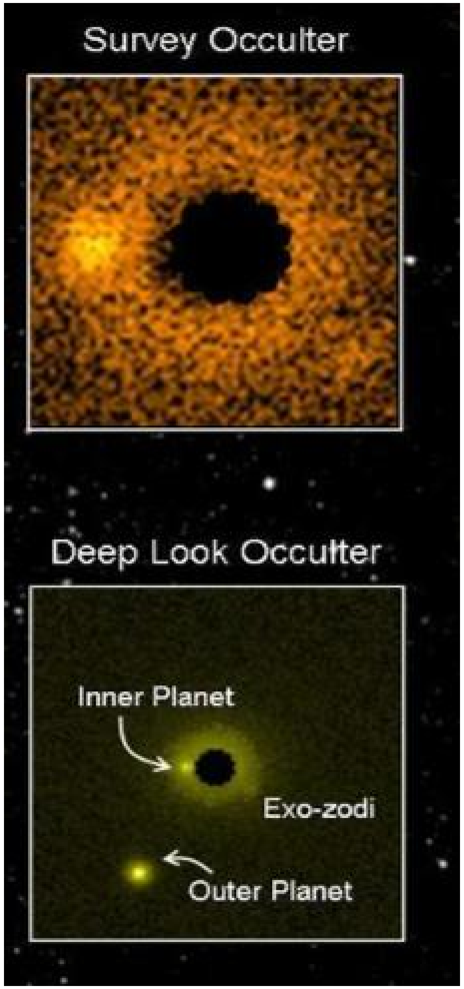
Exoplanet Imaging SAG

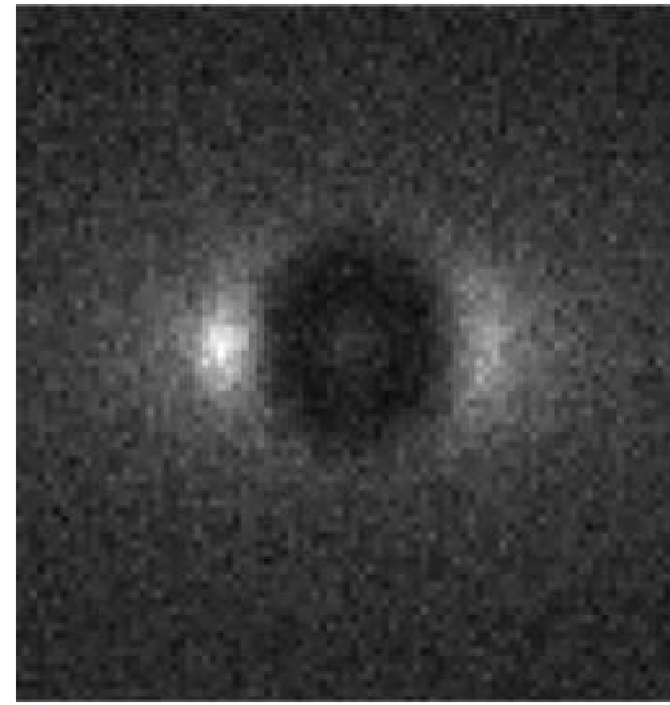


Solar systems as seen by NWO mission (Arenberg 2006)

Progress Report

ExoPAG Meeting

Jan 7, 2012
Austin, TX



Nearby Earth in 1 zodi disk near 2λ/D (Guyon et al. 2009)

Imaging SAG Membership

- C. Noecker & T. Greene are co-chairs. M. Levine is Facilitator.
- ~ 60 scientists, technologists, engineers
- Communicating via http://tech.groups.yahoo.com/group/exopag_flagship/

L name	F name	email	Institution	Interests / Expertise	SAG Task area
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Williams	Darren	dmw145@psu.edu	PSU	Earth-like moons of giant exoplanets	Science

Task and early 2011 Progress

- Coronagraph and Occulter SAGs were combined after Jan 2011 ExoPAG meeting
- The combined SAG is to set science requirements for the 2020+ imaging mission by 2012
  - Define a flagship as likely to find & characterize at least 1 Earth-like planet in a HZ
- Met with the COPAG and agreed that we are both interested in trying to share a D >= 4-m telescope on an observatory that studies exoplanets and astrophysics
  - Consistent with our flagship definition
- Have chosen to focus on terrestrial planets, but super-Earths, giant planets, and exozodiacal dust disks also important
  - Requirements are independent of mission architecture
- Discussed initial requirements via email, at June 2011 ExoPAG meeting, and in a May 2011 telecon
- Framework of science goals, objectives, and requirements emerged at the June meeting

