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Orbital elements for double stars of Population II. The system HD 29907*

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Abstract. — For HD 29907 results are presented from radial-velocity monitoring and from photometric observations on the *uvby* system. The object is a binary system at a distance of around 50 parsecs from the sun. The primary component is a G2 VI star. The secondary component remains unidentified. The absolute visual magnitude of the primary component is M_V=+6.6, and the effective temperature and abundance of heavy elements are given by log $T_{\rm e}$=3.726 and [Fe/H]=−1.7, respectively. The V magnitude appears variable with a range of at least 0.12 magnitudes. Colour indices appear stable. The system has a radial velocity of +67.6 km s^{-1}, an orbital period of 29.9 days and an eccentricity of 0.41. The total space velocity with respect to the galactic center is 340 km s^{-1} and the object approaches escape velocity.

Key words: stars: binaries: spectroscopic — stars: kinematics — stars: Population II — stars: subdwarfs — stars: HD 29907

1. Introduction

In our large-scale programme on stars of Population II (Ardeberg & Lindgren 1985a), we have, as an essential part, taken up a study of binary systems of the Halo Population (Ardeberg & Lindgren 1985b). This study includes identification of such systems, subsequently followed by monitoring in radial velocity and repeated photometric observations. A number of these systems have already been studied in considerable detail (Lindgren et al. 1987, 1989).

Reference to HD 29907 ($\alpha = 04^{\rm h}37^{\rm m}59\overset{\rm s}{.}7$, $\delta = -65°31'$ $52\overset{\prime\prime}{.}0$, epoch 1950.0) has frequently been made under other designations. Some of the most common are CoD-65°253, LTT 2057, CPD-65°361, LHS 195, GCRV 55358, PLX 1050, LFT 369 and LPM 194. HD 29907 is included in the Hipparcos input catalogue with entry number 21609.

2. Previous investigations of HD 29907

The first clear notion of the special status of HD 29907 came from work on proper motions. When plates from Melbourne were surveyed and measured with a blink microscope, the proper motion of the object came out very large (Innes 1921). This was emphasized by Luyten (1923) in his study of stars with large proper motions. Quoting the data of Innes (1921), Luyten noted about HD 29907: "This star seems to have an enormous space velocity, or else the spectrum may be wrongly classified".

The measurement from Pretoria (Innes 1921) was later listed in the Cincinatti catalogue of stars with proper motions exceeding 0.4 arcsec annually (Porter et al. 1930).

Twenty years later, data from trigonometric parallax measurements were published for HD 29907. Whilst Jenkins (1952) reported a parallax of +0.003±0.008 arcsec, corresponding data from the Yale Cape Observatory (1952) were +0.016±0.012 arcsec, and from the Yale Columbia Southern Station −0.003±0.010 arcsec.

Somewhat later, Luyten (1955) published his catalogue of stars with proper motions exceeding 0.5 arcsec annually. Again, Innes' (1921) data were prominent. This was followed by publication of photometric data for HD 29907. In his report on photoelectric three-colour magnitudes for southern stars, Stoy (1958) included the object as of special interest.

Buscombe & Morris (1958) listed HD 29907 in their catalogue of southern stars of high velocity. In a paper on ultra-violet excesses from Cape refractor colours, Eggen (1959) reported a $(U-B)_{\rm c}$ colour excess of 0.13 magnitudes for the star.

In a study of new southern sub-dwarf stars, Przybylski (1961) made spectral classification and measured the

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*Based mainly on observations made with the 1.54 m Danish Telescope at the European Southern Observatory, La Silla, Chile radial velocity of HD 29907. Together with the photometric data previously obtained, Przybylski's classification defined the object as a clear sub-dwarf candidate.

In the Supplement to the General Catalogue of Trigonometric Stellar Parallaxes, Jenkins (1963) confirmed her earlier parallax data (Jenkins 1952), whilst new corresponding data from the Yale Cape Observatory gave 0.017±0.012 arcsec as trigonometric parallax for HD 29907.

Arguing on the identification of sub-dwarf stars, Evans & Stoy (1962) communicated data for HD 29907 on photometry, colour excess, spectral classification and radial velocity. The sub-dwarf status of the object was emphasized. At the same time, comparison between the radial-velocity data given by Przybylski (1961) and by Evans & Stoy (1962) showed an interestingly large difference.

Cousins & Stoy (1963) listed HD 29907 in their catalogue of photoelectric magnitudes and colours of southern stars. Evans et al. (1964) did the same in their report on fundamental data for southern objects.

