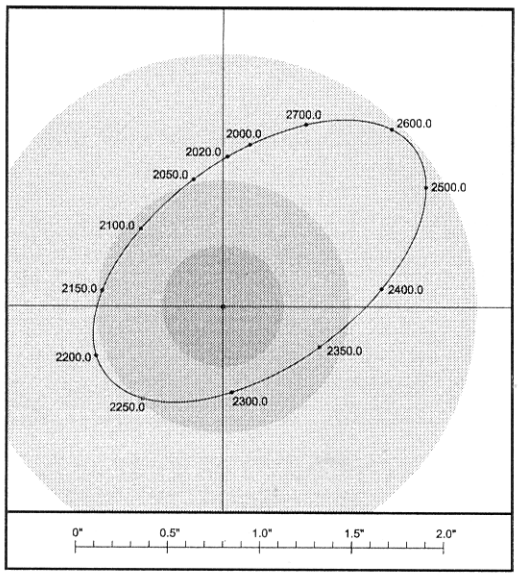
Orbit



Ephemeris for STF 1126 AB (2015 to 2060)

Orbit by Zir (2015a) Period: 752 years, Grade: 4

Year	PA(°)	Sep(")	Year	PA(°)	Sep(")
2015.0	176.3	0.84	2040.0	187.7	0.75
2020.0	178.4	0.82	2045.0	190.4	0.73
2025.0	180.6	0.80	2050.0	193.1	0.71
2030.0	182.9	0.78	2055.0	195.9	0.70
2035.0	185.2	0.77	2060.0	198.9	0.69

The Modern Era

The pair STF 1126 was not observed by Hipparcos but the parallax given in the table above was determined using the Multichannel Astrometric Photometer on the 30-inch refractor at Allegheny Observatory [291]. This was carried out as part of an investigation of the masses of nearby Procyon A and B. The nature of the pair STF 1126 is thrown into doubt by the Gaia DR2 result. The parallaxes of the two stars are significantly different, and the observations made so far do not seem to show unmistakeable curvature.

Observing and Neighbourhood

This close pair is easy to find as it lies just 12 arc minutes east of Procyon, and for that reason it was too close on the sky to the bright star for the Hipparcos satellite to make meaningful measurements. At its current separation it represents a good resolving test for 12-cm aperture. RWA measured 175° and 1″ in 2015, a movement of 10° since a previous measure in 1992, with the separation unchanged. Procyon is close to the Sun and has an annual proper motion of 1″.3 per year. Like Sirius, it has a white dwarf companion, which was found in the same way – by the regular 'wobble' of Procyon against the background stars as it moved across the sky. The white dwarf was finally seen by J. M. Schaeberle at Lick Observatory in 1896 using the 36-inch refractor [293]. It is outstandingly difficult to see. The visual magnitudes of the two stars are 0.3 and 10.8 (2002) and the maximum separation is 5″. The pair is currently widening; in 2017.0 the white dwarf will be found at 304° and 4″.32 whilst the widest separation will occur in 2029 when the position is 8° and 5″.14. The orbit is well defined thanks to direct imaging using WFPC2 on the *HST* [290]. As luck would have it, the lowest possible exposure time (0.11 seconds) on the camera, just showed the white dwarf without saturating the detector with the overwhelmingly bright primary. The resulting dynamical parallax (0″.285) is almost identical to that of Hipparcos (0″.28); this represents a distance of 11.44 light years.

Measures

Early measure (STF)	132°.0	1″.46	1829.43
(Orbit	132°.9	1″.35)	
Recent measure (ARY)	177°.3	1″.00	2016.46
(Orbit	177°.0	0″.83)	

