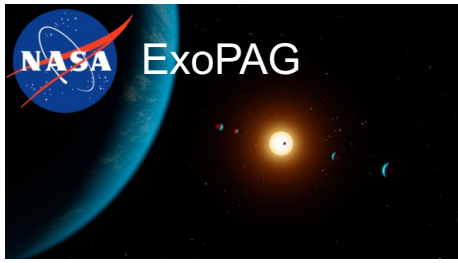
SAG 23: Status Update

John Debes, Yasuhiro Hasegawa, and Isabel Rebollido
on behalf of SAG 23

SAG 23: Revisiting Exozodis



- Create a catalog of known cold debris disks/exozodis/hot dust systems around direct imaging stars
- Review solar system zodiacal cloud as an exozodi analogue
- Revisit exozodi impact on direct imaging missions with new information
- Investigate the impact of hot dust populations on direct imaging
- Identify new gaps in understanding and new opportunities for closing those gaps
- Study the modeling of exozodi emission and origins
- Study data processing and detection of extended sources in planetary systems
- Make recommendations on future missions, studies, instruments

- Over 30 researchers from a variety of science areas and career stages participating

Aki Roberge (GSFC)

Alyssa Columbus (JHU)

Amaya Moro-Martin (STScI)

Angelle Tanner (Mississippi State University)

Bertrand Mennesson (JPL/Caltech)

César Bustos (Northwestern University)

Chris Stark (GSFC)

Christine Chen (STScI)

Devanshu Jha (MVJ College of Engineering)

Emily Rickman (STScI) (she/her/hers)

Ewan Douglas (University of Arizona) (he/him/his)

Geoff Bryden (JPL/Caltech)

Jens Kammerer (STScI)

Jess Rigley (University of Cambridge)

John Wisniewski (The University of Oklahoma) (he/him/his)

Julien Milli (Université Grenoble Alpes)

Karl Stapelfeldt (JPL/Caltech/ExEP)

Katie Crotts (University of Victoria)

Kielan Hoch (STScI)

Mark Wyatt (University of Cambridge)

Max Millar-Blanchaer (UCSB) (he/him/his)

Michael Meyer (University of Michigan)

Neal Turner (JPL/Caltech)

Nicole Pawellek (University of Vienna)

Phil A Willems (JPL/Caltech)

Ramya M Anche (University of Arizona)

Sally Dodson-Robinson (University of Delaware)

Seba Marino (University of Cambridge)

Steve Ertel (University of Arizona) (he/him/his)

Tim Pearce (Friedrich Schiller Universität)

Virginie Faramaz (University of Arizona)

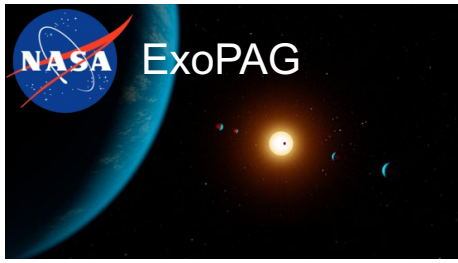
William Balmer (STScI)

William C. Danchi (GSFC) (he/him/his)

Yinzi Xin (Caltech)

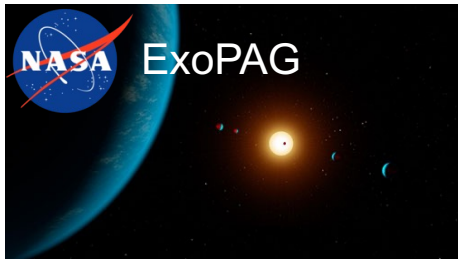
Kevin Ortiz Ceballos (CfA/Harvard)

SAG 23 Subject Areas



- A catalog of dusty systems around nearby stars (S. Ertel)
- A review of hot dust systems (S. Ertel, B. Danchi)
- Theory of exozodi sources and dust evolution (M. Wyatt)
- Post-processing and detection of extended sources (M. Millar-Blanchaer, E. Douglas)
- Update and prioritization of ExEP Gaps relevant to Exozodis (Open)
- Pan-chromatic radiative transfer of exozodis (R. Anche)
- Prioritization of precursor observations and studies of debris disks/exozodis for future direct imaging missions (M. Millar-Blanchaer, B. Danchi)
- Prioritization of precursor theoretical studies of debris disks/exozodis (J. Rigley)
- The Solar System zodiacal cloud and links to exozodi (N. Turner, G. Bryden)

