SOFIA – Status and Context

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Scientific Rationale for SOFIA

- The scientific rationales for SOFIA and the Origins Space Telescope share the same foundation.

- Most of the luminosity of star formation regions, external galaxies, and cooler objects in the universe is in far-IR and Sub-mm dust emission.

- The most important emission lines responsible for the energy balance of the Interstellar Medium are in the far-infrared.

The spectral energy distribution of the entire LMC, based on data from Spitzer, IRAS and FIRAS (Bernard et al. 2008). SEDS are fitted with the dusty PDR model of Galliano et al. (2008). Figure courtesy of Galliano.
SOFIA
Stratospheric Observatory for Infrared Astronomy

- Collaboration between NASA and DLR
- Highly modified 747-SP aircraft with a 2.7-m telescope
- Flies up to 13.7 km (45,000 feet), above 99.9% of the water vapor in the atmosphere
- Suite of infrared imagers and spectrometers
- Provides access to the infrared to the worldwide astronomical community
# SOFIA Instrument Complement

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Description</th>
<th>Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXES (Echelon-Cross- Echelle Spectrograph)</td>
<td>High Resolution (R &gt; 10^5) Echelle Spectrometer</td>
<td>5 – 28 μm</td>
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<tr>
<td>FIFI-LS (Field Imaging Far-Infrared Line Spectrometer)</td>
<td>Dual Channel Integral Field Grating Spectrometer</td>
<td>42 – 110 μm 100 – 210 μm</td>
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<tr>
<td>FLITECAM (First Light Infrared Test Experiment CAMera)</td>
<td>Near Infrared Imaging Grism Spectroscopy</td>
<td>1 – 5.5 μm</td>
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<tr>
<td>FORCAST (Faint Object infraRed CAMera for the SOFIA Telescope)</td>
<td>Mid-IR Dual Channel Imaging Grism Spectroscopy</td>
<td>5 – 25 μm 25 – 40 μm</td>
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<tr>
<td>FPI+ (Focal Plane Imager Plus)</td>
<td>Visible light high speed camera</td>
<td>360 – 1100 nm</td>
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<tr>
<td>GREAT, upGREAT (German REceiver for Astronomy at Terahertz frequencies)</td>
<td>High resolution (R&gt;10^6) heterodyne spectrometer; multi-pixel spectrometer</td>
<td>1.25 – 1.52 THz 1.81 – 1.91 THz 4.74 THz</td>
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<tr>
<td>HAWC+ (High-resolution Airborne Wideband Camera-Plus)</td>
<td>Far-Infrared camera and polarimeter</td>
<td>Five ~20% bands at 53, 63, 89, 154, &amp; 214 μm.</td>
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Key Differences Between SOFIA and Origins Space Telescope

• SOFIA is a warm telescope
  – Compared to the Origins Space Telescope, the background from the telescope is very high

• The number of hours per year provided by SOFIA will always be limited.

• SOFIA is operating now

• SOFIA instrument development can take advantage of the latest advancements in technology.
Growth in Astronomical Sensors
New SOFIA Instrumental Capabilities

• SOFIA is planning on a steady cadence of new instrumental capabilities
  – upGREAT 14-pixel (1.9 THz) array commissioned in 2016
  – HAWC+ commissioned in 2016
  – upGREAT 7-pixel (4.7 THz) + 14 pixel (1.9 THz) available 2017
  – 4GREAT commissioning in 2017
  – HIRMES anticipated commissioning in 2019
DDT Demonstration Observation
upGREAT [C II] Map

Integrated line profile over mapped region.
HAWC+ Commissioning Observation – W3

53 μm
Note: Vectors show polarization direction but not amount of polarization.
High Resolution Mid Infrared Spectrometer

- HIRMES is a direct detection spectrometer covering 25 to 122 μm
- There are four spectroscopic modes to HIRME
  - High-res mode $R \sim 100,000$
  - Mid-res mode $R \sim 10,000$
  - Low-res mode $R \sim 600$
  - Imaging spectroscopy mode: $R \sim 2000$
- To deliver the maximum sensitivity achievable with SOFIA, HIRMES uses:
  - Background limited bolometers
  - Combination of Fabry-Perot Interferometers and gratings
- Very rapid development schedule – Commissioning in Spring of 2019
**HIRMES Interior and Optics**

**High Resolution Mid Infrared Spectrometer**

**Key Elements:**
- 16x64 Pixel TES Bolometer Array
- Low & Medium Res
- 8x16 Pixel TES Bolometer Array
- High Resolution

Grating Wheel

Low Resolution Fabry-Perot

Medium Resolution FPI

High Resolution FPI
Principal SOFIA Legacies

- Physics of the Interstellar Medium
  - Energy Balance in Clouds
  - Lifecycle of the Interstellar Medium
- Star Formation
  - Physics of star forming filaments
  - Star Formation in Nearby Galaxies
- Solar System
  - High resolution spectroscopy of planets
    - Venus
  - High resolution of comets
  - Atmospheres of Trans-Neptunian Objects
- Far-Infrared Community
  - SOFIA provides the only general access to the Far-Infrared for the foreseeable future