Shortly after, Przybylski & Morris Kennedy (1965) measured new radial velocities and *UBV* data for HD 29907. Their data gave new confirmation both of the variability of the radial velocity and of the colour excess.

New proper-motion data for HD 29907 were published by Stoy (1966), at the same time as Evans (1967) included the object in his revision of the General Catalogue of Stellar Radial Velocities (Wilson 1953). See discussion in Sect. 8.

In an investigation of stars with large proper motions, Rodgers & Eggen (1974) communicated new photometric and spectroscopic data for HD 29907. They included photometry in the infra-red spectral range and derived a distance modulus for the star. Also space-velocity components were determined as was a photometric parallax value. At the same time, new radial-velocity data gave repeated confirmation of variability of this quantity. Especially the components of space velocity clearly indicated HD 29907 as an object belonging to Population II.

In consequence, it may seem somewhat surprising that Houk & Cowley (1975) classified HD 29907 as F8 V from a spectrogram of good quality. No remarks were given.

Eggen (1978b) included HD 29907 in his catalogue of photometry on the *uvby*, *RI* and *UBV* systems. At the same time, Eggen & Bessell (1978) estimated the absolute visual magnitude and motion in the galactic plane of the object.

New data for HD 29907 were derived by Eggen (1979a) concerning absolute visual magnitude, components of space velocity and abundance of heavy elements. Carney (1979) derived the colour excess in $U-B$, $\delta(U-B)_{0.6}$, and Bessell & Wickramasinghe (1979) studied HD 29907 in their work on the missing halo-population K sub-dwarf stars.

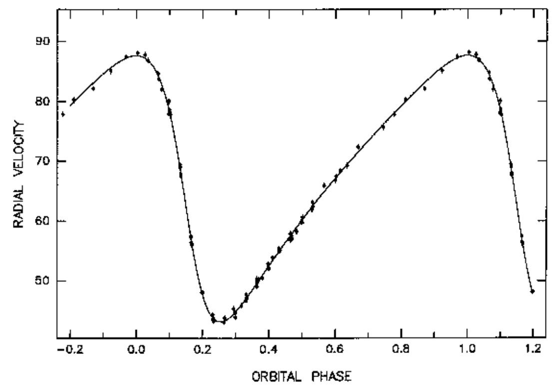

Fig. 1. Individual radial-velocity data for HD 29907 plotted versus orbital phase. Our orbital solution has been indicated with a curve

Luyten (1979) reported on new measurements of the proper motion of HD 29907, whilst Eggen (1979b) included the object in his catalog of stars with annual proper motions of one arc second and more.

UBVRI photometry of HD 29907 was presented by Carney (1980). At the same time, Luyten (1980) included it in the NLTT Catalogue of proper motions for southern stars.

Hauck & Mermilliod (1980) published a catalogue of photoelectric *uvbyβ* data, which included measurements of HD 29907 made by McConnell (1974). The object was also listed by Bartkevičius (1980) in his catalogue of metal-deficient stars. Bartkevičius reported on colour excesses in $U-B$ and in m_1 as well as on the absolute visual magnitude.

In a listing aiming at refined data for parallax stars, Buscombe (1981) took up HD 29907. Gehren et al. (1981) made comparisons between radial-velocity data of their own and corresponding data from the literature as well as between colour excesses in $U-B$ and determinations of [Me/H]. The variable radial velocity of HD 29907 was confirmed.

The Yale Catalogue of the Positions and Proper Motions of Stars between Declinations −60° and −70° (Fallon 1983) gave new proper-motion data for HD 29907.

Investigating the abundances of heavy elements of field dwarf stars, Laird (1985) made photometry and spectroscopy of HD 29907. This provided data on effective temperature, abundance of heavy elements, distance from the sun and space-velocity components in the galactic plane.

Recently, Eggen (1987) reported new data on the absolute magnitude, the photometric parallax and the components of space velocity of HD 29907, whilst Sandage & Fouts (1987) included the object in a study of the kinematics of stars with high proper motions. Finally, Schuster & Nissen (1988) gave photometric data on the *uvby* and Hβ systems for HD 29907. Also, Hartmann & Gehren (1988) published new radial velocities measured for the object.

3. Observations of radial velocities

For all our measurements of radial velocities of the system HD 29907, we have used a CORAVEL photoelectric scanner. For a description of this instrument, reference is made to Baranne et al. (1977, 1979) and to Mayor (1985). In all cases, this scanner has been attached to the Cassegrain focus of the Danish 1.54 m telescope at the European Southern Observatory (ESO) at Cerro La Silla in Chile. Regarding details of instrumentation and observing techniques as well as concerning the transformation of our observed instrumental radial velocities into corresponding data on the standard system of radial velocities (Mayor & Maurice 1985; Stefanik et al. 1986), we refer to Lindgren et al. (1987, 1989).

