Modeling FUV Limb Observations by New Horizons' ALICE at Pluto

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Abstract P35D-2159

Abstract

Detailed analysis of the Far UltraViolet (FUV) spectrum of Pluto's upper atmosphere has previously focused on disk airglow observations. Utilizing data from the New Horizons ALICE spectrometer, this work verifies and expands upon prior disk data modeling studies (e.g., Steffl et al., 2020) to include limb airglow observations, describes a novel maximum likelihood regression (MLR) model, and presents initial comparisons with forward modeled predictions from the Atmospheric Ultraviolet Radiance Integrated Code (AURIC). These results cover the detection and analysis of dayglow emissions from N_2, N I, N II, H I, and CO in Pluto's upper atmosphere for both limb and disk airglow observations. By carefully binning spectra taken at closest approach, in particular long-exposure observations made with limb analysis in mind, we determine intensity profiles of detectable species. Thus far we've obtained preliminary disk and limb spectral fits, modeled the wings of the Lyman Alpha photocathode gap to improve spectral source classification, and verified modeled intensity profiles against ALICE limb observations.

Implementation

Instrument Overview

- Observations are performed using the New Horizons ALICE Ultraviolet spectrograph
- Spectral coverage: 520 – 1870 Å
- Spectral resolution: 3.6 Å
- FOV of airglow slit: 0.1° x 4.0°
- FOV of Solar Occultation Channel (SOC): 2° x 2°
- Two plated photocathodes with Ly-α gap between (1180 – 1250 Å)
- 32 spatial channels across both slits

Data Overview

- Satellite near fly-by of Pluto on 14 July, 2015
- Primary observation modes:
  - PC_Airglow_Appr_4: 18 x 150 second histogram exposures
  - PC_Airglow_Appr_3: 10 x 300 second histogram exposures
  - P_Alice_Airglow_Held_1Dump: 180 second held histogram exposure

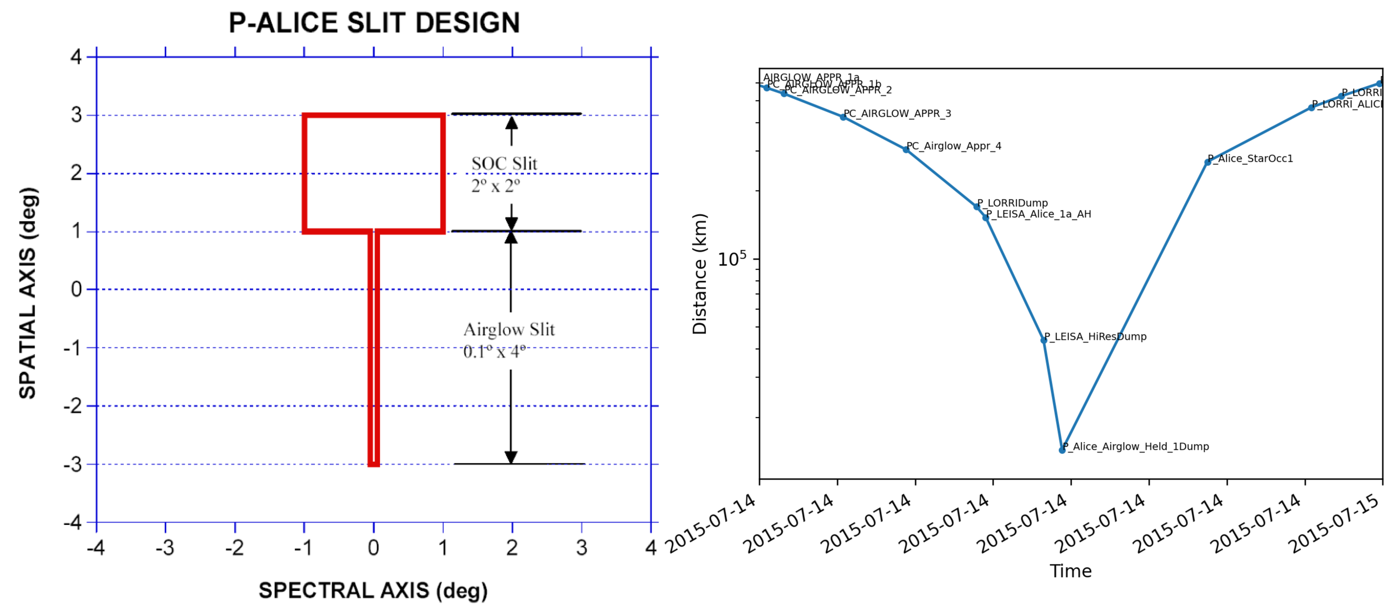

Figure 1: Left: ALICE slit geometry (from [1]). Right: Observation schedule.

