The Nexus for Exoplanet System Science

https://nexss.info

Tony Del Genio, NASA GISS
Natalie Batalha, NASA ARC
Dawn Gelino, NExScI
Shawn Domagal-Goldman, NASA GSFC
Andrew Rushby, NASA ARC

What is NExSS?

- A research coordination network dedicated to the study of planetary habitability and the search for life on exoplanets.

- A NASA cross-division initiative bringing astrophysicists, planetary scientists, Earth scientists, and heliophysicists together to explore the potential of “systems science” thinking* in exoplanet research.

- *Not tied to any single observational strategy.

Scientific goals of NExSS

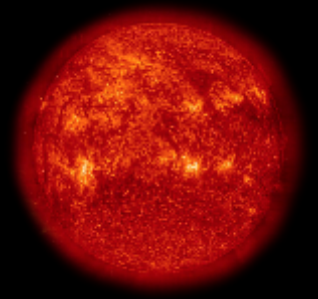
- Investigate the diversity of planets
- Understand how planet history, geology, and climate interact to create the conditions for life
- Put planets into an architectural context as stellar systems built over time by dynamical processes and sculpted by stars
- Use experience from solar system (including Earth) history to identify where habitable niches are most likely to occur and which planets are most likely to be habitable
- Leverage NASA investments in research and missions to accelerate discovery and characterization of potential life-bearing worlds

Strategic Objectives

- To further our joint strategic objective to explore exoplanets as potentially habitable and inhabited worlds outside our solar system.
- To establish common goals across SMD divisions; Planetary Science (PSD), Heliophysics (HPD), Earth Science (ESD) and Astrophysics (APD).
- To leverage existing Programs in SMD to advance the field of exoplanet research, specifically research in comparative planetology, biosignature and habitat detection, star-planet interactions, and planet characterization.
- To establish a mechanism to break down the barriers between divisions, disciplines, and stove-piped research activities.

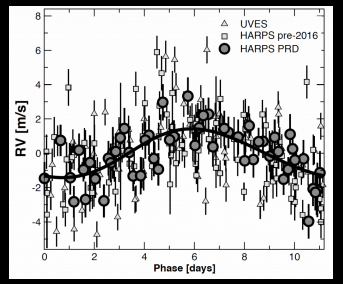
The NExSS Teams

D. Fischer
A. Jensen
J. Graham



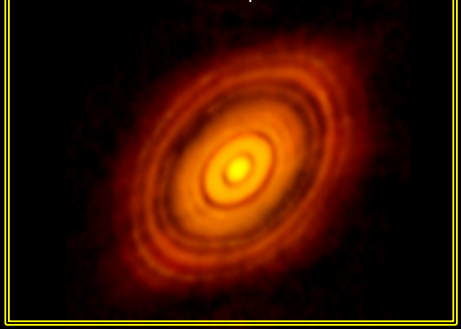
Exoplanet Detection

E. Ford
D. Deming
J. Wright



Exoplanet Characterization

N. Turner
H. Jang-Condell
D. Apai

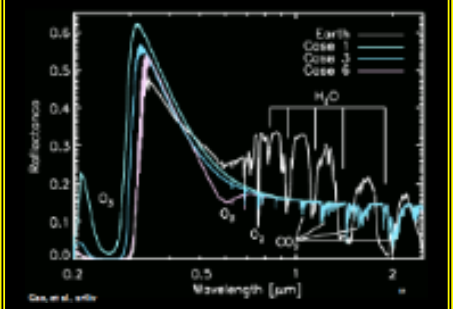


Disks & Planet Formation

HQ reps:
Mary Voytek (PSD)
Doug Hudgins (ASD)
Jeff Newmark (HSD)
Shawn Domagal-Goldman

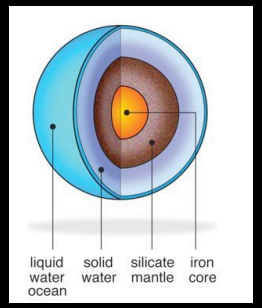
Co-leads:
Natalie Batalha
Dawn Gelino
Tony Del Genio

