Lunar Occultations at Far-IR Wavelengths - A Niche for SOFIA?

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Abstract

We discuss the motivation for and practicality of achieving high angular resolution in the far-IR with the lunar occultation technique. This has been the "poor-man's" interferometric technique at shorter wavelengths for many years. It seems possible that this technique can be used on SOFIA to achieve angular resolutions in the far-IR that can pave the way for future space interferometers. No other far-IR platform can pursue this technology for various practical reasons.

Motivation

- Far-IR angular resolution of a 2.5-m telescope is still limited compared to neighboring wavelengths!
- When will the first far-ir interferometer fly?
- SOFIA is uniquely suited to observe lunar occultations – movability and high background!
- Wavelength dependence of $\lambda^{1/2}$ because of Fresnel diffraction (infinite straightedge)

Occultation Opportunities

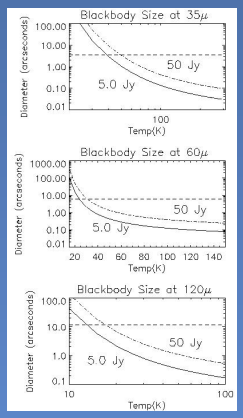
Over the 18 yr occultation cycle

- 190 objects > 50 Jy @ 25μm
- 450 objects > 20 Jy
- 920 objects > 10 Jy

Some familiar names

- IRC +10011 (CIT 3), U Ori, VX Sgr
- IRC +10216, L1551 IRS5

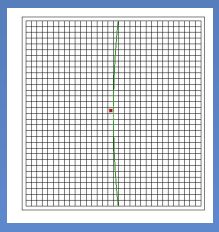
Brightness vs Angular Size



Plots of angular size vs temperature for blackbodies of two possible SOFIA flux limits

Instrumental Details

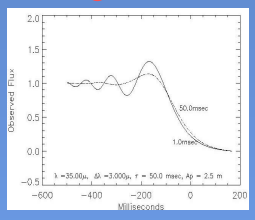
Assume 35μm observations with FORCAST
Better Moon to typical source flux
Large format 2-D array helps
6 arcsec binned "pixel" captures most of flux with some leeway for pointing issues
Sky flux is ~ 20,000 Jy into 6" pixel
Noise in 100msec ~ 2 Jy
Moon flux is ~ 6000 Jy into 6" pixel



How to Observe?

- 1x1 6" "super"-pixel for object
- 16x32 6" pixels to measure sky flux
- Chopping?
- Chop parallel to limb?

Typical Occultation Light Curve

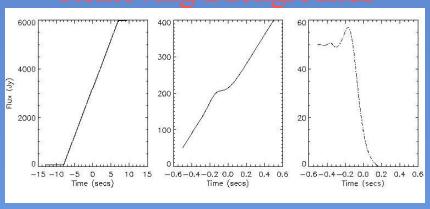


The light curves for a 50 milliarcsecond diameter source and for an unresolved (1 mas) source with likely observing parameters with the FORCAST camera on SOFIA, showing that it is easy to resolve sources much smaller than the telescope diffraction limit of 2".

Problems

- The dark side of the Moon is NOT dark in IR! ~90K
- SOFIA's pointing stability is likely to be a significant issue (but we won't know until we try)
- Like all occultation observations, probably requires a dedicated flight per event

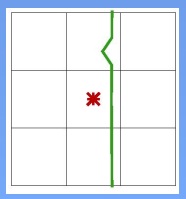
Removing Backgrounds



Light curve: left – including the full change in lunar background in a pixel; center – with the bulk of the background subtracted; right – with all of the linear slope in the background subtracted

The Biggest Problem?

- Irregularities on lunar limb + SOFIA pointing?
- Typical lunar mountain ~ 1" =>150 Jy
- What will be the amplitude of the pointing jitter at the relevant frequencies (1-20 Hz) for occultation observations?



Summary

- The observations will be difficult!
- Minimizing pointing jitter @ 0.2-20 Hz is good!
- The payoff is large
- Hundreds of sources
- Angular size measurements nearly always are crucial for narrowing the range of emission models relevant to a thermal source