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Short communication

Vacuum ultraviolet photoabsorption of prime ice analogues of Pluto and Charon

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ABSTRACT

Here we present the first Vacuum UltraViolet (VUV) photoabsorption spectra of ice analogues of Pluto and Charon ice mixtures. For Pluto the ice analogue is an icy mixture containing nitrogen (N_2), carbon monoxide (CO), methane (CH_4) and water (H_2O) prepared with a 100:1:1:3 ratio, respectively. Photoabsorption of icy mixtures with and without H_2O were recorded and no significant changes in the spectra due to presence of H_2O were observed. For Charon a VUV photoabsorption spectra of an ice analogue containing ammonia (NH_3) and H_2O prepared with a 1:1 ratio was recorded, a spectrum of ammonium hydroxide (NH_4OH) was also recorded. These spectra may help to interpret the P-Alice data from *New Horizons*.

1. Introduction

New Horizons being the first dedicated mission to explore the Pluto and its moons has been returning data from the on board scientific payloads since July 2015. Well before the New Horizons encounter it was widely known that the chemical compositions of both Pluto and Charon were dominated by the presence of simple ices such as N_2/CH_4/CO [1] and NH_4OH [2], respectively. A recent report also indicates compositional diversity of molecular ices on Pluto's surface [3]. The flyby of New Horizons, revealed water to be a component of icy Pluto and pure ammonia exists within Charon system.

The LEISA instrument also found ammonia (NH_3) and crystalline water (H_2O) ices [4–5] to be present on the surface of Charon with the mixture of these ices causing the geological features and activities on Charon's surface [6]. In addition, the spectra of these ices were measured using the Ultraviolet Imaging Spectrograph, P-Alice, from 50 to 180 nm region [7]. In order to determine the morphology and composition of these ices from P-Alice data it is necessary to record laboratory spectra under appropriate simulation conditions [8]. In a recent article, Sivaraman et al. [9] had reported the detectable wavelength for nitriles. In this short communication we report the first VUV (110–180 nm) photoabsorption spectra of ice analogues of both Pluto and Charon. Such experimental spectral signature can also be used for other distant icy bodies such as Eris and Makemake.

2. Experiment

The present experiments were carried out at National Synchrotron Radiation Research Centre (NSRRC) in Taiwan. A detailed description of the experimental setup was provided in an earlier publication [10–11]. In brief, the incident vacuum ultraviolet light from beamline BL03 was dispersed with a 6 m Cylindrical Grating Monochromator (CGM) and passed through a gold mesh with transmission about 90%; the photocurrent was detected with an electrometer (Keithley 6512) to monitor and to normalize the beam [11]. To measure an absorption spectrum, a spectrum (I_o) was recorded before deposition of the ice mixtures. Subsequently, the gaseous samples were conducted into the Ultra High Vacuum (UHV) chamber and were deposited on a Lithium Fluoride (LiF) substrate attached to a cold head of a rotary cryostat (APD HC-DE204S) maintained at 10 K (Fig. 1). Another spectrum (I) was recorded after deposition of the ice mixtures; by this means, the absorption spectrum was derived based on Beer–Lambert's law. The spectra of pure ices were recorded at 0.2–0.5 nm and 1.0 nm step sizes [8] whereas the spectra of ice mixtures were recorded at 1 nm to match the step size of P-Alice.

The molecules forming the ice film were premixed with required ratio before being let into the UHV chamber and deposited on a LiF substrate attached to a cold head maintained at a temperature of 10 K. The Pluto mixture was also mixed with water in the ratio N_2:CO:CH_4:H_2O =