Management



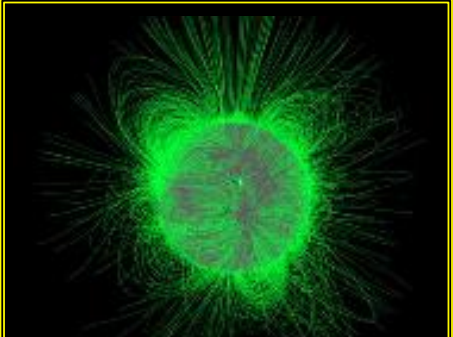
H. Imanaka

Laboratory Astrophysics



W. Henning
J. Fortney

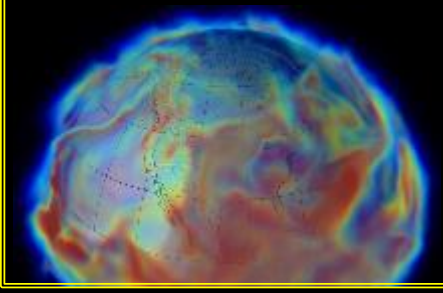
Planetary Structure and Evolution



V. Airapetian
B. Moore
D. Brain

Space Weather and Escape

S. Desch
V. Meadows
T. Del Genio



Planetary Habitability and Detectability

NExSS

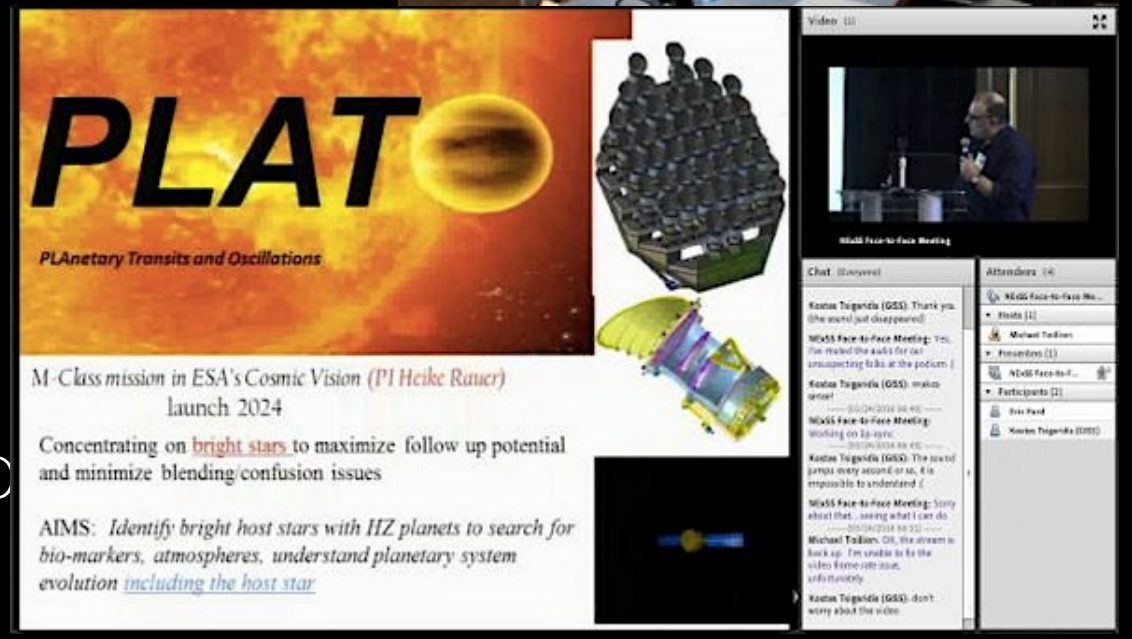
Galaxy

Examples of cross-discipline research by NExSS teams

- Disintegrating exoplanet dust tails as a potential window on the composition of planet interiors
- Geochemical constraints on habitability and detectability of biotic O_2 on aquaplanets
- Space weather effects on atmospheric loss for planets orbiting M-stars
- Bayesian framework for biosignature assessment
- Climate model reassessment of the moist greenhouse HZ inner edge and H_2O detectability

NExSS-wide Activities

- White Papers
- Workshops Without Walls
- Community Working Groups
- Face-to-Face Meetings
- Steering Committee telecons
- Webinars
- Interdisciplinary Postdocs
- Public Outreach
- New Collaborations
- ExoPAG Participation & Leadership
- Habex/LUVOIR Leadership



