VARIABILITY OF 20 CVn

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Abstract. The Delta-Scuti(?)variable, 20 CVn, has been observed photoelectrically on two nights, JD 2446586 and JD 2446949, in U, B and V filters. The average amplitudes on these nights come out to be 0.13 mag and 0.08 mag with the time durations from Maximum to Maximum of 0.035 mag and 0.045 mag, respectively. A period appears to be $0^d.13$. The average spectral type comes out to be F0. The shapes of the light and colour curves are variable. The possibility of it being an eclipsing binary cannot altogether be ruled-out.

1. Introduction

The star 20 Canum Venaticorum (= 20 CVn = BD+41°2380 = HD 115604 = HR 5017 = SAO 44549) was found to be a δ Sct-type variable by Danziger and Dickens (1967) during their observations of new short period variable stars. Breger (1969) collected photoelectric data for B, A, F-type short period variables, and confirmed the light variability in 20 CVn. Leung (1970) presented the interpretation of δ Sct stars and derived P-L and P-C-L relations. Penfold (1971) collected radial velocity observations of δ Sct stars and found 20 CVn showing little radial velocity. He also observed 20 CVn photoelectrically.

The Finding List for Observers of Interacting Binary Stars (Wood *et al.*, 1980) pointed out that slight variability in amplitude and radial velocity may be due to the star being an eclipising binary (EB). Lyubimkov and Rachkovskaya (1985) analysed spectra of 20 CVn and derived certain parameters. Hauck *et al.* (1985) attempted abundance analysis of 20 CVn and derived certain atmospheric parameters.

Unfortunately, none of these observers and investigators have taken into account the whole picture of various kinds of observations, and the photoelectric observations, which have been found to be insignificant In the literature.

2. Observation

The star, 20 CVn, was put on our observing programme and was observed photoelectrically on the 38-cm reflector of the Uttar Pradesh State Observatory, Nainital employing 1P21 photomultiplier, cooled to -20 °C, conventional U, B and V filters and d.c. techniques.

Only two nights of observations could be secured on J.D. 2446586 and J.D. 2446949. 19 CVn(= BD+41°2374 = HR 5110 = HD 115271) was chosen as comparison star. The observations have been converted into standard system with the help of observations of number of standard stars. The details of variable and

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TABLE I
Data of the variable and the comparison star

Star	α_{1986}	δ_{1986}	V (mag)	Sp.	Error of individual observation (mag)
20 CVn (=HR 5017=HD 115604 =BD+41°2380)	$13^h17^m.0$	40°38′.5	4.73	F3	-
19 CVn (=HR 5110=HD 115271 =BD+41°2374)	$13^h26^m.0$	40°55′.8	5.79	A7	±0.03 (U) ±0.02 (B) ±0.01 (V)

TABLE II
Standard U observations of 20 CVn

J.D. (Hel.)	Phase	$\Delta m(v-c)$ (mag)	J.D. (Hel.)	Phase	$\Delta m(v-c)$ (mag)
2446586.1390	0.3000	-0.848	446949.1554	0.7338	-0.942
.1498	0.3830	-0.826	.1630	0.7923	-0.850
.1582	0.4476	-0.844	.1697	0.8438	-0.861
.1664	0.5107	-0.915	.1770	0.9000	-0.833
.1694	0.5338	-0.874	.1865	0.9730	-0.882
.1742	0.5707	-0.867	.1939	0.0300	-0.947
.1805	0.6192	-0.744	.2022	0.0938	-0.891
.1855	0.6576	-0.790	.2091	0.1469	-0.839
			.2144	0.1876	-0.883

comparison star are given in Table I, along with graphical errors of individual observations. The standard differential U, B and V magnitudes have been listed in Tables II, III and IV respectively. The data and parameters derived by various authors have been listed in Table VII. This table shows that on the average, the magnitude of the star is 4.72 mag, spectral type undoubtedly is F0 (with uncertainty in luminosity class), period is approximately $0^d.13$, $B-V \simeq +0.30$ mag. However, all other parameters are variable.

The radial velocity given by various observers shows no consistency, and obtained log g also shows variation. Likewise temperatures obtained are at variance.

