A forgotten episode of the $\eta$ Car light curve in 1860-1865*

V.F. Polcaro, R. Viotti

Istituto di Astrofisica Spaziale, CNR, V. Enrico Fermi 21, 00044 Frascati, Italy

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Abstract. We have found previously unreported observations of the galactic LBV $\eta$ Car covering the period 1860-1865. Contrary to the current belief, these data suggest that the star reached the first magnitude in 1860-1862, with possible large luminosity fluctuations, followed by a deep fading in 1865. A revised historical light curve of this most interesting object is given.

Key words: history of astronomy; stars: emission-line; stars: individual ($\eta$ Car)

1. Introduction

The light history of $\eta$ Car, one of the few well recognized galactic Luminous Blue Variables (LBV), can be traced back to the beginning of the 17th century, thanks to the careful discussion of Innes (1903), which was also summarized by Gratton (1963) and by van Genderen and Thé (1984). $\eta$ Car, called $\eta$ Argus (or $\eta$ of the Ship) in the old astronomical literature, was recorded as a fourth magnitude star in the Bayer's Atlas of 1603 and in the Halley's Catalogue of stars observed at the St. Elena island (1677), while it was reported as a second magnitude star in the Lacaille Coelum Stellatum Australis of 1752, as a fourth magnitude in 1811-15, and again as a second magnitude in 1822-27 and in 1828-1832 (Gratton 1963).

In 1827, 1838 and especially 1843, $\eta$ Car underwent spectacular brightenings, during which it attained the first magnitude, as bright as $\alpha$ Cru ($V=0.8$) in 1827, and as $\alpha$ Car ($Canopus, V=-0.7$) in 1843. At that time, $\eta$ Car was the brightest star in the sky after Sirius with an apparent magnitude of about $-0.8$ (Innes 1903). During the 1838 and 1843 maxima, the star brightened by about one magnitude in a few months. Innes also reports that these maxima were followed by similar gradual fadings, resembling a kind of large flares or slow nova-like explosions. After a slow luminosity decrease to the first magnitude from 1850 to 1855, there was a short-lasting brightening in 1856. According to Innes (1903), $\eta$ Car underwent a spectacular light decrease from the first to the tenth magnitude. This deep fading was very slow and lasted about 14 years. During this phase, the visual luminosity decrease was nearly exponential with an e-folding time of about 1.9 years. A significant deviation occurred in 1862, when, according the Innes' light curve, the fading phase stopped for about one year. This behaviour was never considered by previous researchers, probably because it was considered as one of the many irregularities displayed by the light curve of this object.

$\eta$ Car attained its minimum luminosity in 1870. Since then its visual luminosity gradually but irregularly increased until present. This "secular" trend was marked by a 1 mag outburst in 1889-1893, and by a steeper brightening in 1940-1950 (O' Connell 1956). Presently, $\eta$ Car is a sixth magnitude star showing small irregular variations.

Because of its big fading, $\eta$ Car was in the past included in the category of novae (indeed the slowest nova ever recorded; e.g. Payne-Gaposchkin 1957; Allen 1973), before being recognized as a completely different object (an LBV) in more recent years.

2. The Alan Kulczycky 1860-1865 observations

Despite of the completeness of the $\eta$ Car light curve given by Innes (1903), we have found an original report on the behaviour of this star concerning the years from 1860 to 1865, which casts some doubts on the Innes' reconstructed curve for that period.

The data that we have found come from the Connaissance des temps, a very authoritative journal published by the French Bureau des longitudes since the 18th century, reporting the ephemerides for professional use for "astronomers and sailors", as well as until the end of the 19th century, a few papers written by well known astronomers supposed to be of general interest. (For instance, the Messier Catalogue of "nebulous stars" was first published in this journal). In the August 1865 issue, reporting the ephemerides for 1867, this journal published a paper entitled "Observations sur quelques étoiles circompolaires du ciel austral" ("Observations of some circumpolar southern stars") by Alan Kulczycky (1865). The aim of the paper was mainly to correct a number of errors in southern sky catalogues, but it also included a short note of some variable stars.

Kulczycky starts his note with the description of the behaviour of $\eta$ Car during 1860-65. We give in the following the text in full and its English translation.

L’étoile si remarquable par ses changement d’éclat irréguliers, $\eta$ du Navire, après avoir brillée comme une étoile de 1er° pendant les années 1860, 1861 et
1862, des manière à pouvoir être observée en plein jour, me paraissait cependant diminuer pendant tout cet intervalle. La diminution est devenue plus sensible en 1863, au point que le 20 novembre de cette année je n'ai pu l'observer à 6 h 46 min. du matin. Pendant l'année 1864, en avril, mai, juin, lorsqu'elle se trouvait au-dessus de l'horizon, elle se détaçait bien au milieu de sa nébulosité et paraissait de 2 e ou de 3 e grandeur. Les nuages me l'ont dérobée ensuite, et il était impossible de suivre exactement ses variations. Mais en 1865, le 3 avril, j'ai trouvé avec étonnement que cette étoile ne se distinguait plus dans sa nébuleuse. Le ciel, à cause des nuages, mais elle me paraît décisément d'arrêté de sa nébulosité, et paraissait de 2 e grandeur dans le Catalogue, mais que me paraît bien de 6 e. Depuis cette époque l'étoile me paraît changer très-peu; je crois cependant qu'elle subit quelque fluctuations peu sensibles dans son éclat. Ainsi, le 24 avril, elle me paraissait plus brillant que le n° 3688. Je l'ai vue rarement ensuite à cause des nuages; mais elle me paraît décisément diminuer encor d'éclat. Bientôt elle ne se trouvera au-dessus de l'horizon que pendant le jour, et son examen serait nécessairement suspendu (Connaissance des temps, August 1865, pp. 45-46).

