Building SOFIA’s Instrument Roadmap

Exoplanet Science Potential

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What Method Should SOFIA Use to Study Exoplanets?

• **Radial Velocity**: RV type detections well done already from the ground

• **Microlensing**: ground-based optical observing networks working well

• **Direct Imaging**: SOFIA wavefront quality and aperture diameter not competitive for direct imaging

• **Transits**: maybe an opportunity for SOFIA

Transit observations are the most promising exoplanet science area for SOFIA.
Exoplanet Transit Observations: Discovery and Bulk Density Characterization

- Kepler/K2 legacy
- TESS
- CHEOPS
- Ground-based transit surveys
- Ground-based precision RV surveys

Bulk density characterization is now a statistical area so not well matched to SOFIA.
Exoplanet Transit Observations: Atmospheric Characterization

- HST/Spitzer
  - ~80 planets
- Ground
  - ~lots of planets
- JWST
  - ~29 GTO/ERS planets
- ARIEL
  - ~1000 planets

Atmospheric characterization becoming a statistical area.

Simulated targets Zellem et al. 2019
Selected Ground-based R~100,000 class stabilized spectrometers

- CARMENES
- CRIRES+
- ESPRESSO
- EXPRES
- HARPS
- HARPS-N
- MAROONX
- NEID
- PARVI

CARMENES detection of He in WASP-69 b Nortmann et al. 2020

Ground-based studies will be numerous and impactful.

ESPRESSIONO detection of Fe in WASP-76 b Ehrenreich et al. 2020
Key Takeaways

• Exoplanets is becoming a statistical field (although spectacular individual planet results are important)
• JWST will have an enormous impact and will observe ~50-100 planets
• High resolution spectroscopy (R~100,000) for atmospheric characterization is a rapidly growing area
• ARIEL will observe ~1000 planets
What is left for SOFIA?

• Transit observations
  • SOFIA not competitive for other observing methods

• High value single targets
  • SOFIA not competitive for statistical studies

• Observing constraints
  • 4 hr observing limitation for return to base flight plans
  • Limits transit to 2 hr 1\textsuperscript{st} to 4\textsuperscript{th} contact
  • Implies planets in short period orbits

• Leverage SOFIA mid-IR to far-IR wavelength capability
Notional Concept

• Focus on a few small temperate planets
• For short period orbits, they will be around M dwarfs
• Select a key molecule that only has strong opacity in mid-IR to far-IR
  • Key molecule must resolve important question such as eliminating an abiotic hypothesis for atmospheric composition
  • More than one key molecule would good but perhaps not essential
• Partner with other missions/programs to find the targets