Astron. Astrophys. 79, 115–120 (1979)

ASTRONOMY AND ASTROPHYSICS

Ultraviolet Photometry with the Astronomical Netherlands Satellite (ANS) Observations of β Canis Majoris Variables

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Received November 20, 1978

Summary. We describe detailed observations with the ANS of three β Canis Majoris variables: ξ^1CMa, HD 61068 (whose discovery is reported here) and 15 CMa. Light curves at five ultraviolet wavelengths are presented, and the periods and amplitudes are discussed. The ultraviolet colors are used to derive temperatures and temperature variations, which are compared with the MK spectral types. We also discuss the anomalously high luminosity found for ξ^1CMa on the basis of certain line strengths.

Key words: β CMa stars — variable stars — ultraviolet observations

I. Introduction

Previous studies of the ultraviolet light variations of β Canis Majoris stars, using the OAO-2 and TD-1A satellites (Lesh 1976, 1978; Beeckmans and Burger, 1977) have shown that the ultraviolet light curves for these stars are apparently in phase with the blue light curves (to within the observational errors), and that their amplitudes increase strongly with decreasing wavelength. This makes a satellite-borne photometer an ideal instrument for studying the details of the light variation of a star whose amplitude in the visual wavelength region is small, and also for testing supposedly constant stars for low-amplitude variability. Moreover, very small temperature variations can be measured through the change in a suitably defined ultraviolet color index – $(m_{1910} - V)_0$ in the case of OAO-2 data – and can be used to study the variation in radius, which is related to the pulsation mode.

Well-determined ultraviolet light curves are available for only a few β Canis Majoris stars, however, because of the large amount of continuous satellite observing time required to provide complete phase coverage. (The 4–6 h periods of these stars are often nearly commensurate with the 100 min orbital period of a satellite in a typical Earth orbit.) And no "normal" B stars have yet been monitored in the ultraviolet, to search for previously undetected variations. For these reasons, Plaut proposed a β Canis Majoris observing program for the Astronomical Netherlands Satellite, ANS. We are very grateful to Dr. Plaut for transferring his interest in this program to us. The program consisted of 14 known variables, 3 suspected variables, and 9 early B stars that were not known to be variable. Twenty of these stars were actually observed by ANS at least once, but because of the constraints of the satellite's pointing system (observations limited to an angle of 90° ± 1° from the Sun), only four of them had enough independent observations to allow us to construct light curves. In this paper, we discuss ξ^1 Canis Majoris, 15 Canis Majoris, and HD 61068. The ANS data for 12 Lacertae, a well-known multiperiodic variable that exhibits strong amplitude modulation, will be discussed together with the OAO-2 data for this star in a future paper.

II. The Observations

The five-channel ultraviolet photometer on board ANS has been described by van Duinen et al. (1975). Observations were made simultaneously in five channels with central wavelengths of 1550, 1800, 2200, 2500, and 3300 Å, each having a typical bandwidth of 150 Å. The narrow-band ($\Delta\lambda$ = 50 Å) channel at 1550 Å was rarely used for the stars in this program.

Each observation normally consisted of six or more 8 s integrations with the instrument pointed at the target star, preceded and followed by readings of the dark current.

An automatic reduction program was used to reduce the measurements to counts per second; it subtracted dark current and made corrections for sensitivity changes of the detector outputs as a function of time, and for non-linearity. The absolute fluxes were obtained using the laboratory photometric calibration presented by Wesselius et al. (1978), and converted to magnitudes on the ANS scale, where m(λ) = 0 corresponds to a flux of 3.62 10^{-9} erg s^{-1} cm^{-2} Å^{-1}.

III. Light Variations for Individual Stars

A. Xi[1] *Canis Majoris*

A thorough photometric investigation of this object has recently been made by Shobbrook (1973), who concluded that

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it is one of the most stable pulsators among the β Canis Majoris stars. He derived the following ephemeris:

$$\text{Max. light} = \text{JD}_\odot\, 2441296.0514 + 0.2095755\, E.$$

This star has only one pulsation period, with no detectable secular period variation. Although previous photometric observations (Walker, 1952; Williams, 1954; van Hoof, 1962) indicated possibly asymmetric light curves, Shobbrook found the light curves to be symmetric but slightly non-sinusoidal. This was reflected in the presence of the first harmonic of the fundamental period, with an amplitude about 15% of the amplitude of the fundamental.

