II. OBSERVATIONAL FACTS

SUPERGIANT VARIABLES: RECENT OBSERVATIONAL RESULTS

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Abstract. Recent observations of several types of supergiant variable stars are reviewed: massive blue, yellow and red supergiants; classical and population II Cepheids; RV Tauri stars; yellow semi-regular (SRd) variables, including UU Herculis stars; and R Coronae Borealis stars. The emphasis is on non-linear aspects such as: amplitude and shape of the light and velocity curves; multiperiodicity, irregularity and chaos; long-term changes in period and amplitude; episodic and continuous mass loss.

1. Introduction

Supergiants are rare but interesting stars which can shed much light on stellar properties, processes and evolution. Almost all of the extreme supergiants are variable, and there are enhanced regions of instability among the B supergiants, the supergiants in the Cepheid instability strip, and among the M supergiants. Supergiants can be seen at great distances, and can be useful as distance indicators. Low-gravity supergiants undergo continuous and/or episodic mass loss, which has important implications for both stellar and galactic evolution. This mass loss may be related to the other forms of variability in these stars. Supergiants have relatively short life times, so changes in their properties and behaviour may occur on a short time scale. Non-linear effects of many kinds may occur in supergiants, ranging from dynamical instabilities to amplitude changes, multimode pulsations, irregularity and possibly chaos. This review deals with some recent observational results on supergiant variables. Other papers at this conference have dealt with theoretical results; see also the excellent reviews by Buchler, Kovacs, Takeuti and others in *The Numerical Modelling of Nonlinear Stellar Pulsations* (Buchler 1990).

2. Massive Supergiant Variables in General

Variability is almost universal among the most luminous stars. Maeder (1980) showed that the amplitude of photometric variability increased with increasing luminosity, and that the characteristic time scale P is related to the bolometric magnitude Mbol and the effective temperature Te by

$$\log P = -0.346\mathrm{Mbol} - 3\log\mathrm{Te} + 10.60$$

The mass loss $\dot{m}$ is also related to the luminosity L; Nieuwenhuijzen and de Jager (1990) derive

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$$\dot{m} \propto L^{1.42} m^{0.16} R^{0.81}$$

where m is the mass and R is the radius.

De Jager et al. (1991) have carried out a comprehensive study of the atmospheric motions in luminous stars, and conclude that the observed light and velocity variations are caused by high-mode internal gravity waves. Thus, the time scale P is much greater than the fundamental radial period, as noted for instance by Percy and Welch (1983). The observed irregularities in these stars may therefore be due to multimode pulsation. On the other hand, Buchler and Goupil (1988) have pointed out that stars which are close to dynamical instability may show chaotic behaviour as a result of interaction between the fundamental mode and an overtone. This effect may occur in some extreme supergiants.

2.1. MASSIVE BLUE SUPERGIANT VARIABLES

These stars, also known as Luminous Blue Variables (LBV's) or S Doradus variables, show low-amplitude photometric variations on time scales of weeks, with occasional large outbursts. P Cyg, for instance, varied between magnitudes 3 and 6 in the 1600's and now varies by about $\Delta V = 0.2^{\mathrm{m}}$ on a time scale of about a month (Percy et al. 1988). There are also abrupt increases and decreases of a few $\times 0.01^{\mathrm{m}}$ on time scales of two or three days. Spectroscopically, P Cyg shows a strong wind (indeed, it is the prototype star with "P Cygni line profiles"), along with evidence of shell ejections on a time scales of months (Markova and Kolka 1988). On the basis of polarimetric observations, Hayes (1985) and more recently Taylor et al. (1991) have developed a model in which discrete clouds of gas are ejected in the wind. Coordinated observations of this star would be extremely useful.

Much effort has gone into understanding the nature of the wind and its variability. Leitherer et al. (1989) and Blomme (1991) conclude that the magnitude of the mass loss can probably be explained as a radiative effect, with iron opacities playing a crucial role. Pauldrach and Puls (1990) and Blomme et al. (1991) have investigated the process whereby the stars cycle between high- and low-mass-loss states. They have identified a discontinuity ("bistability") in the mass loss rate and wind velocity at a specific value of the effective gravity. It is not clear, however, what drives the star between these two states.

