Inflatable Starshade for Earthlike Exoplanets

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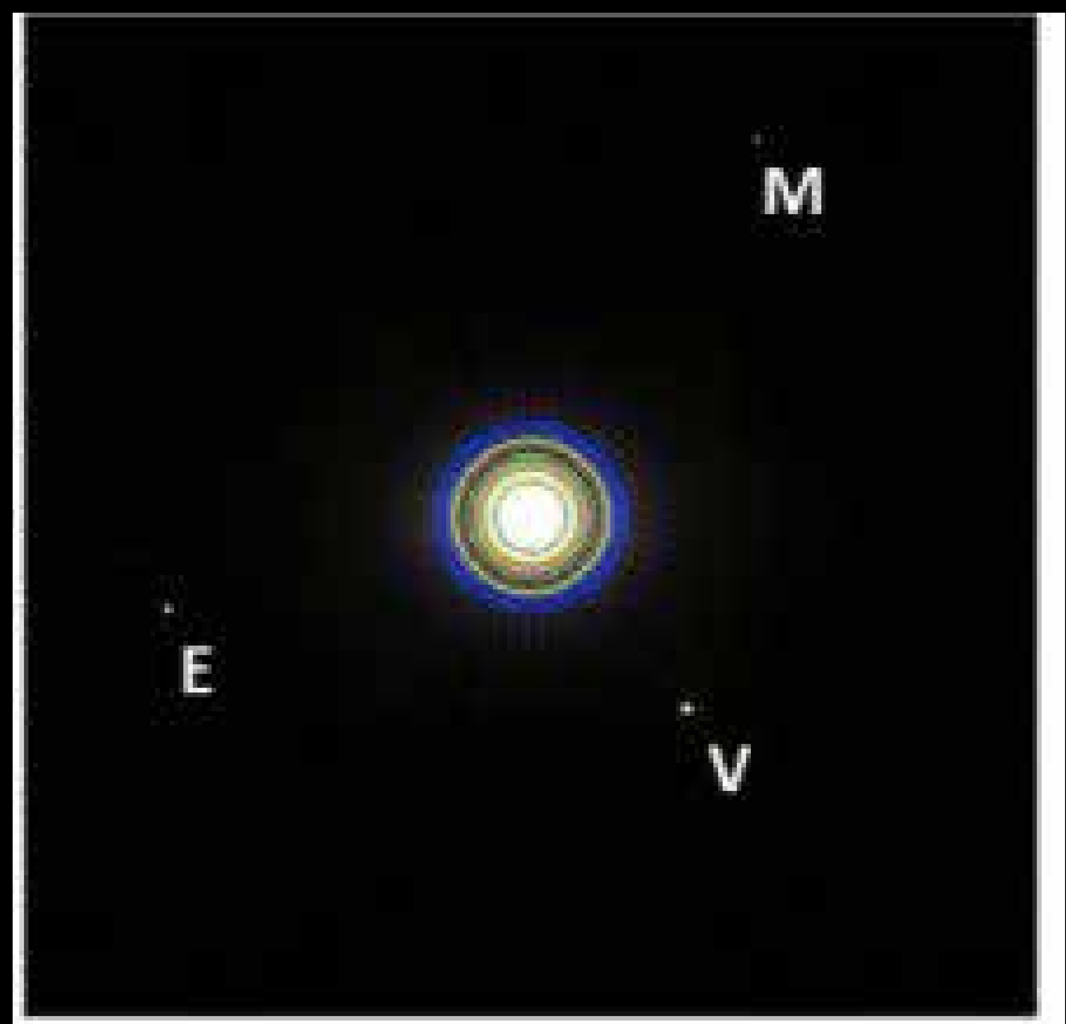
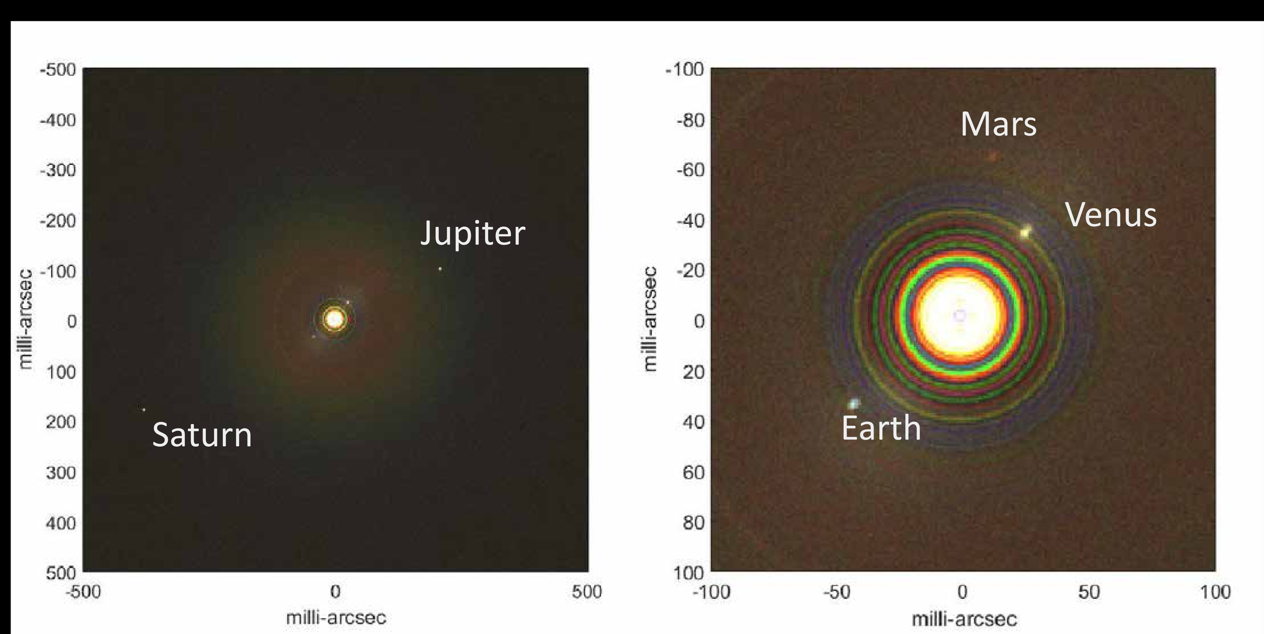
NIAC NASA Innovative Advanced Concepts