Beeckmans and Burger (1977) reported ultraviolet observations of ξ^1 CMa with the TD-1A satellite. From five spectral scans (covering eight different phases) they determined light ranges of 0.143, 0.110, 0.10, and 0.08 mag at 1550, 1950, 2350, and 2750 Å, respectively.

ANS obtained a total of 25 independent observations of ξ^1 CMa in March 1976, over an interval of a little more than two solar days. Eight successive stellar pulsation cycles were covered. The data are well fitted by Shobbrook's ephemeris, with a shift of -0.006 d in the predicted epoch of maximum light (a change $\Delta\phi = +0.030$ in the phase). This is about 2.5 times the expected error, resulting from the standard error in Shobbrook's epoch combined with the standard error in his period (multiplied by 7500 cycles). Moreover, the *optimum* phase shift is slightly larger for the three shorter wavelengths ($\Delta\phi = +0.035 \pm 0.005$ for $\lambda \leqq 2200$ Å) than for the two longer ones ($\Delta\phi = +0.025 \pm 0.005$ for $\lambda \geqq 2500$ Å). This may be the first indication of a phase difference between oscillations at ultraviolet and visual wavelengths in β CMa stars; but simultaneous ground-based and satellite observations would be needed to demonstrate such an effect conclusively.

The light curves obtained for ξ^1 CMa by fitting a sine curve with Shobbrook's period to the data, using the method of least squares, are shown in Fig. 1. The light ranges and mean magnitudes found in this way for each of the five wavelengths observed are listed in Table 1. Like other β CMa stars, ξ^1 CMa has a light amplitude that increases strongly with decreasing wavelength. The light ranges at the shortest wavelengths are larger than those cited by Beeckmans and Burger (1977), by about twice the predicted error. Since Beeckmans and Burger had only a few observations, none of which were made at minimum light, they may have underestimated the amplitude in these cases.

A Fourier analysis showed that no harmonics of the principal period were present with an amplitude greater than 10% of that of the main oscillation. Moreover, the amplitude in the harmonics was constant with wavelength, rather than increasing toward shorter wavelengths, as the amplitude at the principal period does. This probably means that any harmonics present are due to noise and instrumental effects, rather than to the star itself. Therefore we conclude that the oscillation of ξ^1 CMa is essentially sinusoidal. Inspection of the data points in Fig. 1 does not give any indication of asymmetry between the maxima and minima.

B. HD 61068

The star HD 61068 (HR 2928) was put on the observing program because its spectral type (B2 III, Lesh, 1968) is similar to those of the known β Canis Majoris variables. It has no history of suspected variability – in fact, it is a standard star for Walraven's photometric system (Walraven et al., 1963) and has been used as a comparison star for southern hemisphere Cepheids.

