COMMISSIONS 27 AND 42 OF THE IAU
INFORMATION BULLETIN ON VARIABLE STARS
Number 4401

Konkoly Observatory
Budapest
25 November 1996
HU ISSN 0374 – 0676

ON THE CYCLICITY OF THE S Dor PHASES IN AG CARINAE[1]

AG Car (HD 94910) is a most enigmatic LBV of the southern hemisphere. Its light curve displays episodes of fading and brightening with strongly variable amplitude. In 1995, the star was in one of its brightest maxima since the double maximum of 1981–82, and is now again on its decline. Figure 1 displays the light curve since 1980. The dots are visual estimates collected by one of us (A.J.), the open circles that are connected by a full line represent Walraven V data (transformed to Johnson V) taken from van Genderen et al. (1988, 1990) and Strömgren y data from the "Long-Term Photometry of Variables" (LTPV) project at ESO (Sterken 1983, 1994, for the data see Manfroid et al. 1991, 1994 and Sterken et al. 1993, 1995).

Van Genderen et al. (1996) discussed all available photometric data covering more than one century, and introduced the concept **S Dor phase** (SD), viz. the phases of brightening with a more or less regular pattern of recurrence. In particular, they introduce a new nomenclature and distinguish "normal S Dor phases" superimposed on a much slower rhythm of brightening and fading for which they coin the term "Very-long term S Dor phase (VLT–SD)". For more details we refer to their paper.

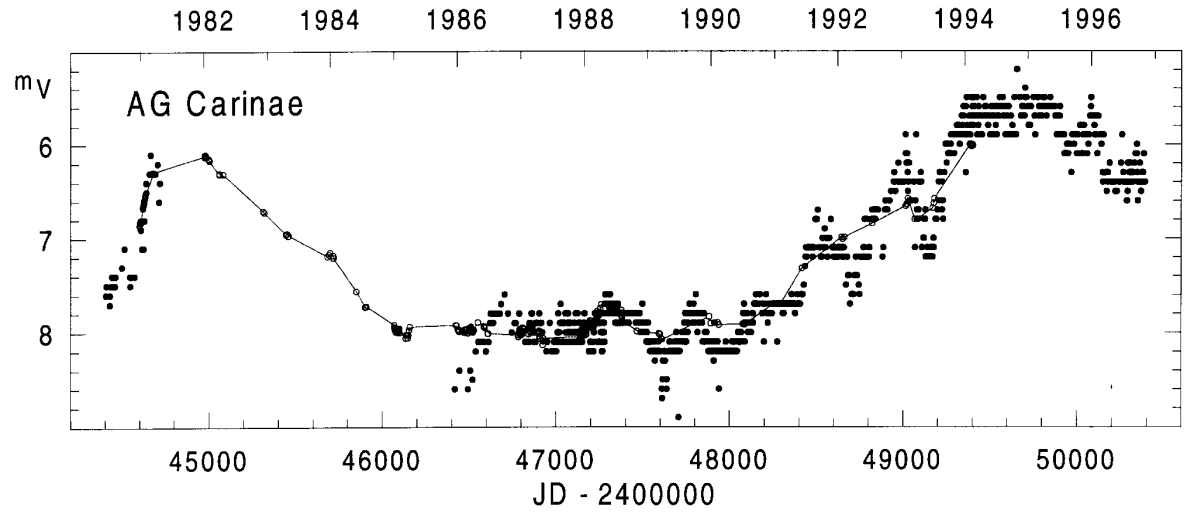

Figure 1. Light curve of AG Car since 1982. • are visual estimates, ○ are based on data from van Genderen et al. (1988, 1990) and on published LTPV data. The continuous line connects all published. photoelectric V data

[1] Based on observations collected at the European Southern Observatory (Chile)

