

Exoplanet Program Analysis Group Report

Astrophysics Subcommittee Meeting
October 22, 2015

Alan Boss
(ExoPAG EC Chair)

ExoPAG EC Membership

Alan Boss (Chair)

Daniel Apai

Rus Belikov

David Ciardi

Nick Cowan

Shawn Domagal-Goldman

Amy Lo

Peter Plavchan

Gene Serabyn

Maggie Turnbull

Lucianne Walkowicz

Carnegie Institution

University of Arizona

NASA Ames Research Center

NASA Exoplanet Science Institute

Amherst College

NASA Goddard Space Flight Center

Northrup Grumman Aerospace Sys.

Missouri State University

Jet Propulsion Laboratory

Global Science Institute

Adler Planetarium

Scott Gaudi (Past Chair, Ex officio)

Martin Still (Ex officio)

Wes Traub *(Ex officio)

Karl Stapelfeldt *(Ex officio)

Ohio State University

NASA Headquarters

Jet Propulsion Laboratory

Jet Propulsion Laboratory

Annual Technology Gap List (TGL): Planning for ExoPAG Involvement

- **“Initial Look at the Coronagraph Technology Gaps for Direct Imaging of Exo-Earths”** (SPIE, 2015, Rhonda Morgan & Nick Siegler, JPL) circulated to ExoPAG EC in September
- *New plan for future ExoPAG community involvement:*
- 1) Winter ExoPAG meeting – recommended TGL presented and input invited from the community
- 2) Verbal and e-mail input accepted until following May
- 3) TGL is revised based upon the inputs received
- 4) Revised TGL presented at Summer ExoPAG meeting in recommended priority order
- 5) Based on discussions, TGL will be finalized
- 6) Repeat above cycle each year

ExoPAG SAGs Overall Status

- 7 SAGS finished work with final report online
- 1 SAG dormant – request permission to drop
- 2 SAGS actively working
- 2 new SAGS proposed – request APS acceptance of their Charters

SAG 12: Scientific Potential and Feasibility of High-Precision Astrometry for Exoplanet Detection and Characterization (Eduardo Bendek, Chair)

1) Community views on astrometric performance and science cases with AFTA/WFIRST discussed in meeting at Princeton on May 6th. Main topics were:

- Astrometry science cases as function of accuracy achievable with AFTA
- Astrometry error budget for AFTA
- Optimization of observing strategies to maximize astrometry performance

2) Plans for determining the giant planet population beyond the ice line have not been properly developed as yet:

- Planet yield estimations being developed as a function of astrometric accuracy (for any telescope)
- Complementarity with RV measurements and sensitivity

3) Ground based testing of diffractive pupil calibration:

- Gemini South MCAO distortion calibration
- Shane AO system at the Lick Observatory

SAG 13: Exoplanet Occurrence Rates and Distributions (Rus Belikov, Chair)

- Approved by APS at July 21-22, 2015 meeting
- **Key objectives and questions:**
- Propose standard nominal conventions, definitions, and units for occurrence rates/distributions to facilitate comparisons between different studies
- Do occurrence estimates from different teams/methods agree with each other to within statistical uncertainty? If not, why?
- For occurrence rates where extrapolation is still necessary, what values should the community adopt as standard conventions for mission yield estimates?

SAG 13: Exoplanet Occurrence Rates and Distributions (Rus Belikov, Chair)

- Monthly telecons being held, with detailed, substantive discussions and voting on key parameters to be used in the estimations
- First question answered by four hours of telecons
- Proposed standard nominal conventions, definitions, and units for occurrence rates/distributions to facilitate comparisons between different studies:
- **Planet radius binning:** $R_i = [1.5^{i-2}, 1.5^{i-1}]R_{\oplus}$
- **Planet period binning:** $\mathcal{P}_j = 10 \times [2^{j-1}, 2^j]$ days
- **Stellar Temperature binning:** M, K, G, F, A in K

NEW SAG 14: Characterization of Stars Targeted for NASA Exoplanet Missions (Keivan Stassun, Chair)

- The accuracy with which we can determine the basic properties of any planet from any exoplanet mission depends fundamentally on our knowledge of the host stars.
- The majority of Kepler Objects of Interest (KOIs) still remain poorly characterized because the host stars remain poorly characterized.
- The TESS mission is now set to imminently provide an additional large number of small planets that will need to be accurately characterized for the primary mission deliverables.
- This SAG will bring together experts in the field, whose specialties include a number of multidimensional approaches to stellar characterization, in order to identify scientific programs that will benefit TESS and follow-on exoplanet missions.

