of a massive greenhouse atmosphere. In this paper we explore the characteristics and implications of such an atmosphere. Using a model developed originally for Triton, we consider the basic characteristics of a thick atmosphere sustained by pressure-induced infrared opacity from collisions among nitrogen, carbon monoxide, methane and hydrogen. All but the last have now been identified as ices on the present surfaces of Pluto and Triton. The stability of such an atmosphere is a sensitive function of the surface heat flux, elevated perhaps early on by tidal evolution of the Pluto-Charon system, and the atmospheric hydrogen mole fraction. During the lifetime of the atmosphere rapid escape and associated fractionation of the volatiles transpired. The fractionation led to preferential retention of methane, with loss of carbon monoxide and nitrogen. The current nitrogen-dominated surface, with carbon monoxide and methane secondary, can be understood in the context of such a models if ammonia (which is cold-trapped near the surface) was available to supply additional nitrogen. We also use our atmosphere model to investigate the important suggestion of Stevenson (1993, LPSC XXIV, 1355) that volatile loss during accretion may have been maximized for bodies between 100 and 1000 km in radius.

35.15-T

Temperature dependent absorption spectra of CH_4 and N_2 ices.

W. Grundy (L.P.L.), B. Schmitt (L.G.G.E.), E. Quirico (L.G.G.E.).

The optical properties of methane and nitrogen ices have traditionally been studied in thin films in the laboratory. At the wavelengths required for interpreting visible and near infrared spectra of Pluto and Triton, thin films of methane and nitrogen ices are too transparent to yield accurate absorption coefficients. Thus the interpretation of telescopic spectra has been hindered by a poor knowledge of the optical behavior of the ices.

We have obtained new absorption coefficient spectra for pure nitrogen[1] and methane ices and liquids, measured in 1 cm thick samples at L.G.G.E. Our spectral resolution was 1 cm^{-1} and our wavelength coverage was approximately 0.68 to 2.5 μm for methane and 1.5 to 2.5 μm for nitrogen. Spectra were obtained at temperatures ranging from 17 K up to the 1-bar boiling points of the liquids. The spectra of both CH_4 and N_2 were observed to change as a function of temperature. In methane ice, our wavelength region contained numerous vibrational overtone bands. Each band became weaker and broader at higher temperatures, with very slight changes in the shapes of some compound bands. In β and liquid nitrogen, similar effects were observed for the 2-0 overtone band around 4650 cm^{-1} (2.15 μm), with a secondary band becoming visible at 4625 cm^{-1} (2.162 μm) at temperatures below ~41 K. On transition to cubic α N_2 below 35.6 K, the 2-0 absorption shifted to 4617 cm^{-1} (2.166 μm) and became much weaker. A strong, narrow double phonon absorption appeared at 4656 cm^{-1} (2.148 μm) as well as a broad, unidentified band of comparable integrated absorption, centered around 4690 cm^{-1} (2.132 μm). In both CH4 and N2, spectral behavior changed very little across the liquid-solid phase transition.

These new data are needed for modeling the albedo spectra of bodies such as Triton and Pluto, and introduce the possibility of independently and remotely determining the temperatures of their icy surfaces via spectroscopy.

[1] Grundy, W.M., B. Schmitt, and E. Quirico 1993. Temperature dependent spectra of α and β nitrogen ice with application to Triton. *Icarus* (in press).

35.16-T

Correlation of Composition with Albedo on Pluto: Past Results and New Problems

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Time-resolved near-IR spectrophotometry of the Pluto–Charon system was obtained in 1988 by Marcialis & Lebofsky (1991, *Icarus* 89, 255). The observations included ~1/3 of the 6.4-day lightcurve, approximately centered on minimum light. Methane band depths varied in the sense that equivalent width was least near minimum light. The most plausible interpretation is that dark regions of the planet's surface are depleted in methane relative to bright areas. This "checkerboard" model gains added plausibility from the 0.3-mag visible lightcurve amplitude.