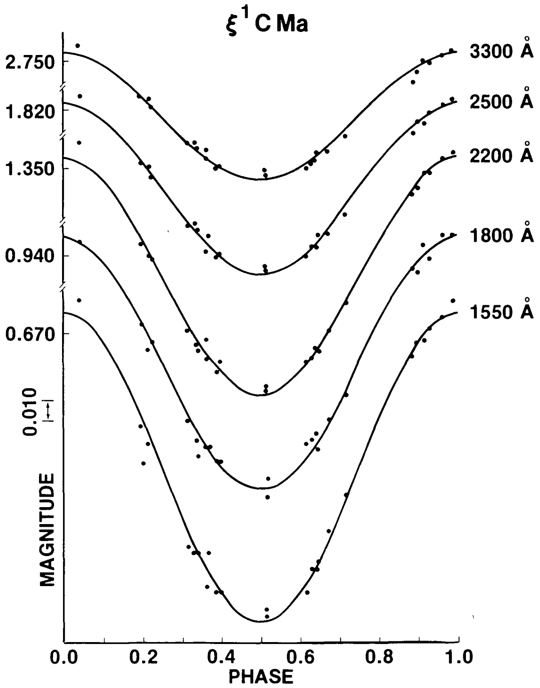

Fig. 1. Ultraviolet light curves for ξ^1 CMa

The satellite observed HD 61068 over two solar days in April 1976, obtaining a total of 22 independent data points at each wavelength. Two more points were obtained in April 1975, and one in October 1975. A plot of the ANS magnitude at 1550 Å versus the epoch of observation quickly revealed that the star is variable, with a period of about four hours.

A Fourier analysis of the 1976 data (separated by wavelength) gave an optimum period of 0.1613 d ± 0.0007. By adding in the April and October 1975 data points, we were able to refine this to 0.16121 d ± 0.00001. A least-squares fit of the data points to a sine curve of this period gave the amplitude and the mean magnitude at each wavelength, as listed in Table 1, and the optimum epoch of maximum light.

Table 1. Mean ultraviolet magnitudes and light ranges of β CMa variables[a]

Star	Wavelength (Å) 3300	2500	2200	1800	1550
ξ^1 CMa	2.779	1.861	1.406	0.996	0.740
	0.064	0.087	0.122	0.130	0.161
HD 61068	3.798	3.519	3.276	2.729	2.527
	0.018	0.026	0.031	0.041	0.043
15 CMa	3.309	2.440	2.118	1.687	1.459
	0.020	0.025	0.030	0.033	0.042

[a] For all three stars, the formal probable error of m_λ is 0.001 or less at all wavelengths. The probable error of Δm_λ is 0.002 at 1550 and 1800 Å, and 0.001 at the other wavelengths

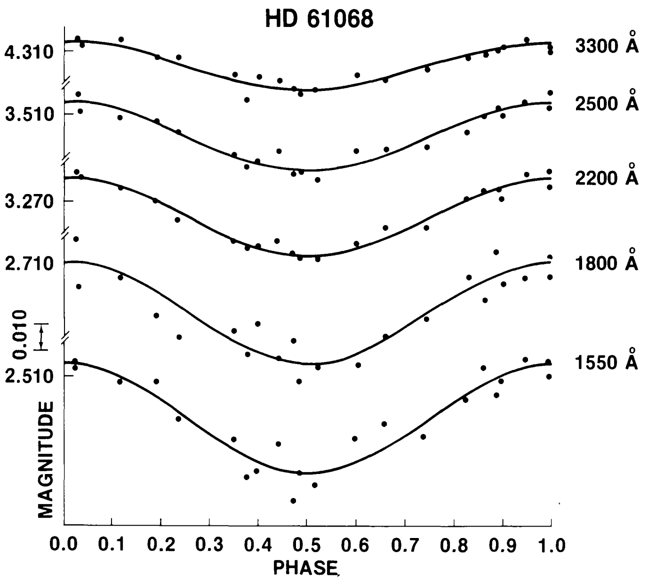

Fig. 2. Ultraviolet light curves for HD 61068

The corresponding ephemeris is:

Max. light = $\mathrm{JD}_\odot$ 2442887.446 + 0.16121 E.

The light curves obtained with the least-squares fitting procedure are shown in Fig. 2; the data do not show any obvious systematic deviation from the sinusoidal curves, but we did not actually search for harmonics in the Fourier analysis, because of the uncertainty of the principal period.

The light amplitude of HD 61068 increases with decreasing wavelength, but not as dramatically as is the case with some other β Canis Majoris stars. The amplitude at the effective wavelength of the B filter (4300 Å) is probably about 0.01 mag, which should be detectable with careful photometry. To the best of our knowledge, this star has never been observed in a photometric survey. Shobbrook (1978) included HD 61068 in a recent program of stars near the β CMa variables in the $\beta/[c_1]$ diagram, but was unable to observe it because of its unfavorable right ascension.