NEW SAG 14: Characterization of Stars Targeted for NASA Exoplanet Missions (Keivan Stassun, Chair)

- **Major question for this proposed new SAG:** What exoplanet host-star characterization programs can be undertaken *now* to ensure the success of the TESS mission and its follow-on missions, and maximize their scientific return? In the process of answering this question, the SAG will:
 - 1. Identify both mission critical and mission enhancing programs -- including observational programs and analysis methodologies -- especially in light of known gaps from previous and current missions, including in particular gaps that will remain after the expected deliverables from Gaia,
 - 2. Identify immediate science to come out of each program, as well as the program's direct impact on the TESS mission and on TESS follow-on missions,
 - 3. For each proposed program, quantify the improved scientific return for the TESS mission and for planned follow-on exoplanet missions,
 - 4. Emphasize programs that can be executed using existing (NASA) resources, and that represent an opportunity for scientific independence from the mission and/or exoplanet discovery teams.

NEW SAG 15: Exploring Other Worlds: Observational Constraints and Science Questions for Direct Imaging Exoplanet Missions (Daniel Apai, Chair)

- While many of the broader science goals of exoplanet characterization are recognized, there has been no systematic assessment of the following two questions:
- 1) What are the most important science questions in exoplanet characterization *apart* from biosignature searches?
- 2) What type of data (spectra, polarization, photometry) with what quality (resolution, signal-to-noise, cadence) is required to answer these science questions?
- *We propose to form SAG15 to identify the key questions in exoplanet characterization and determine what observational data obtainable from direct imaging missions is necessary and sufficient to answer these.*

NEW SAG 15: Exploring Other Worlds: Observational Constraints and Science Questions for Direct Imaging Exoplanet Missions (Daniel Apai, Chair)

- We envision the SAG report to be important for multiple exoplanet sub-communities and specifically foresee the following uses:
 - 1) Future STD teams will be able to easily connect observational requirements to missions to fundamental science goals;
 - 2) By providing an overview of the key science questions on exoplanets and how they could be answered, it may motivate new, dedicated mission proposals;
 - 3) By providing a single, unified source of requirements on exoplanet data in advance of the Decadal Survey, the science yield of various missions designs can be evaluated realistically, with the same set of assumptions.
- Our goal is to carry out this SAG study by Spring 2017 building on both the ExoPAG and NExSS communities.

NEW SAG 15: Exploring Other Worlds: Observational Constraints and Science Questions for Direct Imaging Exoplanet Missions (Daniel Apai, Chair)

- ***Synergy with a potential future SAG proposed by Shawn Domagal-Goldman:*** While the SAG proposed here will include studies of habitable zone rocky planets, it will focus on planets without significant biological processes. A future SAG may be proposed by Shawn Domagal- Goldman to explore biosignatures; if such a SAG is proposed, we envision a close collaboration on these complementary, but distinct problems.

APS Actions Requested by ExoPAG EC

- SAG 4: Planetary Measurements Needed for Exoplanet Characterization (Lisa Kaltenegger, Chair) – unresponsive – drop from consideration
- NEW SAG 14: Characterization of Stars Targeted for NASA Exoplanet Missions (Keivan Stassun, Chair) – approve Charter
- NEW SAG 15: Exploring Other Worlds: Observational Constraints and Science Questions for Direct Imaging Exoplanet Missions (Daniel Apai, Chair) – approve Charter

ExoPAG Future Activities

- Continue monthly ExoPAG EC telecons
- Hold ExoPAG 13 meeting prior to AAS winter meeting: January 3-4, 2016 in Kissimmee, Florida
- Joint session with COPAG on January 4 to hear Paul Hertz's update on APD and Large Missions planning for Astro2020