3. Colours of 20 CVn

The average standard $U-B$ and $B-V$ colour indices of 20 CVn have been derived for each night, and these average colours come out to be $U-B = +0.214$ mag and $B-V = +0.281$ mag, adopting the colour of the comparison star as $U-B =$

TABLE III
Standard B observations of 20 CVn

J.D. (Hel.)	Phase	$\Delta m(v-c)$ (mag)	J.D. (Hel.)	Phase	$\Delta m(v-c)$ (mag)
2446586.1402	0.3092	-0.933	2446949.1561	0.7392	-0.973
.1509	0.3915	-0.934	.1634	0.7953	-0.955
.1587	0.4515	-0.987	.1701	0.8469	-0.953
.1670	0.5153	-0.993	.1774	0.9030	-0.964
.1698	0.5369	-0.949	.1872	0.9784	-0.947
.1746	0.5738	-0.946	.1957	0.0438	-0.954
.1809	0.6223	-0.896	.2026	0.0969	-0.960
.1860	0.6615	-0.863	.2094	0.1492	-1.007
			.2148	0.1907	-1.014

TABLE IV
Standard V observations of 20 CVn

J.D. (Hel.)	Phase	$\Delta m(v-c)$ (mag)	J.D. (Hel.)	Phase	$\Delta m(v-c)$ (mag)
2446586.1412	0.3169	-1.019	2446949.1567	0.7438	-1.093
.1509	0.3946	-1.009	.1637	0.7976	-1.094
.1591	0.4546	-1.039	.1705	0.8500	-1.074
.1670	0.5184	-1.028	.1780	0.9076	-1.050
.1701	0.5392	-1.024	.1876	0.9815	-1.056
.1751	0.5776	-1.015	.1960	0.0461	-1.053
.1810	0.6230	-1.010	.2030	0.1000	-1.089
.1864	0.6640	-0.987	.2098	0.1523	-1.082
			.2157	0.1976	-1.052

TABLE V
Colours of 20 CVn

J.D. (Hel.)	$U-B$ (mag)	J.D. (Hel.)	$B-V$ (mag)	J.D. (Hel.)	$U-B$ (mag)	J.D. (Hel.)	$B-V$ (mag)
2446586		2446586		2446949		2446949	
.1396	+0.205	.1407	+0.276	.1558	+0.151	.1564	0.310
.1504	0.228	.1509	0.265	.1632	0.225	.1636	0.329
.1585	0.263	.1589	0.242	.1699	0.212	.1703	0.311
.1667	0.198	.1670	0.225	.1772	0.251	.1777	0.276
.1696	0.195	.1700	0.265	.1869	0.185	.1874	0.299
.1744	0.199	.1749	0.259	.1948	0.127	.1959	0.289
.1807	0.272	.1810	0.304	.2024	0.189	.2028	0.319
.1858	0.193	.1862	0.314	.2093	0.288	.2096	0.265
				.2146	0.251	.2153	0.238

TABLE VI
Present results of 20 CVn

Details	Results		Average
Observation	J.D.2446586	J.D.2446949	
Error of individual	0.030 (U)	0.025 (U)	0.028 (U)
observation (mag)	0.020 (B)	0.020 (B)	0.020 (B)
	0.015 (V)	0.010 (V)	0.013 (V)
Maximum	Max.= J.D.2446586.1650	Max.I=J.D.2446949.1575	
		Max.II=J.D.2446949.2033	
Minimum	Min.I=J.D.2446586.1475	Min.=J.D.2446949.1800	
	Min.II=J.D.2446586.1875		
Duration	Min.I: $0^d.035$		
	Min.II: $0^d.045$	Min: $0^d.046$	$0^d.046$
Amplitude (mag)	Min.I: 0.105 (U)	Min: 0.095 (U)	0.100 (U)
	0.080 (B)	0.060 (B)	0.070 (B)
	0.045 (V)	0.044 (V)	0.045 (V)
Average of U, B and V amplitudes (mag)	0.077	0.066	0.072
Amplitude (mag)	Min. II: 0.180 (U)		
	0.145 (B)		
	0.052 (V)		
Average of U, B and V amplitudes (mag)	0.126		
$U-B$	+0.219	+0.209	+0.214
$B-V$	+0.269	+0.293	+0.281
Sp. (based on $B-V$ value)	F0	F0	F0
P	$0^d.13$	$0^d.13$	$0^d.13$

$+0.120$ mag and $B - V = +0.190$ mag. Presently obtained $U - B$ colour is considerably different from the one given by Danziger and Dickens (1967). The variation is apparent in assessing the luminosity class of this star, which ranges from II (Danziger and Dickens, 1967) to IV (Kukarkin, 1975). The standard colour indices are listed in Table V, and the colour curves are shown in Figs. 1a and 1b.

Present colours are in the vicinity of the colours given by Frolov (cf. Kukarkin, (1975)) and of the *Bright Star Catalogue* (Jaschek, 1982).

