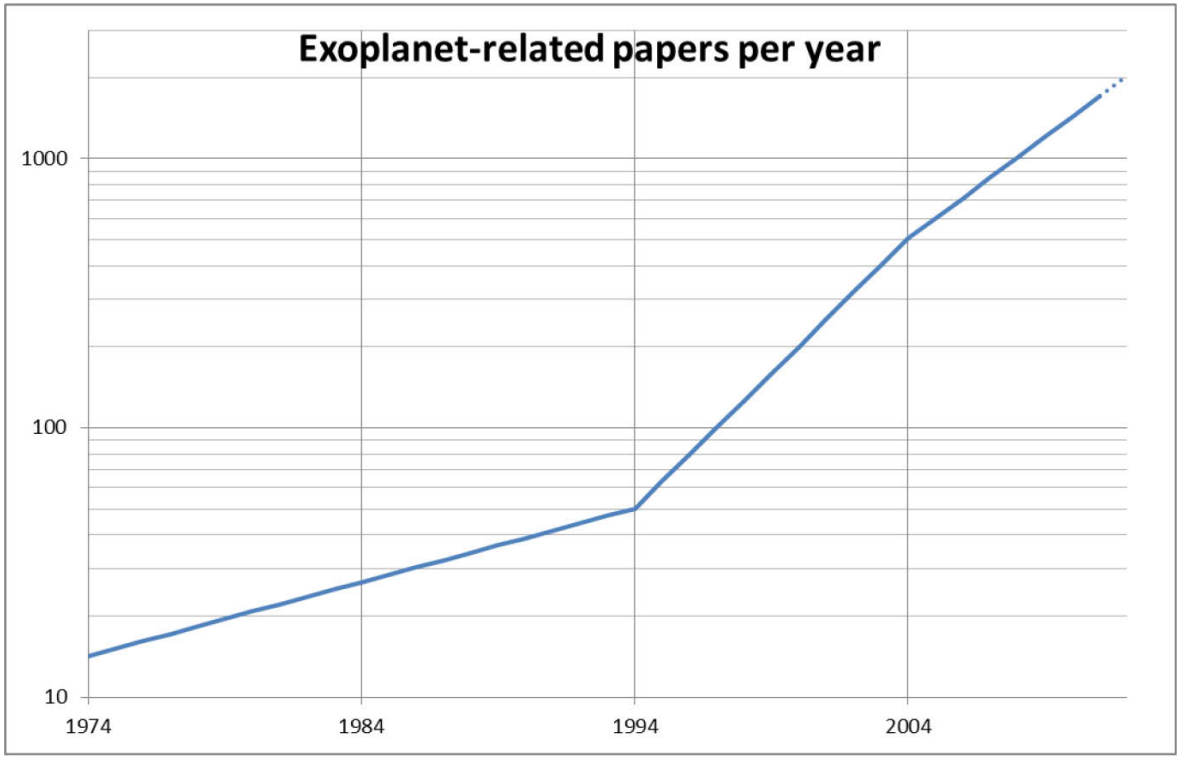
Exoplanet Science of Nearby Stars on a UV/Visible Astrophysics Mission

Members of the ExoPAG community

Charley Noecker
Jet Propulsion Laboratory
California Institute of Technology

Community and NASA interest in Exoplanet Science

- Publication rate
  - Doubling every 3-4 years
- A&A Decadal Survey
  - First priority for technology development
- NASA 2010 strategic plan
  - Astrophysics: "What are the characteristics of planetary systems orbiting other stars, and do they harbor life?"
  - COR: "What are the mechanisms by which stars and their planetary systems form?"
  - ExEP: "to advance our understanding of planets and planetary systems around other stars" and "to extend this exploration to the detection of habitable, Earth-like planets around other stars, to determine how common such planets are, and to search for indicators that they might harbor life"



Narrow scope of this discussion

- We consider the possibility of sharing a large UV-optical telescope
- That narrows our focus to just direct detection & characterization of rocky planets
- Other techniques of exoplanet science are just as important to the field, but do not require a large telescope in space
- That is why the white paper is nearly silent on those techniques

