Acta Astronautica ∎ (∎∎∎∎) ∎∎∎–∎∎∎

Contents lists available at ScienceDirect

Acta Astronautica

journal homepage: www.elsevier.com/locate/actaastro

An investigation into potential causes of the anomalistic feature observed by the Rosetta Alice spectrograph around 67P/Churyumov–Gerasimenko

John Noonan [a,*], Eric Schindhelm [a], Joel Wm. Parker [a], Andrew Steffl [a], Michael Davis [b], S. Alan Stern [a], Zuni Levin [c], Sascha Kempf [c], Mihaly Horyani [c]

[a] Southwest Research Institute, 1050 Walnut Street, Boulder, Colorado, USA
[b] Southwest Research Institute, 6222 Culebra Road, San Antonio, Texas, USA
[c] Colorado Center for Lunar Dust and Atmospheric Studies, Laboratory for Atmospheric and Space Physics, and Department of Physics, University of Colorado, Boulder, Colorado, USA

ARTICLE INFO

Article history:
Received 14 October 2015
Received in revised form
7 January 2016
Accepted 21 January 2016

Keywords:
Rosetta
Comets
67P/CG
Alice
FUV
Anomalistic

ABSTRACT

The Alice far-ultraviolet spectrograph in operation around the comet 67P/Churyumov–Gerasimenko on the Rosetta spacecraft experiences an anomalistic feature (AF) that is ubiquitous at comet separations less than 450 km. This feature is highly temporally variable and displays no relation to any studied parameters with the exception of comet separation. This paper tests several possible causes with simulations and finds that positive ions produce a partial explanation for the anomaly, but still finds no definitive source of the AF.

1. Introduction

Beginning on August 7th of 2014, just after orbital insertion of the Rosetta spacecraft around comet 67P/Churyumov–Gerasimenko, the ultraviolet spectrograph (UVS) Alice on Rosetta began to return images containing a curved feature near the 850 Å portion of the detector. This anomalistic feature (AF) was similar in appearance to a scattered light feature that had been seen before with the Lyman Alpha Mapping Project UVS on board the Lunar Reconnaissance Orbiter, as well as on Alice during the Rosetta Mars flyby, and so it initially was considered to be normal scattered light during this appearance in early August. Less than a month later, on August 29th, the feature began to quickly change in shape and intensity, earning it the nickname the “Chameleon”. By late December 2014, the frequency of the Chameleon in science images rose to nearly 100% at comet separations less than 450 km, with the AF only disappearing in dark calibrations (when the instrument door was closed), and occupying 80% of stellar calibrations, causing concern among the team that it might be harming the instrument and could create problems with science analysis if it persisted. In this report we discuss the morphology, strength, long term effects on operations, and possible causes and relations for the Chameleon.

2. Instrument description

The Alice instrument is a lightweight, low-power, imaging far-ultraviolet (FUV) spectrograph capable of

* Corresponding author.
E-mail address: noonan@boulder.swri.edu (J. Noonan).

http://dx.doi.org/10.1016/j.actaastro.2016.01.021
0094-5765/© 2016 IAA. Published by Elsevier Ltd. All rights reserved.

Please cite this article as: J. Noonan, et al., An investigation into potential causes of the anomalistic feature observed by the Rosetta Alice spectrograph around 67P/Churyumov–Gerasimenko, Acta Astronautica (2016), http://dx.doi.org/10.1016/j.actaastro.2016.01.021

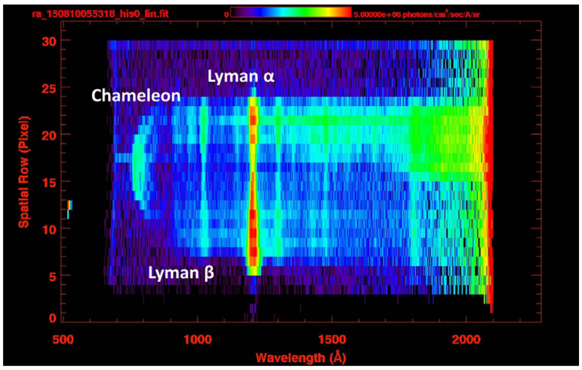

Fig. 1. An average Chameleon for R-Alice, make note of the low counts relative to the cometary signal and slight curvature.

