Exoplanet Program Analysis Group Report.

223rd AAS Meeting
Washington, DC

Scott Gaudi
(ExoPAG EC Chair)
Charter.

The ExoPAG serves as a community-based, interdisciplinary forum for analysis in support of activity prioritization and for future exploration.

• Articulate the key scientific drivers for exoplanet research.
• Evaluate the expected capabilities of potential ExEP missions for achieving the science goals of the program.
• Evaluate ExEP goals, objectives, investigations, and required measurements on the basis of the widest possible community outreach.
• Articulate focus areas for needed mission technologies.
• Identify related activities that enhance the ExEP mission portfolio such as ground-based observing, theory and modeling programs, and community engagement.
EC Membership.

• Current EC members (as of April 2013).

Nick Cowan  Northwestern
Jonathan Fortney  U.C. Santa Cruz
Scott Gaudi (Chair)  Ohio State
Tom Greene  NASA Ames
Lisa Kaltenegger  MPIA
Dave Latham  SAO
Amy Lo  Northrop Grumman
Peter Plavchan  Caltech/NexSci
Aki Roberge  NASA Goddard
Gene Serabyn  JPL
Doug Hudgins (Ex officio)  NASA Headquarters
James Kasting (Ex officio)  Penn State
Wes Traub (Ex officio)  JPL
ExoPAG Direction.

Over the past ~2 years, ExoPAG activities have been (more or less) focused on the following general goals:

• Gathering input from the wide cross-section of the exoplanet community on the future of exoplanet research.

• Considering novel ways in which NASA can address exoplanet research in the short term, Includes ground-based research *in support* of current or future missions

• *Maintaining progress* toward eventual goal of a flagship direct imaging mission.
Methods & Activities.

• Solicit community input through ExoPAG meetings.
• Identify questions and inquiry areas.
• If needed, form Study Analysis Groups (SAGs) to address these questions in depth.
  – Chaired by EC members (generally), but comprised of community members.
• Deliver conclusions and community input to NASA through the Astrophysics Subcommittee (APS) of the NASA Advisory Council (NAC).
  – Includes final reports from SAGs.
ExoPAG 6, 7, 8, 9.

• Since June 2012:
  – ExoPAG 7: January 5+6, Long Beach, CA
  – ExoPAG 8: October 5+6, Denver, CO
  – ExoPAG 9: January 4+5, Washington, DC.
    • Joint meeting with COPAG.

• (most) Talks available online (or will be soon):

  http://exep.jpl.nasa.gov/exopag/exopag7/agenda/
  http://exep.jpl.nasa.gov/exopag/exopag8/agenda/
  http://exep.jpl.nasa.gov/exopag/exopag8/agenda/
ExoPAG 6, 7, 8, 9.

• Primary topics addressed:
  – What is the landscape of current and future missions?
  – What are the radial velocity requirements to support NASA’s goals and current and future missions?
  – What do we need to do to prepare for WFIRST-AFTA exoplanet surveys?
  – What do we need to do to ensure a robust measurement of $\eta_{\text{Earth}}$?
  – What is the potential of JWST to characterize exoplanets?
Completed SAGs.

SAG1: Debris Disks & Exozodiacal Dust - Aki Roberge

SAG2: Potential for Exoplanet Science Measurements from Solar System Probes - Dave Bennett and Dan Coulter
- Completed, no report. Topic explored in detail at Kavli Institute workshop, Santa Barbara CA, May 2010

SAG5: Exoplanet Flagship Requirements and Characteristics - Charley Noecker, Tom Greene
- Final report complete, subject to APS approval.
Current SAGs, Part 1.

SAG4: Planetary Measurements Needed for Exoplanet Characterization - Lisa Kaltenegger
• Draft report completed.
• Final report delivered at ExoPAG 9.

SAG8: Requirements and Limits of Future Precision Radial Velocity Measurements - Dave Latham, Peter Plavchan
• Presentations at ExoPAG 6, 7 and 8
• Report started.

SAG9: Exoplanet Probe to Medium Scale Direct-Imaging Mission Requirements and Characteristics - Rémi Soummer
• Presentations at ExoPAG 8 and 9.
Current SAGs, Part 2.

