Proximity Glare Suppression for Astronomical Coronagraphy (S2.01) and Precision Deployable Optical Structures and Metrology (S2.02)

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Jet Propulsion Laboratory

California Institute of Technology

Overview

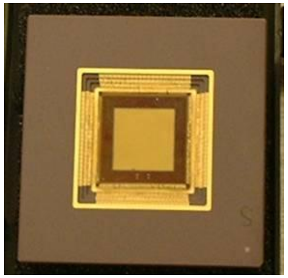
- S2.01: Proximity Glare Suppression for Astronomical Coronagraphy
  - SoA and Needs
  - Subtopic Call
  - Subtopic Proposals

- S2.02: Precision Deployable Optical Structures and Metrology
  - SoA and Needs
  - Subtopic Call
  - Subtopic Proposals

Wavefront Control for Scatter

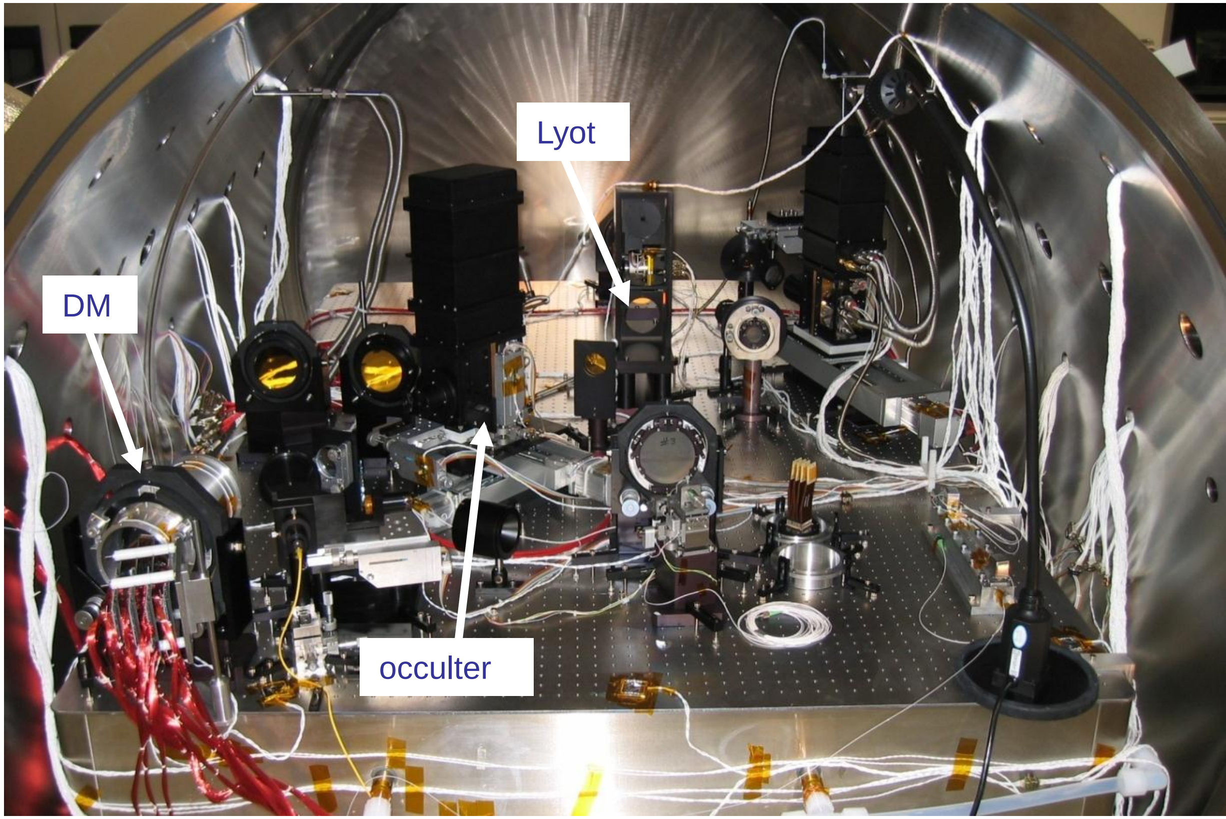
Xinetics, 64x64 DM

Boston Micromachine 32 x32 MEMS



Iris AO 489 actuator segmented DM

High Contrast Imaging Testbed (HCIT) provides experimental validation and guidance to models



Hybrid Lyot Coronagraph Experimental Results

National Aeronautics and Space Administration
Jet Propulsion Laboratory
California Institute of Technology

