- The Near-IR Sky
  - OH- emission lines.
  - Thermal emission.
  - Definition of filter bands - the Mauna Kea system.
  - Sky brightness variations - in J, H, K from WIRCm data.
  - Sky brightness variations - 2MASS movies.
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  - The classical dithering strategy.
  - The nodding strategy on extended targets.
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H-Band, 420 frames of 15-sec, 1.75hr, at zenith
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Atmospheric Transmission

Atmospheric Transmission with 1mm and 3mm of water vapor

Atmospheric Transmission

Atmospheric Transmission with 1mm and 3mm of water vapor

Black Body Thermal Emission

- 9650K (Vega)
- 5700K (Sun)
- 3000K (M dwarf)
- 1000K
- 500K
- 300K (Earth)
- 40K (Pluto)
- 15K (Interstellar Dust)

Log10(frequency [Hz])
Night Sky Emission & Thermal Emission

Mostly OH\(^{-}\), some \(\text{O}_2\) at 1.27\(\mu\text{m}\), \(\text{H}_2\text{O}\) in red K


http://www.gemini.edu/sciops/ObsProcess/obsConstraints/atm-models/nearIR_skybg_16_15.dat
Non-Thermal Emission

• See Ramsay & al. 1992, mnras 259 75.
• Airglow arises from vibrational-rotational levels of the OH-radical.
• Mostly Hydroxil (OH\(^-\)), some \(O_2\) at 1.27\,\text{um}, \(H_2O\) in red K.
• Short period variations, of the order of a few minutes to an hour, are connected with the passage of gravity waves through the ionosphere at an altitude of 80-105 km which produce density and temperature variations.
• These causes changes in the reaction rate and column densities of the constituents and a corresponding variation in the OH-emission intensity.
• Excitation: \(H + O_3 \rightarrow OH^* + O_2\), Relaxation: \(OH^* + O \rightarrow H + O_2\)
• Horizontal wavelengths of \(\sim 25\,\text{km}\), phase speeds of \(\sim 100\,\text{km/h}\), time periods of \(\sim 10-15\) minutes.
• Minor constituents density profile variations explain the 50% drop in the first hours after sunset.
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Temporal CFHT sky brightness variations
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On 7 and 8 June 1996 UT we (Joe Adams and Mike Skrutskie -- pictured above) cooled the 2MASS prototype camera and observed the airglow in a 9-degree field at J and H-band. To achieve this field-of-view they placed a 140mm focal length lens in front of the dewar window. The scale is about 120 arcseconds/pixel or 9 degrees across. To follow are flat-fielded images of the near-zenith sky. The peak to valley variations are about 15%. One could watch these patterns drift across the screen and change in intensity over the course of a few minutes. Yes, these frames have been flat fielded! Each frame is a 15 second exposure.
H-Band, 240 frames of 15-sec, at zenith
H-Band, 420 frames of 15-sec, 1.75hr, at zenith
J-Band, 180 frames of 15-sec, 45 min, at zenith

Galactic Plane Transit
J and H Bands almost simultaneous (1 min lag)
Passing Clouds (J-Band)

Moon Ghost (H-Band)
The sky and its subtraction

- As a canonical rule, the sky brightness amplitude varies by 10% in 10 minutes.
- The sky structure is rarely a smooth function and can often vary on large and small spatial scales (depending on the instrument).
- Subtraction of the sky also removes 2nd-order flat fielding residues.
Lecture on near-IR astronomy

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Standard dithering pattern

Why dither?

1. Fill the gaps between detectors.
2. Median out stars to build and subtract a sky frame.
Detrended images of a DP9 dithering pattern
Detrended images of a DP9 dithering pattern AFTER NORMALIZATION
SKY CONSTRUCTION
Medianing pixel by pixel

Resulting sky noise spread

median
mean

star signal

n
flux
Detrended images of a DP9 dithering pattern AFTER NORMALIZATION
Detrended images of a DP9 dithering pattern AFTER NORMALIZATION & MASKING
SKY CONSTRUCTION
Medianing pixel by pixel

- Median
- Mean

Resulting sky noise spread

- Star signal
- Median: mean
- Noise spread

n
flux
“Sky intensity varies by 10% in 10 minutes...”
- canonical rule

Sky Construction - sliding median with source masking

<table>
<thead>
<tr>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>DPI</td>
</tr>
<tr>
<td>DP2</td>
</tr>
<tr>
<td>DP3</td>
</tr>
<tr>
<td>DP5</td>
</tr>
<tr>
<td>DP7</td>
</tr>
</tbody>
</table>

Adjustable constraints in time and number of DPs:
example: use images taken no more than 15 minutes away and with sky positions different by at least 15”
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Nodding
Example of a good nodding strategy on the Orion Nebula
Example of a good nodding strategy on the Orion Nebula
Example of a good nodding strategy on the Orion Nebula
Example of a good nodding strategy on the Orion Nebula
Example of a good nodding strategy on the Orion Nebula
Wide Dithering Pattern (WDP)

- works for targets < 10 arcmin
- 100% of time on target
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Common errors with standard dithering pattern observations

- Doing a large number of coadds between each DP (example 06BC98 on M81).
- Using a dithering scale smaller than the largest object of interest in the field (example DP scale of 30” when the target is 45” wide).
Golden rules for nodding observations

- Need at least a DP3 on the sky positions, ideally DP5, to do a clean median as often as possible.
- Ideally obtain sky images at the beginning and end of the sequence, to better interpolate sky levels.
What not to do!!

07AC05 on M82 - dithering by only 5” with crowded galaxy field.

07AD92/93 - 60” target, no dithering at all but coadds of 16 at the same position. A DP16 with a scale of ~75” would have been perfect.

but wait! there is more!

07ATxx - 2 sky DP only! i.e. on extended target for 4 dithers then on sky for one single exposure of sky1, then 4 more dithers on target, finally one single exposure on sky2.

07BK02 - sometimes only 1 sky DP!
Common errors for nodding observations

- No nodding at all!!!
- Only DP1 or DP2 used on sky (the equivalent of not dithering the telescope).
- A sky field too distant (>5 deg) from the target field (sky maybe different there).
- Define a sky in PH2 the same as a target (they could be observed on different nights!)