Technology Development for Exoplanet Direct Imaging Missions

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Looking Back Nearly 30 years...to 1990

Are we Alone?
The Search for Other Earths, The Search for Life in the Universe
The Challenge

SAO Solar System Model at 10 PC

Star

Earth

$10^{10}$
Starlight Suppression for High-Contrast Imaging

External Occulter - Starshade

Internal Occulter – Coronagraph

http://exep.jpl.nasa.gov
WFIRST-AFTA
Wide-Field Infrared Survey Telescope (WFIRST)
Astrophysics Focused Telescope Assets (AFTA)

Coronagraph Instrument
- Imaging and spectra channels
- $0.4 - 1 \, \mu m$ bandpass
- $\leq 10^{-9}$ detection contrast
- 100 mas inner working angle at $0.4 \, \mu m$
- $R \sim 70$

Coronagraph Science
- Imaging and spectroscopy of exoplanet atmospheres down to a few Earth masses
- Study populations of debris disks

AFTA's coronagraph will develop the technologies for a future exo-Earth mission
Technology Development for Coronagraphs (Internal Occulters)

- Occulting Masks/Apodizers
- Low Order Wavefront Sensing and Control
- System Demonstration
- Image Post Processing

- Serabyn – Vector Vortex Mask
- Deformable Mirrors
- Ultra-Low-Noise Visible Detectors
- Xinetics
- e2v Electron Multiplying CCD
- Soummer et al. 2011
The External Occulter – the Starshade

The starshade could launch together with a telescope. Once in space, it would split off and move into position to block the starlight.
Technology Development for Starshades (External Occulters)

- Control of Scattered Light
- Formation Flying
- Validation of Optical Models
- Petal Prototype
- Starshade Deployment
Deployment Testing at Northrop Grumman (Astro-Aerospace)

Demonstration of starshade development model
The main science themes reflect the organization of NASA Astrophysics and the 2010 Decadal:

- Formative Era: Large UV-Optical-IR Telescope

**Formative Era Themes:***

- **Gravitational Wave Surveyor**
- **CMB POL**
- **FAR IR**
- **UVOIR**
- **XRAY**

**ExoPlanet Exploration Program (ExEP) Themes:**

- Formation flying
- Interferometry: precision metrology
- X-ray interferometry
- High-contrast imaging techniques
- Optics deployment and assembly
- Broadband coatings
- X-ray optics
- Large-format detector arrays
- New detector capabilities
- Cryogenics

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**Enduring Quests Daring Visions**

NASA Astrophysics in the Next Three Decades
Formative Era: Large UV-Optical-IR Telescope (LUVOIR)

Optics Deployment and Assy
- SiC Active Hybrid Mirror, Xinetics
- MOIRE, BATC
- Lightweight ULE, ITT

Formation Flying
- Broadband Mirror Coatings
- Telescope Mechanical Isolation Systems

Starlight Suppression Systems
- Visible Nuller, GSFC
- Pupil Mapping, Univ. Arizona
- Starshade NGAS, Princeton, JPL
Technology Needs and Priorities

- You are invited to read more about
  - Quantified technology gaps (needs, capabilities)
  - Past and current work conducted through SAT / ROSES / TDEM

http://exep.jpl.nasa.gov

- Next call: November 2014

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Visionary Era: Exo Earth Mapper

- **Formation-Flying Telescope Arrays**
  - 500 m² collecting area
  - >370km baseline
- **Interferometer Technologies**
  - Precision Laser Metrology
  - Beam combination,
  - Aperture synthesis
  - Formation Flying
Acknowledgements

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