Time-Domain Astronomy with *SOFIA*: Results from Current Observations with FORCAST & Prospects with the Proposed New Instrument *S3*

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The most recent Decadal Review identified "time-domain astronomy" as an important frontier for astrophysical investigations. A key advantage to *SOFIA* in this realm is its 20+ year lifetime which allows long-term scientific studies that are not possible with space-based infrared missions alone. Here, we present two time-domain projects enabled by *SOFIA*'s unique capabilities, one with current instrumentation - FORCAST, and the second with a proposed new instrument - *S3*.

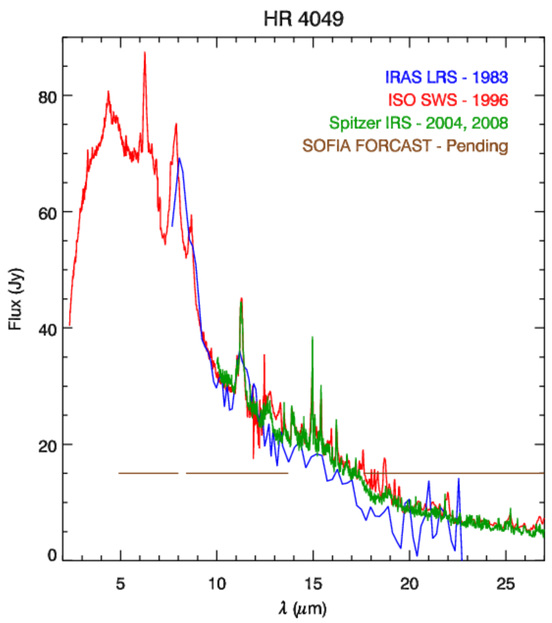
'Real-Time' Evolution of Carbon-Rich Post-Asymptotic Giant Branch Stars

30+ Years: *IRAS* → *ISO* → *Spitzer* → ***SOFIA***

Project 1: Obtain 5–37 μm spectra with *SOFIA*'s FORCAST of carbon-rich post-Asymptotic Giant Branch (post-AGB), one of the most fleeting stages in a star's life.

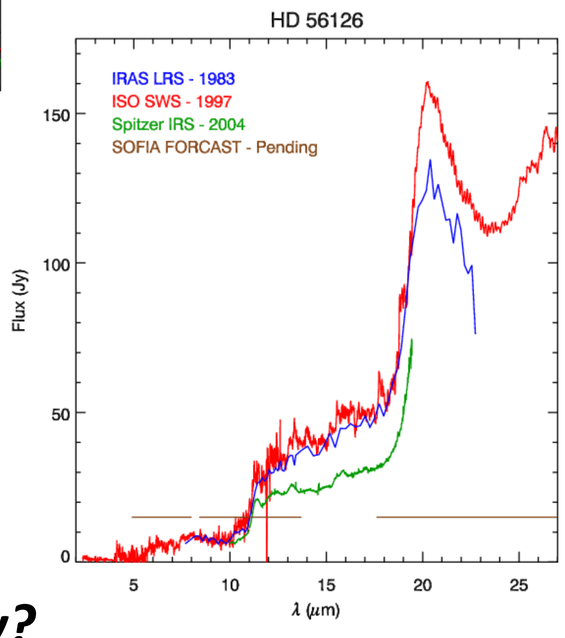
- Most phases of stellar evolution occur on timescales of millions or billions of years, but the post-AGB phase, when a star rapidly transitions from a cool, dust-enshrouded object to a bare white dwarf illuminating a planetary nebula, **lasts only ~1,000-10,000 years**.

➢ We will compare the new FORCAST spectra to mid-IR spectra obtained at ~10–15 year intervals over the past 35 years with *Spitzer, ISO*, and *IRAS*.



◀Example 1: HR 4049

- Good agreement in shape & flux - even small bumps & wiggles for *ISO* & *Spitzer*
- Is the *IRAS/ISO* difference at ~7-8 μm real?



Example 2: HD 56126 ▶

- Intriguing differences in the 11-19 μm *Spitzer* data
- Are the changes in the enigmatic 21 μm feature real?