We have made a total of 79 observations of radial velocities of HD 29907. All these radial-velocity measurements were made between September 1981, and February 1990. The object is relatively bright and delivers a cross-correlation minimum which does not present any significant problems. As a result, integration times depend primarily on the atmospheric seeing quality. In practice, integration times ranged from typically five to twenty minutes.

The accuracy of our measurements of radial velocity for HD 29907 was around 0.4 $\mathrm{km\,s^{-1}}$ as referred to a single measurement. Given the apparent brightness, the colour and the abundance of heavy elements of the system, this accuracy is rather close to the accuracy to be expected.

A detailed listing of radial-velocity data measured for HD 29907 will be published elsewhere in the publication series of the CORAVEL group.

4. Orbital elements

Our radial-velocity data were analyzed with the help of ORBIT, a computer program developed by Zuiderwijk (priv. comm). The program is fully interactive and it runs on a VAX 750 minicomputer system.

HD 29907 has an orbit which is markedly eccentric with an eccentricity of 0.41. This and other orbital parameters have been reported in Table 1. We have also included estimates of the errors for the orbital parameters. For details concerning these error estimates, reference is made to Lindgren et al. (1987).

In Fig. 1, individual radial-velocity data for HD 29907 have been displayed versus orbital phase. In the same figure, we have indicated our orbital solution by a curve.

Using the CORAVEL, we have made a search for the second component of the system HD 29907. However, from the autocorrelation function, we could not find any evidence for such a second component.

The cross-correlation minimum is small and relatively narrow. It does not provide any significant indication of stellar rotation.

5. Kinematical parameters

Based on our derived system velocity and making use of data adopted for parallax, proper-motion components and position (see below), we can derive the components of space velocity, U, V and W, for the system HD 29907. It is noted, that we define the U velocity component as directed away from the galactic center.

In Table 4, we have presented the space-velocity components derived. We have included the total space-velocity, given both with respect to the Local Standard of Rest (LSR), V_{S}, and with reference to the galactic center, V_{c}. For the calculation of our velocities, we have made the assumption that the sun has a peculiar velocity with respect to the LSR, corresponding to $U_{\mathrm{S,LSR}} = -9\ \mathrm{km\,s^{-1}}$, $V_{\mathrm{S,LSR}} = +12\ \mathrm{km\,s^{-1}}$ and $W_{\mathrm{S,LSR}} = +7\ \mathrm{km\,s^{-1}}$ (Delhaye 1965). Reference is further made to the article of Yuan (1983). For the LSR, we have assumed a circular orbit in the galactic plane with a velocity of 220 $\mathrm{km\,s^{-1}}$ (Wielen 1986).

6. *uvby* photometry

For the system HD 29907, we have made photoelectric photometry on the Strömgren *uvby* system. We made our photometric observations with two different photometers.

We made our first *uvby* observations of HD 29907 with a four-channel grating photometer of Strömgren type (Grønbech et al. 1976), attached to the Cassegrain focus of the 50-cm Copenhagen reflector at La Silla. We used this photometer together with uncooled EMI photomultipliers of type 6256. In addition, we employed pulse counting and *uvby* filters of standard type (Crawford 1966; Crawford & Barnes 1970). These filters were located behind slots, used for wavelength pre-selection.

For our last photometric *uvby* observations of HD 29907, we used a photometer of a somewhat modified construction (Florentin Nielsen 1983). Also this photometer was always mounted in the Cassegrain focus of the 50-cm Copenhagen reflector at La Silla. With this photometer we used uncooled EMI photomultipliers of type 9789QA. Further, we used high-transmission *uvby* filters, as before placed behind slots for wavelength pre-selection. Again, pulse counting was employed.

Together with our programme stars, we observed, every observing night, a substantial number of standard stars, normally around 30. These standard stars were selected to cover large ranges in all indices in the *uvby* system.

We have observed HD 29907 on the *uvby* system on a total of four nights, well separated in time. The time interval covered is more than six years. In Table 2, we have reported resulting *uvby* data. We have added standard deviations referring to single determinations of magnitude and colour indices, respectively.