MLR Overview

- Templates from AURIC [2] run through custom instrument simulator
  - N_2 Lyman Birge Hopfield (LBH)
  - N_2 Vegard Kaplan (VK)
  - CO fourth positive group (4PG)
  - Lyman Alpha ground calibration observation
- PSF ~ 5 Å spectral
- Non-Negative Least Squares regression algorithm prevents physically unrealistic fit coefficients

Observations

Summary

The primary modes of observation were a single, long-held exposure (P_Alice_Airglow_Held_1Dump) focused on Pluto's limb, a series of 18 exposures (PC_Airglow_Appr_4) centered on Pluto's disk, and a series of 10 exposures (PC_Airglow_Appr_3), all near closest approach.

Sample Observations

- Two main observation modes are shown in Figure 2:
  - Top Left: Radiance image, SOC at bottom, limb highlighted
  - Top Right: FOV, Pluto's disk overlaid when in frame
  - Bottom Left: Spectra of all spatial rows overlaid
  - Bottom Right: Profile of Lyman-α intensity vs Altitude

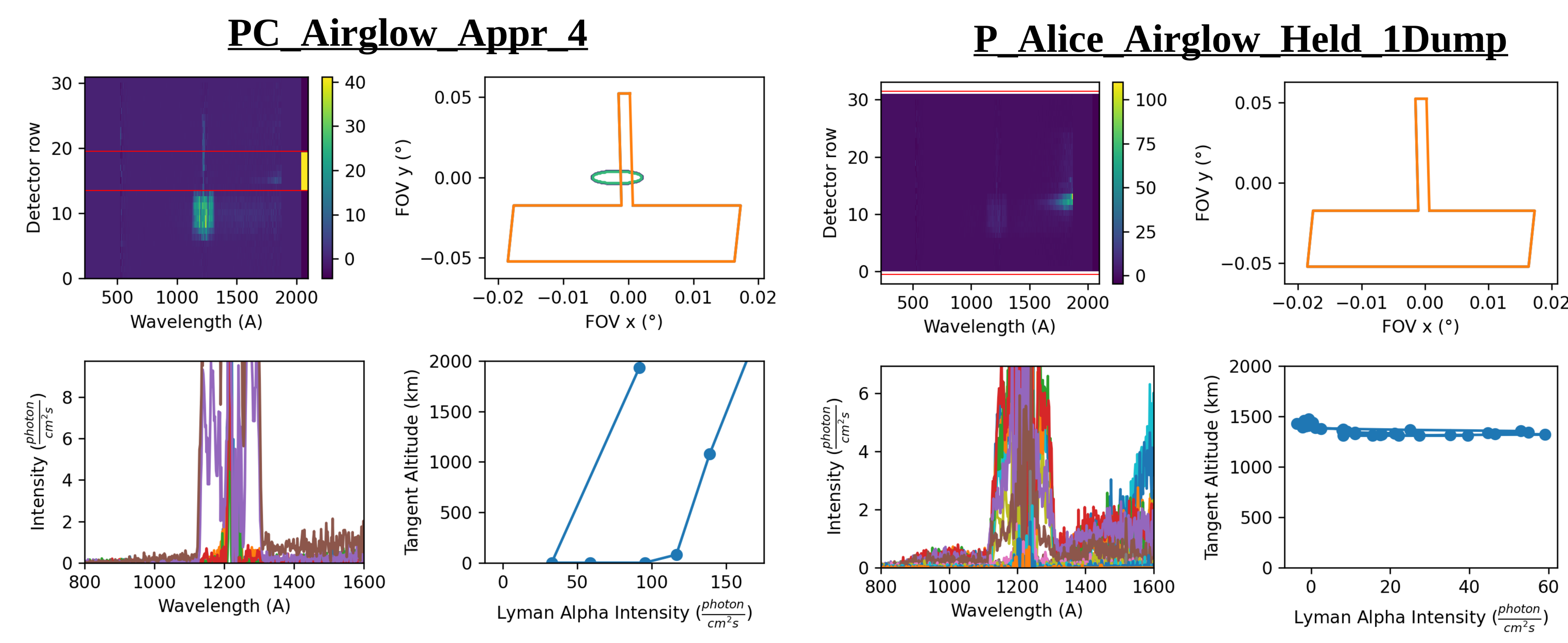

Figure 2: Sample quicklook plots for two of the primary observation modes.