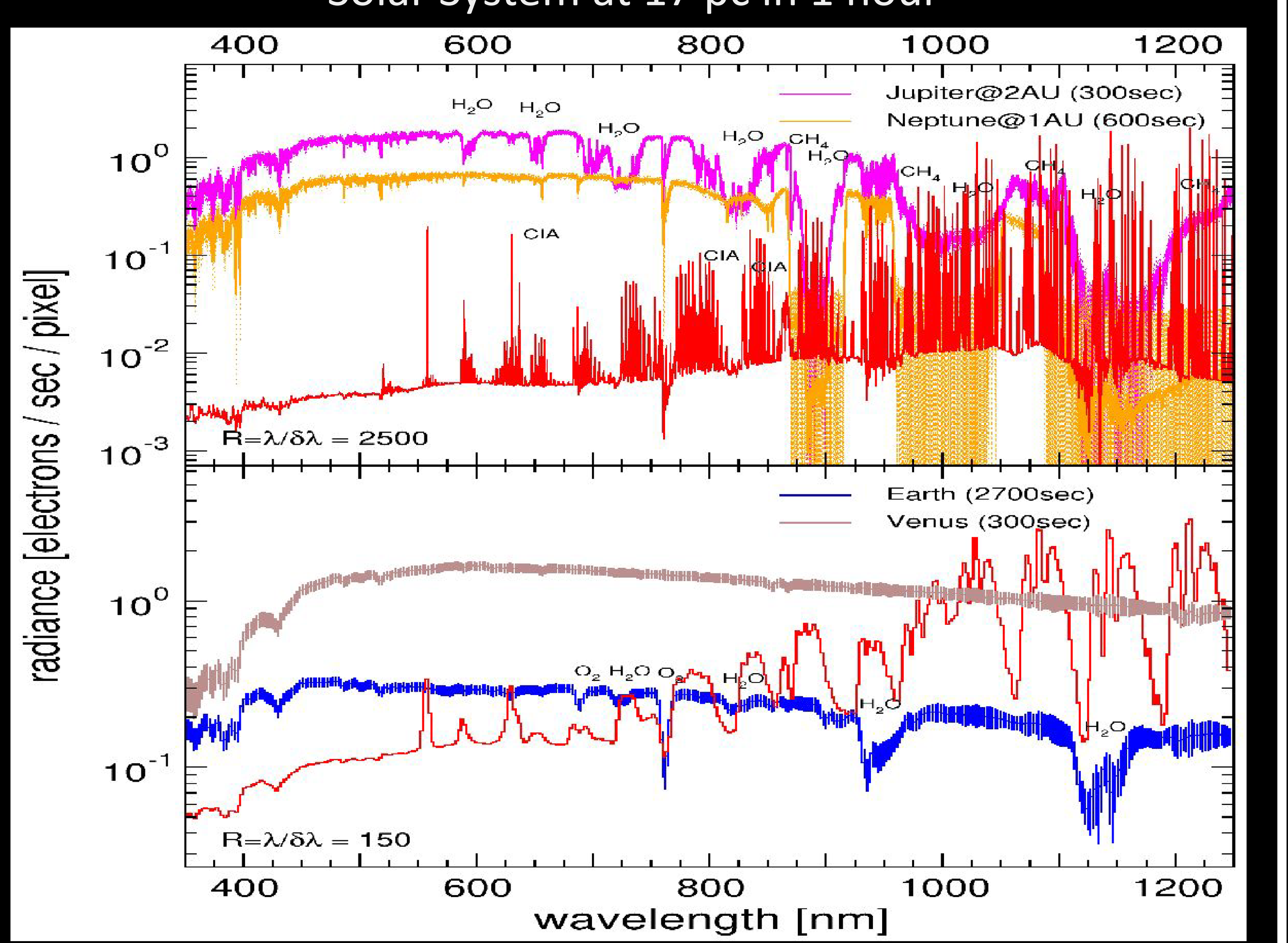
Observing Earthlike Exoplanets Around Other Stars