Table 1. Orbital elements for HD 29907

Orbital Element		Value	Error(±)	Unit
System velocity	γ	+67.64	0.05	km s^{-1}
Orbital period	ϕ	29.9130	0.0007	days
Semi-amplitude	K	22.24	0.07	km s^{-1}
Time of passage of ascending node	T_N	2447013.013	0.029	J.D.
Time of periastron passage	t_0	2447017.715	0.027	J.D.
Periastron angle	ω	104.05	0.44	degrees
	$a_1 \sin i$	8.358	0.027	Gm
Mass function	$f(m)$	0.026		$M_\odot$
Eccentricity	e	0.407	0.0024	
	$\sigma_{\text{o-c}}$	0.45		km s^{-1}
No. of observations		86		

7. Results of *uvby* photometry

The standard deviations for the magnitude and colour indices obtained are rather normal for an object with brightness and colour like those of HD 29907. The only exception is the m_1 index, for which the relatively high value of the standard deviation is assumed to be of accidental origin. As a result, from our photometric data there are no indications of photometric variability. We will return to this question below.

8. Some properties of HD 29907

For the trigonometric parallax of HD 29907, there are, to our knowledge, a total of five reported values. These are given in Table 2 together with the respective error estimates. The data in Table 2 clearly show that it is difficult to assign any reliable value to the trigonometric parallax of HD 29907. Tentatively, we have adopted $\pi = 0.007 \pm 0.005$ arcsec.

Data given in the literature regarding the proper motion of HD 29907 are, as opposed to those on the trigonometric parallax, rather consistent. This is most clearly true also for the very early data given by Innes (1921). See Table 2. Still, we tend to give somewhat lower weight to the first proper-motion data than to the following ones. Also concerning the last Yale data available (Fallon 1983), some caution may be in place, as the conditions governing plate measurements and reductions were not quite ideal (Hoffleit 1983).

The proper-motion data have, by Innes (1921) and by Luyten (1979, 1980) been given in the form of an absolute proper motion plus a direction of this motion relative to the North direction. In terms of proper motion in right ascension, these data, in the same order, convert into +0.666, +0.725 and +0.722 arcsec per year. In declination, the corresponding components are +1.307, +1.297 and +1.303 arcsec per year.

In conclusion, we adopt for HD 29907 the proper-motion components +0.725 ± 0.010 arcsec per year and +1.280 ± 0.020 arcsec per year, in right ascension and declination, respectively. The errors adopted are only unqualified estimates. Our adopted data have been entered in Table 3.

Previous measurements on the (system) radial velocity of HD 29907 have given results in high disagreement with each other (Przybylski 1961; Evans & Stoy 1962; Evans et al. 1964; Przybylski & Morris Kennedy 1965; Hartmann & Gehren 1988). Given the significant radial-velocity amplitude of HD 29907, this is, in itself, easy to understand. Still, it is obvious that the radial-velocity data reported by Przybylski (1961) and by Przybylski & Morris Kennedy (1965) fall outside the range defined by our system radial velocity and corresponding amplitude. In the case of the data given by Przybylski & Morris Kennedy (1965), the deviation from our lower radial-velocity limit is close to 13 km s^{-1}. Even if the real zero-point error in the radial-velocity average presented by Przybylski and Morris Kennedy may well be significantly higher than the formal error reported by the authors, the discrepancy appears strange. Still, for the time being, we assume, that it can be explained by a zero-point error. The data discussed are given in Table 2.

Spectral classification of HD 29907 has been made by Przybylski (1961), by Evans & Stoy (1962) and by Houk & Cowley (1975). See Table 2. Przybylski (1961) noted the difference between the spectral types defined by, on the one side, the continuum and the hydrogen lines, on the other side, the g line of neutral calcium and the G band. In conclusion, Przybylski gave the classification G4 VI with the remark that the under-abundance was rather significant. However, from a spectrogram of relatively good quality (2), Houk & Cowley (1975) classified the object F8 V without any remark. A look at a map shows that there are some rather bright stars at relatively small angular distance in the sky from HD 29907. On the objective-prism plates used by Houk & Cowley (1975) for classification, effects of overlap may, in consequence, have been significant. We adopt for HD 29907 the spectral type G2 VI with