Lyman Alpha Gap

The photocathode gap around Lyman Alpha reduces the 1216 Å peak, but still has residual wings to either side. Fits are currently made above 1350 Å until a proper wing characterization can be completed.

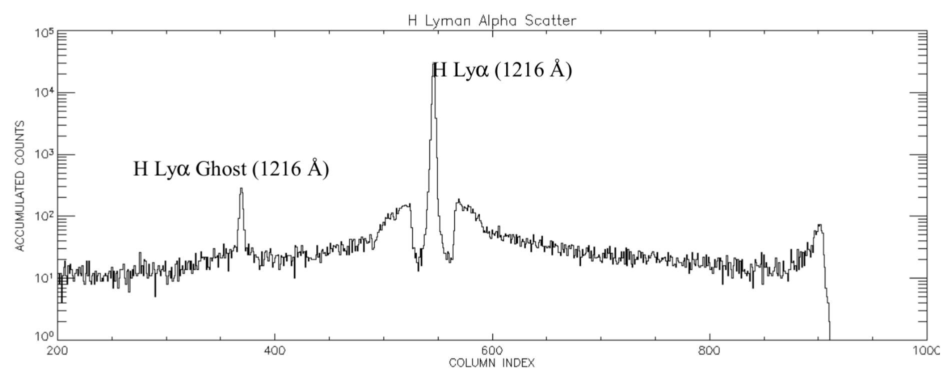

Figure 3: Lyman Alpha spectra showing the photocathode gap and wings. From [1].