C. 15 Canis Majoris

The program star most extensively observed by ANS – 15 Canis Majoris – is described by Shobbrook (1973) as "probably one of the least stable pulsators among β Canis Majoris variables." Shobbrook found a period of $P = 0.184557$ in his 1971–72 photometry, together with the first and second harmonics of this period ($\frac{1}{2}P$ and $\frac{1}{3}P$). However, there were large night-to-night amplitude variations, which apparently could not be explained by beats with additional short-period oscillations. When Shobbrook analyzed other sets of photometric data (van Hoof, 1965) and radial velocities (Lynds et al. 1956), he found that although a period at about 0.185 d was always present, it was not always the most prominent period in the spectrum; the presence of another persistent short period could not, however, be conclusively established. Shobbrook finally concluded that 15 CMa is singly periodic, but that the period is variable and the amplitudes in both light and radial velocity are also randomly variable.

The ANS satellite made three observing runs on 15 CMa in April 1975, October 1975, and April 1976. The October 1975 run, with 49 observations at each of the five wavelengths, is the largest data set. A Fourier analysis of these data yields a principal period of $P_1 = 0.185$ d, which is undoubtedly to be identified with Shobbrook's P. The variance of this data set is small, only twice the expected counting error, and can be completely accounted for by the periodicity P_1. Therefore, although the analysis also shows that $\frac{1}{2}P_1$, $\frac{1}{3}P_1$ and even $2P_1$ are present, there is little reason to believe that these harmonics are really present in the stellar oscillation, rather than being due to beats with the (statistical) noise. However, when the October 1975 data set, which covered 2.4 solar days and 14 pulsation cycles, is analyzed in subsets of a few cycles each, it is clear that the amplitude of the oscillation decreases steadily (at all five wavelengths) over this interval. This is analogous to Shobbrook's finding of large night-to-night variations. Although the presence of a beat period is suggested, a search of the frequency domain corresponding to periods between 1 and 9 d showed no evidence for such a period. Nor is there any short period at the right interval from P_1 to produce a beat period in the 1–10 d range. Therefore we may conclude with Shobbrook that the amplitude of the principal period of 15 CMa is randomly variable. Another possibility, which may be supported by the other two ANS data sets, is that the phase in the principal period is randomly variable.

The April 1975 data (23 points) and the April 1976 data (17 points) do not appear to be dominated by a single short period. The Fourier analysis shows the 0.185 d period to be present, but there are several other competing short periods of comparable amplitude, including the harmonics of P_1. However, since the variance in these data sets is no greater than the expected counting error, there is actually no statistical evidence that the star was variable at all, at these epochs. A very long-term modulation (with a period of about 1 yr) to connect these data sets with the October 1975 data is unlikely, since this would imply the presence of another short period differing from P_1 by less than a minute. The most likely explanation is a randomly varying amplitude and/or phase in P_1.

Figure 3 shows the light curves obtained when the October 1975 data are phased with Shobbrook's period. Different symbols are used for different subsets of cycles in the data sets so that the decreasing amplitude effect may be appreciated. The curves, however, were obtained by a least-squares fit using *all* the data at each wavelength. A rather large phase shift, $\Delta\phi = +0.135$, is required. This corresponds to a change $\Delta T = -0.025$ d with respect to Shobbrook's epoch of maximum light ($\mathrm{JD}_\odot$ 2441296.1640). But in view of the obvious instability of the light curves, it is not possible to attribute this either to an error in the epoch or to a phase shift between the ultraviolet and the visible oscillations.

Table 1 lists the mean magnitudes and light amplitudes obtained from the October 1975 data set, taken as a whole. Although there is a tendency for the amplitude to increase with decreasing wavelength, it is not very marked, probably because such a large proportion of the variance is due to noise. Beeckmans and Burger (1977) found ultraviolet light ranges of the order of $0^m.03$ for 15 CMa.