opposite

57. $\gamma^{1,2}$ VEL = Δ 65 = WDS J08095–4720

Table 9.57 Physical parameters for γ Vel

DUN 65	RA: 08 09 26.97	Dec: −45 50 18.8	WDS: 2543(39)	
V magnitudes	A: 1.79	B: 4.14	C: 7.76	D: 9.4
$(B-V)$ magnitudes	A: −0.25	B: −0.18	C: 0.0	
μ(A)	−6.71 mas yr^{-1}	± 0.58	10.78 mas yr^{-1}	± 0.59 (DR2)
μ(B)	0.50 mas yr^{-1}	± 0.22	3.69 mas yr^{-1}	± 0.26 (DR2)
π(A)	3.56 mas	± 0.33	916 light yr	± 85 (DR2)
π(B)	3.69 mas	± 0.26	884 light yr	± 63 (DR2)
π	2.97 mas	± 0.07	1100 light yr	± 20 (dyn.)
π	2.81 mas	± 0.03	1160 light yr	± 11 (MSF)
Spectra	Aa: WC8	Ab: O7.5e	B: B2III	C: F0
Masses ($M_\odot$)	Aa: 9	Ab: 28.5	B: 14	
Radii ($R_\odot$)	Aa: 6	Ab: 17	B:	
Luminosities ($L_\odot$)	A: 12500	B: 1340	C: 50	D: 10
Catalogues (A/B)	HR 3207/6	HD 68273/243	SAO 219504/1	HIP 39953
DS catalogues	TOK 2 (Aa)	DUN 65 (AB)	WSI 55 (BaBb)	I 1175 (DE)
Radial velocity (A/B)	15.00 km s^{-1}	± 3.1	20 km s^{-1}	± 10
Galactic coordinates	262°.803	−7°.686		

History

James Dunlop observed the three bright components of γ Velorum at Parramatta in 1826. In 1911 Moore [295], using the Mills expedition equipment to Chile, found that the brightest star had a radial velocity which varied by 75 km s^{-1}. Using the 26.5-inch refractor at Johannesburg, R. T. A. Innes [302] found that a fourth star of maguitude 9 which is 34″ distant from C in PA 123° had a companion star, of V = 12.8, 1″.5 distant, which has shown some sign of relative motion between 1926 and 1949 but which has not been measured since. Robert Rossiter also independently found this star at Bloemfontein [303].

The Modern Era

Jeffries *et al.* [300] used main sequence fitting to find the distance to the cluster of stars in the association Vel OB2 which surrounds the brilliant pair γ Velorum. This agrees with distances of the close binary AaAb derived from interferometric observations and with the trigonometrical parallax derived by Hipparcos. The primary star is a double-lined spectroscopic binary with a period of 78.5 days and consists of a Wolf–Rayet star (the nearest such object to the Sun) and a late O star; between them they radiate with the energy of about 400,000 Suns. The third star (B), 41″ distant, is probably connected although the proper motions are small and the uncertainties

58. ζ CNC = STF 1196 = WDS J08122+1739AB,C

Table 9.58 Physical parameters for ζ Cnc

STF 1196 RA: 08 12 12.71	Dec: +17 38 53.3	WDS: 7(1181) (AB)	WDS: 30(613) (AC) → MOVE	
V magnitudes	A: 5.30	B: 6.25	C: 5.85	D: ~10
$(B-V)$ magnitudes	A: +0.55	B: +0.69	C: +0.63	
μ(A)	116.98 mas yr^{-1}	± 0.31	−148.89 mas yr^{-1}	± 0.21 (DR2)
μ(B)	58.77 mas yr^{-1}	± 0.24	−120.89 mas yr^{-1}	± 0.14 (DR2)
μ(C)	21.90 mas yr^{-1}	± 0.87	−139.43 mas yr^{-1}	± 0.72 (DR2)
π(A)	41.30 mas	± 0.17	79.0 light yr	± 0.3 (DR2)
π(B)	40.96 mas	± 0.16	79.6 light yr	± 0.3 (DR2)
π(C)	42.13 mas	± 0.48	77.4 light yr	± 0.9 (DR2)
μ	A: +27.61 mas yr^{-1}	± 1.11	B: −151.73 mas yr^{-1}	± 0.99
Spectral types	A: F7V	B: F9V	C: G0V	D: M + M (?)
Masses ($M_\odot$)	A: 1.11	B: 1.00	C: 0.99	D: 0.93
Luminosities ($L_\odot$)	A: 3.5	B: 1.5	C 2.0 :	D: 0.05
Catalogues (A/B/C)	HR 3208/9/10	HD 68257/5/6	SAO 97645/6	HIC 40167
DS catalogues	Mayer 22 (AB,C)	H 1 24(AB)	STF 1196	HUT 1 (DaDb)
Radial velocity (AB,C)	−7.93 km s^{-1}	± 0.9		
Galactic coordinates	205°.301	+25°.531		

