Retraction of and Re-analysis of the Data from "HD 121620: A Previously Unreported Variable Star with Unusual Properties"

Roy A. Axelsen
P.O. Box 706, Kenmore, Queensland 4069, Australia; reaxelsen@gmail.com

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Abstract The original paper (published in *JAAVSO*, Vol. 48, No. 1, 2020) is retracted, because the photometric data and conclusions in it are erroneous due to varying degrees of saturation of the images of the target star. This paper describes the results of a study of the original data aimed at determining why the erroneous light curves were highly complex.

Editorial note: We concur with this retraction.

1. Introduction

The analysis of time series DSLR photometry on HD 121620 in 2019 led to the conclusion by the author that the star was variable (Axelsen 2020). However, the author's unpublished DSLR observations in 2020 and 2021 showed that the star was constant, with an average magnitude of 7.06 in V. Consultation with Sebastián Otero about this "behavior" led to the suggestion by him that the images taken in 2019 may have been saturated. Investigation by the author confirmed that saturation of HD 121620 was evident in images from both the green and blue channels in line profile plots and in statistics showing peak ADUs. Images of the comparison and check stars were never saturated. Saturated images from 2019 were obtained through an 80-mm refractor, with an exposure time of 180 seconds. Non-saturated images from 2020 were obtained through the same refractor, but with a shorter exposure time of 60 seconds. Further non-saturated images of HD 121620 were captured in 2020 and 2021 through a 200-mm f/2.8 Canon camera lens, with the camera in a fixed position on a tripod.

The original data analysis comprised conversion of DSLR RAW images to FITS, debayering, and calibration with dark frames and flat fields in IRIS (Buil 1999–2021). When aperture photometry was subsequently carried out on the calibrated images in AstroimageJ (Collins *et al.* 2017), the tabulated output of data showed peculiar negative peak values, disguising the fact of saturation. The author has since found that such spurious values for peak ADUs can be avoided by using IRIS only for conversion to FITS, debayering, and channel separation. Calibration with darks and flats and aperture photometry subsequently carried out in AstroimageJ will yield accurate data, including the tabulation of recognizable peak ADU values that indicate the presence of saturation.

After it became apparent that images of HD 121620 from 2019 contained saturated pixels, it was recognized that a particular point of interest was the complexity of the light curves as shown in Figures 1 and 2 of the retracted paper. The images from 2019 were therefore re-analyzed.

2. Methods

To investigate the error, all original DSLR RAW images were re-processed with AIP4Win (Berry 2020) for both calibration and aperture photometry. Plots of peak ADU values for HD 121620 against JD were made for calibrated data from the green and blue channels for all nights of observation. Line profile plots of images of HD 121620 were made in AstroimageJ for representative non-calibrated images selected after studying the plots of peak ADU values. AstroimageJ, not AIP4Win, was used to create the line profiles because the AstroimageJ output, black lines and text on a white background, is more suitable for figures in publications. Plots of total ADU counts versus JD were drawn for HD 121620, the comparison star, and the check star for selected nights to investigate the apparent "flaring" of the target star.

3. Results and discussion

Figure 1 shows the light curves of HD 121620 and the check star from selected panels of Figure 2 in Axelsen (2020). Each panel represents time series photometry taken through one night. The panels were chosen to reflect the range of "behaviors" of HD 121620. The top panel, for the night of 27–28 May 2019, shows an ascending light curve for HD 121620. Near the beginning there is a temporary, apparent brightening interpreted by the author as a flare. In this panel and the others, the light curve of the check star is horizontal. The middle panel, for the night of 11–12 June, shows slight apparent brightening of HD D121620 for the first one-third of the observing run. There is a near-horizontal curve for the remainder of the night, with an average magnitude of 7.07 in V. The lower panel, for the night of 13–14 June, shows a complex, descending light curve.

To investigate these light curves, images from selected nights were analyzed by examining peak and total ADU values and line profile plots of HD 121620.

