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Spectroscopic Observations of ν Centauri

by

B. N. Ashoka, R. Surendiranath, and N. Kameswara Rao

Indian Institute of Astrophysics, Bangalore 560034, India

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ABSTRACT

Presented are radial velocity observations of the single line spectroscopic binary and β Cephei-type variable ν Cen obtained in the period 1983-84. New orbital elements have been determined by combining these observations with observations obtained eighty years earlier. In addition to the orbital period, β Cephei-type variability with 0.1690156 day periodicity seems to be present in these observations separated by eighty years.

1. Introduction

ν Centauri is a bright southern single lined spectroscopic binary which is also a small amplitude β Cephei-type variable. After the discovery of its binary nature by Palmer (1906), Wilson (1914) observed it spectroscopically and determined the orbit to be circular with a period of 2.62516 days. Later Rajamohan (1977) observed the system and redetermined the orbital elements and in the process also discovered that the star is a β Cephei-type variable with a period of 0.175 days. The β Cephei nature of ν Cen was further confirmed by Kubiak and Seggewiss (1982) both from the radial velocity as well as light variations. However, the orbital elements determined by Rajamohan were quite different from the ones determined earlier by Wilson. He obtained an eccentricity of 0.26; also the γ of the system and the amplitude of the radial velocity curve were different. We undertook this study to investigate the nature of this discrepancy and also to see whether any secular change in the period of the binary or β Cephei-type variation can be determined.

2. Observations

The observations have been obtained with the 51 cm telescope of Kavalur Observatory using the Bhavanagar spectrograph. The spectrograms were obtained at a mean dispersion of 27 Å mm^{-1} in blue. Usually the exposure time was about 25 minutes. We selected seven lines for radial velocity measurement including both HI and He I. They are 4026, 4101, 4120, 4143, 4340, 4387 and 4471 Å. We did not find any systematic difference between the hydrogen and helium lines, unlike in the case of Rajamohan (1977). The spectrograms have been measured on Zeiss comparator independently by two of the authors and finally the mean of seven lines was taken for the analysis. The radial velocities and their probable errors are given in Table 1.

Table 1

Radial Velocity Measurements of ν Centauri

plate No.	H.J.D	orbital phase	Helioc. R.V. km s^{-1}	(O–C) km s^{-1}	probable error km s^{-1}
	2440000 +				
309	5452.235	0.0355	+21.13	-09.15	±2.9
407	5788.318	0.0660	+39.72	+10.79	±5.2
92	5389.360	0.0834	+28.25	+00.43	±4.5
409	5788.410	0.1010	+13.84	-12.62	±4.5
424	5796.288	0.1022	+19.74	-06.62	±3.0
94	5389.446	0.1161	+06.03	-19.08	±2.0
24	5376.435	0.1596	+31.83	+11.39	±1.5
60	5384.380	0.1863	+29.63	+12.52	±4.9
447	5799.356	0.2709	+10.86	+05.46	±6.5
417	5789.254	0.4226	-22.0	-10.47	±2.1
54	5382.390	0.4282	-06.93	+04.95	±3.5
383	5784.306	0.5376	-16.88	-03.37	±3.1
139	5406.344	0.5534	+00.63	+13.51	±3.5
385	5784.362	0.5590	-22.33	-09.72	±5.4
67	5385.404	0.5763	-03.33	+08.26	±3.8
72	5385.503	0.6141	-08.14	+00.46	±2.7
255	5472.175	0.6317	-13.47	-06.60	±5.4
302	5438.244	0.7057	-07.16	-09.33	±3.8
367	5782.348	0.7917	+17.33	+03.15	±3.5
146	5407.284	0.9115	+45.77	+18.32	±3.6
397	5785.334	0.9292	+26.38	-02.27	±4.4

3. Binary orbit

The present observations were used for an orbital solution using the Lehmann-Filhes method and later the Sterne's (1941) method for small eccentricities. The computed orbit for the observed radial velocity is shown in Fig. 1. The period and orbital elements were found to be almost

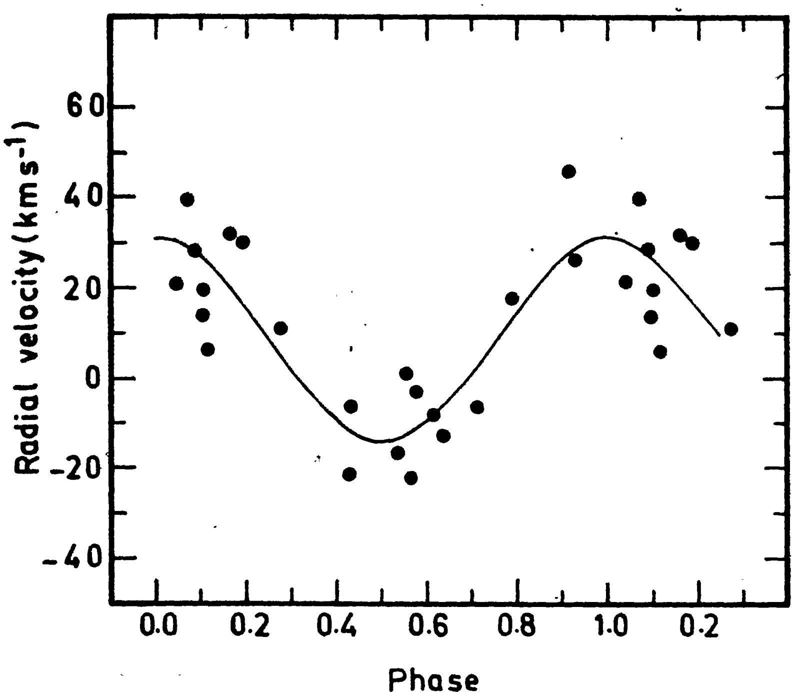

Fig. 1. Radial velocity curve of ν Centauri. Continuous line refers to the computed curve for the new orbital elements. Points represent the mean velocities of seven lines. Beyond phase 1.0, the points are repeated.

the same as those obtained by Wilson (1914). The measurements of Wilson and ours were combined to redetermine the period. With the improved period the other orbital parameters for the present observations were determined; the results are presented in Table 2. The orbital period is fairly accurate and combines observations obtained about eighty years apart. Table 2 also gives the orbital elements obtained by Rajamohan (1977) from his observations obtained during 1968-72.