Moskalik and Dziembowski (1991, preprint) have shown that, using the new Iglesias and Rogers (1991) opacities, the pulsation of the β Cephei stars can at last be explained; it is due to the classical κ - mechanism. Furthermore, the instability seems to extend to the B-type supergiants, thus explaining this region of enhanced instability in the H-R diagram (Maeder 1980).

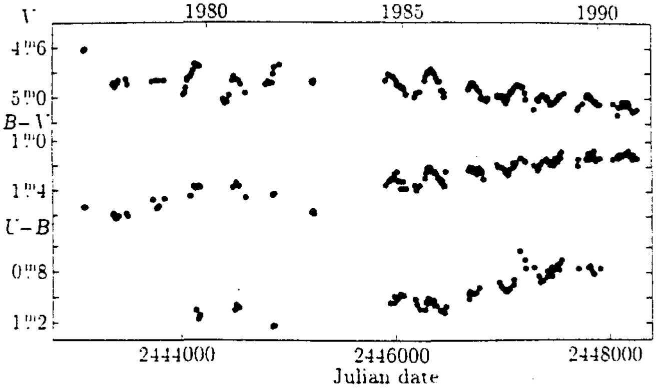

Fig. 1. UBV photometric observations of V509 Cas (HR8752) since 1975 (Percy and Zsoldos 1992, preprint). In the last decade, the star has become fainter and bluer; the amplitude of the pulsation has decreased, and it has become more complex.

2.2. MASSIVE YELLOW SUPERGIANT VARIABLES

These stars lie in the upward extension of the Cepheid instability strip and of the period - luminosity relation. Similar stars are called "Leavitt Variables" in the Magellanic Clouds. They show irregular variations in brightness and radial velocity on time scales of about a year, presumably due to pulsation. Their light curves also show other interesting and unique features which may be related to the extreme properties of these stars.

The prototype stars are ρ Cas (F8Ia-0, variable) and V509 Cas (HR8752; G0Ia-0, variable), which turn out to be virtual twins in many respects. Rho Cas has a photometric period of 298.5 days; it underwent a deeper-than-average minimum in 1946/7 and a larger-than-average pulsation cycle in 1985/6 (Zsoldos and Percy 1991). Since 1985, it has decreased slowly in mean magnitude and in amplitude. The photometric behaviour of V509 Cas in the last decade (Fig. 1) has been very similar (Halbedel 1991; Percy and Zsoldos 1992, preprint). Between 1986 and 1991, this star became fainter and bluer. At the same time, it was pulsating with two (possibly three) periods with changing amplitudes. The unusual shape of the light curve may be connected with the ejection of one or more shells in the last decade or two. Takeuti (1988) has pointed out that episodes of enhanced mass loss may occur if the luminosity temporarily exceeds the Eddington luminosity.

Rho Cas and V509 Cas have been monitored spectroscopically by Sheffer and Lambert (1986, 1987). They find periods of 520 days in ρ Cas, and 421 and 315 days in V509 Cas. At this point, it is not clear if there is enough data to tell whether the photometric and spectroscopic observations are in agreement or in conflict. A decade or more *coordinated* observations are probably needed to address this question.

2.3. MASSIVE RED SUPERGIANT VARIABLES

These stars, typified by α Ori, α Sco and μ Cep. are designated as SRc or Lc types in the *General Catalogue of Variable Stars*. They are of spectral types M1-M4 Ia-Ib. See Johnson and Querci (1986) for a comprehensive review of M-type stars.

The light curves of SRc/Lc variables are irregular, but one can define two characteristic time scales, both of which depend on the temperature and luminosity of the star (Stothers and Leung 1971). The shorter time scale is in approximate agreement with the fundamental radial pulsation period, and can be represented by

$$\mathrm{Mbol} = -7.20 \log P + 12.8$$

The longer time scale is about 10 times the shorter time scale; its nature and cause are unknown. Note, however, that long-term variations also occur in most small-amplitude red variables (Percy and Sen 1991), in the RVb variables discussed later in this review, and in a few other cool variables.

Red supergiants lose mass at rates of typically $10^{-6} m_\odot/a$. There are possibly discrete episodes of mass loss on time scales of 10^4 years, resulting in shell structures within the circumstellar envelope. Pulsation may be important in driving the mass loss, as it is in the M giants (e.g. Bowen 1988).