The analyses revealed that at least some degree of saturation of the images of HD 121620 occurred every observing night, and that the severity of the saturation (a reflection of the number of pixels saturated) varied between nights, across time within a night, and between the green and blue channels. It is standard practice to defocus images for DSLR photometry, to spread the light from each star across many pixels of the Bayer matrix. The factor that determined differences in the severity of saturation from night to night was the degree of defocussing of the images, with the most severe saturation occurring on the nights when the images were taken closer to focus. On the night of the 13–14 June, when no saturation occurred in either the green or the blue channel during the latter part of the night, the degree of defocus was most pronounced.

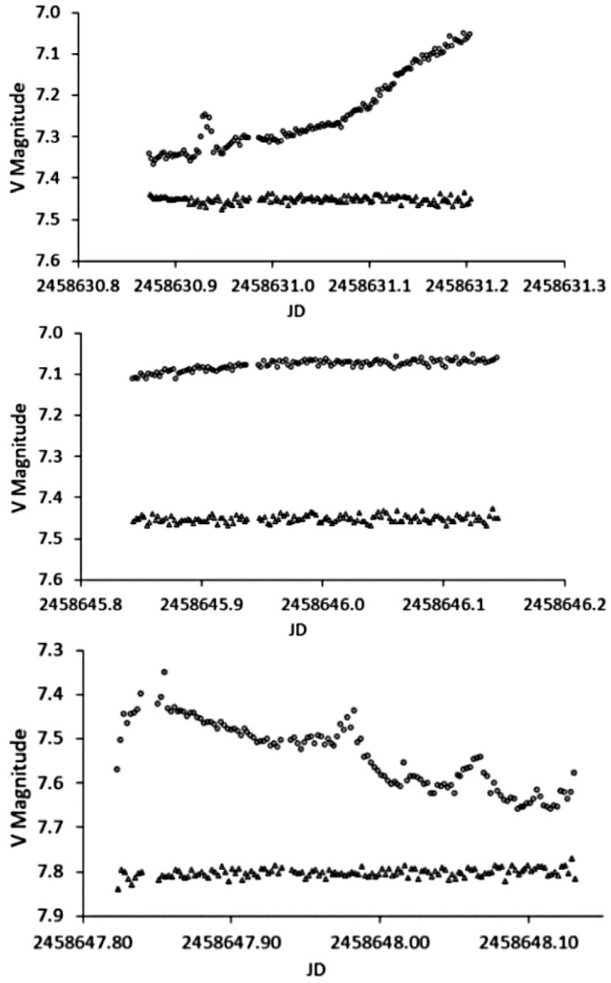

Figure 1. Light curves of HD 121620 and the check star for selected nights in 2019 from Figure 2 of Axelsen (2020), namely, 27–28 May (top panel), 11–12 June (middle panel), and 13–14 June (bottom panel)..

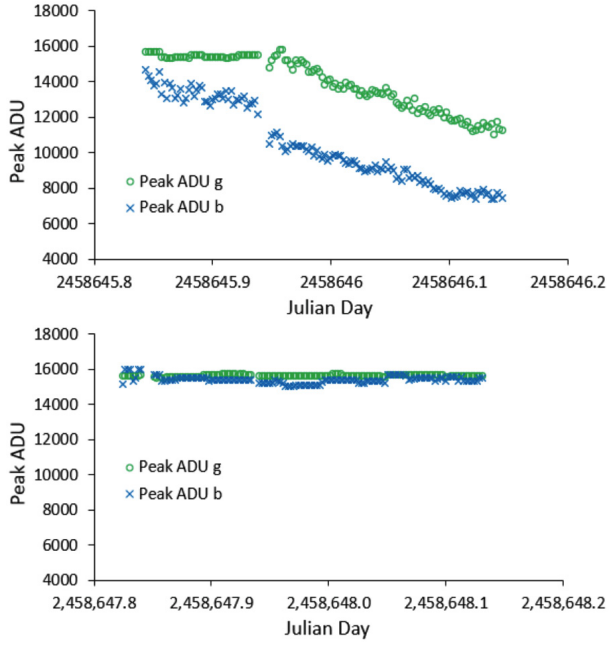

Figure 2. Peak ADU values of HD 121620 for the green (g) and blue (b) channels in calibrated images from the same nights shown in the middle and bottom panels in Figure 1 (the top panel of Figure 1 is discussed toward the end of the paper).

