LUMINOUS BLUE VARIABLES NEED NOT BE BLUE

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ABSTRACT. A number of yellow and red super- and hypergiants show phenomena that are similar to those shown by Luminous Blue Variables. The LBV phenomenon may not be restricted to the blue part of the Hertzsprung-Russell diagram and the conventional name 'S Dor variables' seems more appropriate.

1. CHARACTERISTICS OF LUMINOUS BLUE VARIABLES

It is convenient to distinguish between the LBV-characteristics and the LBV-phenomenon. LBV's are usually defined as blue stars that occasionally undergo mass ejections of such a degree that the level where the continuous optical depth reaches unity moves so far outward that the surface brightness, effective temperature and spectral type change considerably while also the visual apparent brightness changes - because the bolometric correction does so. If so defined, it appears that they occupy an area in the Hertzsprung-Russell diagram as shown in Figure 1 (after Van Genderen, 1988). These stars thus form a subclass of the Alpha Cygni variables. Van Genderen (1988) showed that the maximum light amplitude of the LBV's, in his paper called S Dor variables, are definitely larger that those of the other Alpha Cygni variables, and also larger than those of the hypergiants (the Ia+ type luminosity class). We refer to Figure 1 in Van Genderen's paper (1988).

LBV's must be pulsating stars. Their region of occupancy in the HR diagram is part of that of the (quasi-regularly pulsating) supergiants (Burki, 1978; Maeder, 1980). Van Genderen (1988) remarks that their light variation lacks the high-frequency components that are so often found in those of the non-LBV blue supergiants. This may mean that the average densities of LBV's (and hence also their masses) are smaller than those of non-LBV's at the same position in the Hertzsprung-Russell diagram. In comparison with such stars the LBV's must therefore be more evolved.

It is remarkable that LBV's do hardly occur at the Humphreys-Davidson limit (with the exeption of Eta Car); they are rather found somewhat below it.

2. THE LBV-PHENOMENON ALSO SHOWN BY COOLER STARS

A number of cool super- and hypergiants also show the LBV-phenomenon. We

K. Davidson et al. (eds.), Physics of Luminous Blue Variables, 127–129.

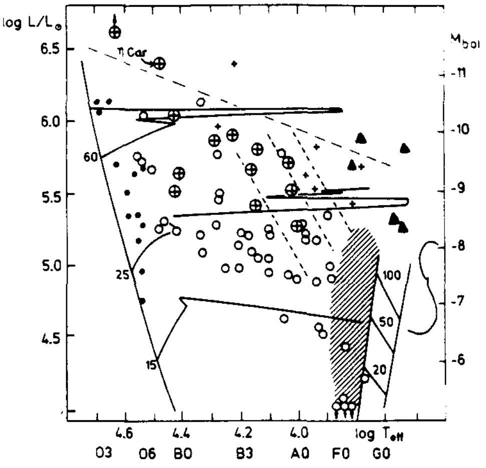

Fig.1: The S Dor Variables in the Hertzsprung-Russell Diagram

Dots: type V stars
Circles: supergiants
Plusses: hypergiants
Circles with plusses: LBV's (blue S Dor stars)
Triangles: cool S Dor stars

describe a few of them; we refer also to a description in De Jager (1980) ch. 3, particularly section 3.8.
Rho Cas (HD 224 014) was classified in 1943 as F8Ia, but during the years 1946-49 it had M-type characteristics, related to a mass ejection. Another ejection started in 1957; it lasted till 1960.
HR 8752 (V509 Cas, HD 217 476) varied between G0Ia to K5Ia and back between 1950 and now, due to a mass ejection between 1968 and 1980 (Piters et al., 1988; Smolinski, priv. comm.).
HR 5171A (V766 Cen. HD 119 796) is at present showing the effects of an increased rate of mass loss that occurred before or since 1953. Since that time the colour (B-V) increased from ~ 1.95 to ~ 2.5 in 1985, which shows the gradual building up of a dust envelope. The extinction at 3200 Å increased by a factor 30 between 1971 and 1987!
Other stars that behave similarly are Var A in M33 (Humphreys et al., 1987) and the infrared source IRC 10420 (F8Ia, Fix and Cobb, 1987).

We conclude that the LBV phenomenon is not restricted to early-type stars. Therefore it is more appropriate to use the name "S Dor stars" to describe the stars described above, in accordance with the definition of the General Catalogue of Variable Stars (Kukarkin et al., 1974; Kholopov et al., 1985).

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https://doi.org/10.1017/S0252921100004371 Published online by Cambridge University Press

DISCUSSION

Sterken: The light curves that you showed for AG Car and R 71 were collected with the same sampling frequency. We expect a shorter period for a less luminous supergiant, and if a short-period light curve is observed with the same time frequency as a longer-period variation, one may automatically obtain a bumpier light curve. Some of the supergiants may have this phenomenon in their observed light curves.

De Jager: I agree. The bumpy character of the light curves of normal supergiants (non-LBV's) may indicate that their periods are shorter than those of LBV's.

Humphreys: IRC +10420 is an OH/IR source. Recent observations show that the strength and structure of of the OH emission is changing. The changes are consistent with dissipation of the dust shell. IRC+10420 is a good candidate for post-red-supergiant evolution. I doubt that all of the cool hypergiants are post-red supergiants.

Walborn: (1) Is a spectral type range observed for HR 5171? (2) Another remarkable point of similarity between HR 8752 and LBV's, which you have discussed previously, is the [NII] emission which may indicate circumstellar processed material.

De Jager: I have no data on the spectral type variation of HR 5171. But the temperatures derived in the past 20 years decreased with the increasing extinction. This may suggest an expanding pseudo-photosphere.

Maeder: Do you also have indications on radial velocity variations for these yellow and red supergiants, in addition to the photometric monitoring?

De Jager: The only star for which a good series of v_{rad}-measurements is available over a sufficiently long period (several years) is α Cygni, which was observed by Paddock around 1930. Lucy has used these measurements for a Fourier analysis and found 16 frequencies with periods from 7 to 100 days (1976, *Astrophys. J.* **206**, 499). It is high time that such measurements be done for other supergiants.

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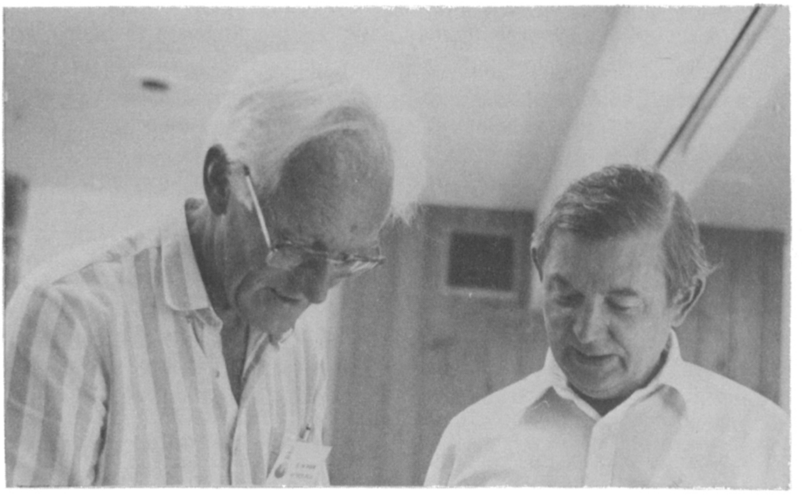

de Jager and Smolinski

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