Solar System at 5 pc in 1 minute

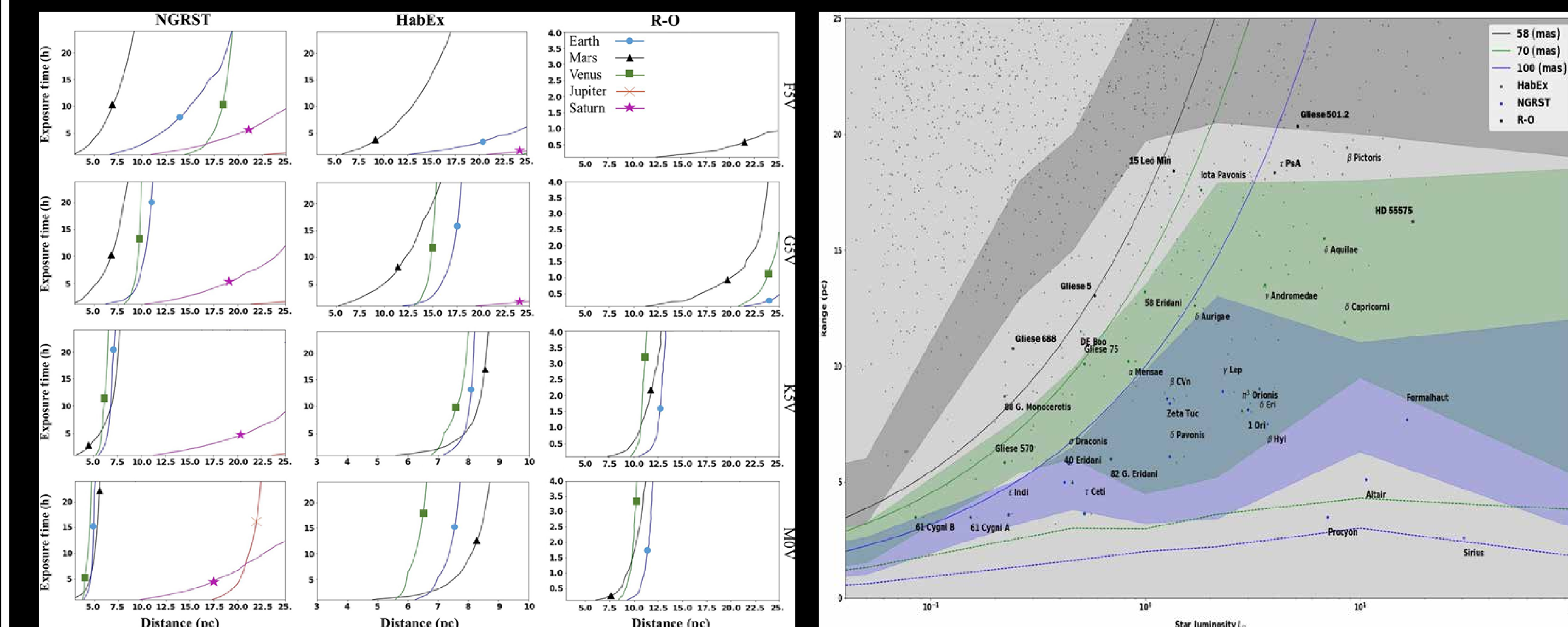


Solar System at 17 pc in 1 hour

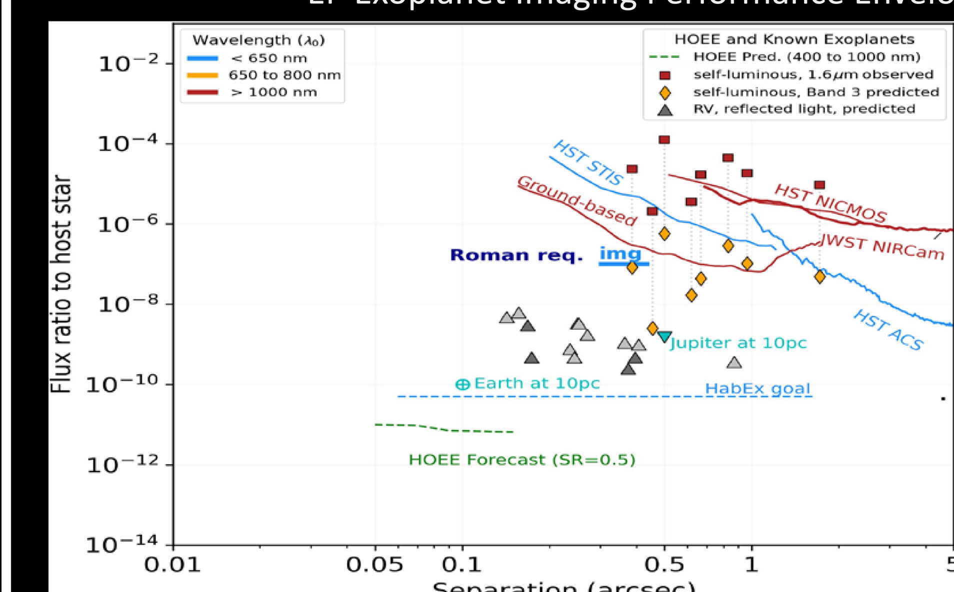


ELT with orbiting starshade observes water and oxygen in an Earth-like planet 5pc (16 light years) away in 1 hour. Lower red curve is sky background, fainter than the planets