Table 2. Observational data for HD 29907

Reference	Quantities						
	Trigonometric parallax in arc seconds						
	Trig. parallax	Error					
Jenkins (1952)	+0.003	0.008					
Yale Cape Ext. (1952)	+0.016	0.012					
Yale Columbia Ext. (1952)	−0.003	0.010					
Jenkins (1963)	+0.003	0.008					
Yale Cape Ext. (1963)	+0.017	0.012					
	Proper motion(s) in arc seconds per year						
Innes (1921)	absolute:	1.467	direction	27°			
Stoy (1966)	right ascension:	+0.730	declination:	+1.269			
Luyten (1979)	absolute:	1.486	direction:	29°.2			
Luyten (1980)	absolute:	1.49	direction:	29°			
Fallon (1983)	right ascension:	+0.717	declination:	+1.247			
	System radial velocity in $km\,s^{-1}$						
	Average	Error	No. of obs.				
Przybylski (1961)	+37.4						
Evans & Stoy (1963)	+69						
Evans et al. (1964)	+68.6	2.2	6				
Przybylski & Morris Kennedy (1965)	+31.4	0.2	3				
Hartmann & Gehren (1988)	+56.4	<5	3				
Present study	+67.64	0.05	86				
	Spectral classification						
	Spectral type	Remarks					
Przybylski (1961)	G4 VI	Continuum and H lines give G2; g lines of neutral calcium gives later type; G band is strong					
Evans & Stoy (1963)	G2 VI	Underabundance marked					
Houk & Cowley (1975)	F8 V						
	Broad-band photometry						
	V	$B-V$	$U-B$	R	$V-R$	$R-I$	Rem
Stoy (1958)	9.82	+0.63	(+1.60)				1
Evans & Stoy (1963)	9.82	+0.64	(+1.60)				1
Cousins & Stoy (1963)	9.82	+0.64	(+1.60)				1
Evans et al. (1964)	9.82	+0.64	(+1.60)				1
Przybylski & Morris Kennedy (1965)	9.88	+0.64	-0.08				
Rodgers & Eggen (1974)	9.82	+0.64	-0.12	9.52		+0.255	2
Eggen (1978b)	9.85	+0.63	-0.10	9.51		+0.26	2
Carney (1980)	9.86	+0.62	-0.13		+0.59	+0.395	3
Laird (1985)	9.84					+0.430	3
	Intermediate-band photometry						
	V	$b-y$	m_1	c_1	$H\beta$	Rem	
Eggen (1978b)	9.85	+0.436	+0.101	+0.269		4	
Hauck & Mermilliod (1980)		+0.413	+0.116	+0.125			
Schuster & Nissen (1988)	9.940	+0.452	+0.106	+0.132	2.538		
Present study	9.857	+0.435	+0.112	+0.141			
Present study σ:	0.004	0.004	0.013	0.008			

Remarks
1. $U-B$ given in Cape refractor system, $(U-B)_c$
2. R and I given on Kron system. See text
3. R and I given on Johnson system
4. Eggen *uvby* system. See text

the remark that the under-abundance of heavy elements is considerable. This classification has been entered in Table 3.

Data from broad-band photometry of HD 29907 have been listed in Table 2. The data for the V magnitude seem especially interesting. The range defined from the broad-band data is somewhat large although not presenting any convincing evidence for photometric variability. However, inclusion of the V data obtained via intermediate-band photometry changes the picture rather significantly, indicating a total range in V of at least 0.12 magnitudes. We note that the faintest V magnitude value included, that of Schuster & Nissen (1988), is based on two measurements. Further, the photometric quality of the data given by Schuster and Nissen are very good, also for magnitudes.

Taking all V data together, we find that there is considerable evidence for photometric variability in this magnitude. Stretching conclusions somewhat, one might even suggest a slow decrease in brightness with stronger variations superposed. This may, however, be an over-interpretation. At any rate, the system merits special attention photometrically. Accordingly, we have taken up long-term monitoring of HD 29907 in the *uvby* system.

In $B-V$, HD 29907 does not seem to show any signs of variability. At the same time, the range of published $U-B$ colour indices is somewhat large. However, for objects with pronounced ultra-violet colour excesses, transformation from instrumental to standard data is notoriously difficult for $U-B$. We tend to believe that the $U-B$ range displayed in Table 2 is due to this fact rather than to real variability of the object. As a result, we find it reasonable to adopt for HD 29907 a variable V magnitude and stable $B-V$ and $U-B$ colour indices. Tentatively, we adopt $V = 9.82$ to 9.94, $B-V = +0.63 \pm 0.01$, $U-B = -0.11 \pm 0.02$. These data have been entered in Table 3.