➢ ***What will the FORCAST data show?***

Post-AGB Targets & Data

Star	Prior Datasets	*SOFIA* FORCAST	
		Observations	Data Delivery
RAFGL 618	*IRAS* LRS, *ISO* SWS	Aug. 22, 2018	Pending
IRAS 17441-2411	LRS, SWS,	Aug. 24, 2018	Pending
IRAS 19454+2920	LRS, SWS, *Spitzer* IRS	Aug. 25, 2018	Pending
IRAS 20000+3239	LRS, SWS, IRS	Aug. 25, 2018	Pending
V5112 Sgr	LRS, SWS	Aug. 29, 2018	Pending
HD 235858	LRS, SWS	Aug. 29, 2018	Pending
IRAS 19480+2504	LRS, SWS, IRS	Aug. 30, 2018	Pending
HD 44179	LRS, SWS	Pending	TBD
HR 4049	LRS, SWS, IRS	Pending	TBD
HD 56126	LRS, SWS, IRS	Pending	TBD

Kinematic Imaging of Biogenic Molecules in Protoplanetary Disks with ***S3: The Submillimeter Spectrometer for SOFIA***

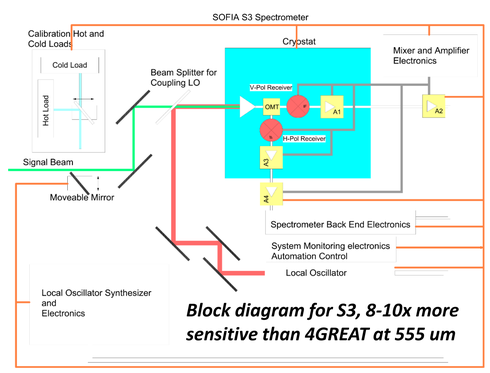
Project 2: Observe protoplanetary disks with a proposed new instrument: the high sensitivity, high spectral-resolution, heterodyne ***Submillimeter Spectrometer for SOFIA, S3***

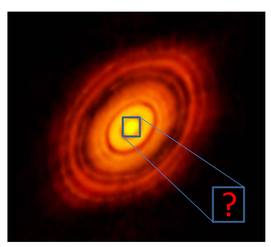
❑ Enabled by improved digital backend spectrometers, low noise amplifiers, local oscillators, and closed cycle refrigerators

❖ *Repeatedly* observe the line profiles of NH_3 and isotopic H_2O in protoplanetary disks with *S3* *and their changes* over the course of 3 years.

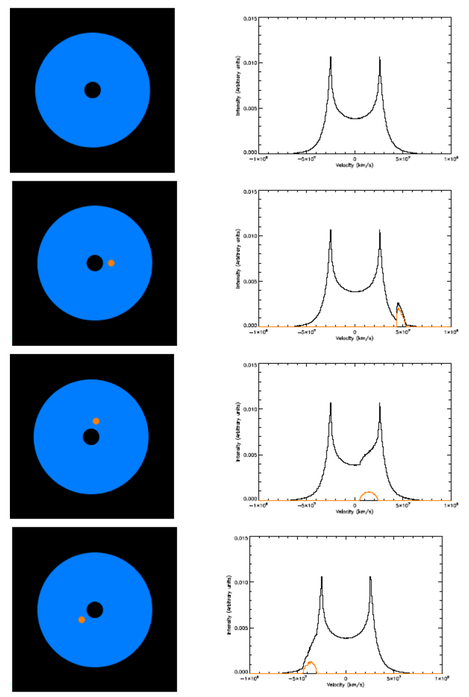
❖ Trace the structure and composition of the disk, constraining disk dynamics and planet formation models for each system.

➢ **These observations by S3, *8-10x more sensitive than 4GREAT*, would allow Doppler tomography and similar techniques to kinematically image, for the first time, the *inner* regions of the planet-forming systems.**





Kinematic Imaging



***S3*: 2 unique new bands and a 3rd band an order of magnitude more sensitive than 4GREAT's**

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