(The star η of the Ship, very remarkable because of its irregular change of brightness, following the brightening as a 1er magnitude star in 1860, 1861 and 1862, so that it was visible in full day-light, seemed to me to be fading during all this interval. The fading became more sensible during 1863, so that the 20th November of this year I was unable to observe it at 6 h 45 min. a.m., During 1864, in April, May and June, when it was over the horizon, it was clearly distiguishable on the middle of its nebulosity and seemed of 2 e or 3 e magnitude. In the following, clouds sheathed it to me, and it was impossible to follow exactly its variations. But, on 1865 April 3rd, I was astonished to find the star undistinguishable from its nebul. The cloudy sky has not allowed me to see it again until April 9th. That day, I examined it by means of the meridian transit instrument and by means of a portable telescope enlarging 56 times. I compared it with the nearby stars; p et q du Navire, de 4 e et de 5 e grandeur, étant beaucoup plus brillantes, et η du Navire me paraissait exactment égale au n° 3688, estimée de 5 e 1/2 grandeur dans le Catalogue, mais que me paraît bien de 6 e. Depuis cette époque l'étoile me paraît changer très-peu; je crois cependant qu'elle subit quelque fluctuations peu sensibles dans son éclat. Ainsi, le 24 avril, elle me paraissait plus brillant que le n° 3688. Je l'ai vue rarement ensuite à cause des nuages; mais elle me paraît décisément diminuer encor d'éclat. Bientot elle ne se trouvera au-dessus de l'horizon que pendant le jour, et son examen serait nécessairement suspendu (Connaissance des temps, August 1865, pp. 45-46).

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be supported by the fact that in the footnote of the Kulczycky’s paper it is said that the observations used in that work were performed (by the author) during 1864-1865 using the Bruuner portable meridian, and this could be coincident with the period of permanence of the author in Port-de-France. On the other hand, in reporting the high luminosity state of $\eta$ Car during (1860-62), Kulczycky has added his personal impression that the star seemed to be fading during the whole period. The author also appeared to be astonished by the fact that on November 20, 1863 he was unable to see the star at the sunrise. We are therefore led to the conclusion that also for the period 1860-63 Kulczycky is reporting his own observations, which strongly supports the reality of the high luminosity state of $\eta$ Car during 1860-62.

Fig. 1 shows the light curves of $\eta$ Car based on Innes and Kulczycky data. For the latter we have assumed a visual magnitude of $+1$ in 1860, and a slight luminosity decrease in the following 2 years. The visual magnitudes of 2.5 and 5.5 were adopted for April-June 1864 and April 1865, respectively. The slight brightening of April 24th, 1865 is not reported.

At this point we have to explain why Abbott and Tebbutt have not reported an extraordinary phenomenon such as the day time visibility of $\eta$ Car, as clearly stated by Kulczycky. We should first consider that Kulczycky does not give the duration of this visibility. In fact it is possible that the luminosity maximum of 1860-62 was not a plateau, but a series of short lasting peaks, which could therefore have been lost by the other observers for instance because of the bad weather. In this regard, we remind that, according to Innes (1903) the 1843 maximum lasted a few days. The other possibility already discussed above is that some observers did report these luminosity peaks, but their observations were later discarded by themselves or by Innes. A careful analysis of the original observations should be made in order to clarify this point.

On the other hand, even if we do not consider Kulczycky’s data for 1860-62, there is little doubt about his detailed description of the star’s luminosity during the following period of 1864-65. According to him the stellar magnitude in 1864 was between 2 and 3, in strong contrast with the value of 4.5 reported by Innes, while the 1865 magnitudes are in good agreement. In practice, the slight 1862-63 luminosity hump in the Innes curve is strongly enhanced, suggesting that either $\eta$ Car underwent a strong outburst (or several short lasting outbursts) during 1860-63, or the actual stellar luminosity was still the same as one decade before, but the star was subject to a number of R CrB-type fadeings clearly associated with the formation of circumstellar dust.

It should be finally remarked that the papers published in the Connaissance des temps were widely known to the astronomical community, certainly including Abbott and Tebbutt, and that they were frequently followed by discussions and comments published in the following issues. This would have certainly be happened if an important announcement such as the day-time visibility of a star would had been a trivial mistake. But no comment of the Kulczycky’s paper was published in the following issues of the same journal.

3. Conclusions

We have found previously unreported observations of $\eta$ Car during its deep fading phase, which strongly supports the existence of a more extended high luminosity phase of the star. The apparent disagreement with the well known light curve of Innes (1903) could be explained by the presence of large luminosity fluctuations, which are consistent with the fact that during this period of time the star was subject to huge mass ejection followed by the formation of circumstellar dust clouds which were irregularly masking the stellar light.

Clearly, a careful search and analysis of all the archival data on $\eta$ Car is required in order to have a more precise picture of its historical light curve, in particular before and during the deep fading phase which is fundamental to unveil the nature of this extremely interesting object.

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