

Cepheid-like Supergiants in the Halo

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Abstract. The newly proposed UU Her-type stars are discussed; their main features being long-period variability and high galactic latitude. It is unlikely that the UU Her stars originated in the plane of the galaxy as they are now located more than a kiloparsec above it. An alternative explanation of their normal Population I characteristics must be looked for.

In the past several years, there has been considerable interest in the so-called Cepheid-like supergiants. One intent of these studies has been to find very long-period Classical Cepheids. However, it has gradually become evident that there also exist variable supergiants blueward of the instability strip. The star UU Her is a good example of such a variable, yet, for many years, little attention has been paid to it. However, now it seems that pulsation to the left of the blue radial pulsation edge can be explained theoretically (e.g., Shibahashi & Osaki 1981, predict observable low-harmonic non-radial modes in these regions). Thus the similar variability of many supergiants of different status might be the result of a single pulsation mechanism. Such stars could be considered as part of a wider class (Percy 1980); however we then lack overall homogeneity. Accordingly, we might expect that subtle differences in the variability of Cepheid-like supergiants should exist; and as more details of their photometric behaviour become known, this appears to be the case.

In that context comes our suggestion that there exists a small group of Cepheid-like supergiants sharing similar variability, and having other properties in common, such as their galactic distribution. We have called these stars UU Herculis stars (Sasselov 1983). They seem to be F0-F7 supergiants of roughly normal composition yet located at high galactic latitudes - an apparent contradiction in terms (Sasselov 1984). The main features of their semi-regular variability are:

- small amplitudes (0.1 to 0.6 mag) and long periods (40 to 100 days);
- pulsation mode switching: two (or three) distinct alternating modes (within the above period range), switching semi-regularly from one to the other, with a shorter interval of erratic fluctuations in between;
- short standstills: unpredictable abrupt ceasing of pulsation for a couple of months.

Nonradial pulsations seem to offer the least contradictory explanation but evidence is inconclusive so far.

At present the established UU Her stars are five in number and there is a list of some 33 suspected, as well. We tend to widen the frames of the term "variability type", paying particular attention to the contradiction between their Population I parameters and high galactic latitudes.

Concerning the status of the UU Her stars: Are they really normal Population I supergiants, or are they post-AGB stars of the old-disk population masquerading as normal? The latter explanation has been suggested recently by Bond, Carney & Grauer (1984) who call them 89 Her variables. Another suggestion comes from the work of Belyakina et al. (1984) who find many similarities between the PU Vul-phenomenon and the UU Her stars. Following this line of reasoning there is an interesting analogy with the discussion about the status of the high-latitude B-stars. The initial suggestion that they are subluminescent and "mimic" normal Population I parameters seems now to be inconsistent with the many detailed analyses of Keenan et al. (1982), Keenan & Lennon (1984), Tobin & Kaufmann (1984) and other. Similarly normal A-type stars have been found towards the South Galactic Pole by Rodgers et al. (1981).

So, our further discussion of the UU Her stars depends critically upon the reliability of their spectroscopic and photometric analyses. We prefer as most reliable the parameters derived from detailed studies of the two UU Her stars in binary systems, namely BL Tel and 89 Her. For them normal Population I parameters and solar abundances have been obtained (Table 1). As regards the other UU Her stars, HD 161796 seems to have solar abundances (see Fernie & Garrison, 1984); and HD 112374 is moderately (Luck et al., 1983) or slightly (Sasselov & Kolev, 1984) metal-poor. The latter fact perhaps should not lead automatically to a low-mass interpretation, as there exist young massive F-supergiants in the plane which are also slightly metal deficient (e.g. ι Car, analysed by Boyarchuk & Lyubimkov, 1984). On the other hand, it should be realised that we are quite likely to come upon some low-mass old stars among the suspected UU Her stars, as is the case with HD 46703 (Bond et al., 1984). However, it seems that generally the low mass alternative is preferred mainly because of the problems arising from the high galactic latitudes of these stars. Otherwise, we should have to admit that star formation is possible in the halo. Indeed, this unorthodox possibility does not appear so exotic at present. Dyson & Hartquist (1983) showed recently that OB-stars may well be formed in the halo by the collision of cloudlets within intermediate and high-velocity clouds. Their quantitative calculations are based on parameters derived from radio observations. Moreover now that there is evidence for normal B-stars in the halo (as mentioned above) such early-type objects might be the predecessors of the UU Her stars.

Following the theoretical results of Dyson & Hartquist (1983) one should expect to find in the halo a very sparse population of early-type stars, occasionally forming in wide groups of several stars each.

Perhaps such might be the concentration of F-type supergiants (MK-classification) we have noted around SA 11, 27, 28 and 31. They comprise 5 to 7 stars each, of 8th to 10th magnitude in an area of 4 to 6 deg². This gives rough dimensions of about 200 to 400 pc. Thus they seem to resemble some peripheral isolated OB-groups in the nearby galaxy M33. However a detailed study of these stars is necessary before discussing the structure of the apparent concentrations they form.

In summary, we suggest the existence of a group of Cepheid-like supergiants - UU Her stars - which pose two major problems. First of all, they exhibit a quite specific variability with some unusual properties such as pulsational mode switching and standstills. On the other hand, they are at high galactic latitudes being either tracers of recent occasional star formation in the halo, or perhaps post-AGB stars - both alternatives being interesting. Or it may be so, that stars of both status exist but are not well separated yet.

We would like to conclude here, leaving the questions open, being only convinced that the UU Her stars deserve our special attention in the future.

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Table 1

	89 Her	BL Tel(F)
MK	F2 Ib	F5 Ia
<B-V>	0.25	0.37
T_{eff}	$7000^{\circ}\text{K} \pm 100$	$6700^{\circ}\text{K} \pm 100$
M_{v}	-6.8	-7.2
R/R_{\odot}	210 ± 100	200 ± 40
M/M_{\odot}	13 - 24	14 - 23
Z	1100 pc	-2900 pc
V_{r}	-27 km/sec	+92 km/sec
Abundance	solar	solar
Binary type	SB (?)	SB, EB
Source	Fernie (1981) Arellano Ferro (1984)	van Genderen(1982)

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