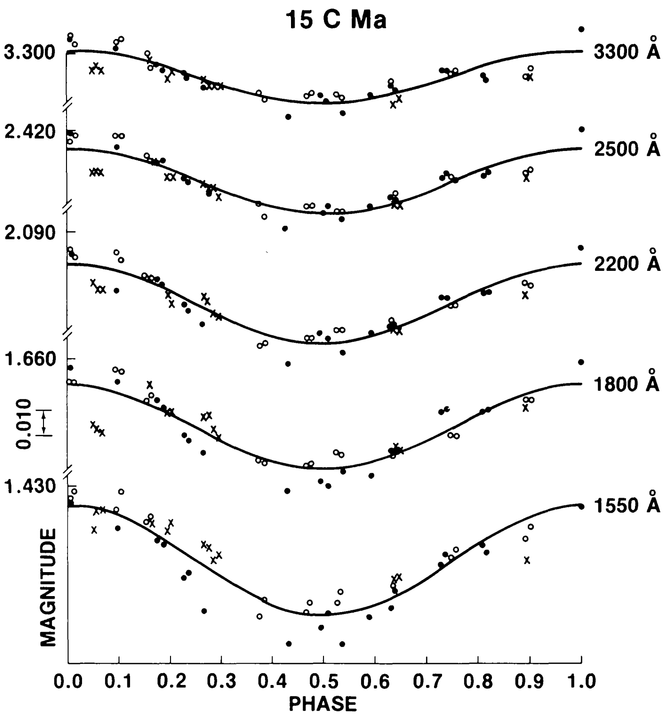

Fig. 3. Ultraviolet light curves for 15 CMa. Filled circles, cycles 1–6; open circles, cycles 7–9; crosses, cycles 10–14

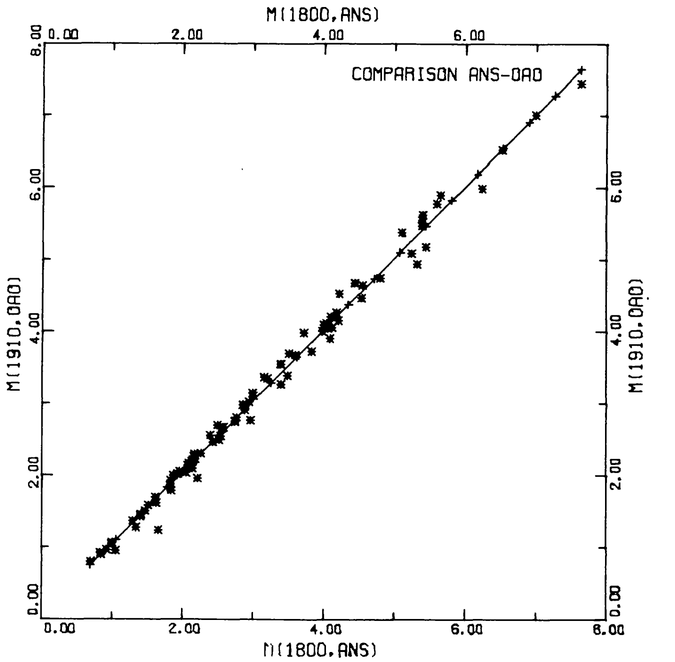

Fig. 4. Linear regression between m_{1910}, as observed by OAO-2, and m_{1800}, as observed by ANS, for 88 stars

IV. Physical Parameters Derived from Ultraviolet Photometry

A. Temperatures and Related Quantities

Lesh (1976) showed that the temperature of a B star can be deduced from OAO-2 photometry by means of the formula

$$\theta_{\text{eff}} = \underset{\pm 0.001}{0.111}\,(m_{1910} - V)_0 + \underset{\pm 0.002\ \text{(p.e.)}}{0.565} \tag{1}$$

where m_{1910} is the observed magnitude in the OAO-2 channel centered on 1910 Å. It follows that the temperature change in a variable star is given by

$$\Delta\theta_{\text{eff}} = 0.111\,(\Delta m_{1910} - \Delta V). \tag{2}$$

This temperature scale was used by Lesh (1977) to calibrate MK spectral types for main sequence B stars (luminosity classes III–V) in terms of effective temperature. The temperature of an individual star, derived in this way, is uncertain by ±3%. The mean temperatures per spectral type have a standard error of ±400 °K.