Recently, spectral features attributed to CO and N_2 were identified in Pluto's near-IR spectrum by Owen *et al.* (1992, *IAU Circular* No. 5532). Subsequent analysis of these data (Owen *et al.* 1993, *Science* in press) shows that, "...Pluto's CH_4 bands are shifted from their laboratory-measured wavelengths, demonstrating that methane and nitrogen must be mixed at the molecular level, forming a solid-state solution. A checkerboard or salt-and-pepper model...will not explain the observed wavelengths of the CH_4 bands." The new data were obtained at rotational phases ~0.1–0.3, which is included in the span of our 1988 CH_4 data.

Here exist two separate, well-founded observational results which at face value point to apparently different models for Pluto's surface. How can they be reconciled? The simplest configuration which seems to work is that offered by Owen *et al.*, whereby CH_4 and N_2 form a solid solution. CH_4 actually serves as a *tracer* for N_2, *i.e.*, wherever nitrogen goes, methane rapidly follows.

One way to test this hypothesis is to monitor the depth of the N_2 absorption throughout an entire rotation of Pluto. If true, the band depth should vary in step with the continuum (visible) lightcurve, *à la* the CH_4 absorptions. Some time-resolved spectra were obtained by deBergh *et al.* during 1993, but they cover the hemisphere opposite that of the 1988 data.

Should the nitrogen absorption not modulate in step with Pluto's lightcurve, alternative explanations would have to be concocted. Is N_2 ice somehow much darker than CH_4? Can the nitrogen/methane solid solution be restricted to an axisymmetric distribution (polar cap), while pure methane varies with longitude near the equator? These explanations are both more complicated and less tenable than the solid solution idea, but at least the means to test the conjecture are within reach.

35.17-T

Introducing PLUBIB: A Pluto–Charon Bibliography Database

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PLUBIB is a database of literature citations which has been assembled as a by-product of 13 years of research on the Pluto–Charon system. As of this writing it contains 1,005 citations (oops—make that 1,006), and continues to grow an average rate of about 3 per week.

PLUBIB has been found to be an extremely valuable research tool. Some of its uses include: preliminary search of the literature for topic, author, or year of interest, rapid assembly of references for publications in progress, verification and tracking down incorrect or incomplete citations, rapid location of coauthors' names in case the primary investigator is unreachable (who *is* this guy "Al" in *et al.*?), preparation of review articles, and to gain insight into the historical perspective of Pluto–Charon research. More than once, browsing through PLUBIB has sparked new ideas for future investigation.

Inclusion of a citation into the database (and the accuracy thereof), is the sole responsibility of this author. The main criteria for inclusion of a citation into PLUBIB are that the reference must mention "Pluto" or "Charon," or for those prediscovery citations, refer to searches for a new planet. Granted, reference to many topics having direct bearing on the Hadean system are excluded by this criterion (*e.g.*, vapor pressure of methane as a function of temperature). However, examination of the literature cited by those relevant references included in the database usually can direct the researcher where to look.

The current format of PLUBIB is an ASCII file of TeX-based definitions, with citations arranged alphabetically by name of the first author. The definitions are supplied in a separate file called BIBLIO.TEX. Both files are available via anonymous ftp at organpipe.uug.arizona.edu, in the subdirectory /public/lpl.marcialis. Alternatively, an up-to-date copy of the file may be obtained if the magnetic medium is supplied in a self-addressed, stamped mailer package. Only under extenuating circumstances will hard copy be provided. (The file currently is about 50 pages in length.)

35.18-T

Individual Light Curves of Pluto and Charon

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Individual light curves of Pluto and Charon in the visible spectrum have been determined from B filter imaging data taken at the University of Hawaii's 88-inch telescope. Pluto, Charon and ten field stars brighter than B-mag 19 were observed for six days at the end of 1992 Feb. as Pluto passed through its stationary point in right ascension. Astrometric analysis of this data set is being reported by Young et al. (this conference). The Pluto and Charon images were fit using DAOPHOT (Stetson 1987, PASP **99**, 191), which defines a numerical point spread function from selected field stars. Differential photometry was carried out relative to one field star and then transformation coefficients were applied to the results to get standard magnitudes. The resulting light curves show a peak-to-peak amplitude of 0.370 +/- 0.007 mag for