A Starshade Offers a Variety of Advantages



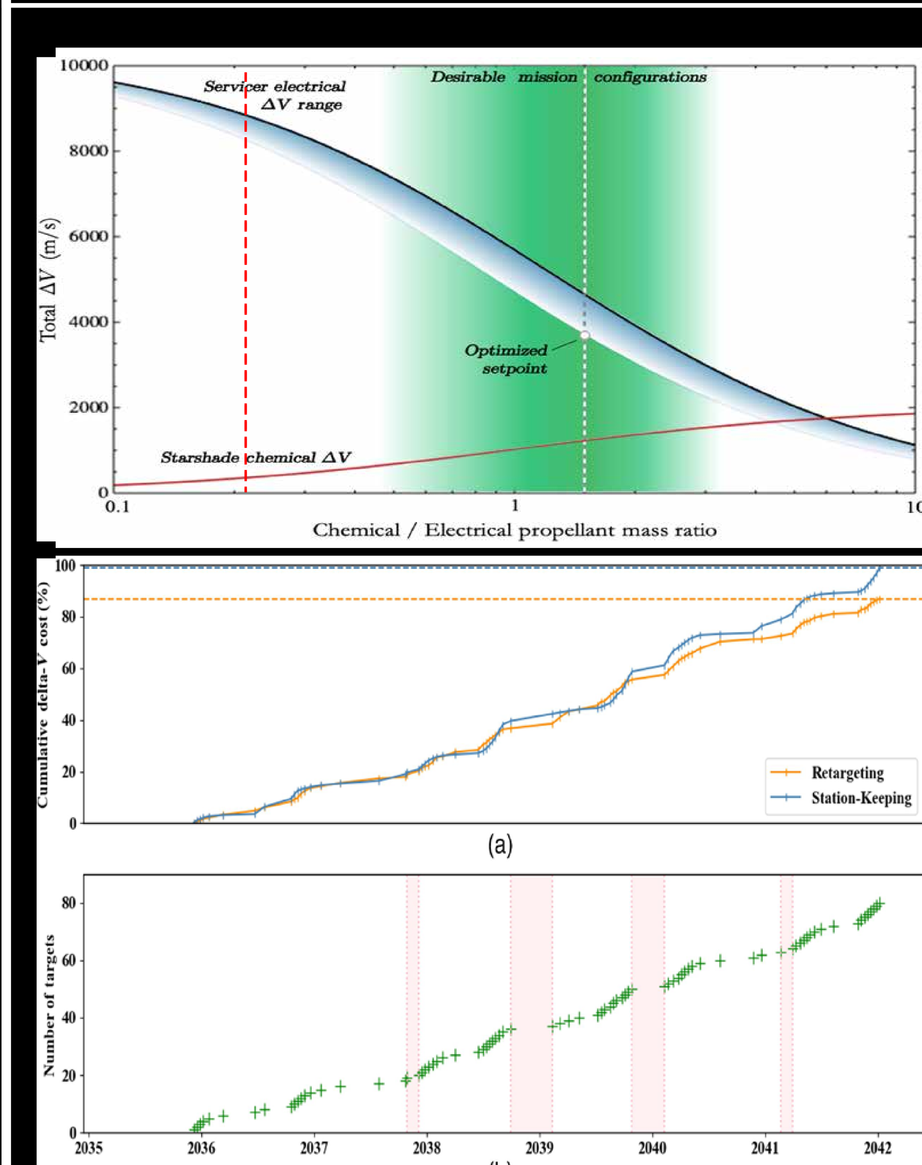
More Planets and moons are accessible, shorter exposure times, Larger SNR, Less sensitive to Exo-Zodi or Debris.
EP Exoplanet Imaging Performance Envelopes for Starshade Based Missions Peretz et al.