Rather than develop a new temperature scale based on the ANS photometry, we have derived a simple formula to convert from the observed magnitude at 1800 Å on the ANS system to the OAO-2 magnitude at 1910 Å. Using 88 stars observed by both satellites and fitting a straight line to the data by the method of least squares, as drawn in Fig. 4, we find

$$m_{1910} = \underset{\pm 0.006}{0.995}\, m_{1800} + \underset{\pm 0.022\ \text{(p.e.)}}{0.062} \tag{3}$$

Therefore the light range at 1910 Å is

$$\Delta m_{1910} = 0.995\,\Delta m_{1800}. \tag{4}$$

The computed effective temperature can be used to find the bolometric correction

$$\text{B.C.} = \underset{\pm 0.07}{-5.31} \log T_{\text{eff}} + \underset{\pm 0.3\ \text{(p.e.)}}{20.8} \tag{5}$$

according to Lesh and Aizenman (1973). Combining this with the absolute visual magnitude M_v, usually derived from the Hβ index for these stars, we can recompute the absolute bolometric magnitude on the basis of the new temperature. Then from

$$M_{\text{bol}} = 42.35 - 10 \log T_{\text{eff}} - 5 \log (R/R_{\odot}) \tag{6}$$

(Allen, 1963), we can find the equilibrium radius of the variable star. Lesh and Aizenman (1974) showed that the radius derived in this way is uncertain by ±13%.

The ratio of the radius variation to the luminosity variation (Watson, 1971),

$$\frac{\Delta R/R}{\Delta M_{\text{bol}}} = \frac{24}{17} \frac{P}{2\pi R} \frac{2K}{(\Delta M_v + \Delta \text{B.C.})}, \tag{7}$$

can be computed from the above quantities. The probable error in this ratio is ±21%, according to Lesh (1976).

One of the biggest sources of error in these calculations is the reddening correction, which is much greater in the ultraviolet than at visual wavelengths. We determine the color excess $E(B-V)$ from the UBV photometry, using the intrinsic colors of Johnson (1963). The ultraviolet color excesses are then given by $E(m_{1910} - V) = 5.38\,E(B-V)$ (Code et al., 1976), and $E(m_{1800} - V) = 4.79\,E(B-V)$ (Wu, private communication).

In addition to comparing the computed effective temperatures with the mean value for the appropriate spectral types (26,000 ± 400 °K for B1 III, 21,800 ± 400 °K for B_2 III according to Lesh, 1977), we can compare the dereddened color $(m_{1800} - V)_0$ directly with the average value observed for stars of that type (-3.39 ± 0.2 for B1 III, -2.98 ± 0.2 for B2 III, according to Wu, private communication.)

Table 2 lists the principal physical parameters derived for the three stars under consideration here. The input data are referenced in the following paragraphs, and comparisons with other results are given.

For ξ^1 CMa, the *UBV* photometry was taken from Lesh (1972), the period and yellow light range from Shobbrook (1973), and the radial velocity amplitude from McNamara (1955). The quantity $(m_{1800} - V)_0$ was found to be -3.39, identical to the average value for B1 III stars. The effective temperature also agrees with the expected value for B1 III, and the temperature range is the same as that found by Beeckmans and Burger (1977) for ξ^1 CMa. We conclude that the ultraviolet colors of ξ^1 CMa, and the effective temperature derived from them, are completely normal for the MK spectral type. The computed radius agrees with the value derived by Lesh and Aizenman (1974), and the ratio $(\Delta R/R)/\Delta M_{bol}$ is similar to the values of 0.10 and 0.11 found by Lesh (1976) for γ Peg and δ Cet, respectively, and to the mean value for β CMa stars quoted by Watson (1971). Beeckmans and Burger (1977), however, found the conspicuously high value of $(\Delta R/R)/\Delta M_{bol} = 0.31$ for ξ^1 CMa.