In the infra-red spectral range, broad-band photometry on the *VRI* system has been presented by Rodgers & Eggen (1974), by Eggen (1978b), by Carney (1980) and by Laird (1985). Whilst Carney (1980) and Laird (1985) gave their *VRI* data on the Johnson system (Johnson et al. 1966), Rodgers & Eggen (1974) and Eggen (1978b) reported their *RI* data on the Kron-system (Kron et al. 1957). For conversion of the Kron-system *RI* data we have used the transformation relations given by Eggen (1973). Such transformation gives, with $R_{\rm J}$ and $(R-I)_{\rm J}$ denoting data on the Johnson system, for Rodgers & Eggen (1974) $R_{\rm J} = 9.21$ and $(R-I)_{\rm J} = +0.381$, and for Eggen (1978b) $R_{\rm J} = 9.20$ and $(R-I)_{\rm J} = +0.388$. We do not see any significant indication of variability in the infra-red spectral range and adopt for HD 29907 $R_{\rm J} = 9.21$, $(V-R)_{\rm J} = +0.59$ and $(R-I)_{\rm J} = +0.40$. We have reported these data in Table 3.

Data on the intermediate-band Strömgren *uvby* system have been given by Eggen (1978b), by Hauck & Mermilliod (1980), quoting results by McConnell (1974), by Schuster & Nissen (1988) and in the present study. It should be noted that the data reported by Eggen (1978b) are on his own, modified version of the *uvby* system (Eggen 1977, 1978a). With respect to the standard Strömgren *uvby* system, differences are to be expected, especially for the c_1 index. This seems to be confirmed from the data given in Table 2. We note that Bond (1980) and Olsen (1984) have discussed transformations between the Eggen *uvby* system and the standard Strömgren *uvby* system.

If we disregard the c_1 value given by Eggen (1978b), the four sets of *uvby* data reported in Table 2 agree reasonably well. Whilst V magnitudes have already been discussed, we conclude from Table 2 that there are no significant indications of variability in the *uvby* colour indices. For HD 29907 we adopt $b-y = +0.435$, $m_1 = +0.110$, $c_1 = +0.135$. For Hβ, we adopt the value given by Schuster & Nissen (1988), H$\beta = 2.538$. These data can be found in Table 3.

HD 29907 has also been measured in the Geneva Observatory photometric system (Rufener 1988). The V value obtained from these observations is close to that from our *uvby* measurements. The Geneva system data do not indicate any variability.

With the *uvby* and broad-band photometric data and the spectral classification discussed and adopted, we are in a position to derive information concerning the effective temperature, the surface gravity or absolute magnitude and the abundance of heavy elements of HD 29907. However, for correct interpretation of our observational data, it is of importance to know the extent of possible influences of the secondary component and of interstellar absorption on quantities measured and estimated.

The variability in V could, possibly, be interpreted as indication of significant influence of the secondary component. At the same time, we have not detected any corresponding effect on the colour indices observed. Whilst this, in itself, does not exclude that part of these indices may be due to the secondary component, we do not regard any significant influences very probable. First of all, no trace of the secondary component has been found in the radial-velocity cross-correlation measurement data. Further, no signs of duplicity has been noted in spectrograms used for spectral classification. For these reasons, we have, for our continued interpretation, assumed influence of the secondary component to be negligible. At the same time, we regard it as very important to increase our efforts concerning a correct interpretation of the nature of the system HD 29907. For this reason, we have, in parallel to our observing programme aiming at photometric monitoring, initiated a programme of spectroscopic observations of the object at high spectral resolution.

Table 3. Derived and adopted data for HD 29907

Reference	Quantities					
	Trigonometric parallax in arcsec					
	Parallax	Error				
Adopted	0.007	0.005				
	Photometric parallax in arcsec					
	Parallax	Error				
Adopted	0.022	0.004				
	Proper motions in arcsec per year					
	Right ascension	Error	Declination	Error		
Adopted	+0.725	0.010	+1.280	0.020		
	Broad-band photometry					
	V	$B-V$	$U-B$	R	$V-R$	$R-I$
Adopted	9.86v	+0.63	–0.11	9.21	+0.59	+0.40
	Intermediate-band photometry					
	V	$b-y$	m_1	c_1	$H\beta$	
Adopted	9.86v	+0.435	+0.110	+0.135	2.538	
	Spectral classification					
	Spectral type	Remarks				
Adopted	G2 VI	Under-abundance of heavy elements is considerable				
	Equivalent spectral type from *uvby* photometry					
	Spectral type	Remarks				
Derived	G5 VI	Low luminosity				

	Absolute visual magnitude
Derived from *uvby*+our calibrations	+6.6
Derived from *uvby*+Olsen's (1984) calibration	+6.7
Derived from spectral classification	+6.3
Eggen & Bessell (1978)	+5.4
Eggen (1979a)	+6.45
Bartkevičius (1980)	+8.03
Rodgers & Eggen (1974)	+6.8
Norris (1986)	+6.5
Eggen (1987)	+7.0
Adopted	+6.6

