 5\text{kg}$ (maybe more)
- **Height?** May need to be $\sim 0.5\text{--}1\text{km}$, above 3000m high telescope
- **Stability/telemetry?** Telescope must find fibre in sky within $\sim 1\text{mm}$ to take a ~ 1 second exposure (pref. more)

Telescope

- **Focus?** Telescope must focus on nearby object ($\sim 500\text{m}$?)
- **Tracking?** Cannot track quickly; drone must do the work here

Comb

- Astrocombs are new ***benchtop*** facilities. Making them smaller, lighter, drone-mountable may need emerging comb technologies not yet demonstrated in astrocombs.

Conclusions

- High-priority, fundamental astrophysical discoveries require absolute calibration of full optical path
- Drones may be the enabling technology
- Significant questions and R&D challenges must be addressed
- Show-stoppers certainly not ruled out yet!