It is not clear whether the light curves of SRc/Lc variables are multiperiodic, chaotic or irregular. The long-term variability of μ Cep and RS Cnc often takes the form of occasional large-amplitude cycles of the short-term variations, as in the massive yellow supergiant variables described in the previous section.

3. Cepheid Variables

3.1. CEPHEID VARIABLES: FUNDAMENTAL PROPERTIES

Much progress has been made in determining the fundamental properties of Cepheids, and this makes it possible for theorists to construct hydro dynamical models with some confidence. The mass of SU Cyg has been found to be 5.9–6.2$m_\odot$ from its binary orbit (Evans and Bolton 1990), and the mass of other binary Cepheids are within reach, thanks to the work of Evans, Szabados and others. Indirect determinations of Cepheid masses ("pulsation" mass, "beat" mass, "bump" mass) seem now to be in agreement with direct mass and evolutionary masses thanks to the new Iglesias and Rogers opacities (Petersen 1990; Moskalik et al. 1991, preprint).

Cepheid luminosities have been reviewed by Feast and Walker (1987) and by Madore and Freedman (1991). Fernie (1992, preprint) has recently refined the Cepheid and δ Scuti period - luminosity relations by combining these two groups of young population I stars. The resulting relations for Cepheids are:

$$\begin{array}{rcll} < M\mathrm{v} > & = & -2.902 \log P & - \quad 1.203 \\ & & \pm 0.030 & \quad \pm 0.029 \end{array}$$

$$\begin{array}{rcll} \log(R/R_\odot) & = & 1.1116 \; + & 0.7385 \log P \\ & & \pm 0.0060 & \pm 0.0060 \end{array}$$

It will be interesting to compare these results with the forthcoming results from the HIPPARCOS mission. Cepheid reddenings and intrinsic colours have been investigated by Fernie (1990a) and mass loss rates by Deasy (1988) and by Welch and Duric (1988).

The evolution of intermediate-mass stars such as Cepheids has reviewed by Chiosi (1990). An important recent development has been the identification and study of many Cepheids in NGC 1866 and other Magellanic Cloud clusters (e.g. Welch et al. 1991).

3.2. CEPHEID VARIABLES: LIGHT AND VELOCITY CURVES

In the last decade, Fourier decomposition has proven to be an effective tool in the interpretation of the shapes of Cepheid light and velocity curves (Simon and Lee 1981). It has been used, for instance, to interpret the Hertzsprung progression - a systematic trend, with period, in the shape of these curves. A secondary maximum or bump in the curve is found to coincide with the primary maximum at a period of 9 to 10 days. This is found to be due to a resonance between the fundamental (P_0) and second overtone (P_2) radial periods: $P_2/P_0 \sim 0.5$ (Simon and Davis 1983; Buchler et al. 1990; Kovacs et al. 1990). Until recently, agreement between observations and predictions from hydrodynamic models did not occur at the correct period and/or mass, but this deficiency seems to be remedied by the new Iglesias and Rogers opacities.

Fernie (1990b) has investigated the structure of the Cepheid instability strip, and found that (a) light amplitude increases with increasing period, (b) there is no tendency for the amplitude to be greater at the red or blue edge of the instability strip, (c) the amplitude is generally greater in the middle of the instability strip, but large- and small- amplitude stars can co-exist at any place in the strip, (d) the strip seems to be wider in (B-V) than would be expected theoretically, and (e) there is a non-uniform distribution of stars in the strip, with relatively fewer stars in the upper left and lower right sections. Sasselov (this meeting) has suggested that some of these effects may be due to the problem of determining a valid mean (B-V) for a pulsating atmosphere. This may possibly explain the well-documented apparent presence of non-variable stars in the Cepheid instability strip.

Moskalik et al. (1991, 1992) have found that hydrodynamic models of Cepheids with periods of 25-40 days (or 22.5 days with Iglesias and Rogers opacities) show incipient RV Tauri behaviour, due to a 3/2 resonance between P_0 and P_1. There is no evidence of this phenomenon in classical

Cepheids (Fernie, private communication), but it may be present in population II Cepheids. Winzer (1973) suspected that the light curve of the 3.7-day Cepheid RT Aur might show fine structure at the 0.01^m level, but that is close to the noise level of the observations.

