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THE TEMPERATURE OF NITROGEN ON PLUTO; K.A. Tryka, Division of Geological and Planetary Sciences, Caltech, R.H. Brown, Jet Propulsion Laboratory, D.P. Cruikshank, NASA Ames, T.C. Owen, Institute for Astronomy, University of Hawaii

Millimeter flux measurements of the Pluto/Charon system [1,2] have placed the temperature of Pluto between 30 and 44 K. This is in conflict with previous infrared flux measurements obtained by IRAS [3,4] which placed the temperature of Pluto closer to 55 K. Recent spectroscopic measurements of Pluto have shown that nitrogen and carbon monoxide exist on the surface of Pluto [5], in addition to the methane previously identified [6]. Laboratory work [7,8] has shown that the 2.148 μm band of solid N_2 is temperature dependent. Using laboratory data of N_2 and groundbased spectral data of Triton [9] Tryka et al. [7] determined a temperature for the nitrogen on Triton which is in agreement with Voyager 2 measurements. Thus, an analysis of the spectrum of Pluto is expected to yield an accurate temperature for the nitrogen on that body.

Solid nitrogen exists in three phases [10]. The cubic α phase exists at temperatures below 35.6 K at 0 pressure; the hexagonal β phase exists at temperatures above 35.6 K and below the triple point (63.15 K) at 0 pressure. The γ phase exists only at high pressures and is not relevant to planetary surfaces.

There is a dramatic change in the shape of the 2.148 μm band in solid nitrogen as it passes from the β to α phase [11]. In the β phase the band is quite shallow and very broad while in the α phase the band is much deeper and very sharp. More recent work has shown that changes in the spectral band are not only a function of the nitrogen phase, but also a function of temperature [7,8]. As β N_2 is cooled the 2.148 μm band systematically deepens and gets narrower (Figure 1). In addition, between 35.6 K and about 41 K a second feature appears at 2.16 μm. Thus the shape of the spectral band is a reliable indication of the temperature of the nitrogen.

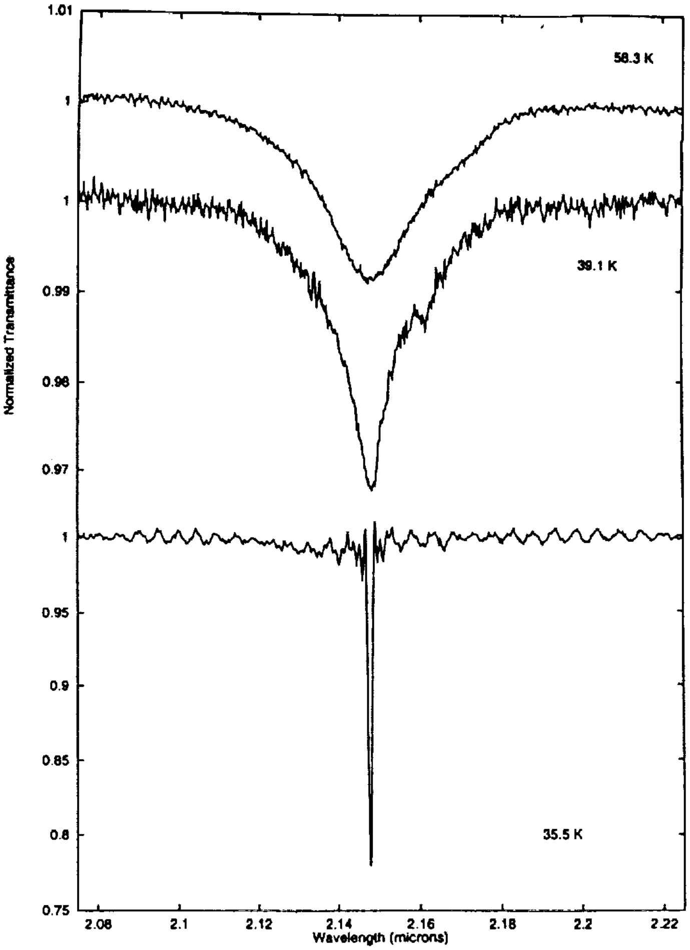

Figure 1

With Hapke scattering theory [12] and absorption coefficients derived from our laboratory measurements of N_2 ice we have modeled the spectrum of Triton [9]. By comparing a Hapke scattering model to the measured spectrum from Triton we determined the temperature of the N_2 on the satellite's surface to be 38 (+2,-1) K which is in accord with the measurements of Voyager 2 [13,14].