History of COPAG-ExoPAG collaboration

- Joint meeting at Space Telescope Science Institute (4/26/2011)
  - Topic: compatibility of the ExoPAG and COPAG mission concepts
  - http://exep.jpl.nasa.gov/exopag/exopagCopagJointMeeting/
  - http://cor.gsfc.nasa.gov/copag/mtgs/stsci_apr2011/
- Summary of that meeting given at the ExoPAG public meeting in June 2011 (Kasting)
  - http://exep.jpl.nasa.gov/files/exep/Kasting_Review%20of%20ExoPAG_COPAG.pdf in http://exep.jpl.nasa.gov/exopag/exopag4/agenda/
- Joint meeting of the full ExoPAG and COPAG at AAS January 2012
  - http://exep.jpl.nasa.gov/exopag/exopag5/agenda/ near the bottom
- The ExoPAG continues to share the COPAG's interest in a "flagship class" optical and UV telescope of 4m diameter and larger
  - Key tool in the effort for direct detection and characterization of planets down to Earth size orbiting nearby F, G, K stars
  - Internal coronagraph
  - External starshade

Exoplanet investigations that are compatible with a UV-optical astronomy space mission

1. Detection of individual exoplanets
   - semi-major axis, inclination, eccentricity
2. Spectral characterization of those exoplanets
   - Color → type of planet (gas giant, ice giant, terrestrial)
   - Estimate the mass, radius, and density via models based on brightness, orbit, and color, perhaps with intensive radial velocity measurements
   - Assess habitability (temperature, water abundance, solid surface)
   - Search for signs of life (oxygen, ozone, chlorophyll spectra)
3. Origin and ultimate fate of planetary systems
   - Presence, brightness, and distribution of debris disks
   - Long-term observations of position, photometry, and spectroscopy
   - Estimate of the state of the atmosphere (gas composition, clouds), and weather (variability of atmosphere)

➢ Unifying picture of the birth, evolution, and ultimate fate of planetary systems

Ultraviolet-Exoplanet Synergy

- L2 or drift-away orbits are advantageous to both
  - Stable environment, away from Earth and geocorona
- Unobscured (off-axis) telescopes are advantageous to both
- No strict requirements on size, although size determines what kinds of science we emphasize
  - 1-2 m diam → Giant planet spectroscopy and disk studies
  - 2-4 m diam → Terrestrial planets and their spectra → basic characteristics, habitability, and evidence of biology
  - 4-8 m diam → Sensitive higher-resolution spectroscopy of terrestrial planets to find stronger evidence of biology and begin to characterize it
- Possibility of long simultaneous UV and exoplanet observations in neighboring fields
- UV spectroscopy of planets

Telescope Characteristics and Drivers for Exoplanet Science

<u>Preliminary features of our flagship telescope requirements:</u>

- Wavelengths from 0.5 to 0.8 µm
  - Extra value for extending to 1 µm and toward the UV
- Aperture diameter of order 4 meters and larger
  - Could be smaller, with corresponding science descopes (see previous pg)
  - Could be larger, with some impact on telescope stability and substantial impact on cost
- Diffraction limited point spread function over a narrow FOV, roughly 1”×1”
  - Some options demand stringent optomechanical stability as well
- Obscurations and segmentation are compatible with some star-suppression options but not others;
  Technology readiness of those options will drive our decision at least as much as obscurations and segmentation.

Conclusions

- Exoplanet science is compatible with UV-optical astrophysics in
  - wavelength range
  - wavefront quality
  - operations/scheduling
  - telescope size
  - coatings
- Excellent opportunity to use one telescope to support both sets of science objectives

ExoPAG Executive Committee	ExoPAG community members	
Jim Kasting, former Chair, ex officio	Gerard van Belle	Marshall Perrin
David Bennett, Notre Dame, ex officio	JB Barentine	Joe Pitman
Jonathan Fortney, UCSC	Joseph Catanzarite	Lewis Roberts
Charley Noecker, JPL	Bill Danchi	Gene Serabyn
Peter Plavchan, Caltech/NexSci	Dawn Gelino	Arif Solmaz
Aki Roberge, GSFC	Tiffany Glassman	Zlatan Tsvetanov
Rémi Soummer, STScI	Tony Hull	Bob Vanderbei
Tom Greene, ARC	Jeremy Kasdin	Kaspar von Braun
Bruce Macintosh, LLNL, ex officio	Rick Lyon	Amir Vosteen
Wes Traub, ExEP Representative, ex officio	Bertrand Mennesson	