4. Discussion of Results

The error of individual observations in U, B and V filters is $\approx$ 0.02 mag, on the average. Our results are listed in Table VI , and are, thus, real. None of the

TABLE VII

Results of 20 CVn given by various authors

Results	Danziger and Dickens(1967)	Berger (1969)	Leung (1970)	Penfold (1971)	Wood et al. (1980)	Bright Star Catalogue (1985)	Hauck (1985)	Lyubimkov and Rachkovskaya (1985)	Astronomical Almanac (1986)	Present Work
Observation (J.D.)	2439149	2439302 2439304		2440362						2446586 2446949
Error of V Observations (mag)	±0.01			±0.01						±0.01 (Av. of U,B,V)
Magnitude (V)	4.74				4.7	4.73		4.71		
Amplitude (V) (mag)	0.031	0.028		0.035			0.035			0.044, 0.052
Period	$0^d.14$(?)	?	$0^d.122$	$0^d.135$ and $0^d.176$			$0^d.135$			$0^d.13$
$B-V$ (mag)	+0.32					+0.30			+0.30	+0.28
$U-B$ (mag)	+0.08									+0.21
Spectral Type	F0II-IIIp	F0II-IIIp	F0II-IIIp		F0	F0II-III			F3III	F0(?)
Nature	Variable, EB?	Delta Sct	Delta Sct	Delta Sct	EB ?	Delta Sct	Delta Sct			EB?
Radial Velocity	< 10 km s^{-1}			1.5 km s^{-1}		8 km s^{-1}	0.9 km s^{-1}	15 km s^{-1}		
$\log(L/L_\odot)$								1.53±0.33		
$L/L_\odot$								34.0		
$\log(R/R_\odot)$								0.52±0.14		
$R/R_\odot$								3.3		
M_V (Abs. mag.)	+1.15		+1.27			−0.7				
$m/m_\odot$ (comp.)	0.4									
$m/m_\odot$ (from Mbol.-T_e diagram	2.0									
Q (pulsation constant)	0.009									
log g	2.72						3.0±0.4	3.7		
Abundance								[Fe/H]=0.48±0.2		
Evolution	Probable member of Hyades moving group									

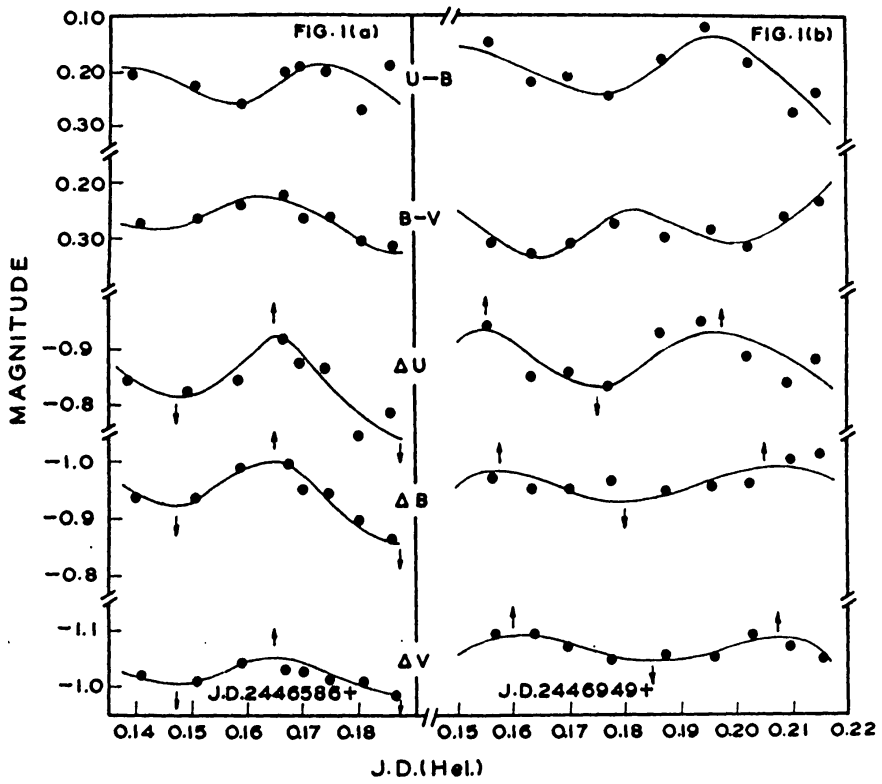

Fig. 1. Light and colour curves of 20 CVn.

earlier observers have observed more than a single night as compared to two by us, except Breger (1969), whose one night is scantily covered, as such our results are important. The period obtained by us is intermediate between the periods given by Leung (1970) and Danziger and Dickens (1967). Being observable in May and June (at the end of observlng season) at our place, the average error of individual observations of $\simeq$ 0.02 mag, is not too high.

