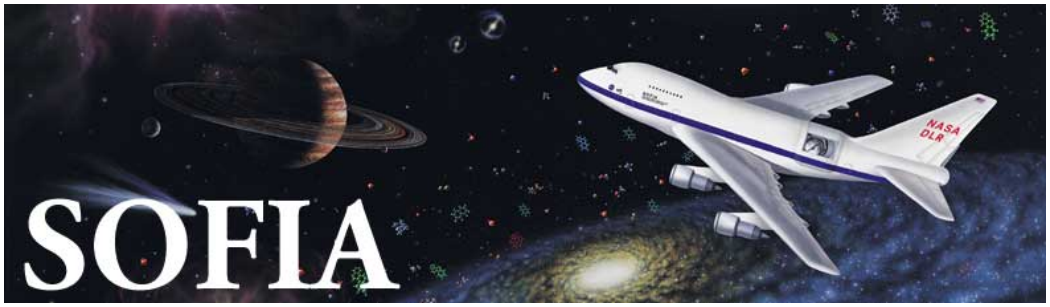
HIPO:

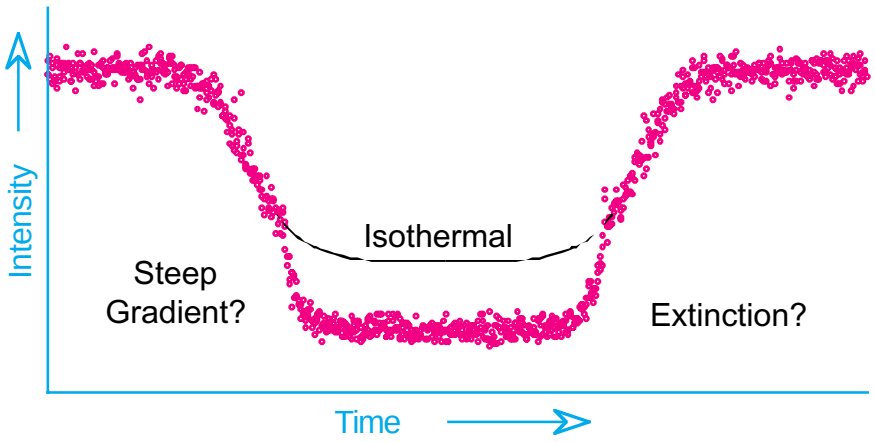
A High-speed Imaging Photometer for Occultations



HIPO is a special-purpose science instrument for SOFIA designed to provide simultaneous high-speed time resolved imaging photometry at two optical wavelengths. It will be possible to mount HIPO and FLITECAM on the SOFIA telescope simultaneously to allow observation at two optical wavelengths and one near-IR wavelength. HIPO will have a flexible optical system and numerous readout modes, allowing many specialized observations to be made. HIPO is also well suited for critical tests of the completed SOFIA Observatory, and will be used for them.

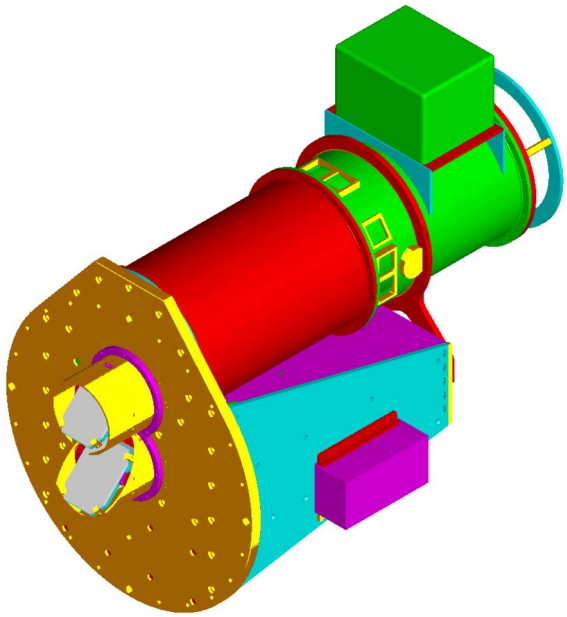
Our main scientific interest is in the use of HIPO for observing stellar occultations. In a stellar occultation, a star serves as a small probe of the atmospheric structure of a solar system object or the surface density structure of a planetary ring or comet. Such observations provide information at high spatial resolution that would otherwise require a space mission to obtain. This work makes use of SOFIA's mobility, freedom from clouds, and near-absence of scintillation noise to provide the best possible occultation data.