Applying this technique to Pluto we find that the temperature of N_2 on that body is 40±2 K (Figure 2). If the distribution of N_2 on the surface and in the atmosphere of Pluto is controlled by vapor pressure equilibrium (as is apparently the case on Triton) the areas of N_2 will be isothermal while areas bare of N_2 could have a significantly higher temperature. By considering Pluto to be a non-isothermal body we were able to create a model which is able to match the millimeter and infrared flux points simultaneously.

Our model Pluto consists of a spherical planet with symmetric, isothermal N_2 polar caps. The equatorial region is bare of N_2 and assigned a bolometric albedo. It's temperature is determined by instantaneous equilibrium [15]. Charon is modeled as a spherical planet with an albedo typical of icy satellites and its temperature is also calculated using instantaneous equilibrium.

Figure 3 shows a sample flux model

(solid line) along with flux measurements of the Pluto/Charon system (shown with error bars) and upper limits to fluxes determined by non-detections (short horizontal lines). The model has polar caps down to ±20° latitude, an equatorial albedo of 0.2, and a Charon albedo of 0.4. This model falls within the error bars of all the data points with the exception of the 1200 μm measurement. Models with other parameters also fit the data, but they have these points in common; the polar caps are very large (extending to latitudes of ±20°-±25°) and the equatorial albedo of Pluto is quite dark (<0.4). Thus, it is possible to match the observed flux points with a simple model of Pluto.

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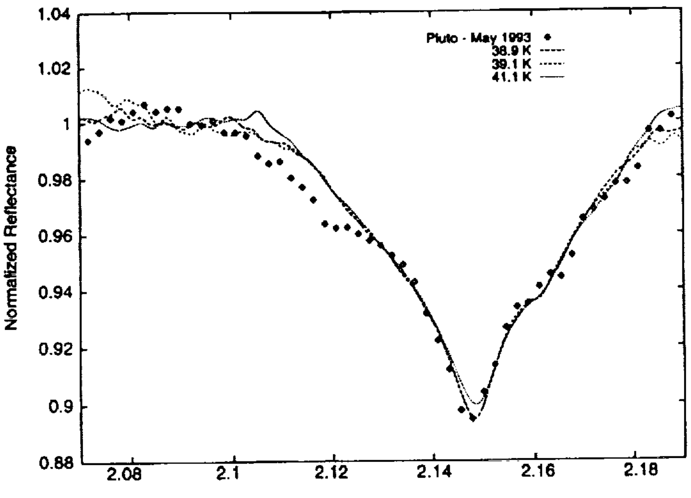

Figure 2

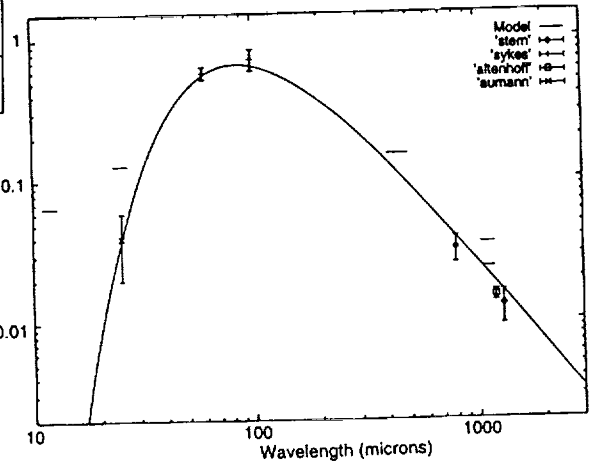

Figure 3