5. Variability of 20 CVn

The observations and results of various investigators are listed in Table VII, and their observations are plotted in Fig, 2. There seems no set-type of variability. The amplitude (Max. to Min.) is variable and ranges from 0.022 mag (Breger, 1969) to 0.052 mag (present work) in V. There appears no consistency in the shapes of various light curves. We have obtained a period of $0^d.13(\pm 0^d.01)$ after trials. The phases computed with this period using the epoch, J.D.(Max.) 2440362.74 (Penfold, 1971), when plotted, the light curves indicate some set-type of variation, giving two minima of different shapes and two maxima. These features do point towards the older suspicion of 20 CVn being a different type of variable than δ Sct-type, and may be an EB.

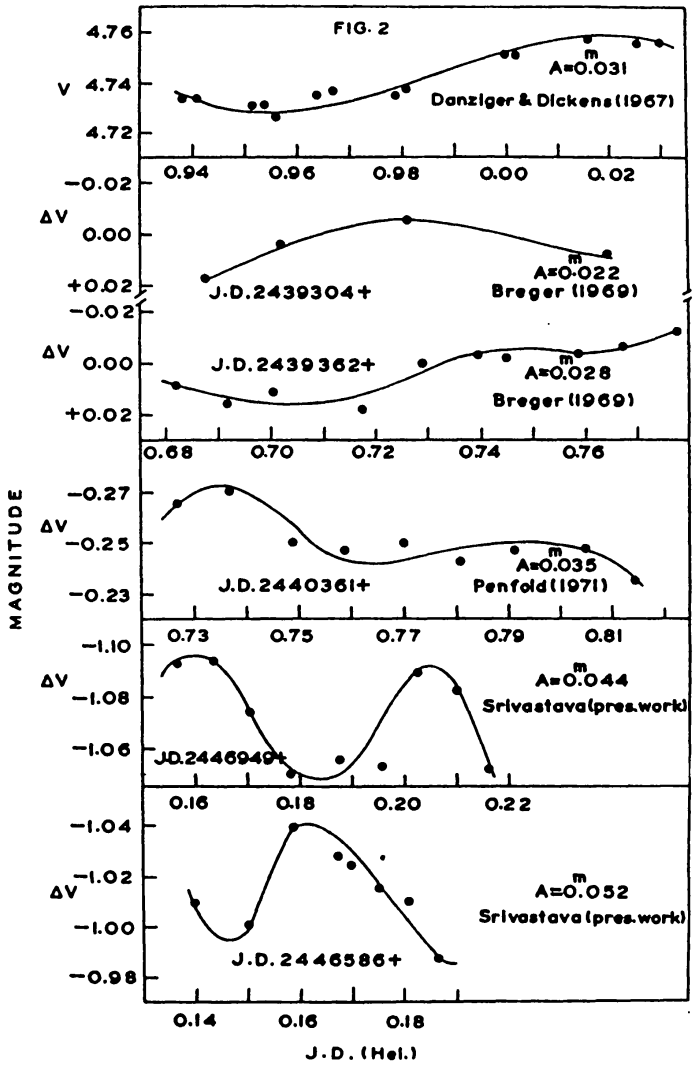

Fig. 2. Light curves of 20 CVn in V filter, given by various authors.

Some improvement may be desirable on getting more and more data. Wood *et al.*, 1980) stated slight variation in light of about 0.03 mag and radial velocity of 1.5 km s^{-1} may be due to EB? Thus, it will be interesting to see whether 20 CVn changes its shape from δ Sct-type to EB-type or vice-versa, having unequally spaced minima, or some other alternative explanation is needed to explain its typical variation. In nut shell, the δ Sct nature of 20 CVn-variability needs further attention for its confirmation in the light of present observations, wherein the amplitudes are much higher than the ones given earlier. The amplitudes in U and B filters have been given for the first time which show that the magnitudes in U, B and V filters are in descending order.

6. Summary

From the perusal of the literature, 20 CVn appears to be a photoelectrically neglected star. Our present observations show highest amplitude and different type of light variation, showing two distinct minima, which are not placed $\frac{1}{2}P$-apart. Period also differs considerably from the one given by Penfold (1971). More observations are needed to confirm the nature of its variability, allowing the doubt cast by Wood *et al.* (1980), of it being an EB.

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