A Search for α N_2 on Pluto and Eris

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Laboratory studies of N_2 ice near 2.15 μm show that the two phases of solid N_2 ice have different spectroscopic characteristics [1]. At temperatures > 35.61 K, N_2 is in the β (hexagonal) phase, while at lower temperatures it is in the α (cubic) phase. The N_2 band has been detected on Triton and Pluto [2, 3], but not on other Kuiper Belt Objects (KBOs). The observed band shapes on Triton and Pluto are consistent with β N_2 ice. However, if α N_2 is present as a minor fraction of the total N_2 abundance, then the 2.15 μm band would be a spectral blend of α N_2 and β N_2.

Visible and near-infrared spectra have shown that the band positions and depths of N_2, CO and CH_4 change with rotation [4, 5]. These variations support other studies that have also shown the surface to be heterogeneous [e.g., 6]. [5] showed that CH_4 absorption features have a weak and strong component and that the strong CH_4 bands are correlated with Pluto's visible light curve. Both the greatest CH_4 band depth and visible light curve are maximum around 215° E. longitude [5]. The N_2 band, however, is deepest near 110° E. longitude and is nearly constant through 200° E. longitude while CO has a maximum near 170° E. longitude. This suggests that N_2, CO and the weak CH_4 are isolated from the source of the strong CH_4 bands.

We will present analysis of Pluto's N_2 band from Gemini North/NIRI in 2003 and 2004, Gemini North/NIRI+Altair in 2005 and 2008, and Gemini South/GNIRS in 2004. These observations cover the rotation of Pluto in approximately 40° longitudinal intervals. We analyze the data by producing Hapke models and finding which combination of materials produce a model spectrum that best fits the observations by minimizing χ^2. Fitting the N_2 band is done in a two step process. First, a model is made of Pluto's spectrum from 2.10 to 2.23 μm while the N_2 region (2.12-2.17 μm) is masked out. The data are fit to a Hapke model assuming a salt-and-pepper mixture of pure CH_4 and diluted CH_4 at 40 K. The optical constants for pure CH_4 are shifted to shorter wavelengths by about 4 nm and are used to substitute the optical constants for diluted CH_4. In addition to the surface components, the model also includes the contribution of gaseous CH_4. In the Gemini North observations it is difficult to know whether or not the gaseous CH_4 is telluric or from Pluto because of the low resolving power blends the CH_4 features. In the Gemini South observations, the lines are more distinguished and mostly appear as sharp features near the minimum of the 2.20 μm CH_4 band. This model is used to remove the slope behind the N_2 band and CH_4 absorption feature near 2.2 μm. The normalized spectrum is then fit by either (i) β N_2 only, or (ii) a mix of α and β N_2. Preliminary results show that α N_2 may be present at the 20% level at longitudes corresponding to areas of deepest N_2 absorption [5].

The arrival of *New Horizons* at Pluto in 2015 will not be able to clearly detect α N_2. The LEISA instrument on *New Horizons* has a resolving power of 250 from 1.25-2.50 μm, and a high resolution ($\lambda/\Delta\lambda \sim 500$) region at 2.10-2.25 μm designed to map out the location and abundance of N_2. While *New Horizons* will obtain superior spatial information, its spectral resolution is similar to the NIRI+Altair observations analyzed here.

The 2.15 μm N_2 ice band has not been detected on any other KBO, but evidence exists for its presence on Makemake and Eris [*e.g.*, 7–9]. The band centers of CH_4 appear shifted to shorter wavelengths. On Pluto and Triton, this indicates that CH_4 is diluted in N_2. In the case of Eris, which has a heliocentric distance of ∼97 AU, its blackbody equilibrium temperature would be 29 K if it had *zero* albedo. However, Eris' albedo is closer to 60-80% [10–12] and therefore it has a blackbody temperature closer to 19 to 23 K. If N_2 is present on Eris, then it is most likely in the α phase. We present analysis based on the high resolution ($\lambda/\Delta\lambda \sim 5000$) data from [9]. We estimate that Eris' surface could be as much as 99.75% α N_2 and still not be detected in these data.

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