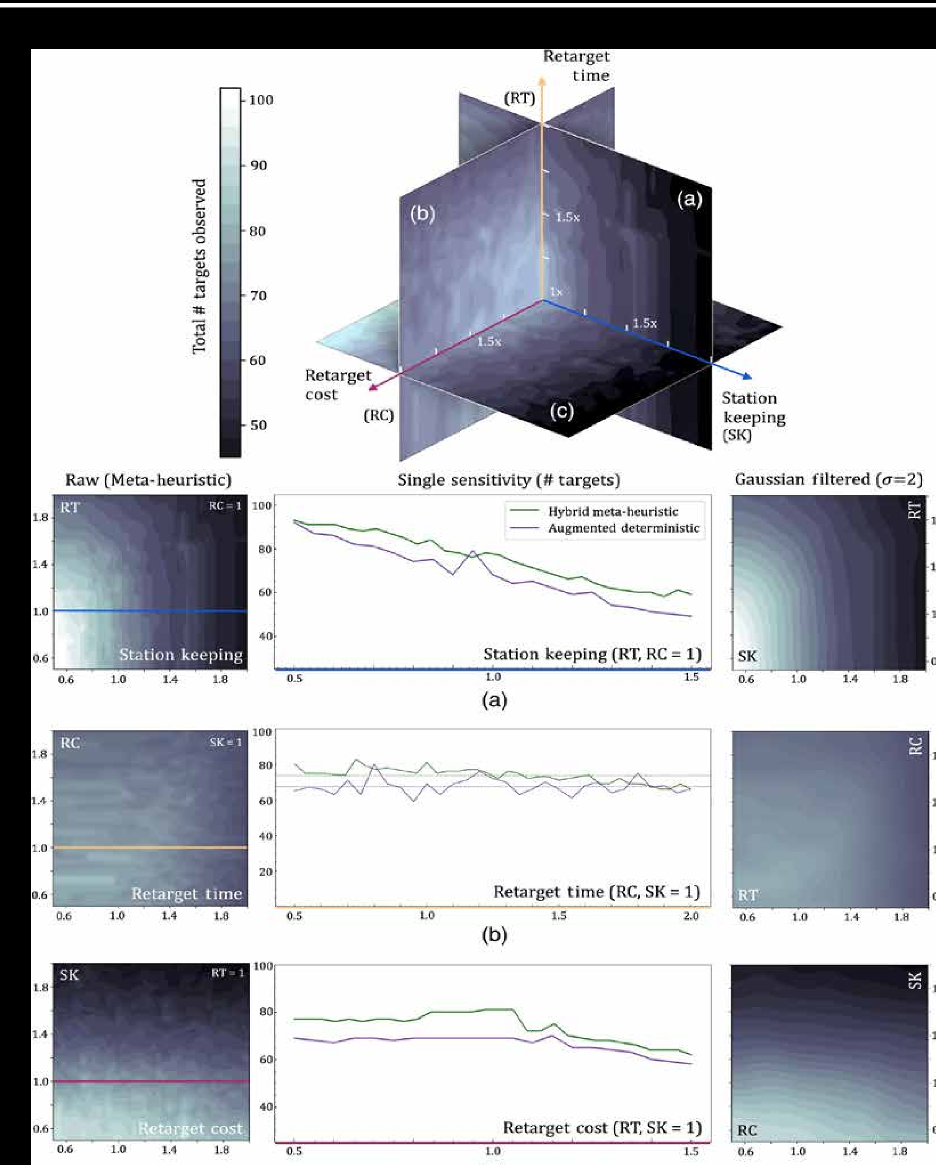


1. Pristine Science Data - Higher contrast and fainter detection limits than are capable with a coronagraph. When using a Starshade, the tolerances of the primary mirror and supporting optics of the telescope can be relaxed. Reduced optical complexity also translate into less signal loss.
2. Enables lower required level of technology development and relaxed metrology requirements.