SAG10: Characterizing the Atmospheres of Transiting Planets with JWST and Beyond - Nick Cowan
• What is the full diversity of planet properties needed to characterize exoplanets?
• Which measurements are needed?
• Will JWST be able to characterize habitable planets?
• Which critical measurements will be too expensive or inaccessible to JWST?

SAG11: Preparing for the WFIRST Microlensing Survey – Jennifer Yee
• Identify both mission critical and mission enhancing programs,
• Identify immediate science to come out of each program, as well as the program's direct impact on the WFIRST mission,
• For each proposed program, quantify the improved scientific return for the WFIRST mission,
• Emphasize programs that can be executed using existing (NASA) resources.
What we’ve learned.

• Need to figure out overlap of RV surveys and ground-based direct imaging surveys with potential future direct imaging (space) missions.
• The frequency of potentially habitable planets is not one number. Need to specify distribution functions and/or agree upon a fiducial definition for a habitable planet.
• Continued investment in extracting science from Kepler is both worthwhile and critical.
• Need to figure out what is needed to characterize exoplanets. Need to figure out whether or not JWST can characterize habitable planets.
• Need to identify the future roles of astrometry and interferometry.
Recent and Upcoming Developments.

1. WFIRST-AFTA blessed for future study, with coronagraph baselined, coronagraph architectures selected.
2. Science and Technology Definition Teams convened.
4. *Gaia*, *JWST*, *TESS* are imminent.
5. Mid-decadal Review.
Toward an Exoplanet 5-10 Year Plan.
Goal.

To develop a holistic, broad, unified, and coherent exoplanet roadmap for the next 5-10 years, with community consensus, focusing on areas where NASA can contribute.
2010-2020

A Complete Exoplanet Statistical Census

2020-2030

Characterization of a Diversity of Other Worlds

2030-2040

Our Nearest Neighbors:
Surveying Nearby Planetary Systems and Searching for Habitable Climates

Science Roadmap

Mission Roadmap

Ground-Based Mission-Supporting Observations

TESS
JWST
WFIRST+C
F-DIM: (Flagship Direct Imaging Mission)

HST
Spitzer
Kepler
Transit Char. Mission?
Astrometry Mission?

Mission Roadmap

Transit Char. Mission?
Astrometry Mission?

Science Roadmap

A Complete Exoplanet Statistical Census

Characterization of a Diversity of Other Worlds

Our Nearest Neighbors:
Surveying Nearby Planetary Systems and Searching for Habitable Climates
### Mission Matrix, e.g.

<table>
<thead>
<tr>
<th>What is the frequency and diversity of planetary systems? (Demographics)</th>
<th>RV</th>
<th>HST</th>
<th>Spitzer</th>
<th>Kepler</th>
<th>Gaia</th>
<th>TESS</th>
<th>JWST</th>
<th>WFIRST+C</th>
<th>Transit Char. Mission</th>
<th>F-DIM</th>
<th>Astrometry</th>
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<tbody>
<tr>
<td>Obtain a complete statistical census of planets in the Galaxy.</td>
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<td>Survey the closest planetary systems.</td>
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<td>(Measure the frequency of potentially habitable planets)</td>
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<tr>
<td>What are the natures of planetary interiors, surfaces, and atmospheres?</td>
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<td>Characterize a diverse set of planetary atmospheres.</td>
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<td>Characterize exoplanets orbiting the closest stars.</td>
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<td>(Understand the interiors, surfaces, and atmospheres of Earthlike exoplanets)</td>
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<td>Is there life on other planets?</td>
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<tr>
<td>Measure the frequency of potentially habitable planets.</td>
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<tr>
<td>Understand the interior, surfaces, and atmospheres of Earthlike exoplanets.</td>
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<td>Find nearby potentially habitable planets.</td>
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<td>Discover habitable climates on nearby planets.</td>
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<td>Search for surface and atmospheric biomarkers.</td>
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Technology, other support.
ExoPAG 9.

Broad support (as demonstrated by a show of hands) to continue with this activity and for a Science Interest Group.
Future.

• Continue work on SAGs.
• Form a Science Interest Group (SIG) to coordinate efforts to develop a 5-10 year plan, with approval of APS.
• Work with other PAGs to develop a consistent plan.
• Let us know if you have input, or would like to contribute to these efforts!
• Email me: gaudi@astronomy.ohio-state.edu
• More information on website, including email list: http://exep.jpl.nasa.gov/exopag/