Figure 2 exemplifies these artefacts, showing peak ADU values for HD 121620 from the green and blue channels for the nights of 11–12 June and 13–14 June. Where the plot is a near-horizontal line, at least some pixels are saturated. The author's Canon EOS 500D DSLR camera is routinely set to ISO 400 when taking images for photometry, since the gain is then close to unity. At this setting saturation of pixels occurs at 15,761 ADUs. The saturated regions of the plots in Figure 2 are near-horizontal lines close to this value. The lines are not uniformly at 15,761 because the plots are of data from calibrated images. In Figure 2, saturation of green pixels is evident in the early part of the night of 11–12 June, and for the entire night of 13–14 June. There appear to be no saturated blue pixels on 11–12 June, but blue pixel saturation appears to be present for the entire night of 13–14 June.

Figures 3 and 4 show line profiles of HD 121620 from selected images from the nights of 11–12 June and 13–14 June, respectively. Each panel displays a line profile from one image. In each figure the top panels are from the green channel, and the bottom panels from the blue channel. The panels on the left side of each figure are from an image take early in the night, specifically, the fifth image from the start. The panels on the right side are from an image taken late in the observing run (after midnight), specifically, the fifth image from the end.

The line profiles in Figure 3 show no saturated pixels, although the graphs of peak ADUs for this night in Figure 2 would suggest that there was saturation of at least one or a few pixels in the green channel early in the night. The light curve for this night (Figure 1, middle panel) shows slight apparent brightening early in the night. Later, the light curve of HD 121620 is almost horizontal with an average magnitude in V of 7.07. Since neither the green channel nor the blue channel was saturated late in the observing run, the V light curve here almost certainly shows the true (constant) magnitude of the star. The line profiles of HD 121620 in Figure 4 show extensive green channel saturation both early and late, but only few saturated blue pixels, consistent with the lower panel of Figure 2, which indicates that at least some pixels were saturated in both green and blue channels throughout the entire night of 13–14 June. The presence of a complex light curve for this night presumably reflects variation in the numbers of pixels saturated across the night and non-linearity effects just below saturation. Although not illustrated here, the light curves of HD 121620 drawn from non-transformed green channel magnitudes are essentially the same as the light curves of transformed V magnitudes.

Figure 5 displays total ADUs for HD 121620 for the night of 27–28 May, during which a "flare" was believed by the author to have occurred early in the night (top panel, Figure 1). However, Figure 5 reveals that the fluctuation also affected the comparison and check stars, and was thus due to atmospheric disturbance. The fact that the fluctuation persisted in the final light curve of HD 121620 but not in the light curve of the check star could perhaps be attributed to non-linearity of data just below saturation.

A final point is that data from the All-Sky Automated Survey for Supernovae (ASAS-SN, http://www.astronomy.ohio-state.edu/~assassin/index.shtml) (Shappee *et al.* 2014; Kochanek *et al.* 2017) were interpreted by the author in the original paper