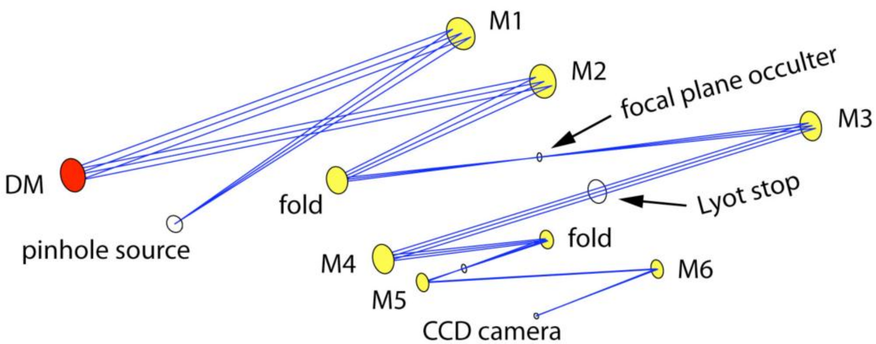
Coronagraph Technology Milestone:
Demonstration of ≤ 10^{-9} contrast w/ hybrid-Lyot Masks @ 3λ/D & 20% BW

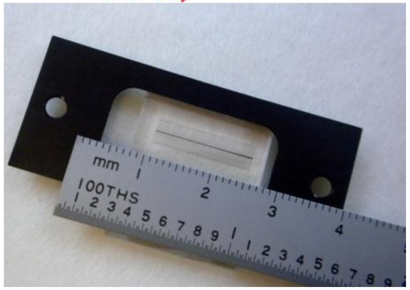
Facility: High Contrast Imaging Testbed 1, JPL

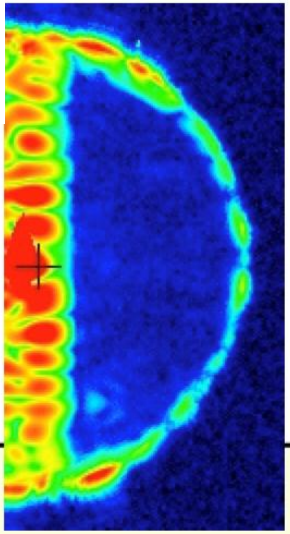
Current Status: 2×10^{-9} contrast @ 3-4 λ/D and 20%

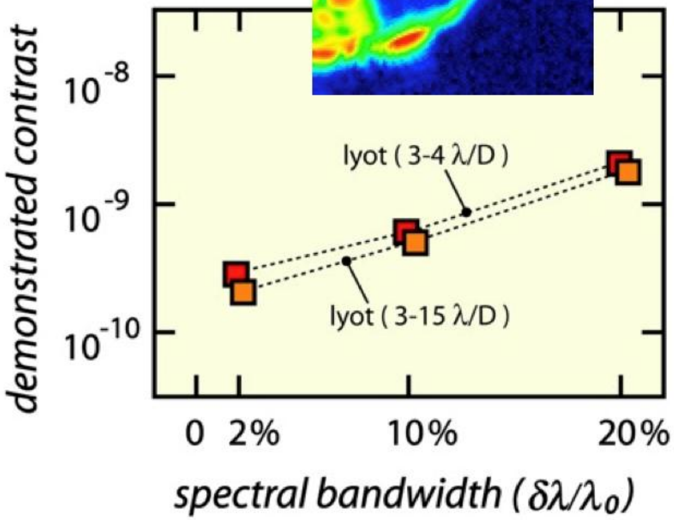
Challenges: Calibration of the dielectric layer during manufacturing.

Future Work: New masks, better contrast at 20% bandwidth. Fabrication and testing of circular masks