Progress since June ExoPAG

- We have drafted and iterated hierarchical material for our report:
  - 3 overarching science goals flow to...
  - 11 more specific science objectives flow to...
  - Numerous particular requirements
- Particular requirements have been divided into "Musts" and "Discriminators" to aid in evaluating mission concept yields
- We worked with the leads of SAG #4 in setting characterization requirements and with SAG #1 in exozodi requirements
- Numerous drafts, telecons, and revisions since June meeting
- We have essentially finished this work with some caveats:
  - Several requirement values are TBR, pending better values of Eta Earth (Kepler) and Exozodi levels (LBTI?)
  - We will not assign weights to the Discriminator requirements
- On track for delivering a concise report in early 2012

Draft Report Outline

- Definition of task and scope
  - Immediate task
  - Previous work (i.e., TPF-C STDT report)
  - Architecture independent
- Inclusive Approach: Processes and People
- Science Goals
- Science Objectives
- Requirements Tables
- Requirements Flowdown and Rationale
- Musts and Discriminators Rationale
- Epilogue: Application to Future Work

Science Goals (Top Level)

Goal1: **Determine the overall architectures** of a sample of nearby planetary systems. This includes determining the numbers, brightnesses, locations, and orbits of terrestrial to giant planets and characterizing exozodiacal dust structures in regions from habitable zones to ice lines and beyond. This information will also provide clues to the formation and evolution of these planetary systems.

Goal 2: **Determine or constrain the atmospheric compositions** of discovered planets, from giants down to terrestrial planets. Assess habitability of some terrestrial planets, including searching for spectral signatures of molecules and chemical disequilibrium consistent with the presence of life. Determining or constraining surface compositions of terrestrial planets is desirable but is not strictly required.

Goal 3: Determining or constraining **planetary radii and masses are stretch goals** of this mission. These are not strictly required. However, measuring radii and masses would provide a better understanding of detected planets, significantly increasing the scientific impact of this mission.

Science Objectives (condensed)

1. Detect terrestrial planets
2. Measure orbital parameters
3. Obtain multi-band photometry
4. Confirm planets and distinguish among them (motions & colors)
5. Determine or constrain planet masses if possible
6. Spectroscopic characterization of terrestrial planets
7. Detect giant planets
8. Spectroscopic characterization of giant planets
9. Measure location and extent of dust disks
10. Detect and measure substructures in dusty disks to infer planets
11. Understand the evolution of circumstellar disks: pre-planetary to debris

Reference Material

Flagship Exoplanet Science Objectives (1)

Objective 1: Directly detect terrestrial planets that exist within the habitable zones around nearby stars or, alternatively, observe a large enough sample of nearby systems to show with high confidence that terrestrial planets are not present.

Objective 2: Measure or constrain orbital parameters (semi-major axis and eccentricity) for as many discovered planets as possible, especially those that show evidence of habitability.

Objective 3: Obtain absolute photometry in at least three broad spectral bands for the majority of detected planets. This information can eventually be used, in conjunction with orbital distance and planet radius, to constrain planetary albedos.

Objective 4: Distinguish among planets, and between planets and other objects, through relative motion and broadband measurements of planet color.

Objective 5: Determining or constraining planetary masses is highly desired but not required. Determining masses would allow estimates of planetary radii to be made, thereby enabling calculation of planetary albedos (Objective 3).

Objective 6: Characterize at least some detected terrestrial planets spectroscopically, searching for absorption caused by O_2, O_3, H_2O, and possibly CO_2 and CH_4. Distinguish between Jupiter-like and H_2O-dominated atmospheres of any super-Earth planets. Such information may provide evidence of habitability and even of life itself. Search for Rayleigh scattering to constrain surface pressure.

Objective 7: Directly detect giant planets of Neptune's size or more and Jupiter's albedo in systems searched for terrestrial planets. Giants should be detectable within the habitable zone and out to a radius of 3 times the outer habitable zone radius or more.

Flagship Exoplanet Science Objectives (2)

Objective 8: Characterize some detected giant planets spectroscopically, searching for the absorption features of CH_4 and H_2O. Distinguish between ice and gas giants as well as between Jupiter-like and H_2O-dominated atmospheres of any mini-Neptune planets.

Objective 9: Measure the location, density, and extent of dust particles around nearby stars in order to identify planetesimal belts and understand delivery of volatiles to inner solar systems.

Objective 10: In dusty systems, detect and measure substructures within dusty debris that can be used to infer the presence of unseen planets.

Objective 11: Understand the time evolution of circumstellar disk properties, from early protoplanetary stages through mature main sequence debris disks.

The above Science Goals and Objectives are related as follows:

Science Goal	Science Objectives
1. Architectures	1, 2, 4, 5, 7, 9, 10, 11
2. Compositions	3, 4, (5), 6, 8
3. Masses & radii (desired)	3, 4, 5, 10