Optical performance of Hybrid Observatory for Earth-like Exoplanets

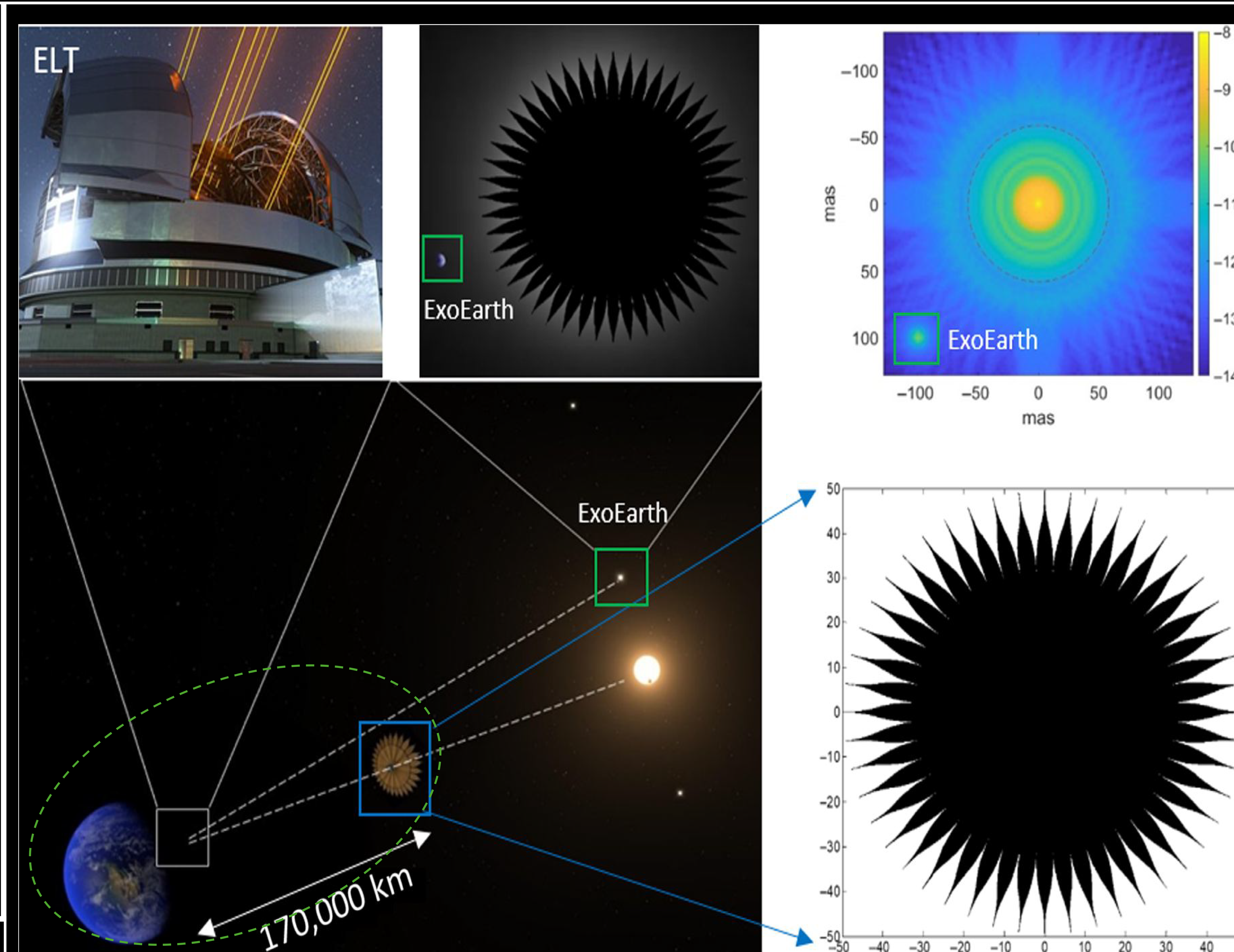
HOEE Could Observe Dozens of Earthlike Exoplanet Systems





Mass Reduction Leads for more targets to be seen (11 ton to 1.5 ton)
Scheduling Optimization of an orbiting starshade working with Extremely Large Telescopes

How?



24-39 m Extremely Large Telescope (ELT) with visible AO (adaptive optics) on Earth
Pointed petals suppress starlight diffraction to better than 10^{-11} contrast

- 39 m Extremely Large Telescope is under construction in Chile, will have adaptive optics to achieve diffraction-limited resolution (nearly perfect) despite atmospheric turbulence.
- If feasible, 39 m ground telescope with an orbiting starshade could work MUCH better than next NASA flagship space telescope, 6 m diameter with perfect optics, $10 B in 2045?
- Observing speed is proportional to the 4th power of telescope diameter, $(39/6)^4=1785$.
- Visible band adaptive optics already demonstrated with Keck and orbiting laser beacon LCRD.
- NIAC Challenge: The starshade is huge but must be pushed with rocket thrust to stay aligned during observation and for retargeting.
- Orbit: long ellipse, >170, 000 km apogee, matches velocity of observatory at time of observation
- Propulsion: solar electric to change to different target; chemical to hold alignment during observation
- Must be ultralight: The objective is <1000 kg for 100 m diameter starshade component.
- Must be stiff to recover quickly after rocket thrust (seconds).
- Key insight: stronger and heavier isn't better– need better configuration and better materials.
- An inflatable system rigidized after launch could be ultralight, compact, meet requirements, and avoid tangles and complex mechanisms from prior designs.
- Approach:
  - Update requirements: much looser tolerances than for small telescopes; starshade is in near field, and coronagraph in telescope blocks light from it
  - Lab studies of deployments and construction methods using small scale (1 m class)
  - Develop inflation and rigidization concept
  - Lab tests and calculations
  - Extrapolation to large sizes: scaling laws
  - Implications for mission design, test program, technology development
  - Smaller version (35-70 m) could work with HWO

- Lower Cost
- Inflatable
- Many Units
- Low Mass