3.3. CEPHEID VARIABLES: OVERTONE PULSATORS

Most Cepheid variables pulsate in the fundamental radial mode. The double-mode or "beat" Cepheids pulsate in the fundamental and first overtone modes. Theoretical models have so far not succeeded in reproducing stable double-mode behaviour (Moskalik et al. 1992). The amplitude ratios (A_1/A_0) of the first overtone to fundamental mode do not show any obvious trend with period, which suggests that some other parameter may affect this ratio.

There are also Cepheids with small amplitudes, sinusoidal light curves, and periods less than five days which, on the basis of Fourier decomposition, seen to be separate from "normal" Cepheids. These are thought to be first overtone pulsators. Two examples are SU Cas and CO Vir. Welch et al. (1991) have found one such variable in NGC 1866 among fundamental mode pulsators. Antonello et al. (1990) have identified about 20 of them morphologically. They do not follow the Hertzsprung progression e.g. in the ϕ_{21}–P and ϕ_{31}–P diagrams. Diethelm (1990) has classified Cepheids with periods between one and three days according to their pulsation mode and their evolutionary state or metallicity.

3.4. CEPHEID VARIABLES: LONG-TERM CHANGES

The light and velocity curves of classical Cepheids change relatively slowly. The double-mode Cepheids are an obvious but well-understood exception. A less well-understood exception is HR7308 (V473 Lyr), the classical Cepheid with the shortest known period (1.49^d). The photometric amplitude of this star varies from about 0.05^m to 0.40^m in a period of 1210 days (Percy and Ford 1981). The cause of this modulation is unknown. Another exception is Polaris, whose light and velocity amplitudes have been decreasing for at least two decades, any may reach zero by the year 2000 (Dinshaw et al 1989). The light amplitude of Y Oph may also be decreasing (Fernie 1990c). Fernie (1990c) points out that both Polaris and Y Oph appear to be situated in the middle of the instability strip.

The observed period changes in classical Cepheids are in good agreement with those predicted by evolutionary models (Saitou 1990). Fernie (1990c) has pointed out that the period change in Y Oph is not linear (the O–C diagram is a cubic), and that this is to be expected from evolutionary models. Szabados (1991) has detected apparent "phase shifts" in the O–C diagrams of some classical Cepheids, but the evidence for these is not compelling. This is fortunate, since no obvious explanation for such a phenomenon comes to mind!

4. Population II Cepheid Variables

These variables (also known as W Virginis stars) are low-mass stars of the disc or halo population which are situated in the Cepheid instability strip. The least luminous of these are the BL Her subgroup, which are evolving away from the horizontal branch, and which have periods of one to three days. Since these are classified as giants rather than supergiants, they will not be discussed further here, except to point out that Moskalik and Buchler (this meeting) have predicted from hydrodynamic models that some BL Her stars should show period doubling i.e. alternating larger and smaller amplitude. This phenomenon should be looked for in the observations.

More luminous population II Cepheids are believed to be executing "blue loops" from the asymptotic giant branch (AGB) due to shell flashes in the interior. These loops occur on time scales of a few thousand years, so period changes and perhaps even amplitude changes may be observable. RU Cam is a population II Cepheid whose amplitude decreased from over a magnitude to nearly zero in 1962–64 (Fernie and Demers 1966; Huth 1966). This may provide a "natural experiment" on the effect of pulsation amplitude on period and mean colour. All bright population II Cepheids should be systematically monitored - preferably photoelectrically but, if not, photographically or visually.

A few luminous population II Cepheids should be contracting rapidly from the AGB to the white dwarf stage. One or two such stars show some evidence for RV Tau behaviour (Arp 1955).

Population II Cepheids can also be sub-classified, according to their light curves, into "crested" and "flat top". Fadeyev and Muthsam (1990) have postulated, on the basis of hydrodynamic models, that this effect is due to a resonant coupling between the fundamental and first overtone modes. These same authors also comment on the origin of the shock waves which are prominent in the spectra of population II Cepheids at some phases.