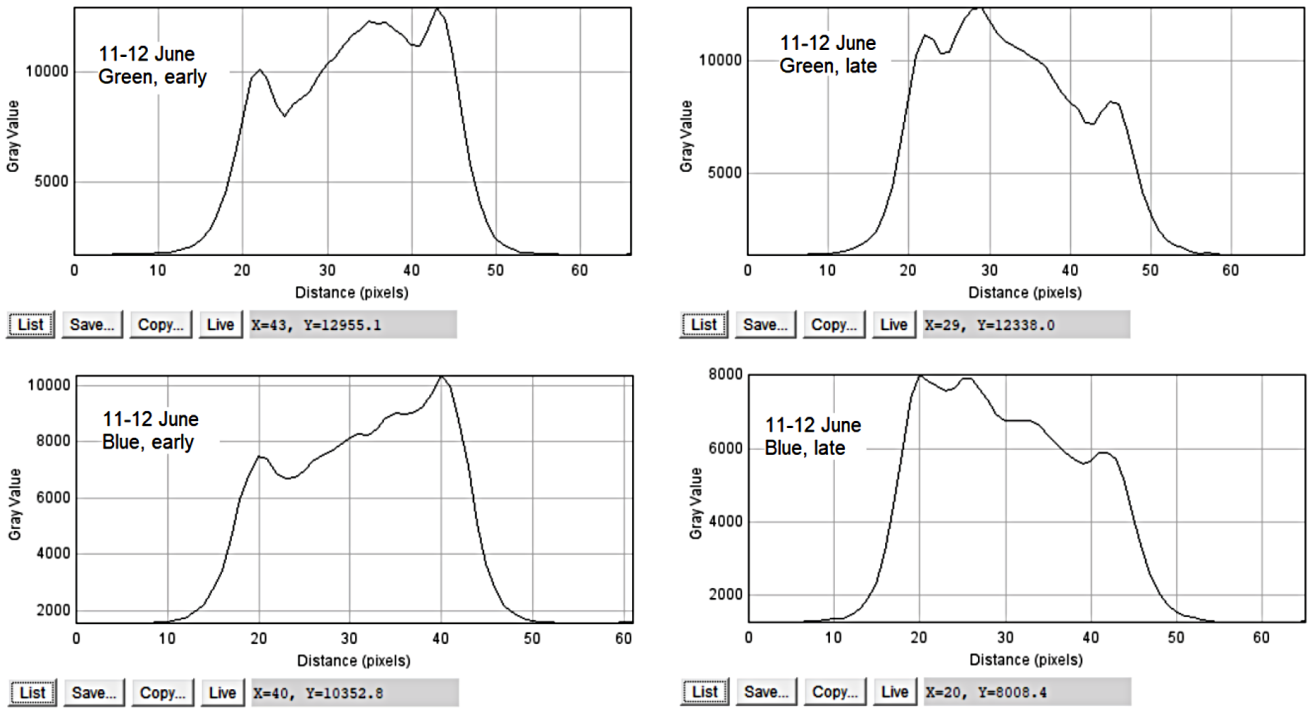

Figure 3. Line profiles of HD 121620 from AstroimageJ in selected uncalibrated images from 11–12 June 2019. Peak ADU values are shown in the grey box at the bottom of each panel. These values should be compared with the graph of peak ADUs in Figure 2 from the same date.

