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THE DRAMA OF η CARINAE†

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S Doradus variables — commonly aliased as Luminous Blue Variables — are evolved massive stars which display two major types of photometric variability: 'microvariations' (such as the small-amplitude α Cyg variations covering fractions of a magnitude on time scales of 2–3 months) and 'S Doradus phases' (large-amplitude long-term variability in light and colour ranging over magnitudes on time scales of years) which are associated with wanderings over significant areas in the HR diagram. For a very detailed discussion of these types of variabilities, we refer to van Genderen (2000).

η Car has a historical record of visual-magnitude estimates and photoelectric measurements. Especially since its *'Great Eruption'* in the 1840s and the following years, η Car has been the subject of several photometric investigations which, unfortunately, leave an appreciable margin of doubt on the exact quantification of η Carinae's magnitude and colour. This is because the internal level of precision of the acquired data is quite often correctly described, though at the same time a proper assessment of the external accuracy of the data falls short, specifically for datasets spanning years or decades.

Very recently, η Car has been the focus of attention since it underwent a rapid rise in visual magnitude that started in the beginning of 1999 with a brightness gradient amounting to -0.15 mag y^{-1} in the visual passband. The steady increase in visual light output somewhat slowed down earlier this year, and a preliminary analysis of CCD data obtained on November 12, 2000 with the Danish 1.54 m telescope at ESO La Silla reveals that η Car is now over its recent peak brightness, and could be in regress from its rightward and redward excursion in the HR diagram — its farthest excursion since about a century (see Figure 1).

It is exactly these substantial excursions in the HR diagram, together with the many peculiarities present in the spectra of these stars, that render invalid the photometric transformations to a standard system. From the perspective of the photometrist, η Car — if not the most famous amongst the S Doradus variables — certainly is the most troublesome S Dor star: it simply is the photometrist's ultimate nightmare. In previous papers (Sterken et al. 1999a, 2001a) we have given an elaborate outline of the major problems which photometrists face when performing long-term monitoring of a composite object like η Car. By its appearance as an extended object and by its anomalous spectral nature, this star is the single most difficult stellar object to measure or to monitor over a long time interval. The problems belong to several levels:

†Based on observations obtained at the Danish 1.54 m telescope at ESO La Silla, Chile

- the extreme brightness of η Car as a naked-eye star
- light curves that are interrupted by seasonal gaps
- the annual recurrence of high air masses that induces significant colour errors in broad-band photometry
- non-availability of a versatile photometric setup, viz. a modest-size telescope, suitable photometric instrumentation, and an appropriate photometric system
- incompatible photometric filter systems
- presence of variable and strong emission lines in the spectrum
- PMT and CCD photometry with diaphragms and apertures of different sizes

The photometric transformation problems are only relatively undisturbing in the visual passbands, but they do render any comparison of isolated photometric magnitudes and colour indices very difficult: the combination of non-overlapping data taken with different detectors, different diaphragm sizes and different filter systems (even seemingly-close UBV systems) is, to say the least, hazardous. From our previous experience, we estimate that such systematic effects may easily reach 0.1–0.2 mag. As such, when comparing isolated V magnitudes of η Car, great care must be taken because the unavoidable differences between photometric systems may result in very severe discrepancies, rendering the morphological shape of the light curve piecewise dependent on the instrumental setup.

But even more disturbing than the problems to bring magnitudes and colours to a conform scale are the long intervals during which η Car was not observed. After 1902 there is a gap of almost half a century during which there are virtually no recordings of the star's visual magnitude that could qualify as a light curve. Then, Albert Jones started observing in 1952 and carried on for almost 15 years estimating the brightness from his home observatory in Nelson, New Zealand. Systematic photoelectric measurements only started in the 1980s under impetus of Arnout van Genderen in the framework of the Long-Term Photometry of Variables project (LTPV, Sterken 1983).

The case of η Car vividly illustrates the loss of fundamental calibrated light- and colour information that is so crucial for supporting high-resolution ground-based and space-borne observations, a situation most detrimental for the correct understanding of the physics of this unique object. We, therefore, **urge observers in the southern hemisphere to turn their telescopes to η Car in order to quantitatively document the forthcoming phase of decline**. We underline that any useful photometric monitoring of this most enigmatic star must satisfy the conditions of

1. including at least one colour index in the magnitudes time series
2. delivering a vast amount of data — that is, sparse and isolated data sets in mutually incompatible filter systems are inadequate to understand the brightness evolution
3. yielding data that overlap in time in order to assure contiguous and homogeneous blending of adjacent light-curve sections
4. dissemination of data through publication, preferably after pooling, homogenization and quality control

That multi-colour photometry is carried out in an established standard system is not an absolutely necessary condition, as long as the internal homogeneity of the data on the natural photometric system is guaranteed.