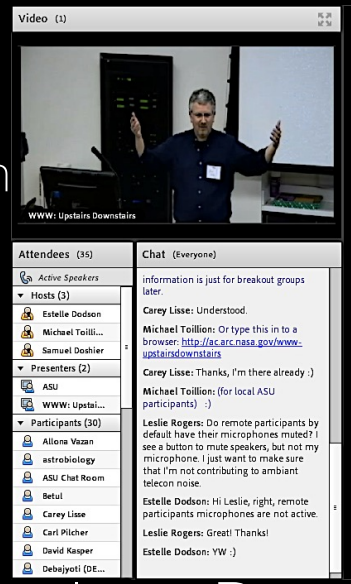
Lab Work for Understanding Exoplanet Atmsopheres

Fortney et al. 2016 arXiv: 1602.06305

- Topics raised by NExSS team members
  - Pressure-induced line broadening parameters (self-, foreign)
  - Optical properties of particles, haze formation
  - Reaction rate constants
  - Photo-absorption cross-sections at high T
  - Lab spectroscopy of continuum absorption
  - Oxygen absorption by early magma ocean
- NASA Astrophysics R&A program (ROSES 2016, 2017, 2018): "highlights the timeliness of Laboratory Astrophysics proposals pertaining to JWST"

Workshops Without Walls

1) Upstairs Downstairs: Consequences of Internal Planet Evolution for the Habitability and Detectability of Life on Extrasolar Planets
   - Tempe, AZ, Feb. 17-19 (led by PSD)
   - Joint NExSS-NAI-NSF effort, in-person + virtual participation
   - Winter school for students/postdocs
2) Exoplanet Biosignatures
   - Seattle, WA, July 27-29. 2016 (led by PSD, ASD)
   - Joint NExSS-NAI-ExEP effort
   - 5 papers to be published in *Astrobiology*
3) Approaching the Stellar Astrophysical Limits of Exoplanet Detection
   - Aspen, CO, Aug 28 – Sep 18, 2016
   - Joint NExSS & Aspen Center for Physics , Penn State
4) Impact of Exoplanetary Space Weather on Climate & Habitability
   - New Orleans, LA, Nov 29 – Dec 2, 2016
   - Paper in preparation for *Int. J. Astrobiology*