References

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Results

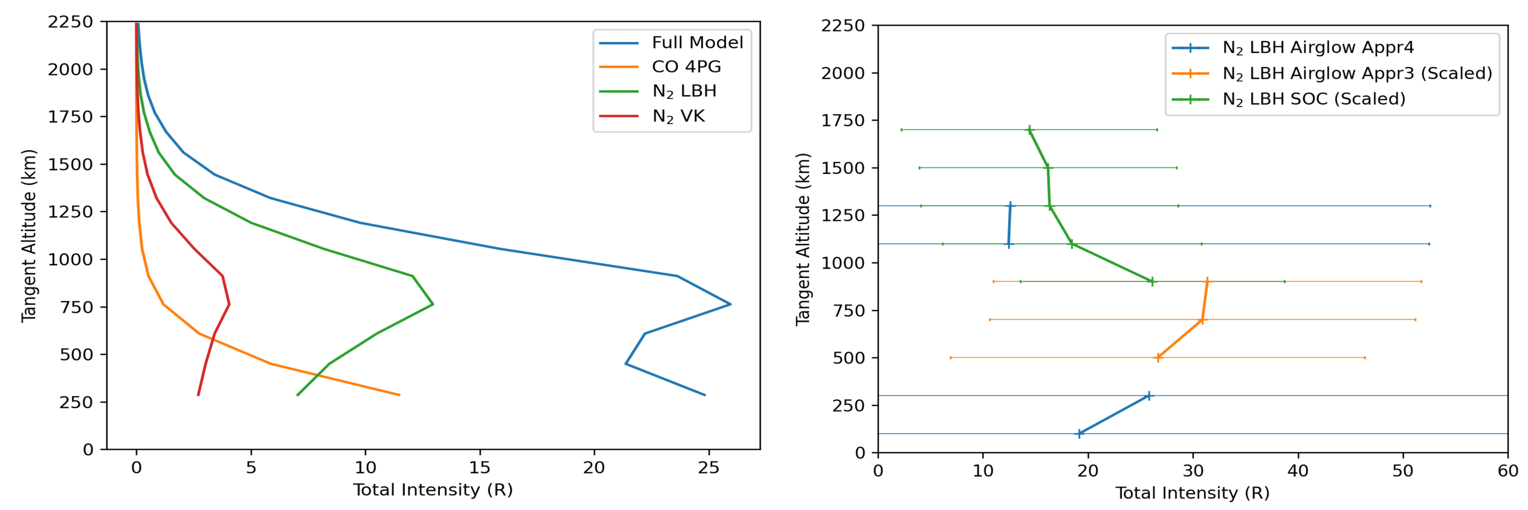
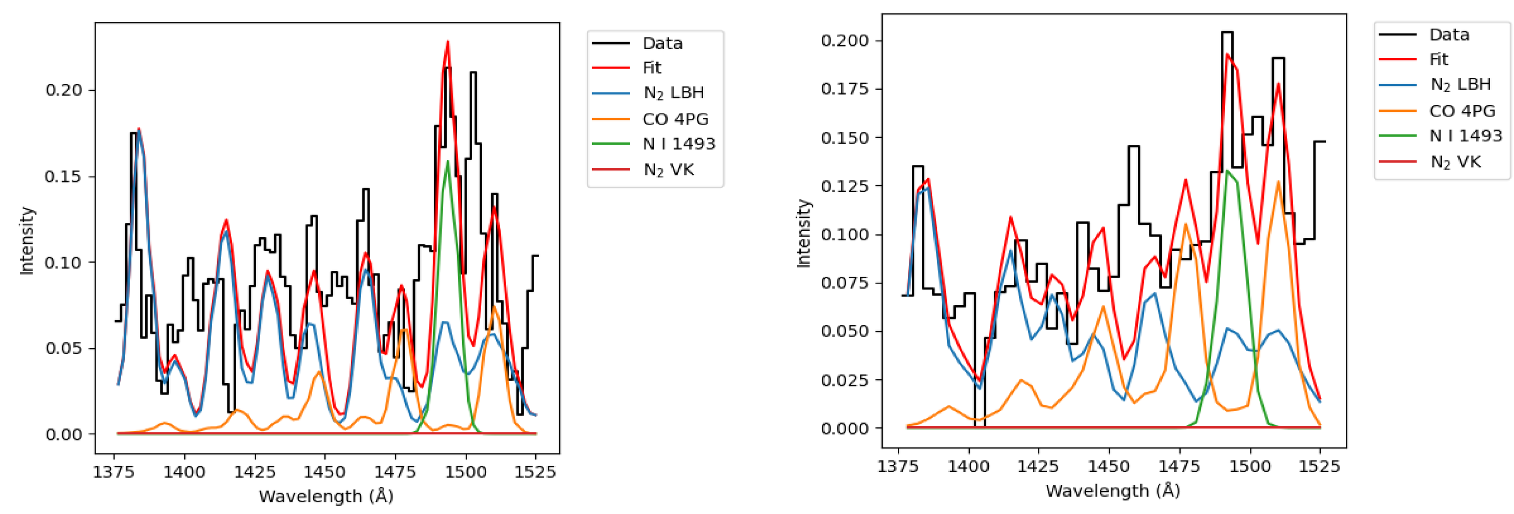


Figure 4: AURIC limb profile (left) and combined airglow observations (right).

AURIC [2] limb profile model (Fig. 4) suggests a peak N_2 LBH tangent altitude of ~800 km. Integration of 1400-1600 Å airglow limb observations supports the general shape. A composite of three observation modes, one using the airglow slit at closest approach (blue), one using the airglow/SOC border pixel just before closest approach (orange), and one using purely SOC slit at closest approach (green) have been scaled to highlight the profile shape, since SOC observed intensities include a higher baseline due to sensitivity differences, and since no single observation mode contains limb observations covering the entire region of interest using the same observation slit.

A sample disk model fit (Fig 5.) highlights the significant contribution N_2 LBH makes in the region, which is further supported by a sample limb model fit, which has been binned to half the original spatial resolution to increase the signal to noise ratio. This also suggests that sources detected on the disk continue to be observed in limb observations.

Figure 5: Sample disk (left) and limb (right) model fits to observed spectra.



Acknowledgements

This material is based upon work supported by the National Aeronautics and Space Administration under Grant 20-NFDAP20_2-0057 issued through the New Horizons Data Analysis Program.

Lyman Alpha ground calibration data provided by Dr. Alan Stern and Dr. Mike Davis at Southwest Research Institute.