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The state of Pluto's atmosphere in 2012–2013 ☆,☆☆,☆☆☆

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ABSTRACT

We observed two stellar occultations on UT 4 May 2013 and UT 9 September 2012, with the aim of measuring Pluto's atmospheric parameters. Both of these events were observed by world-wide collaborations of many observers, and both occurred within 1 month of Pluto's stationary points. The PC20120909 event was observed at the McDonald Observatory (MONET 1.2-m), and Olin Observatory (the Ortega 0.8-m); the P20130504 event was observed at the Las Campanas Observatory (du Pont 2.5-m), the Cerro Tololo Inter-American Observatory (SMARTS 1-m), and the Cerro Calán National Astronomical Observatory (Goto 0.45-m). Analysis of the data indicates an atmospheric state similar to that in June 2011. The shadow radius for the event is unchanged from recent events, indicating an atmosphere that is holding stable and not in the midst of global collapse. We discuss the advantages and disadvantages of comparing various atmospheric parameters across events (the shadow radius vs. the pressure at a particular radius). These analyses suggest that Pluto will still have an atmosphere when the New Horizons spacecraft arrives in July 2015.

1. Introduction

Pluto's eccentric orbit and large obliquity result in significant changes in global and local solar insolation over the course of a Pluto year. Because its nitrogen-dominated atmosphere is supported by vapor pressure above the surface ices, the properties and existence of the atmosphere depend critically on the surface temperature of these ices. Pluto's perihelion passage was in 1989; therefore, solar insolation has been decreasing since then yet its atmosphere has persisted and even increased in pressure (Elliot et al., 2007). Pluto's atmosphere will respond to the changing insolation (Hansen and Paige, 1996; Young, 2013), and the manner in which it does is of great interest. Will the atmosphere slowly freeze out or disappear suddenly and dramatically? Models by Hansen and Paige (1996) and more recently by Young (2013) investigate the phase space of possibilities for the evolution of the atmospheric pressure, bounded by estimates of the thermal inertia of the surface ices. While recent occultation results suggest that Pluto's atmosphere may not collapse at any time during its orbit (Young, 2013; Olkin et al., 2013), other attempts at modeling

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the global behavior of Pluto's atmosphere find areas within the parameter space that allow for total collapse. One of the most pressing questions is whether the New Horizons spacecraft will find an atmosphere around Pluto when it arrives at the system in July 2015. We present the results of two recent stellar occultations, in 2012 and 2013, and discuss the implications for the survival of Pluto's atmosphere through the New Horizons encounter in 2015.

2. Occultation events

In 2012 and 2013, we attempted observations of several Pluto occultations; two were successful in that the observers were within Pluto's shadow and the weather allowed observations. In Table 1, we list event parameters for our two successful events: PC20120909 and P20130504. In our naming scheme, "PC" indicates an occultation by both Pluto and Charon, while "P" indicates an occultation only by Pluto. We summarize the observing sites and detectors in Table 2.

2.1. PC20120909

The prediction for the occultation of PC20120909 (Fig. 1) placed the shadows of Pluto and Charon directly over large areas of North and South America. Although the star is only $m_R = 15$ and thus fainter than our highest SNR events, this event occurred near Pluto's stationary point. The geocentric sky-plane velocity was only 5.5 km/s rather than the more usual 20–25 km/s. As a result, this event was accessible to small telescopes down to 24 inches. Observers could employ longer than usual exposure times of up to 5 s to achieve 2 points per scale height.

As a result of the favorable viewing geometry for PC20120909, we had arranged for many observers in North and South America to observe this event. Unfortunately, weather hampered almost

Table 1
Event parameters.

	PC20120909	P20130504
Geocentric midtime (UT)	2012 September 09 02:58	2013 May 04 08:22
Earth ephemeris	DE405	
Pluto ephemeris	PLU017	
Catalog position	(J2000; epoch of event)	
Catalog	UCAC4	UCAC2
R.A.[a]	18 28 47.380 ± 0.129	18 47 52.534 ± 0.184
Dec.[a]	−19 36 36.780 ± 0.126	−19 41 24.248 ± 0.174
μ_α (mas/yr)	−4.4 ± 5.7	−5.4 ± 12.4
μ_δ (mas/yr)	−6.5 ± 5.7	−36.6 ± 12.4
Measured position	(J2000; epoch 2012.5)	
R.A.[a]	18 28 47.377 ± 0.028	18 47 52.533 ± 0.014
Dec.[a]	−19 36 36.774 ± 0.037	−19 41 24.386 ± 0.017
Geocentric close approach (arcsec)	0.044 ± 0.035	0.004 ± 0.039
Geocentric sky-plane velocity (km/s)	5.52	10.21
Magnitudes[b]		
B	16.80	13.85
V	15.86	14.13
R	15.04	14.01
J	13.04 ± 0.03	12.74 ± 0.02
H	12.23 ± 0.03	12.49 ± 0.02
K	11.99 ± 0.03	12.40 ± 0.02
Sub-occultation locations on Pluto longitude, latitude in decimal degrees	MONET	du Pont
	I 221.5 32.7	I 13.8.5 38.1
	E 296.4 −27.2	SMARTS
	FIT	I 130.3 39.3
	I 114.8 26.2	E 358.5 −22.4
	E 43.5 −31.7	Santiago
		I 104.1 39.2
		E 15.4 −10.3

[a] Positions in hms for RA, dms for Dec. Position errors (1 sigma) are in arcseconds.
[b] BVR magnitudes are from NOMAD (Zacharias et al., 2004); all are from the unpublished USNO YB6 catalog. JHK magnitudes are from 2MASS (Skrutskie et al., 2006).

Table 2
Observing sites.

	MONET	FIT	du Pont	SMARTS	Santiago
Aperture (M)	1.2	0.8	2.5	1.0	0.45
Location	McDonald Observatory, TX	Melbourne, FL	Las Campanas, Chile	Cerro Tololo, Chile	Cerro Calán, Chile
Latitude	30°40′17″	28°03′45″.46	−29°00′26″.4	−30°10′07″.92	−33°23′45″
E. longitude	−104°01′18″	−80°37′26″.8	−70°42′13″.2	−70°48′21″.83	−70°32′11″
Elevation (km)	2.0	0.006	2.325	2.2405	0.896
Detector	Apogee Alta	iKon OL936	POETS[a]	POETS[a]	POETS[a]
Filter	Clear	Open	Open	Open	Open
Exposure time (s)	5.0	5.0	0.25	1.0	1.0
Dead time (s)	3.0	1.0	0.0017	0.0017	0.0017
Series duration (UT)	2012 September 09 2:38:37–5:08:00	2012 September 09 2:24:00–3:55:30	2013 May 04 7:50:00–8:50:00	2013 May 04 6:20:00–09:50:00	2013 May 04 8:17:30–8:50:50

[a] The Portable Occultation, Eclipse, and Transit System (POETS) is described in Souza et al. (2006).

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