	Abundance of heavy elements [Fe/H]
Derived from *uvby*+our calibration	–1.8
Derived from *uvby*+calibr. Ardeberg et al. (1983)	–1.5
Derived from *uvby*+$H\beta$ + calibr. Ardeberg et al. (1983)	–1.6
Derived from *uvby*+Olsen's (1984) calibration	–2.1
$\delta(U-B)_{0.6}$ + Carney's (1979) calibration	–1.9
Eggen (1979a)	–1.6
Laird (1985)	–1.67
Norris (1986)	–1.60
Adopted	–1.7

	Effective temperature $\log\ T_{\rm e}$
Derived from *uvby*+calibr. Ardeberg et al. (1983)	3.729
Derived from *uvby*+Olsen's (1984) calibration	3.721
Laird (1985)	3.728
Adopted	3.726

	System radial velocity				
	Velocity	Error	Unit	No. of meas.	
Our data	+67.64	0.05	km s^{-1}	86	
	Space-velocity components				
	U	V	W	$V_{\rm lsr}$	Unit
Adopted	+328	–134	+12	355	km s^{-1}

The galactic latitude of HD 29907 is $-38°$, implying that it is situated well outside the galactic plane. Further, the distance from the sun is rather modest (see below). Consultation of the data on local interstellar absorption reported by Strömgren (1962), by FitzGerald (1968) and by Lucke (1978) confirm that effects of interstellar absorption on the observational data for HD 29907 should be very small, if at all noticeable. As a consequence, we assume effects of interstellar absorption on these data to be negligible for our interpretations.

An equivalent spectral type for HD 29907 can be derived from our *uvby* data, used together with the calibrations for stars of late spectral types by Ardeberg & Lindgren (1981, 1982, 1985c). As a result, the object is defined as a sub-dwarf star of low luminosity. The spectral type is around G5. From the calibration of absolute magnitudes given by Schmidt-Kaler (1982a), the corresponding absolute visual magnitude is around $M_V = +6.6$. As an alternative, we can combine our *uvby* data with the calibration of absolute magnitudes given by Olsen (1984). This procedure results in $M_V = +6.7$. In addition, from the spectral type adopted, together with the absolute-magnitude calibration of Schmidt-Kaler (1982a), we obtain an absolute visual magnitude of approximately $M_V = +6.3$. These data for the absolute visual magnitude of HD 29907 have been reported in Table 3 together with corresponding data taken from the literature.

Among the M_V data from the literature included in Table 3, those of Eggen & Bessell (1978), Eggen (1979a) and Bartkevičius (1980) are given directly as absolute visual magnitudes in the respective papers. In addition, we have included three values for M_V as obtained from data on alternative absolute magnitudes, converted to absolute visual magnitudes. The bolometric absolute magnitude for HD 29907 reported by Rodgers & Eggen (1974) has been converted to an absolute visual magnitude through application of the bolometric correction taken from Schmidt-Kaler (1982b). This gives $M_V = +6.8$, as listed in Table 3. Using the adopted apparent visual magnitude of HD 29907, we have converted the distance given by Norris (1986) into an absolute visual magnitude, as before assuming effects of interstellar absorption to be negligible. This gives $M_V = +6.5$, entered in Table 3. Finally, we have used the absolute infra-red magnitude of Eggen (1987) together with our adopted values for the colour indices $V-R$ and $R-I$ (see Table 3) to arrive at the absolute visual magnitude $M_V = +7.0$, given in Table 3.

As can be seen from the data given in Table 3, the values obtained for the absolute visual magnitude of HD 29907 are in very good internal agreement. We adopt $M_V = +6.6$. This absolute magnitude results in a photometric parallax of approximately 0.022 arcsec, irrespective of whether we exclude the data given by Norris (1986) or not (see above). With an estimated error in the absolute visual magnitude adopted of 0.2 magnitudes, the corresponding formal error in the photometric parallax is 0.002 arcsec. We adopt, somewhat arbitrarily, a final error of 0.004 arcsec.

In order to determine the abundance of heavy elements of HD 29907, we can make use of our *uvby* data together with the calibration of such data in terms of [Fe/H] given by Ardeberg & Lindgren (1981). This results in [Fe/H] = -1.8. If we, as an alternative, use the *uvby* data together with the calibration given by Ardeberg et al. (1983), we obtain [Fe/H] = -1.5. Using the same calibration (Ardeberg et al. 1983) and using the *uvby* data combined with the Hβ data, we derive [Fe/H] = -1.6. Applying the calibration of [Fe/H] by Olsen (1984) to our *uvby* data, we obtain [Fe/H] = -2.1.