5. RV Tauri Variables

RV Tauri stars are rare, luminous pulsating variables which tend to show alternating deep and shallow minima in their light curves. They are believed to be post-AGB stars on the basis of their location on the H-R diagram, their period changes (Percy et al. 1991), and their dust envelopes (e.g. Jura 1986). There is some disagreement as to whether they left the AGB about 10^2 years ago (Alcolea and Bujarrabal 1991) or about 10^3 years ago (Jura 1986; Percy et al. 1991); the latter number seems more reasonable. In an important recent development, Buchler, Kovacs and their co-workers have shown that, in a sequence of models of low-mass yellow supergiants of decreasing effective temperature, there is a transition from periodic behaviour, through successive period doublings, to chaos (Buchler et al. 1987; Buchler and Kovacs 1987; Kovacs and Buchler 1988). The population II Cepheids, RV Tauri variables, and SRd variables may represent the observational manifestation of this sequence, though it might be more correct to think of the observational sequence as being a continuous one. Since the transition may be a function of luminosity, the "structure" of the yellow supergiant region of the H-R diagram could be quite complex.

RV Tauri-like behaviour has been found in a number of theoretical models, including Christy (1966), Stobie (1969), Deupree and Hodson (1976), and Fadeyev (1984). Deupree and Hodson attribute the behaviour to the effect of convection, Buchler and Kovacs to resonant interaction between modes. It is entirely possible that two or more physical mechanisms may contribute to the behaviour.

A long-standing question is whether the physical period of an RV Tauri star is the "single" period (between adjacent minima) or the "double" period (between adjacent deep minima). Recent spectroscopic studies have been divided on this issue (e.g. Lebre and Gillet 1991; Mozurkewich et al. 1987) but, if two modes are present in the atmosphere in 2:1 resonance, then it is possible that both answers to the question are correct.

5.1. RV TAURI STARS: HOW REGULAR?

Although RV Tauri stars are defined as showing alternating deep and shallow minima, the range of behaviour is actually very wide. A preliminary examination of the long-term light curves of RV Tauri stars complied by Payne-Gaposchkin et al. (1943) shows that the incidence of alternating deep and shallow minima ranges from 99% in AC Her and V Vul to 60% or less in U Mon, TT Oph, AR Pup and RV Tau (Fig. 2). This analysis is very crude, being based on sparse visual and photographic data. It should be repeated with better data. Five-day means of the dense visual observations in the AAVSO database (Mattei and Percy, this meeting) should be adequate for the purpose. Individual RV Tauri stars can go through exceptionally irregular phases (e.g. R Sct; Lebre and Gillet 1991).

Another approach to this question is to construct return maps for RV Tauri stars. This has been done by Veldhuizen and Percy (1989), Saitou et at. (1989) and Kollath (1990). In each case, the authors have used visual observations (since these are dense and extend over many years) but, in each case, the authors conclude that visual observations are only marginally suitable for the purpose at hand. Perhaps if the visual observations were processed in a more sophisticated way (such as by spline interpolation), they would yield a more definite result. It is also possible that RV Tauri stars are inherently irregular!

It is nevertheless interesting to look at the range of behaviour shown by Saitou et al.'s (1989) return maps of RV Tauri and SRd stars. These maps