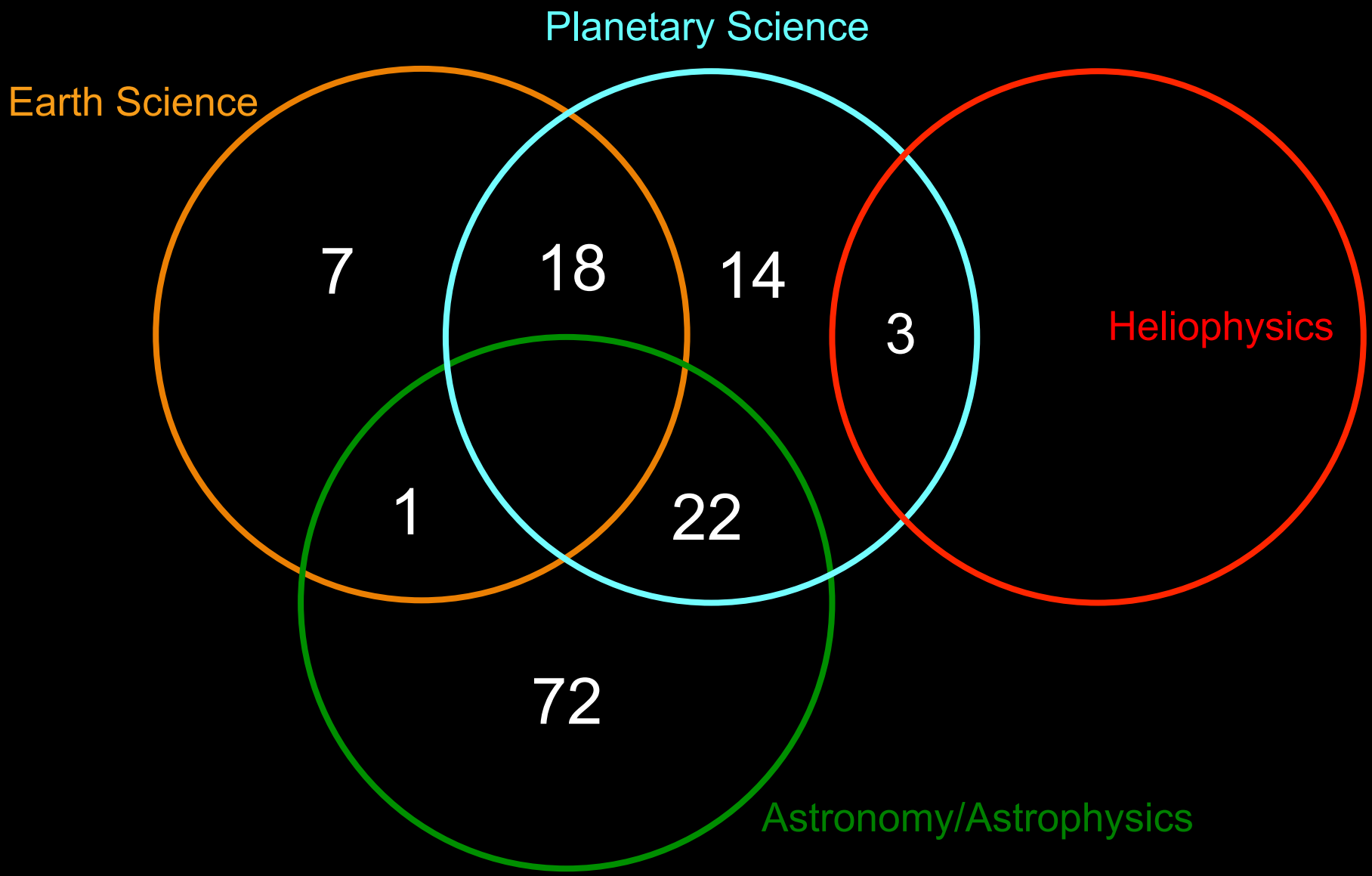
Exoplanet Biosignatures WwW

- Seattle, WA, July 27-29. 2016
- Five papers developed from breakout sessions:
  1. A Review of Remotely Detectable Signs of Life
  2. Understanding Oxygen as a Biosignature in the Context of Its Environment
  3. A Framework for Their Assessment
  4. Future Directions
  5. Observational Prospects
- Post-workshop, community-wide discussion and feedback enabled by NExSS online infrastructure: https://nexss.info/groups/ebwww/

- Laramie, Wy., Nov. 13-17 2017
- First NExSS Conference
- NExSS (57) & non-NExSS (85) attendees
- Emphasis on breakouts, panels, hacks
- Live-streaming of talks and some breakouts
- Balanced contributions from astro, planetary, Earth, and helio
- NASA TV event, Reddit AMA

Diversity of Expertise at HabWorlds*

*Roughly grouped from abstracts/Google Scholar/chats over coffee

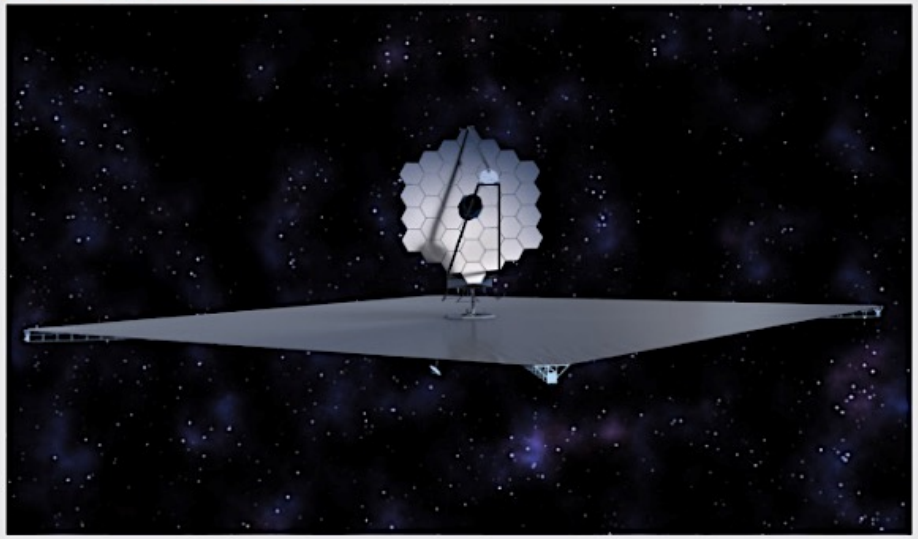


72 Astro
63 All else

Public Engagement

Movement in The Search For ExoLife

Posted on 2016-01-22 by Marc Kaufman



A notional version of an observatory for the 2030s that could provide revolutionary direct imaging of exoplanets. GSFC/JPL/STScI

Assuming for a moment that life exists on some exoplanets, how might researchers detect it?

Search ...

About Many Worlds

There are many worlds out there waiting to fire your imagination.