We are aware that — though measuring this object takes less than five minutes per night — the future of long-term monitoring of η Car looks grim, since so many useful telescopes at major observatories have been decommissioned. Large telescopes do not

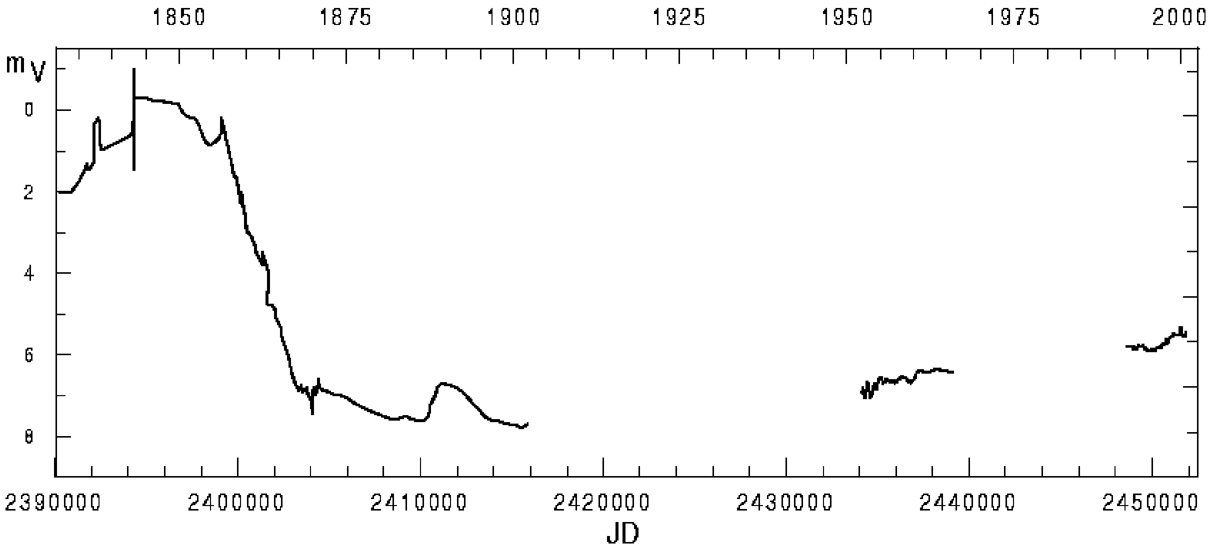

Figure 1. Schematic visual-band light curve of η Car 1830–2000. Based on data from Innes (1903), Jones and Sterken (1997, moving average), van Genderen et al. (1999), Sterken et al. (1999b, 2001b), this paper

serve the purpose because they enforce too short integration times. The present situation seems an apparently unavoidable consequence of the last decade's deployment of large and very large telescopes.

Van Helden (1994) argues that scientific instruments serve different purposes: in the first place instruments confer authority — though he shows that frequently a scientist will claim more authority than the instrument reasonably provides. In astronomy, authority comes by the size of the primary mirror: data from big telescopes are identified with *Big Science* — the happy term coined by Derek John de Solla Price to describe the shining and all-powerful large-scale character of modern science (Price 1963). Capshew and Rader (1992) even accentuate that *Little Science* is usually defined as *lacking one or another characteristic of Big Science.* Our everyday experience, though, shows that *characteristics of Little Science that are lacking in Big Science* are never discussed.

Big Science is an inevitable stage in the development of science. But η Carinae's temporary move to a maximum in the S Dor phase — a fact that we know and partially understand through the efforts of Little Science — more than ever supports the need for a systematic long-term watch of η Car and some other most eminent massive stars. The available data — perhaps even more the gaps without data — vividly support Alvin Weinberg's statement

> *"We must make Big Science flourish without, at the same time, allowing it to trample Little Science — that is, we must nurture small-scale excellence as carefully as we lavish gifts on large-scale spectaculars."* (Weinberg 1961)

Epilogue

The drive for larger size is not confined to mirror size alone. It is equally reflected in other aspects of our scientific activities, not in the least when assessing the value and impact of scientific journals. No one today will deny that IBVS, a Little Journal, over three decades has grown to a journal of Big Stature. Not just by natural growth, but through most dedicated fostering by its scientific and technical Editors. Often at the cost of their own scientific time and for no other return than rendering a very useful tool for Little Science.

I dedicate this paper to Dr. László Szabados who retires as Editor at the very moment that this 5000th Bulletin appears in press.

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