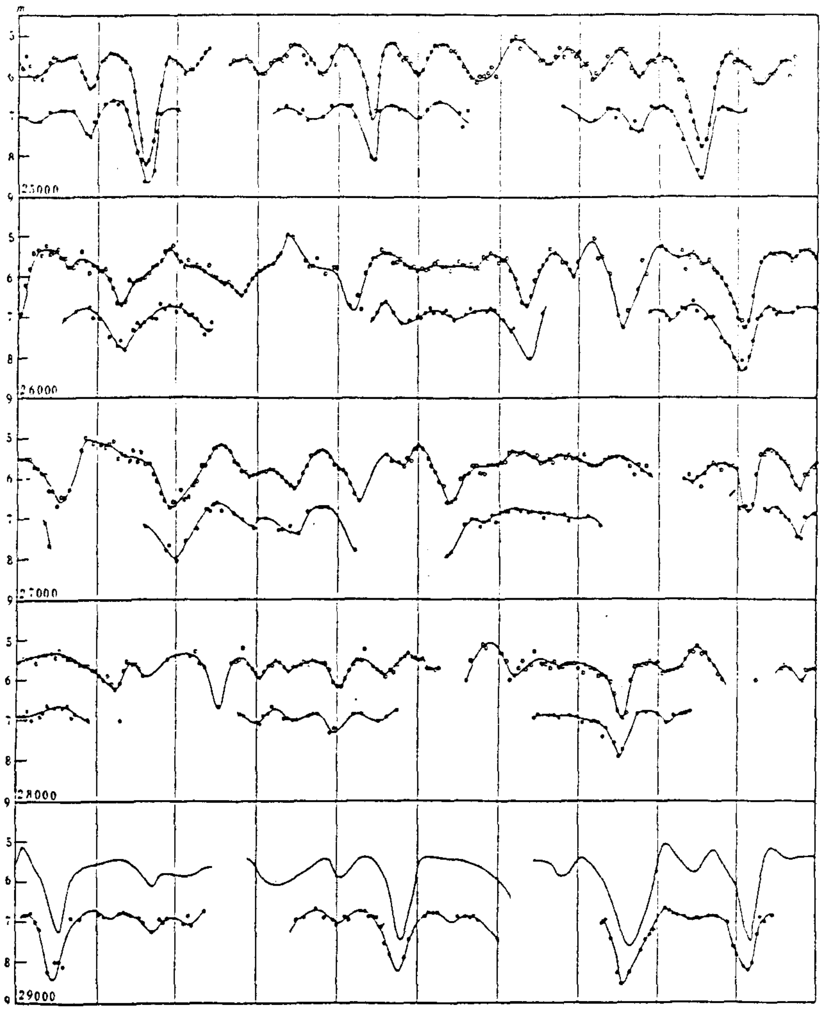

Fig. 2. Long-term visual (open circles) and photographic (filled circles) observations of the RV Tauri star R Sct (Payne-Gaposchkin et al. 1943). Note that alternating deep and shallow minima do not always occur; the pulsation can be quite irregular.

support the idea that RV Tauri stars may exhibit a smooth progression from period-2 behaviour to irregularity or chaos. The return map of S Vul is particularly interesting, and supports the suggestion that this 68.8-day "Cepheid" shows RV Tauri characteristics.

5.2. RV TAURI STARS: LONG TERM CHANGES

The periods of RV Tauri stars exhibit a wide variety of long-term changes (see Percy et al. 1991 and references therein). There are *abrupt* changes whose magnitude, when averaged over the duration of the observations, is in rough agreement with evolutionary predictions. There are *cyclic* changes (especially prominent in AC Her; see Zsoldos 1988) which are not due to, for instance, light travel time in a binary system. There are *irregular* changes which can be explained by random changes in period from one cycle to the next (Percy, Csatary and Zorgdrager, unpublished results), which are similar to the period fluctuations in Mira stars. All of these period changes are useful in constraining evolutionary models of RV Tauri stars.

About half of all RV Tauri stars (the RVb stars) show long-term changes in mean brightness, on time scales of up to 2500 days. The long period is roughly 10 times the shorter one. In the case of U Mon, the long-term light curve is similar to that of a totally-eclipsing binary (!). The amplitude of pulsation becomes very small when the star is at its long-term minimum. Long-term radial velocity variations have been observed in U Mon, but the cause of the RVb phenomenon has yet to be identified.

6. Semi-Regular (SRd) Yellow Supergiants

This is a heterogeneous group of seldom-studied, poorly-understood stars. In the *General Catalogue of Variable Stars*, there are 122 RV Tauri stars and 78 SRd variables. In many cases, there may be insufficient observations to classify the star reliably. Zsoldos and his collaborators have published a number of studies of individual RV Tauri and SRd stars, utilizing new UBV photometry as well as archival data. See Eggen (1986) for a recent review of SRd variables.

As mentioned in Section 5, theoretical results suggest that the sequence W Vir → RV Tau → SRd may show a continuous spectrum of behaviour from periodicity through successive period-doubling to chaos. Mantegazza (1984) used factor analysis to separate partially the RV Tauri and SRd variables on the basis of DDO colours; the SRd variables are cooler, in agreement with the theoretical results.

The problems of identifying period-4, period-5, and chaotic behaviour in SRd variables are in most cases similar to those in RV Tauri stars, or worse: too little data and/or too little precision. There is also the very real problem of determining the effective temperature and luminosity.