The *UBV* photometry for 15 CMa also came from Lesh (1972). The computed value of $(m_{1800} - V)_0 = -3.32$ does not differ significantly from the average value for B1 III stars. The effective temperature is likewise in agreement with the expected value. We find the same value for the radius as did Lesh and Aizenman (1974). Because of the changing amplitude in the light variations of 15 CMa, and the lack of visual observations made simultaneously with the ultraviolet observations, it is not possible to compute the temperature change and the other related quantities.

The best available photometry for HD 61068 is from Nicolet (1978). The computed value of $(m_{1800} - V)_0$ is -3.25, more than 0.2 mag bluer than the average value for a B2 III star. The effective temperature computed from Eqs. (3) and (1) is also significantly hotter than average. The calculated radius of 7.2 $R_\odot$ is in reasonable agreement with radii of other β CMa stars with a spectral type of B2 III: 9.2 $R_\odot$ for ν Eri and 8.1 $R_\odot$ for BW Vul, according to Lesh and Aizenman 1974. With no measure of the visual light amplitude, the temperature variation of HD 61068 cannot be determined as yet.

Since the "observed" temperatures depend strongly on the reddening correction, it is useful to have an independent check of the quantity $E(B - V)$. As described by Pottasch et al. (1976) it is possible to derive $E(B - V)$ values from the ultraviolet data alone, assuming only that the intrinsic spectrum is smooth between 1800 and 2500 Å. We used this method and the ANS data to compute values of $E(B - V)$ for ξ^1 CMa, 15 CMa, and HD 61068. The results were 0.00, 0.00, and 0.04, respectively. Because of the systematic uncertainty in the absolute calibration of ANS, there is a systematic uncertainty of about 0.02 in these values of $E(B - V)$. The values used in the preceding paragraphs, derived by the conventional method, were 0.01 for ξ^1 CMa, 0.04 for 15 CMa, and 0.05 for HD 61068.

B. Luminosities and the Period-Luminosity Relation

It was already pointed out by Lesh and Aizenman (1973) that the absolute visual magnitude of ξ^1 CMa ($M_v = -5.05$ as derived from the Hβ index) is much brighter than the average for its MK spectral type of B1 III ($M_v = -4.0$, according to the calibration of Lesh, 1968). Panek and Savage (1976) subsequently noted that the Si IV and C IV lines in the OAO-2 spectra of this star are abnormally strong for its luminosity class. Beeckmans and Burger (1977) gave a spectral type of B0.5–1 I to ξ^1 CMa, using the ultraviolet classification system of Cucchiaro et al. (1976). This system is based on the Si IV, C IV, Fe II, and Fe III lines; Beeckmans and Burger's results essentially confirms Panek and Savage's observation that the Si VI and C IV resonance lines are too strong for the MK type.

However, we have already seen that the ultraviolet colors of ξ^1 CMa, and the temperature derived from them, are normal for its spectral type. Moreover, Garrison (private communication) has taken new spectrographic plates of ξ^1 CMa at both 120 Å/mm and 67 Å/mm, and he confirms the MK spectral type of B1 III, which was originally published in Hiltner et al. (1969).

Blaauw and Savedoff (1953) derived an empirical period-luminosity relation for the β Canis Majoris stars in the form

$$M_v = -10 - 9 \log P \text{ (days)}. \tag{8}$$

Similarly, Leung (1967) found an empirical period-luminosity-color relation:

$$M_v = 2.60 - 5.67 \log P \text{ (hours)} + 10.4\,(B - V)_0. \tag{9}$$

With Shobbrook's well-determined period for ξ^1 CMa, both of these relations predict an absolute visual magnitude of -3.9 to -4.0, which would be appropriate for a normal B1 III star. This is a further indication that the high luminosity deduced from the ultraviolet resonance lines and from the Hβ index is spurious. Apparently there is an anomalous effect on these strong lines (which are not used in MK classification) that does not appreciably change the continuous spectrum or the weaker lines. This is an interesting situation which merits further study, to see if the mechanism responsible for the anomalous line strengths is related to the pulsational instability.

