9.04 The Methane Abundance and Structure of Cloud Bands on Uranus

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Telescope: Keck II with Adaptive Optics  
Instrument: NIRC2, grism  

OBJECTIVES: Constrain the CH4 mixing ratio.  
Locate the Uranus cloud layers in pressure.  
Determine composition of cloud layers.
spatial scans at different wavelengths sample different atmospheric levels

Pressures at which $a=0$ to $a=1$ change in surface produces I/F change of $1/e$, $1/e^2$, $1/e^4$ or 0.36, 0.13, 0.02.
the bright band is seen above the 2-3 bar level

part of the bright band is between 1.7 bars and 2.5 bars

the bright band is not seen above the 1.5-bar level

1.3-2 bars

2-3 bars
the bright band location is verified by bandpass filter imaging
part of bright band between 1.5 and 4 bars
using spectral fits to constrain cloud structure models
Recent improvements in modeling methane absorption:


a simple reflecting layer model of cloud structure

<table>
<thead>
<tr>
<th>adjustable parameters</th>
<th>fixed parameters</th>
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</thead>
<tbody>
<tr>
<td>broken</td>
<td>fstrat, Pstrat</td>
</tr>
<tr>
<td>broken</td>
<td>Pmid, fmid</td>
</tr>
<tr>
<td>opaque</td>
<td>Pbot, abot</td>
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\[
I(\lambda) = f_{\text{strat}} \times I_1(P_{\text{strat}}, \lambda) + f_{\text{mid}} \times I_1(P_{\text{mid}}, \lambda) + (1 - f_{\text{strat}} - f_{\text{mid}}) \times \\
[ a_{\text{bot}} \times I_1(P_{\text{bot}}, \lambda) + (1 - a_{\text{bot}}) \times I_0(P_{\text{bot}}, \lambda) ]
\]
effect of CH$_4$ mixing ratio on H-band fit quality

Baines et al. 1995
Lindal et al. 1987
sample fits for 1% CH4

Pmid = 2.1 bars
Pbot = 6.8 bars
fmid = 0.006
abot = 0.030

Pmid = 1.9 bars
Pbot = 5.8 bars
fmid = 0.008
abot = 0.033
In the bright band clouds are more reflective and at a lower pressure.

Main clouds are near 2-3 bars and 7 bars at all lats.

The dark northern hemisphere is due to lower reflectivity of main clouds (50% lower at 35 N).
SUMMARY

• 1.0+/-0.3% CH4 provides best fits to H spectra at most latitudes (lower than prior estimates of 1.6% and 2.3%)

• There is no significant cloud contribution at the methane condensation level (near 1.2-1.3 bars), nor at the expected level of 3.8 bars from prior analyses.

• Bandpass filter images confirms lack of band structure at 1.2-bar methane condensation level.

• Instead we find the main clouds are near 2-3 bars and 7 bars, slightly lower at higher CH4 mixing ratios (similar pressures found from analysis of 0.6-0.83 micron STIS spectra; presented in Fry and Sromovsky poster 55.03).

• The darker northern hemisphere is due to lower reflectivity of the main clouds near 2 bars and 7 bars.

• The bright band is due to increased reflectivity and lower pressure of main clouds (both vary across bright band).