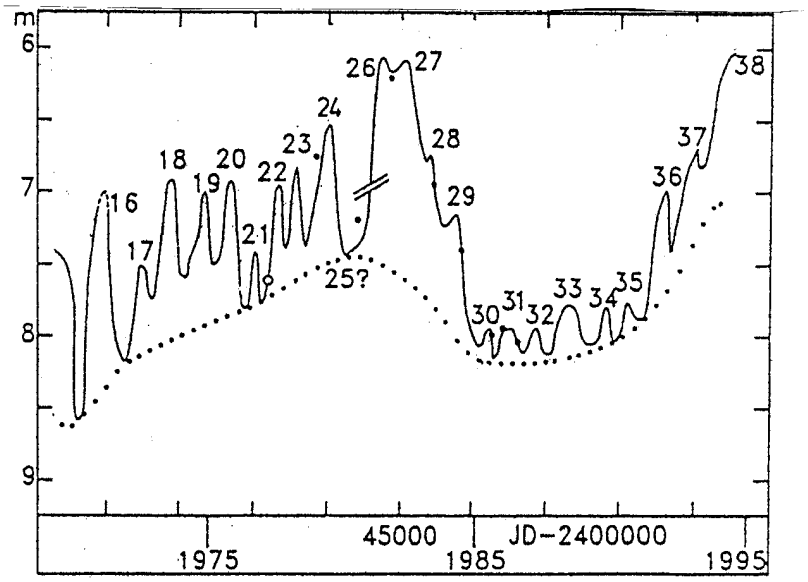

Figure 2. Schematic light curve of AG Car since 1970 (adapted from van Genderen et al. 1996). The solid line covers the observations, the dotted line is the lower envelope of the continuous line and illustrates how the authors think the underlying VLT-SD phase could be represented. The numbered maxima do not correspond to the cycle numbers as shown in Figure 4. Note the double maximum 26–27.

From 1970 on (after JD 2440000), the light curve shows a fairly uninterrupted sequence of S Dor maxima. Numbered 17–38 in the van Genderen et al. (1996) paper, this sequence of 22 times of maximum yielded a period of $373^{\rm d}\pm1\overset{\rm d}{.}8$ (see Figure 2 for a partial reproduction of Figure 1 of van Genderen et al. 1996). Extrapolating the cycle-numbering scheme to the past, these authors refined the period to $P = 371\overset{\rm d}{.}4 \pm 0\overset{\rm d}{.}6$. The resulting $O-C$ diagram did not show a random pattern, but suggested a possible cyclic behaviour on a time scale of about 7900 d or 21.6 y (for the time interval 1970–1994).

Unfortunately, diminishing opportunities for observing AG Car in the framework of LTPV made a complete coverage of the 1994–1995 (double) maximum impossible. However, from a preliminary reduction of yet unreleased LTPV data collected in November and December 1995, we could derive one additional time of maximum, viz. HJD 245 0080, corresponding to cycle $E = 23$ (see Figure 3). The visual light curve also suggests maxima at JD 244 9750, 245 0083 and 245 0350. The photoelectric maximum at $E = 23$ fully confirms the one derived visually. The first of the new visual maxima was not taken to correspond to the brightest estimate, because the real maximum likely occurs around the middle of the corresponding block of data (as is also illustrated by the difference between the brightest y measurement and the maximum of the fitted curve in Figure 4). The maximum at $E = 21$, provisionally estimated at JD 244 9400 and bracketed in Table 1 of van Genderen et al. (1996), in reality seemed to have occurred later—that is, around JD 244 9455. Note that the estimation of the time of extremum during a supermaximum (maxima 26–27 in Figure 2, the double maxima in 1981–82 and in 1994–95) is particularly difficult because the star does not have the time to fall back to its low state of light output before the 371 d cycle is completed.

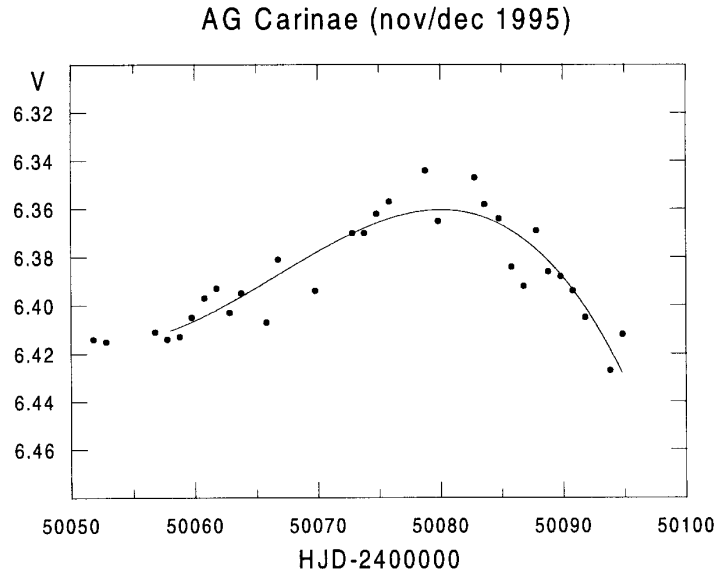

Figure 3. LTPV-1995 $y \equiv V$ photometry (in the natural system). Each data point represents one differential measurement. The line represents the fitted third-degree polynomial used to calculate the time of maximum. Note the asymmetric form, with a descending branch that is much steeper than the ascending branch, a phenomenon that is typical for normal SD phases on the descending branch of the VLT-SD phase, see also Figure 2.

