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A search for additional volatile ices on dwarf planet (136472) Makemake

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Abstract

The spectrum of dwarf planet Makemake is dominated by volatile CH_4 absorption, preventing direct identification of the other volatiles N_2 and CO. A new absorption feature at 2.238 μm was recently identified in the lab as being due to N_2 and CO in solution, with near-equal amounts producing the strongest absorption. We observed Makemake with the twin LUCI spectrographs at the LBT in order to search for the 2.238 μm feature.

1. Introduction

The surface compositions of Kuiper Belt Objects (KBOs) provide clues about the environment in which these objects formed, their original and current inventories of volatile ices, the ongoing chemical and physical processes at work on these bodies, and the potential to support atmospheres. Volatile ice species, those with high enough sublimation pressures at typical KBO surface temperatures (~40 K), are CH_4, N_2, and CO [1]. Over the age of the solar system, volatile ices should be lost from the surfaces of smaller, warmer bodies while larger, colder bodies retain them [2,3]. Only a handful of objects, including Pluto and the captured KBO Triton, should (and do) retain volatile ices on their surfaces. Understanding the exact physical and orbital circumstances that result in retention of volatiles is a key question in KBO studies.

The dwarf planet (136472) Makemake represents the perfect opportunity to test volatile retention theories in the Kuiper Belt. According to [2], Makemake is within the transition region for retention of volatile ices. Methane is definitively identified in the spectrum of Makemake, but due to the strength of these CH_4 absorption features [e.g., 4] direct detection of the N_2 and CO features at 2.15 μm and 2.35 μm, respectively, is not feasible. Previous work reported an indirect detection of N_2 due to the shift in the central wavelengths of multiple CH_4 features [e.g., 5]. No previous investigations have attempted to identify CO on Makemake due to the prior lack of observable features.

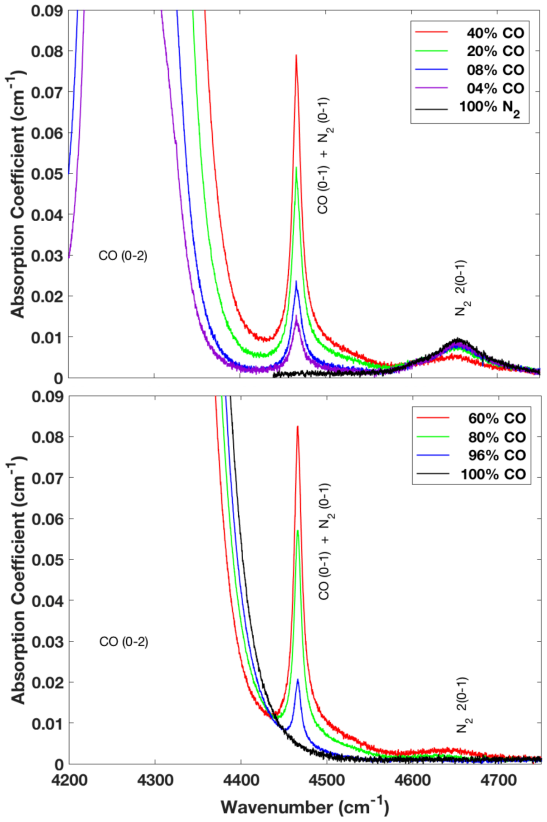

Figure 1: Absorption coefficients for various N_2:CO mixtures. The 4468 cm^{-1} (2.238 μm) absorption feature is strongest for comparable concentrations of N_2 and CO. (Figures from [6].)

Recent work by [6] identified a new absorption band at 2.238 μm that indicates the presence of both N_2 and CO ice and was detected in the near-infrared spectrum of Triton (Fig. 1). This band is unusual in that it is strongest when these two ice species are in solution in equal amounts, but is not present for pure N_2 or pure CO. On the only outer solar system bodies with direct detections of N_2 ice, Pluto and Triton, CO is present as well, identified by the

2.35 μm absorption feature [e.g., 7,8]. These species also show peak abundances at similar longitudes, suggesting that N_2 and CO may frequently co-exist on icy surfaces [8,9].

2. Observations

Near-infrared spectra of Makemake were obtained on March 30 and April 1, 2019, in order to search for the 2.238 μm absorption feature. These spectra were obtained with the twin LBT Near Infrared Spectroscopic Utility with Camera and Integral Field Unit for Extragalactic Research (LUCIFER) instruments at the Large Binocular Telescope (LBT) [10]. These instruments, typically referred to as LUCI1 and LUCI2, operate in parallel, one for each primary of the LBT. The spectra were obtained at a resolving power of ~6700 over the wavelength range 2.05-2.37 μm using the 210_zJHK grating, the N1.8 camera, and the 0.5" slit. Total time on-target was 2 hours each for LUCI1 and LUCI2.

3. Results

We present the reduced, corrected, and combined spectrum of Makemake between 2.05-2.37 μm. The presence or absence of the 2.238 μm N_2:CO feature, and its implications for Makemake's surface evolution and potential for an atmosphere at closer heliocentric distances, will be discussed.

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References

[1] Fray, N., Schmitt, B.: Sublimation of ices of astrophysical interest: A bibliographic review, P&SS, Vol. 57, pp. 2053-2080, 2009.

[2] Schaller, E.L., Brown, M.E.: Volatile loss and retention on Kuiper Belt Objects, ApJ, Vol. 659, pp. L61-L64, 2007.

[3] Johnson, R.E., et al.: Volatile loss and classification of Kuiper Belt Objects, ApJ, Vol. 809, id. 43, 2015.

[4] Licandro, J., et al.: The methane ice rich surface of large TNO 2005 FY_9: A Pluto-twin in the trans-neptunian belt?, A&A, Vol. 445, pp. L35-L38, 2006.

[5] Tegler, S.C., et al.: Evidence of N_2-ice on the surface of the icy dwarf planet 136472 (2005 FY9), Icarus, Vol. 195, pp. 844-850, 2008.

[6] Tegler, S.C., et al.: A new two-molecule combination band as diagnostic of carbon monoxide diluted in nitrogen ice on Triton. AJ, in press, 2019.

[7] Grundy, W.M., et al.: Near-infrared spectral monitoring of Triton with IRTF/SpeX II: Spatial distribution and evolution of ices, Icarus, Vol. 205, pp. 594-604, 2010.

[8] Grundy, W.M., et al.: Near-infrared spectral monitoring of Pluto's ices: Spatial distribution and secular evolution, Icarus, Vol. 233, pp. 710-721, 2013.

[9] Holler, B.J., et al.: On the surface composition of Triton's southern latitudes, Icarus, Vol. 267, pp. 255-256, 2016.

[10] Seifert, W., et al.: The NIR spectrograph LUCIFER for the LBT, Proc. SPIE, Vol. 4841, pp. 962, 2003.