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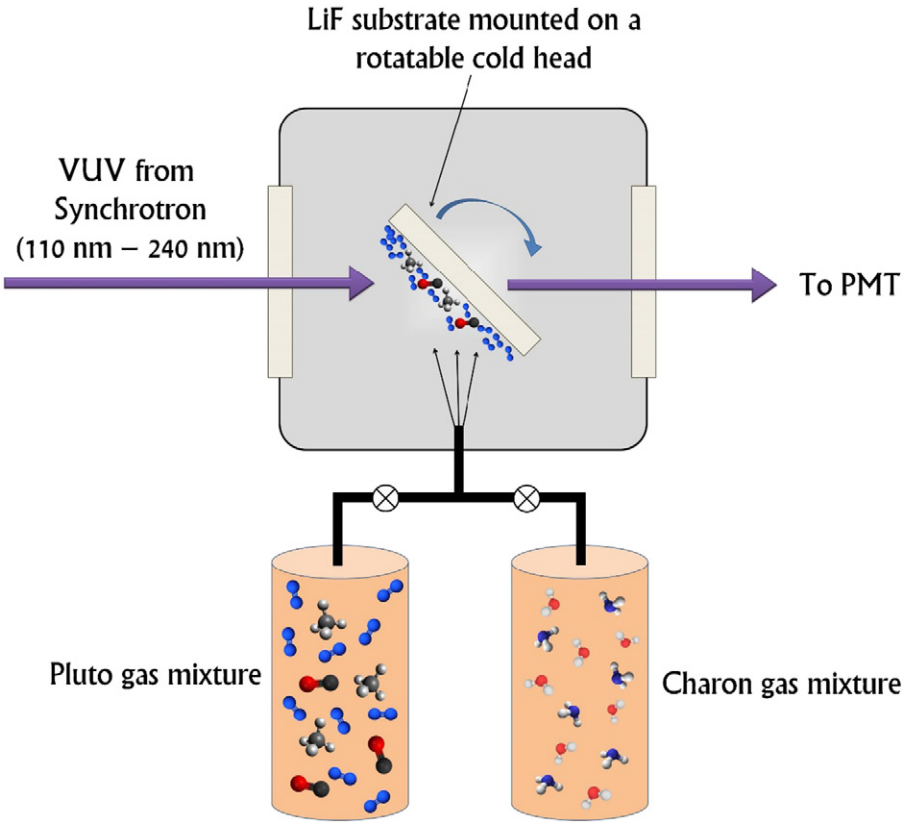

Fig. 1. Schematic of the Experimental Facility housed at NSRRC, Taiwan to record VUV spectra of Pluto and Charon ice analogues.

100:1:1:3 to explore the effect of water in the VUV spectra of the surface of Pluto. Such a mixture is an analogue of certain regions of Pluto's icy surface due to molecular compositional diversity across different regions in Pluto. In order to mimic the ice layers on Charon NH_3 (99% pure) and H_2O molecules were mixed in gas phase in the ratio 1:1 and then allowed to condense onto the LiF substrate at 10 K. Spectra of NH_4OH ice, as a function of temperature, were also recorded to compare with observational data on the surface ices of Charon. Due to the lack of ice thicknesses values for those ice mixtures used in these experiments we are unable to present the cross-section values for those spectra recorded.

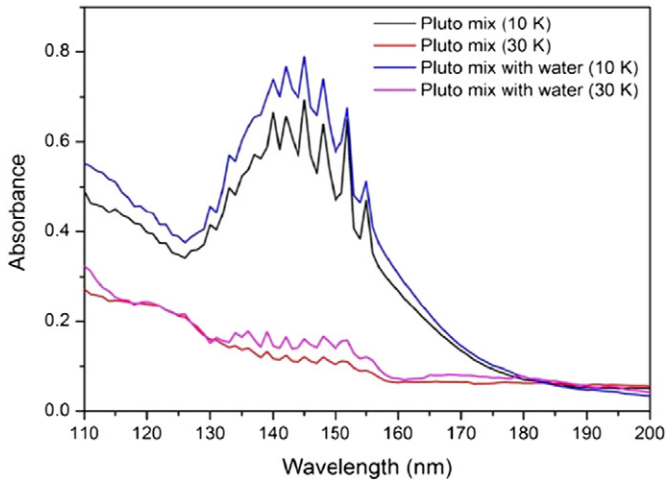

Fig. 2. VUV Photoabsorption spectra of Pluto ice mixtures at 10 K and warmed to 30 K.

3. Results and Discussions

3.1. Pluto Ice Analogue

N_2, CO and CH_4 were mixed in the ratio 100:1:1 in order to mimic Pluto's chemical composition and the gas mixture was deposited on the LiF substrate maintained at 10 K to form an ice layer of a few

Table 1
Peak positions observed in the photoabsorption of pure ices N_2, CO, CH_4, H_2O [8] and the Pluto ice mixtures with and without H_2O. The spectral scan steps for ice mixtures were 1 nm.

N_2 (nm)	CO (nm)	CH_4 (nm)	H_2O (nm)	Pluto mixture (nm)	Pluto mixture with water (nm)
111.5	130.5	110–133	110–160	121	121
113.1	132.6			123	123
114.9	135			130	130
116.7	137.2			133	133
118.5	139.7			137	137
120.3	142.2			140	140
122.2	145.3			142	142
123	148.5			145	145
124.5	152.8			148	148
125.2	156.2			152	152
126.8				155	155
127.5					
129.2					
130					
131.8					
132.8					
134.2					
135.6					
137.2					
138.6					
142					
145.5					