The Hβ index for HD 61068 is $\beta = 2.620$ (Crawford et al., 1971), which with the calibration of Crawford (1970) corresponds to an absolute magnitude of $M_v = -3.31$, in very good agreement with the average value of -3.3 for B2 III stars (Lesh, 1968). With the period found in the present work, the star does not fit Blaauw and Savedoff's period-luminosity relation

Table 2. Parameters derived from ultraviolet data

Star	T_{eff}(K)	ΔT_{eff}(K)	$R/R_\odot$	$(\Delta R/R)/\Delta M_{bol}$
ξ^1 CMa	26,000 ± 800	1400	15.1 ± 2.0	0.09 ± 0.02
15 CMa	25,300 ± 800	—	12.0 ± 1.6	—
HD 61068	24,500 ± 800	—	7.2 ± 0.9	—

(which predicts $M_v = -2.9$), but does fit Leung's period-luminosity-color relation (which predicts $M_v = -3.2$).

For 15 CMa, the absolute magnitude deduced from the Hβ index is -4.49 (Lesh and Aizenman 1973), which is brighter than the average value of -4.0 for B1 III stars; the difference is not as great as for ξ^1 CMa, however, and probably does not indicate an abnormality. With Shobbrook's principal period of 0.184557 d, Blaauw and Savedoff's relation (Eq. 8) predicts $M_v = -3.4$, while Leung's relation (Eq. 9) predicts $M_v = -3.8$. The indicated luminosities are both much smaller than the observed value, but because the value of the period is uncertain and possibly variable, we cannot draw any conclusions about the true luminosity of 15 CMa.

V. Conclusions

Detailed observations of three β Canis Majoris stars are presented in this paper. We may summarize the conclusions for each star as follows:

1. ξ^1 CMa

This is a well-known β Canis Majoris star with a single, well-determined period. This period fits the ultraviolet light variations well, but there may be a small phase lag between the ultraviolet and visual variations. The ultraviolet light curves are apparently sinusoidal; the light amplitude increases strongly with decreasing wavelength. The ultraviolet colors and the temperature derived from them are normal for the MK spectral type of B1 III; the temperature variation associated with the pulsation is about 1400 °K. However, the Si IV and C IV resonance lines appear to be too strong for the spectral type, and the Hβ index implies a luminosity that is one full magnitude brighter than normal. The cause of this anomaly, which does not seem to affect the weaker lines or the continuous spectrum, remains unknown, and merits further investigation.

2. HD 61068

This star, which has no history of suspected variability, is the first β Canis Majoris star to be discovered by satellite observations. We derive a period of 0.16121 d, which should of course be refined by further, ground-based observations. The maximum amplitude is 0.04 mag at 1550 Å. HD 61068 appears to be hotter than average for its MK spectral type of B2 III. The luminosity derived from the Hβ index is normal. Radial velocity measurements are also needed to confirm the star's membership in the β Canis Majoris class.

3. 15 CMa

The ultraviolet observations confirm the fact that this is a very unstable pulsator, whose amplitude and period may both be variable. Variations with a period close to that derived from ground-based observations were observed in only one out of three observing runs. The temperature derived from the ultraviolet colors is normal for the spectral type of B1 III, while the luminosity may be slightly higher than average.

Acknowledgements. The ANS project was sponsored by the Dutch Committee for Geophysics and Space Research of the Royal Netherlands Academy of Sciences. We acknowledge the cooperation of the other members of the ANS-UV team: Drs. J. W. G. Aalders, K. S. de Boer, R. J. van Duinen, D. Kester, and C. C. Wu.

We are indebted to Prof. L. Plaut for his proposal to make UV observations of β Canis Majoris stars with the ANS.

Dr. D. J. Faulkner kindly provided the computer code for period analysis by Fourier series fitting. We are especially grateful for helpful conversations with Dr. D. D. Meisel and Dr. C. C. Wu.

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