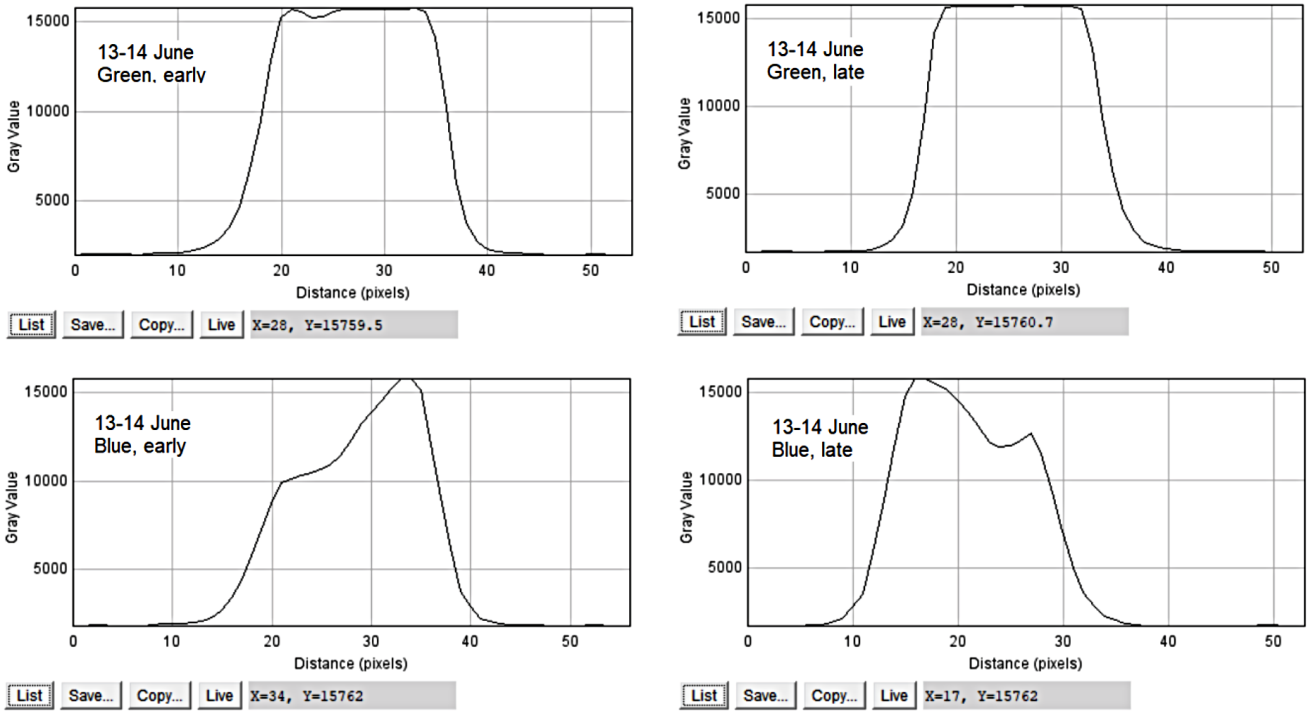

Figure 4. Line profiles of HD 121620 from *AstroimageJ* in selected uncalibrated images from 13–14 June 2019. Peak ADU values are shown in the grey box at the bottom of each panel. These values should be compared with the graph of peak ADUs in Figure 2 from the same date.

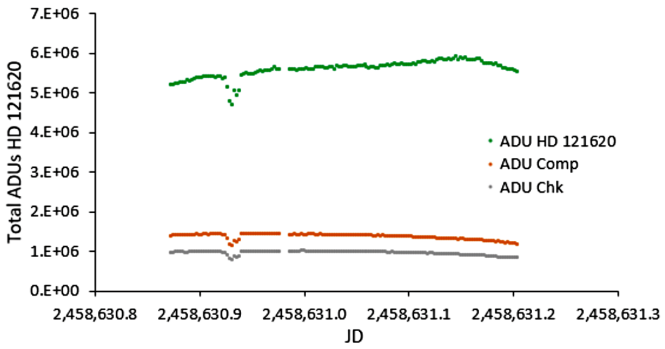

Figure 5. Total green channel ADUs of HD 121620, the comparison star, and the check star for the night of 27–28 May 2019. The light curve of HD 121620 for this night in Axelsen (2020) (reproduced in the upper panel of Figure 1 of this paper) showed a fluctuation in the early part of the light curve for HD 121620, interpreted by the author as a flare, as it was not present in the light curve of the check star. The plot of total ADUs from HD 121620 shown here demonstrates that the fluctuation was due to atmospheric disturbance, as it also affected the comparison and check stars.

to support the proposal that HD 121620 was variable. However, the ASAS-SN images typically saturate at a V magnitude of 10, and algorithms to extend this limit are unlikely to render accurate measurement of 7th magnitude stars.

4. Conclusion

The error reported herein emphasizes the well-known necessity to avoid saturation of images taken for photometry. It also reveals that, when the severity of saturation varies between images in time series studies, between different nights, and between the blue and green channels, the resulting light curves can be complex, rather than simply having a near-horizontal trajectory. Non-linear effects occurring in pixels near the point of saturation could also contribute to artefactual fluctuation in measured signal. These problems can be avoided by using line profiles of the images of stars to check for saturated pixels, and by checking the output from photometry software that tabulates peak ADU values. It is also important for observers to know the upper ADU limit of the linearity of their sensor, which can be determined from a series of images made with different exposure times.

5. Acknowledgements

The author wishes to thank Sebastián Otero for the insight that led to investigation of the erroneous data described above.

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