6.1. METAL DEFICIENT YELLOW SUPERGIANTS

Several authors (most recently Waelkens et al. (1991); see also references therein) have called attention to this small but interesting group. HR4049 and HD 52961 have [Fe/H] = −4.8, low photometric amplitudes, and periods of several weeks. They are presumably post-AGB stars, but how long do they spend in this stage, and where are their progenitors?

6.2. UU HERCULIS STARS

These are defined as high galactic latitude F and G supergiants with low photometric amplitudes and periods of several weeks. They were thought by some to be massive, young stars (in which case, how did they reach high galactic latitude?) but are now generally believed to be low-mass stars of the old disc population, in the post-AGB stage of evolution (Arellano Ferro et al. 1989; Luck et al. 1990).

The best-studied examples are UU Her itself, 89 Her (Fernie 1991a) and HD161796 (Fernie 1991a). 89 Her is fairly regular with a period of 65.0±1.2 days; HD161796 is more irregular. The latter star is cooler, and its greater irregularity conforms to the theoretical predictions of Buchler, Kovacs and their collaborators.

Fernie and Sasselov (1989) have shown that the lack of observable period and colour variations in UU Her place strong constraints on its evolutionary status.

7. R Coronae Borealis Variables

R CrB stars are rare carbon-rich hydrogen-deficient yellow supergiants which undergo unpredictable rapid decreases in brightness, followed by slower recovery to normal brightness. The fadings are due to obscuration by dust clouds. Most R CrB stars (and cool hydrogen-deficient carbon stars in general) also undergo small-amplitude brightness variations on time scales of 40 to 200 days or more, probably due to pulsation (Lawson et al. 1990).

The pulsations are most obvious in RY Sgr. In this star, they are sufficiently regular that the observed period changes can be compared with an evolutionary model (of a 0.7 solar mass star in the post-AGB contraction phase). The agreement is good, at least to first approximation. In R CrB itself, Fernie (1991b, and references therein) has found that the pulsations are somewhat irregular, though there is a characteristic time scale of 40 to 50 days. A subsequent analysis by Lawson (1991) of 1985–90 photometry reveals two or more periods in the 1986–89 data, and a different period in the 1985 and 1990 data. Thus, it is not clear whether the pulsations are multiperiodic, chaotic or irregular.

Feast (1986) has proposed a model in which dust clouds are ejected every 40 days in a cone angle of 40°, in random directions. The average rate of mass loss is $10^{-6} m_{\odot}/a$. These ejections are adequate to explain the observed frequency of fadings.

The similarity between the time scale of the ejections in this model, and the time scale of the photometric variations, is one of several indications that the pulsations may be connected with the ejections. But why are discrete clouds of dust produced? Is it because they are somehow triggered by non-radial pulsation? G. Clayton, B. Whitney and their collaborators (1991, preprints) have proposed that the dust forms within one or two stellar radii of the photosphere, and that individual dust clouds form as a result of density enhancements caused by the passage of shocks through the atmosphere.

8. Discussion

The study of non-linear processes in supergiant variables requires long series of observations of good and consistent quality. Long-term projects are often not encouraged or supported in astronomy. This is unfortunate, because they provide types of information not otherwise available.

Long-term visual and photographic observations exist for many supergiants. In "raw" form, these observations may be inadequate for some purposes, such as to identify multiperiodicity or chaos. It may be possible to process these observations so as to extract the maximum possible information. This requires that the observations be preserved and archived in electronic form - and continued, of course.

Long-term photoelectric observations of some supergiants are now becoming available, both from Automatic Photometric Telescopes (APT's) and networks of skilled amateur astronomers such as those in the AAVSO photoelectric program. The papers by Fernie (1991a,b) and by Zsoldos and Percy (1991) illustrate the type of research which can be done. The most interesting results, however, often take a decade or more of data.

Some degree of coordination is essential. APT's and human observers should share the monitoring of selected stars. Long-term coordinated photometric, spectroscopic and polarimetric observations should be made of selected stars; objects such as P Cyg, ρ Cas, α Ori, R Sct, 89 Her and R CrB come immediately to mind. The planning of such observations should be an important part of future meeting of this kind.

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