4. β Cephei-type variations

After determining the orbital elements, the residuals $(O-C)$ were examined for the β Cephei-type variation discovered by Rajamohan (1977) and Kubiak and Seggewiss (1982). Our time resolution of a single plate was about one tenth of the expected period so the amplitude of the variation might be slightly underestimated. However, the residuals do

Table 2

Orbital elements of ν Centauri

elements		R.E. Wilson	R.Rajamohan	this paper
K (km s^{-1})	=	20.63±0.77	29.9	22.48±2.25
γ (km s^{-1})	=	+9.05±0.5	-2.8	8.35±1.62
e	=	0.00	0.26	0.00
ω (degree)	=	-	44.64	-
P (days)	=	2.62516	2.625275	2.625024
μ (degree)	=	137.135	-	137.142
a sin i (km)	=	745.000	-	811.639
f (m) in solar units	=	0.00239	-	0.00309
T (HJD)	=	2420301.39±0.015	2440855.608	2445407.516±0.051

indicate the presence of 0.17 day period. We further examined the possibility of finding one dominant period which is consistent with all the observations of Wilson (1914), Kubiak and Seggewiss (1982) and ours. The $(O-C)$ of all the observations fit a period of 0.1690156 days. The $(O-C)$ curve is shown in Fig. 2, where both Wilson and our observations are plotted together on lower panel and Kubiak and Seggewiss's observations on top panel (apparently there is a zero point shift in Kubiak and Seggewiss's observations). With epoch of radial velocity maximum taken as JD 2416591.584, observations separated by about eighty years combine well with the above period indicating that it is stable and the dominant one. The amplitude is ~ 5 km s^{-1}.

5. Discussion

The orbital solution and γ-axis determined by Rajamohan from two He I lines differ from those obtained by him from other lines: γ-value is smaller and there seems to be a phase shift of $0.15P$ (Table 2). We force-fitted our orbital solution to Rajamohan's hydrogen line measurements and although the scatter is large, the solution and γ-axis are roughly the same. Thus it seems that He I lines bahaved anomalously.

Hendry and Bahng (1981) found He I λ 5876 to show radial velocity of +122.5 km s^{-1} (*i.e.* redshift) whereas Hα absorption component showed −19.6 km s^{-1} in agreement with expected orbital solution. This time, however, Hα apparently had emission on both sides of absorption, similarly as in Be stars. This behaviour indicates that in addition to the orbital variations and the β Cephei phenomenon, emission episodes causing anomalous line shift may also occur; one might be present during Rajamohan's observations in 1968-72. Negative γ-velocity obtained by him from He I lines might indicate an expanding atmosphere relative to the quiescent state. Phenomena leading to the emission and possibly to mass ejection

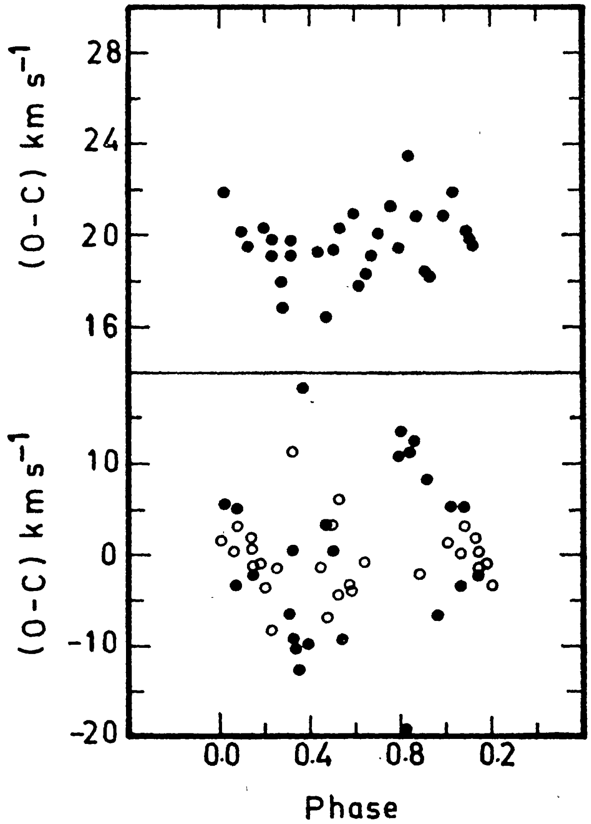

Fig. 2. Residuals plotted for the period of $0\overset{d}{.}1690156$. Beyond phase 1.0, the points are repeated. The lower plot represents Wilson's (open circles) and present (filled circles) observations, and the upper plot — those by Kubiak and Seggewiss, for a common initial epoch HJD 2416591.584 and period $0\overset{d}{.}1690156$. $(O-C)$ values for all the observations were derived using the new orbit.

left the period of β Cephei-type variations unaffected during last eighty years. The study of these phenomena needs further systematic observations.

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