Dusty systems catalog



Approach:

- Use Angelle Tanner's Starchive.
- Ingest all relevant references and their data if not already available.
- Create custom queries for star lists (e.g., from SAG22 report "Target Star Archive for Exoplanet Science") and relevant data.
- Provide public access through Starchive, use Starchive infrastructure to facilitate work, share effort, leverage common resources
- Release of catalog independent of release of Starchive

Status:

- Mostly complete list of references and data compiled
- Ingestion into Starchive in progress
- Custom queries already implemented in Starchive, just need to create them
- Output to be formatted into convenient format for distribution

What is the Starchive?

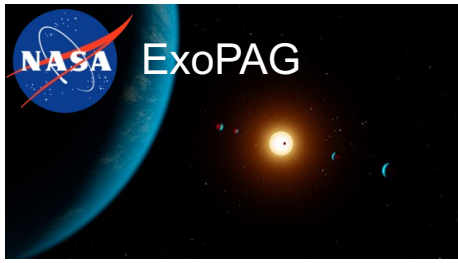
It is an open-source, open-access stellar database with an intuitive web application with multiple search options, dynamic plots, and interactive tools for data exploration. It should be your one stop shop for most data available for each star in the database.

Members:
Angelle Tanner,
Chris Stark
Karl Stapelfeldt
John Debes
Virginie Faramaz
Ramya M Anche

https://starchive.org

NASA ADAP funded

Review of hot dust systems

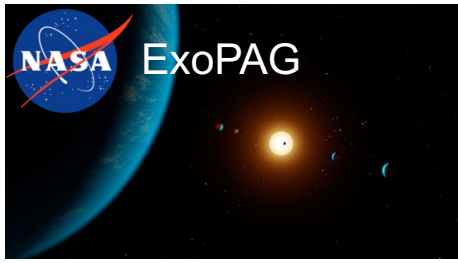


- This area will review the literature, current knowledge, and future prospects in the field of hot exozodiacal dust. Discuss impact on Future Great Observatories exo-Earth imaging mission
- Review is 30% written (observations part mostly done, theory and implications need more work).
- Goal: a report and a peer-reviewed paper.

Members:

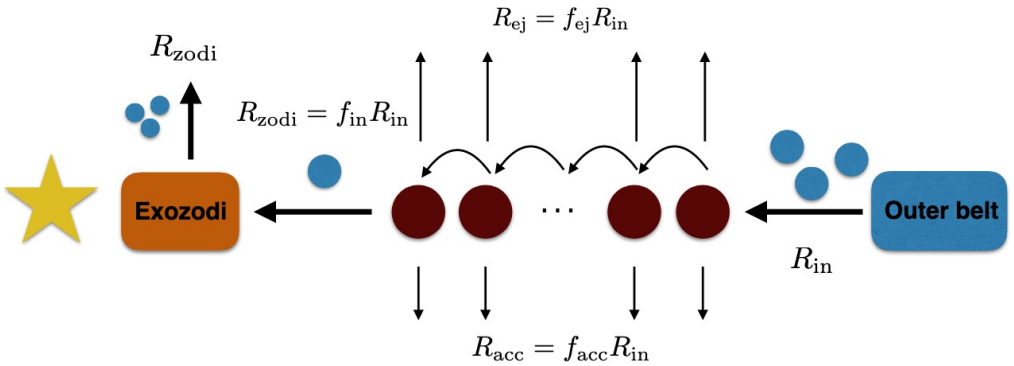
Chris Stark
John Debes
Virginie Faramaz
Ramya M Anche

Theory of exozodi sources and dust evolution



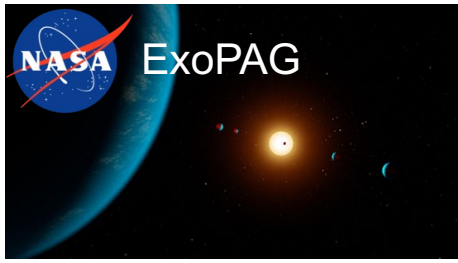
Summary of current knowledge on exozodi origins:

- Dust dragged in from outer belt interacting with planets on way in
- Comets scattered in by planetary system
- Other dynamical mechamisms (e.g., Kozai from outer companion)
- In situ asteroid belt
- Recent collision
- Models to explain hot dust
- Observational constraints (correlations, composition)



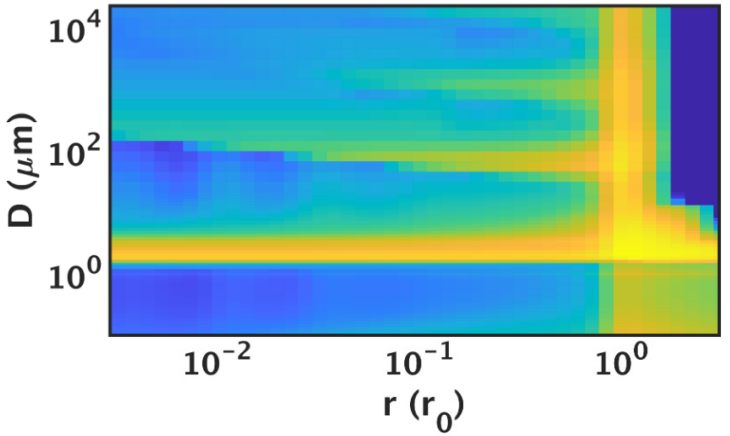
Members:
Virginie Faramaz
Tim Pearce
Isa Rebollido
Jess Rigley
Chris Stark

Theory of exozodi sources and dust evolution

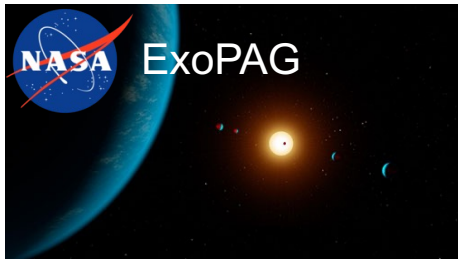


Aspirations:

- Inform predictions for exozodi level from sparse information about system – what info needed?
- Inform physically plausible exozodi models for yield simulators (e.g., size distribution vs distance)
- Demonstrate degeneracies in converting mid-IR to scattered light
- What is dominant exozodi delivery mechanism?
- Consider implications for volatile delivery
- Better understanding of physics relevant to warm vs hot dust populations
- Identify gaps in knowledge to motivate new studies and collaborations



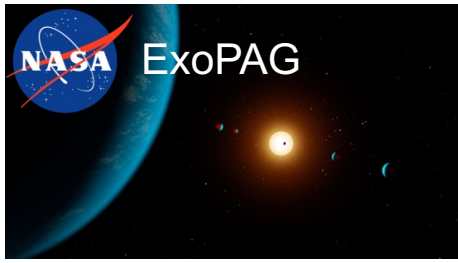
Post-processing and detection of extended sources



- **Primary outcome:** A gap list with a focus on three main topics
- **Strategy:** ID main science questions that need answering, understand the existing tools/techniques, develop gap list for future studies
- **Areas:**
  - How do we define a detection of a disk? (filters, SNR, resels, etc.) How to best define post-processed noise?
  - How do disks get post-processed into planet-like features?
  - How well does polarization improve post-processing and discriminating between planets and disk features?

Members:
Kellen Lawson
Bertrand Mennesson
John Debes
Yinxi Xin
Jens Kammerer
Ramya Anche

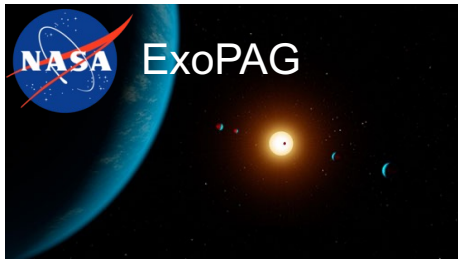
Pan-Chromatic Radiative Transfer of Exozodis



Sub-areas to be studied during this year:

- **Review the dust grain models used in the radiative transfer modeling of disks:** Analyze different grain compositions, optical constants, grain size distribution used in the literature. Understand the degeneracy with compositions and predicting surface brightness. (Examine how Astrosilicates behave in scattered vs. thermal IR as opposed to specific minerals such as Olivine, Pyroxene)
- **Comparison of Radiative transfer modeling software:** Different Open-source software available and capabilities. Review the benchmark papers. Compare key features, approximations, polarization, grain populations, run time, and symmetry. Finally, model a few of the well-studied disks and compare them with the observations.
- **Analyze archival data of Multi-wavelength observations of a few debris disks:** Identify the problems associated with constraining dust properties: Key parameters/ observations required, the connection between disks with cold dust rings and hot zodi. Analyze archival data of Beta-Pic (representative of dust closer to the habitable zone) and HR4796A (have better SNR data) to understand if we can produce a unique model.
- **Recommendations for Multi-wavelength observations for future instruments:** Categorize the existing and near-future instrument capabilities, IWA, OWA, wavelength, etc. Advocating for observations required using future telescopes (ground-based+Space) with inputs from the radiative transfer modeling and deriving constraints

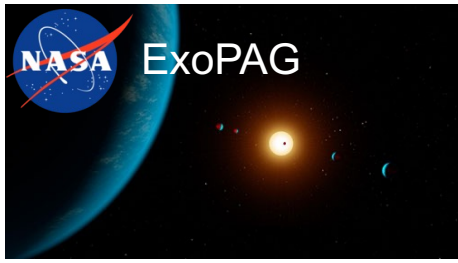
Prioritization of Future Observations



- **Primary outcome:** A compilation of open science questions and a prioritized list of future observations for current and future facilities
- **Overall strategy:** Identify the most pressing science questions related to exozodi, and the facilities and measurements required to answer them, considering both ground-based and space-based facilities. The effort is science-based and will consider upgrades to existing instruments and the full scientific capabilities of next generation telescopes in the prioritization.
- **Current status:** Preliminary science question and instrument capability lists have been started and will be expanded after consultation with the broader SAG group.

Members:
Yasuhiro Hasegawa
Isa Rebollido
Bertrand Mennesson
Steve Ertel
Emily Rickman
Karl Staplefeldt

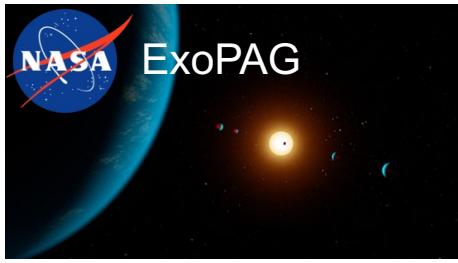
Prioritization of future theoretical studies



- **Primary outcome:** A compilation of open science questions and a prioritized list of future theoretical studies that will inform precursor observations or mitigate risks to missions
- **Overall strategy:** Define metrics for prioritization based on key science questions related to direct imaging of planets and understanding exozodis, obtain input from other SAG 23 subject areas
- **Current status:** The group has identified metrics for prioritization:
  - How well will a study help to detect or characterize exoplanets?
  - How well will a study constrain dust composition and morphology?
  - How well will a study determine dust sources and predicted spatial distribution of dust?
  - How feasible and testable is the study?

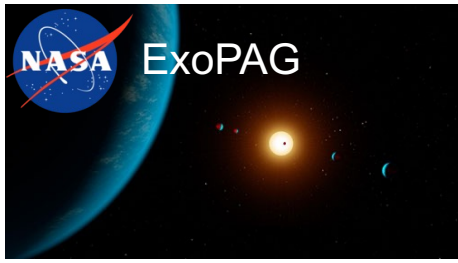
Members:
Virginie Faramaz
Sally Dodson-Robinson
John Debes
Isa Rebollido

SAG 23 Workshop



- The SAG is developing a plan for community input to our final report(s) in late 2023
- Workshop committee has been formed, looking for venue and time
- Idea is to impact final report due to late-breaking community results (i.e. JWST, new theoretical studies)
- More details to come (check ExoPAG announcements)
- If interested, contact myself or Yasuhiro Hasegawa

It is not too late to get involved!



- Contact me, Yasuhiro Hasegawa, or Isa Rebollido if interested
- Contact subject area leads to sign up for specific area
- SAG 23 website:
  https://sites.google.com/view/sag23-exozodiacaldust/home