Marc Kaufman is an experienced journalist, having spent three decades at The Washington Post and The Philadelphia Inquirer, and is the author of two books on searching for life and planetary habitability. While the "Many Worlds" column is supported by the Lunar Planetary Institute/USRA and informed by NASA's NExSS initiative, any opinions expressed are the author's alone.

This site is for everyone interested in the burgeoning field of exoplanet detection and research, from the general public to scientists in the field. It will present columns, news stories and in-depth features, as well as the work of guest writers. Many Worlds will be updated on most Tuesdays and Fridays, and sometimes in between.

To contact Marc, send an email to marc.kaufman@manyworlds.space.

TRANSITING EXOPLANETS WITH JWST:

Community Efforts for Early Release Science

ERS Working Group

- Initiated October 2016 by NExSS
- Formed Executive Committee: Fortney, Lopez-Morales, Line, Knutson, Sing
- Open invitation announced via ExoPAG; > 100 responses
- NExSS facilitated:
  - Online training, virtual meetings, discussion boards
  - An open science environment
  - Strategic planning & preparatory HST observing campaigns
  - Democratic decision-making processes
  - ERS Proposal Submission (8/18/2017)

JWST Early Release Science Awards

1366	The Transiting Exoplanet Community Early Release Science Program	Batalha (NASA ARC), Bean (Chicago), Stevenson (STScI)	Planets and Planet Formation
1386	High Contrast Imaging of Exoplanets and Exoplanetary Systems with JWST	Hinkley (Exeter), Skemer (UCSC), Biller (Edinburgh)	Planets and Planet Formation

Exoplanet science won 2 of 13 Cycle 1 awards
78.1 h + 38.3 h = 116.4 h = 25% of 460 allocated
(vs. 17% for HST)

Approved Guest Investigator programs

This page details the programs for execution by TESS as part of the Guest Investigator program.

The target lists are posted on this page as soon as the team has prepared the final target list for upload to the spacecraft, which happens 1-2 weeks before the start of a sector.

You can click on the title of each program to read a summary of the research objectives.

Cycle 1

Cycle 1 contains all targets proposed through the Guest Investigator program for the first year of the TESS mission. All programs are to observe sources in the Southern Ecliptic hemisphere.

Approved Cycle 1 programs			
G011264	Davenport, James	Superflare Rates In GKM Stars With Tess	Small
G011268	Scaringi, Simone	Testing Self-Similar Accretion-Driven Variability In Compact Interacting Binaries	Small
G011273	Metchev, Stanimir	Ultra-Cool Dwarfs Viewed Equator-On: Surveying The Best Host Stars For Biosignature Detection In Transiting Exoplanets	Small
G011285	Cody, Ann Marie	A TESS Monitoring Survey Of Young Intermediate-Mass Stars	Small
G011291	Quintana, Elisa	Searching For Planets In The Continuous Viewing Zone With TESS Full Frame Image Data	Small
G011294	Vanderburg, Andrew	Disintegrating Rocky Bodies Transiting White Dwarfs: The Key To Understanding Exoplanet Compositions	Small
G011299	Airapetian, Vladimir	Evolving Magnetic Lives Of Young Suns	Small

Measures of Success

- Investigators carry out and propose interdisciplinary research through new collaborations
  - e.g. Exo-Mineralogy
- Produces a plan for utilization of current space telescopes
  - ERS Working Group
- Spawns ideas for new and exciting missions
  - STDT Leadership
- Identifies new targeted technologies needed not yet reported elsewhere
  - Lab Astro Gap List White Paper
- Contributes to decadal review efforts for both PSD and APD
  - 4 NExSS white papers submitted to NAS-Astrobiology, 9 to NAS-Exoplanets
- Enhances International engagement
  - Invited lectures; invites to F2F meeting; travel awards to international conference; 46% participation in ERS working group; Les Houches “Cloud Academy” summer school

NExSS white papers for NAS-Exoplanets

- A comprehensive understanding of planet formation (Apai)
- Exoplanet science priorities from the perspective of internal and surface processes (Henning)
- Exoplanet diversity in the era of space-based direct imaging missions (Kopparapu)
- Exploring factors of exoplanet habitability (Airapetian)
- Climates of potentially habitable exoplanets (Del Genio)
- Remotely detectable biosignatures (Domagal-Goldman)
- Procedures and policies affecting the future of exoplanet research (Batalha)
- Technology development (Kalas)
- Stellar contamination in exoplanet transmission spectra (Apai)