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# Uranus' cloud structure and scattering particle properties from IRTF SpeX observations

**D.S. Tice (1)**, P.G.J. Irwin (1), L.N. Fletcher (1), N.A. Teanby (2), G.S. Orton (3), G.R. Davis (4).

(1) Atmospheric, Oceanic and Planetary Physics, Department of Physics, University of Oxford, Clarendon Laboratory, Parks Rd. Oxford OX1 3PU, United Kingdom (tice@atm.ox.ac.uk), (2) Department of Earth Sciences, University of Bristol, Wills Memorial Building, Queen's Road, Bristol BS8 1RJ, United Kingdom, (3) Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Dr., Pasadena, CA 91109, USA, (4) Joint Astronomy Center, 660 N. A'ohoku Place, Hilo, HI 96720, USA.

## Abstract

Observations of Uranus were made in August 2009 with the SpeX spectrograph at the NASA Infrared Telescope Facility (IRTF). Analysed spectra range from 0.8 to 1.8 µm at a spatial resolution of 0.5" and a spectral resolution of R = 1,200.

Spectra from 0.818 to 0.834 µm, a region characterised by both strong hydrogen quadrupole and methane absorptions are considered to determine methane content. Evidence indicates that methane abundance varies with latitude.

NEMESIS, an optimal estimation retrieval code with full-scattering capability, is employed to analyse the full range of data. Cloud and haze properties in the upper troposphere and stratosphere are characterised, and are consistent with other current literature. New information on single scattering albedos and particle size distributions are inferred.

## 1. Introduction

A wealth of observations and analysis has focused on Uranus during the past decade. These studies, surrounding the 2007 spring equinox, have characterised the planet as much more dynamic than originally concluded through study of *Voyager* observations.

A comparison of methane and hydrogen absorption data applied in a 2002 Uranus study showed evidence that the standard interpretation of a constant latitudinal methane mixing was likely flawed (3). Utilising a similar method, we will show that our 2009 data supports the conclusion that Uranian methane abundances are latitudinaly dependant.

Publications demonstrate that in 2009 there exists a deep, optically thick cloud deck between 2 and 3 bars, as well as an optically thinner cloud above this, ranging from 0.1 to 0.5 bar, depending on latitude. Both cloud layers trend higher when moving away from the equator towards northern and southern midlatitudes (2). Our analysis will build on these findings, further refining the characteristics of these clouds and providing evidence for some scattering properties that were inaccessible in previous studies.

## 2. Observations & Data Reduction

Observations in this study were acquired over 3 nights in August 2009 using NASA's IRTF telescope facility on Mauna Kea, Hawaii. The data were taken with the SpeX infrared spectrograph operating in its short wavelength, cross-dispersed mode between 0.8 and 2.4 µm (4). The data were mapped at spectral resolution R = 1,200 onto a 1024 x 1024 pixel array.

Data reduction was completed using SpeXtool (1,5), an image-processing package designed for SpeX data. Additional processing was required to optimize SpeXtool results for extended source observations and to provide latitudinal mapping. An A0V-type star (HD1160) was used to correct for telluric absorption. The data analysed here range from 0.8 to 1.8 µm and have a spatial resolution of 0.5" ± 0.1".

## 3. Methane Mixing Variation

Strong methane absorption lines dominate Uranus' spectrum between 0.8 and 1.8 µm, making it difficult to distinguish changes in methane abundance and changes in cloud height. At 0.825 µm, however, collision-induced absorption of hydrogen has an impact on the spectrum comparable to that of methane, affording us a method of making this determination.

If methane were evenly mixed with hydrogen at all latitudes, one would expect the shape of a latitudinal radiance plot of points where methane absorption dominates to match the shape of a similar plot for hydrogen-dominated absorption. Figure 1 indicates this is not the case. The difference in shape of these two groups indicates that methane is not well mixed; rather methane abundance is latitudinally dependent. Implications will be discussed.

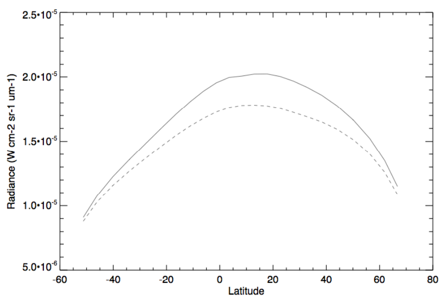


Figure 1: Latitudinal radiance at 0.825 µm. Absorptions that are hydrogen-dominated (solid) and hydrogen/methane balanced (dashed).

## 4. Scattering Particle Properties

Our data, which unlike many previous studies extends below 1.0 µm, provide additional constraints on scattering particle properties. Previous models seem to fit our data well in regions longward of 1.2 µm. Additional data at shorter wavelengths, however, allows further model refinement. Our model fit is shown in Figure 2. Differences between our model and the Irwin et al. model (2) will be discussed.

## 5. Summary & Conclusions

The IRTF SpeX data has proved particularly useful due to its extent shortward of 1.0 µm. Due to this spectral extent, methane mixing ratios and single scattering albedos of scattering particles, in particular, have been explored. With these additional details and constraints, previous models have been refined.

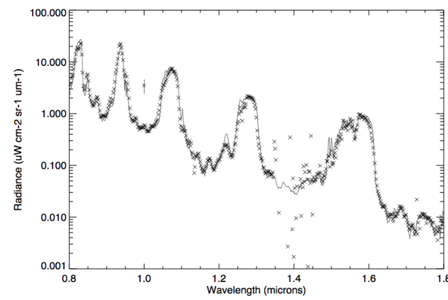


Figure 2: Model fit (line) and observations (x's).

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