The Effect of Stellar Contamination on Space-based Transmission Spectroscopy

Nestor Espinoza (STScI) & Benjamin Rackham (MIT) on behalf of SAG21

ExoPAG 23 Update | January 6th, 2021
Outline

1. What is and who is part of SAG21
2. Timeline of SAG21
3. Subgroups and Science Questions
4. Community Symposium
1. What is and Who is Part of SAG 21
The Challenge: “Stellar Contamination”

Stellar heterogeneity affects transits depths too!
The Transit Light Source Effect

Pre-transit Stellar Disk is the Assumed Light Source

Actual Light Source is the Chord Defined by the Planet’s Projection

Spectral Difference due to Different Spot/Faculae Contributions Contaminates Transit Spectrum

Rackham et al. (2018)  See also: Pont+08, Bean+10, Berta+11, Sing+11, Aigrain+12, Huitson+13, Jordán+13, Kreidberg+14, McCullough+14, Nikolov+15, Herrero+16, Zellem+17
To what extent will this impact space-based transmission spectra?
Goals

What do we know & what can we learn from the star?

e.g., chromospheric activity, photometric monitoring, polarization
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What can we learn from transits?

- Planet
  - e.g., transit spectroscopy

- Star
  - e.g., unocculted surface, occulted active regions, flares.

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What will the impact be on future studies?
**Goals**

What can we learn from transits?

Planet
- e.g., transit spectroscopy

Star
- e.g., unocculted surface, occulted active regions, flares.

What do we know & what can we learn from the star?
- e.g., chromospheric activity, photometric monitoring, polarization

What will the impact be on future studies?

What complementary observations will be useful?
Main deliverable:
SAG21 report to NASA by mid-2021
Current members (106 researchers)
# Current members (106 researchers)

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Current members (106 researchers)

Gender identity (57 responses)
- Female: 42.9%
- Male: 57.1%

Ethnic origin:
- White: 42 (74.5%)
- Hispanic and/or Latinx: 9 (16.1%)
- Black and/or African American: 1 (1.7%)
- Native American: 0 (0%)
- Asian/Pacific Islander: 6 (10.3%)
- South-East Asian Indian: 1 (1.7%)
- Indian/South Asian: 1 (1.7%)
- Mixed: 1 (1.7%)

Career stage:
- Undergraduate or Postbaccalaureate: 42 (72.4%)
- Graduate student: 9 (15.5%)
- Postdoctoral researcher: 1 (1.7%)
- Non-tenure-track Faculty/Staff: 1 (1.7%)
- Non-tenured Faculty/Staff: 1 (1.7%)
- Tenured Faculty/Staff: 0 (0%)
- Other: 1 (1.7%)
Current members (106 researchers)

Career stage

59 responses

- Undergraduate or Postbaccalaureate: 33.9%
- Graduate student: 18.6%
- Postdoctoral researcher: 18.6%
- Non-tenure-track Faculty/Staff: 10.2%
- Non-tenured Faculty/Staff: 10.2%
- Tenured Faculty/Staff: 11.9%
- Staff: 0%
2. Timeline of SAG21
SAG21 Timeline

- **Sep. 3, 2020**
  - Kick-off meeting

- **Nov. 30, 2020**
  - Final definition of subgroups & questions
  - **We are here!** New year

- **Oct. 1, 2020**
  - SG & leads

- **Nov. 1, 2020**
  - SG questions defined

- **Mar. 1, 2021**
  - Community Symposium (CS)
  - Subgroups perform literature review, modelling & analysis to answer (even partially) defined questions. To be presented in March's CS.

- **Jun. 1, 2021**
  - Draft Report
  - Subgroups use symposium feedback to guide/modify the writing of their sections of the report.

- **Jul. 1, 2020**
  - Red team reviews

- **Aug. 1, 2021**
  - SAG 21 report submission to NASA
3. Subgroups and Science Questions
Subgroups

SAG 21
S1: Stellar Photospheric Heterogeneity

Leads: Svetlana Berdyugina, Heidi Korhonen & Alexander Shapiro
S1: Stellar Photospheric Heterogeneity

Leads: Svetlana Berdyugina, Heidi Korhonen & Alexander Shapiro

Photometric monitoring
Figure source: Santos & Mathur (2020)
S2: Stellar Spectral Decomposition

Leads: Joanna Barstow, Benjamin Rackham, & Nestor Espinoza
S2: Stellar Spectral Decomposition

Leads: Joanna Barstow, Benjamin Rackham, & Nestor Espinoza

The case of TRAPPIST-1

Wakeford et al. (2019)
S3: Occulted Active Regions

Leads: Mahmoud Oshagh & Brett Morris
S3: Occulted Active Regions

Leads: Mahmoud Oshagh & Brett Morris

The case of WASP-19b

Figure source: Espinoza et al. (2019)
S3: Occulted Active Regions

Leads: Mahmoud Oshagh & Brett Morris

The case of WASP-19b
Figure source: Espinoza et al. (2019)
S4: Unocculted Active Regions

Leads: Yvonne Unruh & Ben Montet
S4: Unocculted Active Regions

Leads: Yvonne Unruh & Ben Montet

The Transit Light Source Effect

Figure source: Rackham et al. (2018)
S4: Unocculted Active Regions

Leads: Yvonne Unruh & Ben Montet

Transit depth variations in time
Figure source: Croll et al. (2015)
S5: Future Complementary Observations

Leads: Elisa Quintana & Rob Zellem
S5: Future Complementary Observations

Leads: Elisa Quintana & Rob Zellem

Spectroscopic monitoring

Figure source: Robertson (2016)
All this information (+more):

sites.google.com/view/sag21
4. Community Symposium
SAG21’s (virtual) Community Symposium

March 8 and 9, 2021

More info: sites.google.com/view/sag21symposium

Presentations from subgroup leads

Contributed talks from the community

RSVP open!
Summary

1. **SAG21’s goal** is to deliver a report to NASA by mid-2021: currently over 100 members, with over 50 “active” members divided in 5 sub-groups.

2. **SAG21 is on track with its self-defined timeline**: currently working on literature reviews, methods & analyses on defined questions.

3. **SAG21’s Community Symposium registration** is open until January 18th, 2021: objective is to both share SAG21 work to the community and receive input from it.