The new $O - C$ diagram is shown in Figure 4. The two estimates of the time of maximum corresponding to $E = 21$ have been flagged by an arrow in Figure 4, as well as the last point in the diagram, which ultimately may turn out to shift upward as suggested in the figure. The figure clearly confirms the cyclic pattern on a time scale of ~ 20 y as suggested by van Genderen et al. (1996).

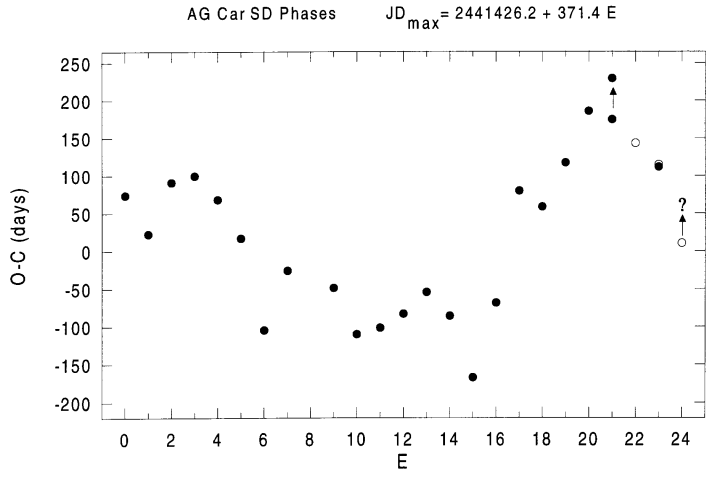

Figure 4. $O - C$ diagram for SD maxima 17–38 (cycle numbers 0–21) of AG Car for the linear ephemeris constructed with $P = 371\overset{\mathrm{d}}{.}4$, van Genderen et al. (1996). The • at $E = 23$ is derived from a sequence of photoelectric measurements, see Figure 3. The open circles at $E = 22 - 24$ are based on new visual estimates. The upper vertical arrow indicates the corrected position of the $E = 21$ maximum (which was provisionally estimated on the basis of incomplete data by van Genderen et al. 1996). The ? indicates the shift to be expected when the current SD phase will have been observed completely.

The new visual and photoelectric data collected after the conclusion of the study of van Genderen et al. (1996) allow us to confirm that the cyclic behaviour of the "normal" S Dor phases of AG Car is maintained.

This work was supported by a research grant from the Belgian Fund for Scientific Research (NFWO). The data have been obtained during ESO time allocation 57 D-0133.

C. STERKEN[1]
University of Brussels (VUB)
Pleinlaan 2
B-1050 Brussels, Belgium

A. JONES
Carter Observatory
P.O. Box 2909
Wellington, New Zealand

B. VOS
I. ZEGELAAR
A.M. van GENDEREN
Leiden Observatory
Postbus 9513
2300RA Leiden, The Netherlands

M. de GROOT
Armagh Observatory
College Hill
Armagh BT61 9DG, Northern Ireland

[1]Belgian Fund for Scientific Research (NFWO)

References:

van Genderen, A.M., Sterken, C., de Groot, M., 1996, *A&A*, in press
van Genderen, A.M., Thé, P.S., Augusteijn, Th., et al., 1988, *A&AS*, **74**, 453
van Genderen, A.M., Thé, P.S., Heemskerk, M., et al., 1990, *A&AS*, **82**, 189
Manfroid, J., Sterken, C., Bruch, A. et al., 1991, *A&AS*, **87**, 481
Manfroid, J., Sterken, C., Cunow, B. et al., 1994, *A&AS*, **109**, 329
Sterken, C., 1983, *The Messenger*, **33**, 10
Sterken, C., 1993, in *Precision Photometry*, D. Kilkenny, E. Lastovica, J. Menzies (Eds.), South African Astronomical Observatory, 57
Sterken, C., Manfroid, J., Anton, K., et al., 1993, *A&AS*, **102**, 79
Sterken, C., Manfroid, J., Beele, D., et al., 1995, *A&AS*, **113**, 31