HIPO will also be well-suited for detection of P-mode stellar oscillations in sunlike stars and for acquiring high S/N multiwavelength lightcurves of transits by extrasolar planets.



Pluto/P8 occultation, 1988

In an occultation by an object with an atmosphere differential refraction is normally the only significant factor causing the star's brightness to decrease. Under certain circumstances extinction, either by aerosols or by molecular absorption, can also contribute. The lightcurve above (obtained with the Kuiper Airborne Observatory; Elliot, *et al. Icarus* **77**, 148-170 (1989)) can be explained either in terms of a strong thermal gradient in Pluto's atmosphere or by extinction due to aerosols. These competing models can be tested with an occultation by Pluto observed simultaneously in optical and infrared bands with HIPO and FLITECAM.



The CAD drawing to the left shows an isometric view of HIPO with FLITECAM co-mounted. HIPO is in the form of a large box with FLITECAM being the large cylindrical dewar attached to the main mounting plate above HIPO. Light from the telescope enters from the lower left, passing through an optional IR dichroic beamsplitter and a pressure window to HIPO. Inside HIPO an optical dichroic directs light to the red and blue channel reimaging optics and detectors. If FLITECAM is co-mounted, the reflected beam from the IR dichroic is directed into the FLITECAM dewar by a fold mirror. The region between the instrument mounting plate and the telescope's gate valve is toward the lower left in this figure. It can be either evacuated or allowed to be at stratospheric conditions.

HIPO Specifications

• Wavelength Range:	0.3-0.6 µm (Blue channel), 0.4-1.1 µm (Red channel).
• CCD Quantum Efficiency:	88% peak, ≥40% from 0.35 µm to 0.85 µm.
• Detectors:	MAT CCD47-20 frame transfer silicon CCDs, thinned and backside illuminated, with optimized antireflection coatings Format: 1Kx1K with 13 micron square pixels.
• Throughput of HIPO optics:	≥ 70% from 0.4 to 0.9 microns
• Spectral Resolution:	Defined by filters, as narrow as 0.003 µm, with 8 position motorized filter wheels on both channels.
• Number of channels:	2 optical channels, with 1, 2, or 3 subframes per channel Optional simultaneous FLITECAM mount
• Time & 3-D posn accuracy:	< 1 µsec and 30 meters via GPS
• Maximum Frame Rate:	20 ms for three 80x80 pixel subframes per CCD 10 ms for one 80x80 pixel subframe per CCD (in High-speed Series Mode)
Highest Time Resolution:	500 µs (continuously with 1-dimensional intensity profile) 50 µs (in a burst of ~30 images)
• Read Noise:	≤ 6 electrons maximum ≤ 3 electrons for slow read
• Field of View on SOFIA:	square, 5.6 arcmin on a side, 8 arcmin diagonal.
• Pixel scale on SOFIA:	1.0 "/pixel (binned) for occultations, 0.33 "/pixel for testing, 0.055 "/pixel with single bare CCD.
• Optical system:	80% enclosed light in 1x1 (Red) and 2x2 (Blue) unbinned pixels Low, well characterized distortion for chopper testing Shack-Hartmann capability in red channel Pupil imaging mode and Focault test capability Pupil mask with x-y adjustment Optional evacuated light path from instrument to gate valve
• Data Format:	Simple FITS, 2d or 3d files, one per subframe

HIPO will be available for Guest Investigator use on a collaborative basis, and potential Guest Investigators should contact the PI prior to proposing to ensure that the proposed observations are feasible and make the best use of HIPO's capabilities.

The HIPO Team

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