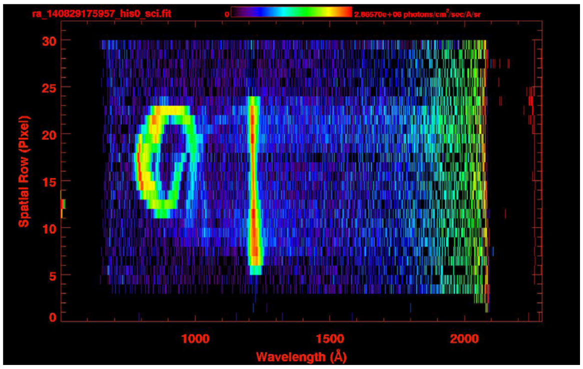

Fig. 2. A Chameleon with increasing curvature, notice extension of shape into opposite facing curves.

gathering spatially resolved spectra in the 700–2050 Å range with a spectral resolution of 8–12 Å for extended sources filling the field of view. The Alice slit is 5.5° long and has a dog bone shape that is 0.05° (100 μm) wide in the center 2.0°-long section and 0.10° (210 μm) wide in the sections on either end. The microchannel plate (MCP) detector format is 35×20 mm with a pixel size 34×620 μm for the 1032 spectral columns and 32 spatial rows; rows 6–24 are illuminated by the slit, and each row subtends 0.30°. The detector uses dual solar blind opaque photocathodes (CsI and KBr) as well as a two-dimensional double delay-line readout. An off-axis telescope feeds into a 0.15-m normal incidence Rowland circle spectrograph with a concave holographic reflection grating, all of which are in an open system. More information on the Alice instrument is detailed by Stern et al. [6].

3. AF morphology and behavior

The early appearances of the Chameleon had a slight curve that opened toward the Ly-α emission line at 1215.67 Å and only extended between rows 13 and 20 on the detector (Fig. 1). The width of these earlier Chameleons is relatively narrow, about 10–20 Å or 5–10 columns (170–340 μm) on the detector. On the 29th of August, 2014 the curvature became much more pronounced, forming curls, tails, and growing in size (Fig. 2). The tails began to extend past Ly-α, extending either from the bottom part of the Chameleon or the top and moving towards the longer wavelength end of the detector (Fig. 3). In the worst cases, like on November 30th, 2014 these tails extend to 1800–1850 Å in the spectral dimension and beyond row 25 in the spatial dimension, which is a part of the detector inaccessible to light following the normal optical path. Additionally the Chameleon feature began to exhibit multiple curves appearing out of the original 850 Å, seeming to extend to the blue end of the detector in a ripple. At the time of this report up to three such curves have been seen in single images, and some combination of these curves is now present in nearly all science images. The majority of counts reported in images containing the Chameleon come from the 790–1000 Å range, which corresponds to columns 790–900 on the detector, with a

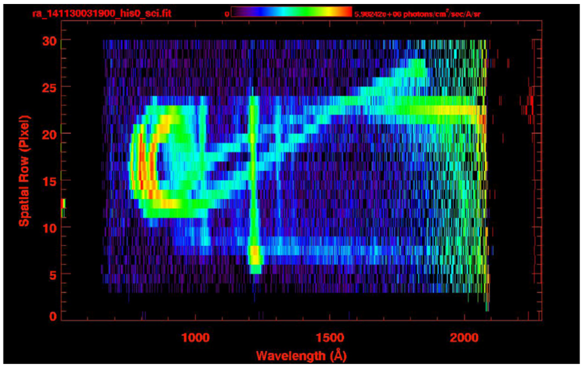

Fig. 3. A Chameleon with increasing strength and tails, notice extension of tails into areas past Ly-α.

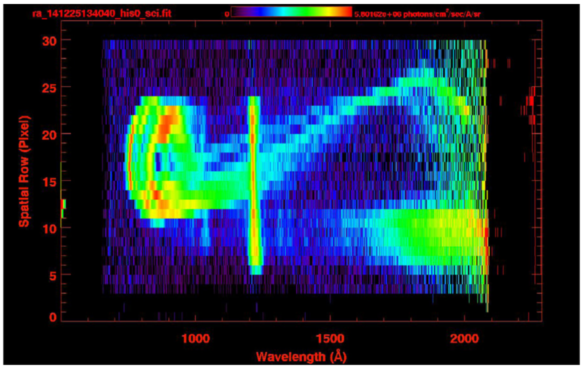

Fig. 4. Similar morphology as in Fig. 3, but with increased non-focused counts in the low wavelength, middle rows on the detector.

width of about 3.7 mm. On December 25th, 2014 several new morphologies were seen that were quite troubling, due to the increased size of the tails (Fig. 4). However, these tails do not appear often, and when they do they have much lower count rates than the primary Chameleon region containing the curves. While the tails have increased in curvature, the most intense count rates of the feature have not moved beyond the column 790–900 region.