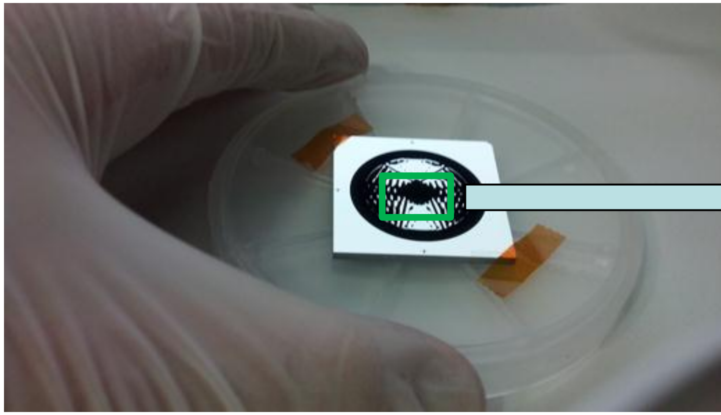


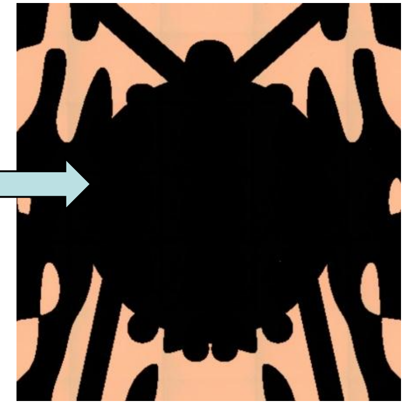
Hybrid Lyot Contrast Achieved to Date (Trauger TDEM)			
Inner Working Angle	Bandwidth		
	2%	10%	20%
3-4 λ/D	$3.2\ 10^{-10}$	$6.0\ 10^{-10}$	$1.9\ 10^{-9}$
3-15 λ/D	$2.0\ 10^{-10}$	$5.2\ 10^{-10}$	$1.9\ 10^{-9}$

Trauger et al, 2012

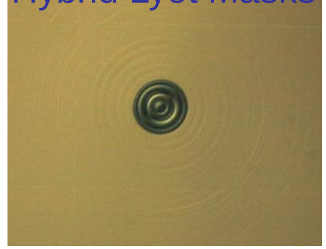
WFIRST/AFTA Coronagraph Technologies

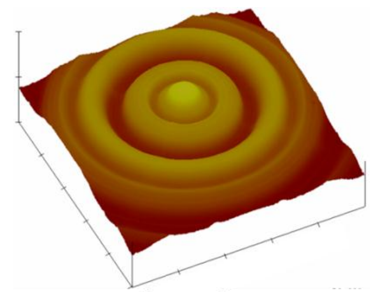
Reflective Shaped Pupil Masks with Black Silicon AR surface