In addition, the abundance of heavy elements may be obtained from available data on the ultra-violet colour excess, $\delta(U-B)$, and the [Fe/H]; $\delta(U-B)_{0.6}$ calibration of Carney (1979), based on the work of Sandage (1969), (see also Cameron 1985). For $\delta(U-B)_{0.6}$, Carney (1979) gave the value 0.27 and Carney (1980) 0.28 magnitudes. With our adopted UBV data and Sandage's (1969) correction tables, we get $\delta(U-B)_{0.6} = 0.26$ magnitudes. We have used the latter value, noting that Carney's $U-B$ value probably is marginally too negative. We get [Fe/H] = -1.9.

The abundance data obtained as discussed have been reported in Table 3. In addition, we have listed corresponding data found in the literature.

The abundance data given in Table 3 are in rather acceptable internal agreement. We adopt for HD 29907 [Fe/H] = -1.7.

The effective temperature of HD 29907 may be derived from our *uvby* data together with the calibration in terms of $\log T_e$ by Ardeberg et al. (1983). This gives $\log T_e = 3.729$. We may also use our *uvby* data with the calibration given by Olsen (1984). This way, we obtain $\log T_e = 3.721$. In Table 3 we have listed these data together with the effective temperature reported by Laird (1985), converted to $\log T_e$. The three sets of $\log T_e$ data discussed are in acceptable internal agreement. For HD 29907 we adopt $\log T_e = 3.726$, as given in Table 3.

For derivation of the components of space velocity of HD 29907 we need to know, among other things, the parallax of the object. In Table 3, we have listed two different adopted values for this parallax. Especially given the high consistency of the absolute visual magnitudes derived, we tend to believe that the adopted photometric parallax is more reliable than the corresponding trigonometric parallax. For our calculations of space-velocity components, we have used a parallax of 0.020 arcsec.

Our space-velocity components, reported in Table 4, agree quite well with corresponding data taken from the literature. We adopt for HD 29907 the space-velocity components $U = +328$, $V = -134$, $W = +12$, $V_{lsr} = 355$, all expressed in $\mathrm{km\,s^{-1}}$. These velocity components have

Table 4. Space-velocity components for HD 29907

Reference	U	V	W	V_{lsr}	Unit
Present study	+328	–134	+12	355	$km\,s^{-1}$
Rodgers & Eggen (1974)	+309	–115	+18		$km\,s^{-1}$
Eggen (1979a)	+308	–131	+8		$km\,s^{-1}$
Norris (1986)		–133	+9		$km\,s^{-1}$
Eggen (1987)	+328	–135	+10		$km\,s^{-1}$

Note 1: Eggen & Bessell (1978) give $(U^2+V^2)^{\frac{1}{2}} = 320$ $km\,s^{-1}$
Note 2: The total space velocity with respect to the galactic center is $V_c = 340$ $km\,s^{-1}$

been listed in Table 3. The velocity in the galactic plane is considerable. Comparison with other sub-dwarf stars in a Bottlinger diagram reveals that it approaches escape velocity. Reference may be made to Eggen (1970) and to Rodgers & Eggen (1974). This point was also discussed by Gehren (1982). We have also compared our space-velocity components for HD 29907 with those given by Carney et al. (1988) for stars with extreme velocities. Also compared to this sample, HD 29907 comes out as having high velocity.

9. Conclusions

HD 29907 is a binary system with a system radial velocity of +67.6 $km\,s^{-1}$, a total radial velocity amplitude of 44.5 $km\,s^{-1}$ and an orbital period of 29.9 days. The orbit has an eccentricity of 0.41.

The primary component of the system is a sub-dwarf star of low luminosity. The absolute visual magnitude is $M_V = +6.6$, the effective temperature is given by $\log T_e = 3.726$, and the abundance of heavy elements corresponds to [Fe/H] = −1.7. The spectral type is G2 VI as defined from spectral classification.

A search for the secondary component in the radial-velocity auto-correlation function has given negative result. Spectrograms for spectral classification have not shown any sign of the secondary component.

HD 29907 appears variable in the V magnitude with a range of 0.12 magnitudes or, possibly, larger. There are no significant indications of variability in colour indices.

The system is close to the sun with a parallax of around 0.020 arcsec. The proper motion is close to 1.5 arcsec per year. The total space velocity with respect to the LSR is 355 $km\,s^{-1}$ and the object approaches escape velocity.

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