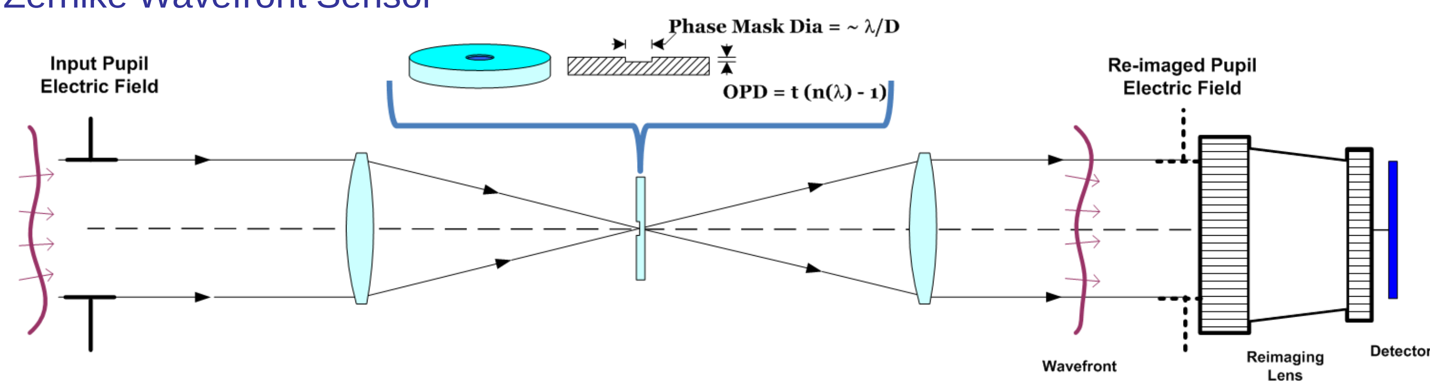


Hybrid Lyot Masks

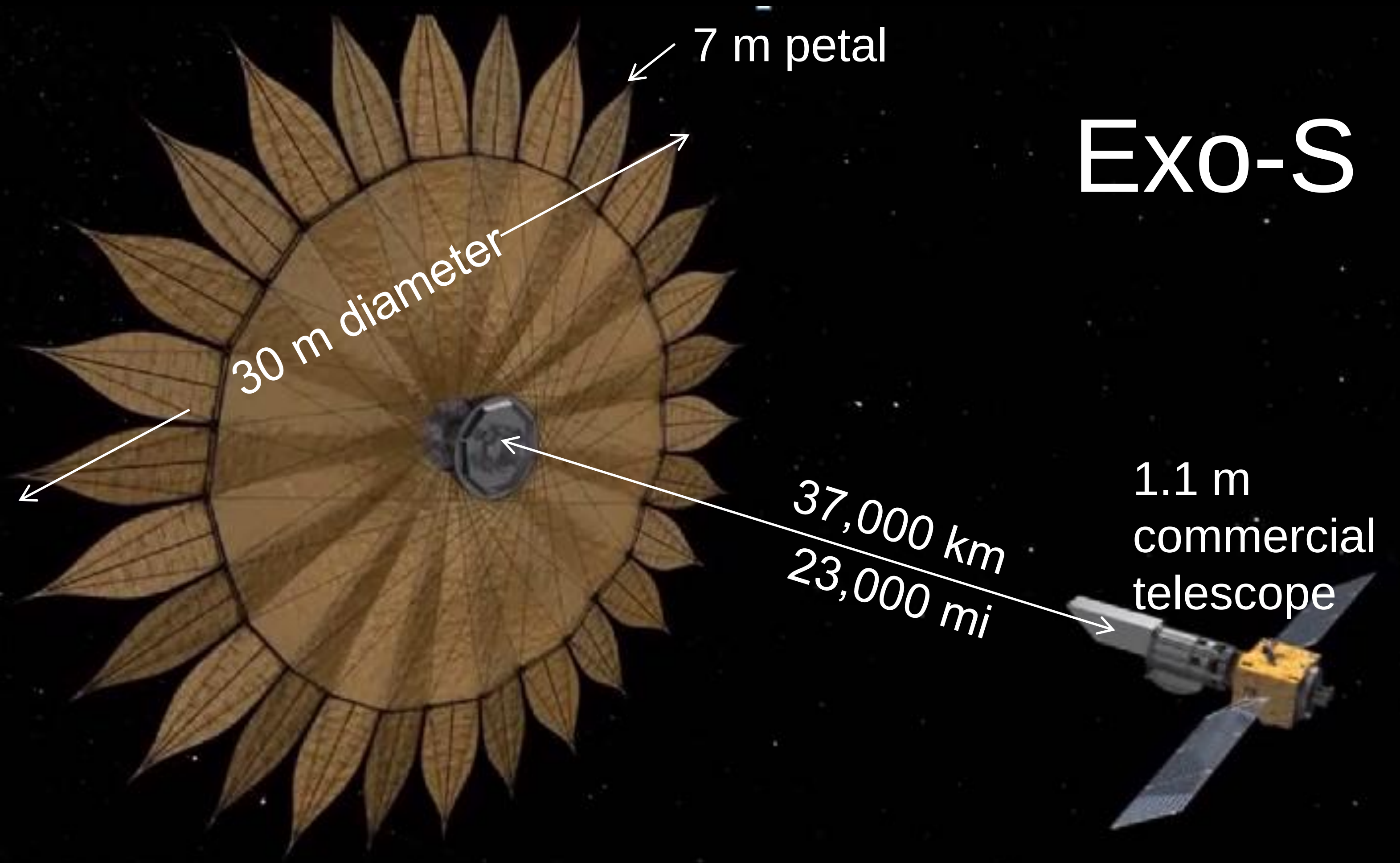




Zernike Wavefront Sensor



Exo-S

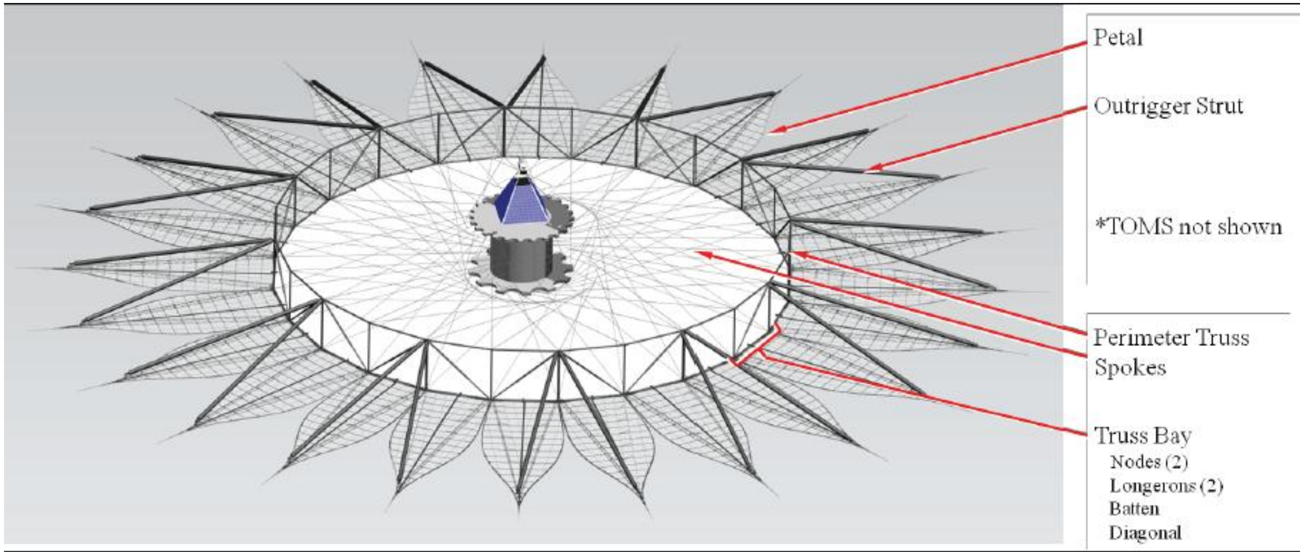

7 m petal
30 m diameter
37,000 km
23,000 mi
1.1 m
commercial
telescope

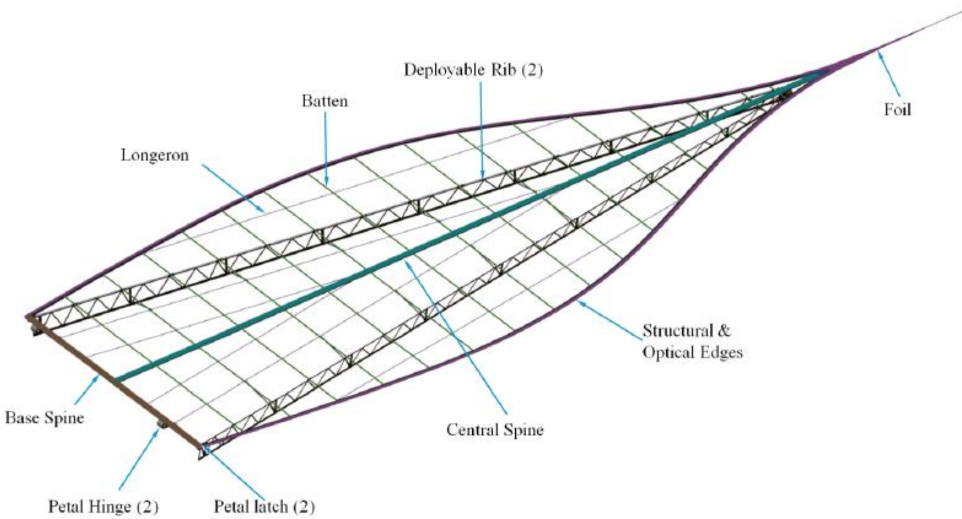
WFIRST Telescope Joined by a Starshade

WFIRST will launch in the early 2020’s and will make high-resolution infrared images over 100x the field of HST.

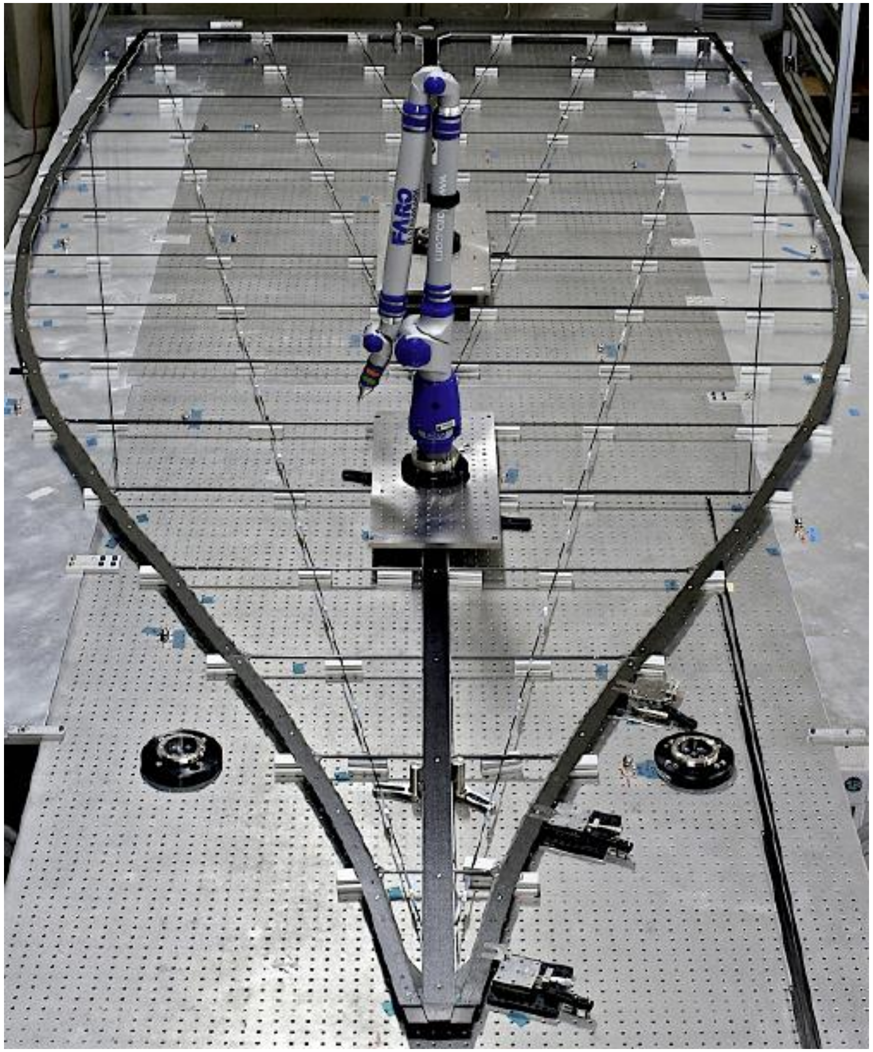
2.4 m telescope

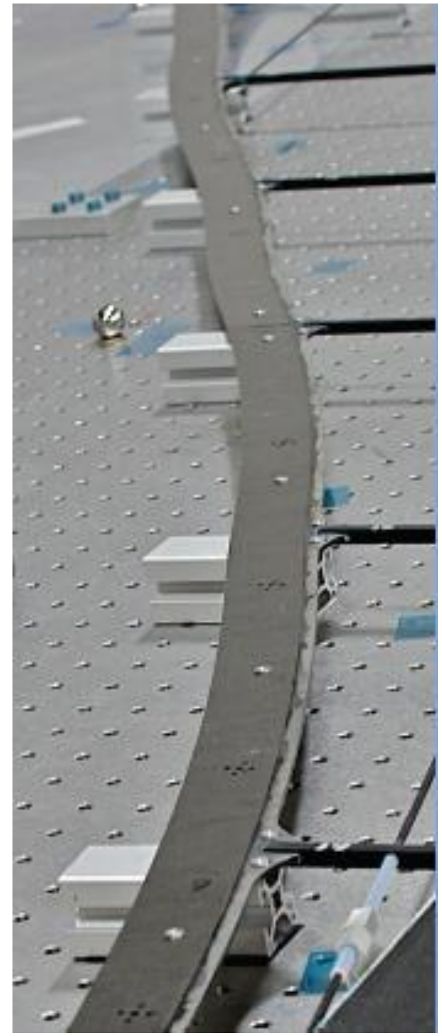
Starshade Construction and Deployment



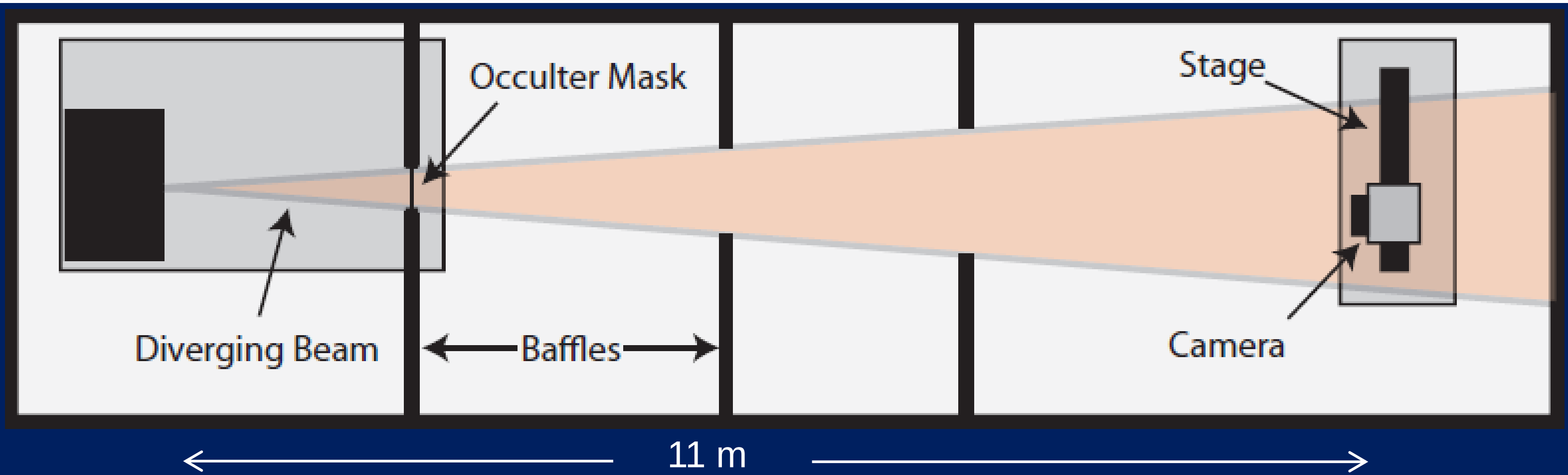


Precision Starshade

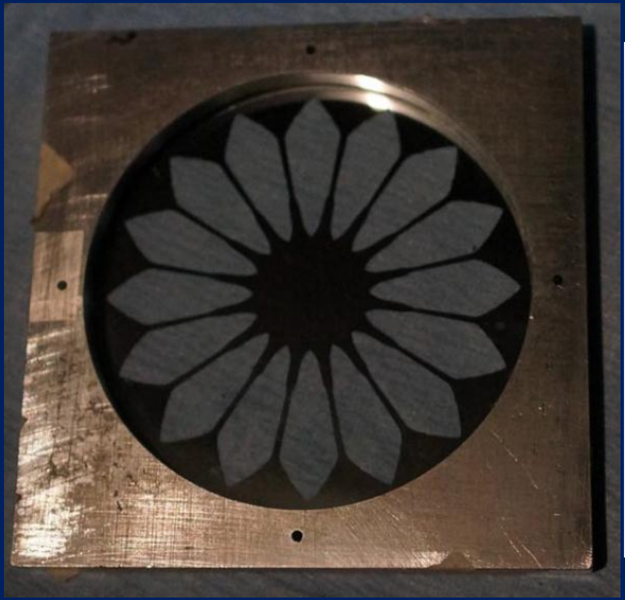




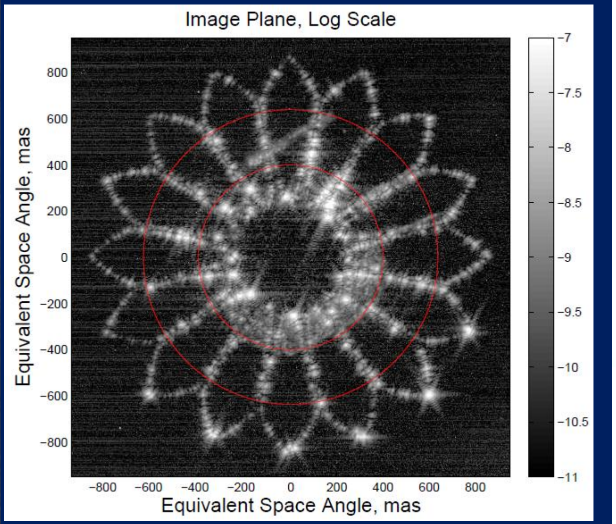
Princeton Starshade Testbed



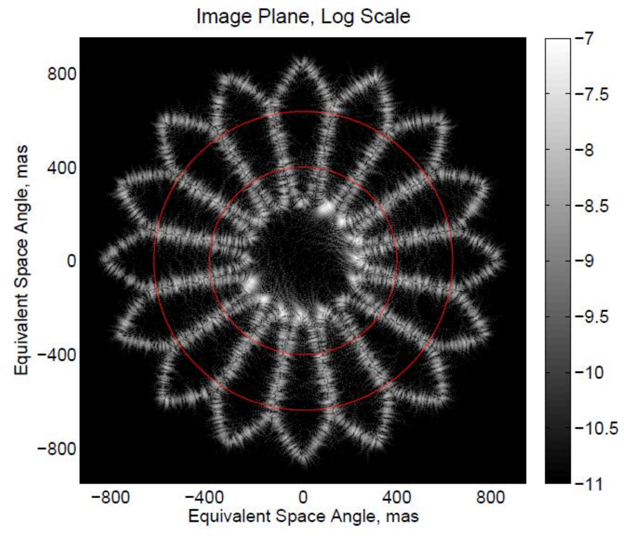
Mask



Measurement



Model



At Princeton: Jeremy Kasdin, Dan Sirbu, Robert Vanderbei

S2.01 Proximity Glare Suppression

Lead Center: JPL, subtopics mgr Stuart Shaklan
Participating Center(s): ARC, GSFC

- This subtopic addresses the unique problem of imaging and spectroscopic characterization of faint astrophysical objects that are located within the obscuring glare of much brighter stellar sources.

Starlight Suppression Technologies

- Image plane hybrid metal/dielectric, and polarization apodization masks in linear and circular patterns, and pupil remapping technologies.
- Transmissive holographic masks for diffraction control and PSF apodization.
- Sharp-edged, low-scatter pupil plane masks.
- Low-scatter, low-reflectivity, sharp, flexible edges for control of scatter in starshades.
- Systems to measure spatial optical density, phase inhomogeneity, scattering, spectral dispersion, thermal variations, and to otherwise estimate the accuracy of high-dynamic range apodizing masks.
- Coherent fiber bundles consisting of up to 10,000 fibers with lenslets on both input and output side, such that both spatial and temporal coherence is maintained across the fiber bundle for possible wavefront/amplitude control through the fiber bundle.

S2.01 Cont'd

Wavefront Measurement and Control Technologies

- Small stroke, high precision, deformable mirrors and associated driving electronics scalable to 10,000 or more actuators (both to further the state-of-the-art towards flight-like hardware and to explore novel concepts). Multiple deformable mirror technologies in various phases of development and processes are encouraged to ultimately improve the state-of-the-art in deformable mirror technology. Process improvements are needed to improve repeatability, yield, and performance precision of current devices.
- Instruments to perform broad-band sensing of wavefronts and distinguish amplitude and phase in the wavefront.
- Integrated mirror/actuator programmable deformable mirror.
- Multiplexers with ultra-low power dissipation for electrical connection to deformable mirrors.
- Low-order wavefront sensors for measuring wavefront instabilities to enable real-time control and post-processing of aberrations.
- Thermally and mechanically insensitive optical benches and systems.

S2.01 Cont'd

Optical Coating and Measurement Technologies

- Instruments capable of measuring polarization cross-talk and birefringence to parts per million.
- Highly reflecting, uniform, broadband coatings for large (> 1 m diameter) optics.
- Polarization-insensitive coatings for large optics.
- Methods to measure the spectral reflectivity and polarization uniformity across large optics.

Other

- Methods to fabricate diffractive patterns on large optics to generate astrometric reference frames.
- Artificial star and planet point sources, with 1e10 dynamic range and uniform illumination of an f/25 optical system, working in the visible and near infrared.
- Deformable, calibrated, collimating source to simulate the telescope front end of a coronagraphic system undergoing thermal deformations.
- Technologies for high contrast integral field spectroscopy, in particular for microlens arrays with or without accompanying mask arrays, working in the visible and NIR (0.4 - 1.8 microns), with lenslet separations in the 0.1 -0.4 mm range, in formats of ~140x140 lenslets.

Current S2.01 Proposals

2012 PHASE II

- *Fabrication Process and Electronics Development for Scaling Segmented MEMS DMs IRIS AO Inc.*
- *Driver ASICs for Advanced Deformable Mirrors Microscale, Inc.*

2011 PHASE II

- *Nanostructured Super-Black Optical Materials Nanolab, Inc.*
- *Topography Improvements in MEMS DMs for High-contrast, High-resolution Imaging, Boston Micromachine Corp.*

2010 PHASE II

- *Enhanced Reliability MEMS Deformable Mirrors for Space Imaging Applications Boston Micromachines Corp.*

S2.02 Precision Deployable Optical Structures and Metrology

Lead Center: JPL, subtopic mgr Greg Agnes
Participating Center(s): GSFC, LaRC

- Planned future NASA Missions in astrophysics, such as the Wide-Field Infrared Survey Telescope (WFIRST) and the Exoplanet Exploration Program (Exo-C coronagraph, Exo-S starshade) will push the state of the art in current optomechanical technologies.
- “Everything but the shiny stuff”
- Components and subsystem technology, for large apertures and small satellites
- Precision deployable structures and metrology for optical telescopes
- Architectures, packaging and deployment designs for large sunshields and external occulters.
- Mechanical, inflatable, or other precision deployable technologies.
- Thermally-stable materials (CTE < 1ppm) for deployable structures.
- Innovative testing and verification methodologies.
- Proposals should show an understanding of one or more relevant science needs, and present a feasible plan to fully develop the relevant subsystem technologies and to transition into future NASA program(s).

Current S2.02 Proposals

2012 PHASE II

- *An Outrigger Component for a Deployable Occulter System*
  Roccor LLC.

2014 PHASE I

- *Precision Mobile-Joint and Latching Technologies for Deployable Optical Systems, MMA Design LLC*
- *Optical Precision Deployment Latch, Physical Sciences Inc.*
- *Enhanced-Strength, Thermally-Stable, Edge-Bonded, Composite Joints, Vanguard Space Technologies Inc.*