History

The wide components of this pair were first noted, according to Roger Griffin [306], by Flamsteed in the course of his regular observations from Greenwich. Flamsteed recorded only the brighter component on 22 March 1680. Subsequent measures have shown that the two components revolve around each other once every 1115 years or so, according to W. D. Heintz [205]. As the ephemeris below shows, the movement in angle amounts to about 4°degrees in 10 years and the separation hardly changes.

About a century later, when William Herschel was conducting a survey for double stars, he came across zeta Cancri and noted on 21 November 1781 'If I do not see extremely ill this morning (4 am) the large star consists of two'. When including the pair in his first published list of new double stars he notes 'Minute treble ...' and it became H 1 24 (see the table for the explanation of Herschel's categories). The pair was not noted by Herschel during a follow-up set of observations in 1802, and it was not until 1825 that Admiral Smyth, observing from Passy near Paris, saw it again at a separation similar to that in 1781.

From then on, the significant orbital motion of AB recommended itself to the observers of the day and it was taken up enthusiastically by F. G. W. Struve at Dorpat and by Dawes, O. Struve, and others. By the middle of the nineteenth century the period was generally agreed to be about 60 years. Observers would make measurements of star C with repect to

59. $\kappa^{1,2}$ VOL = BSO 17 = WDS J08198–7131AB

Table 9.59 Physical parameters for κ^1 Vol

BSO 17	RA: 08 19 49.00	Dec: −71 30 54.0	WDS: 4508(26)	
V magnitudes	A: 5.33	B: 5.61	C: 7.90	
$(B-V)$ magnitudes	A: −0.07	B: −0.11	C: +0.91	
μ(A)	−17.65 mas yr^{-1}	± 0.14	34.61 mas yr^{-1}	± 0.19 (DR2)
μ(B)	−17.03 mas yr^{-1}	± 0.27	36.96 mas yr^{-1}	± 0.30 (DR2)
μ(C)	−18.24 mas yr^{-1}	± 0.04	35.79 mas yr^{-1}	± 0.06 (DR2)
π(A)	7.80 mas	± 0.09	418 light yr	± 5 (DR2)
π(B)	8.00 mas	± 0.15	408 light yr	± 8 (DR2)
π(C)	2.97 mas	± 0.03	1098 light yr	± 11 (DR2)
Spectra	A: B9III-IV	B: A0IVMn	C:	
Luminosities ($L_\odot$)	A: 100	B: 70	C: 65	
Catalogues (A/B)	HR 3301/2	HD 71046/66	SAO 256497/9	HIP 40817/34
DS catalogues	BSO 17			
Radial velocity (A/B)	+36.00 km s^{-1}	± 7.4	−6.5 km s^{-1}	
Radial velocity (C)	+30.16 km s^{-1}	± 0.14 (DR2)		
Galactic coordinates	284°.825	−19°.046		

History

This object was noted by John Herschel on 21 February 1835. He gave the stars' IDs as Brisbane 2018+2022+2023. The brightest star is also known as LAC 3355. The Brisbane catalogue was instigated by Sir Thomas Brisbane, the Governor of New South Wales, who in 1822 set up an observatory at Parramatta near Sydney and equipped it with with several instruments, including a five and a half foot transit instrument by Troughton and a two foot mural circle by the same maker. Brisbane employed Carl Rümker and James Dunlop to do the observing and the latter actually did the greater part of the practical side of this project. The result was a catalogue of 7935 stars; the work of reducing the observations and preparing the lists for publication was done by William Richardson, a member of staff at the Royal Observatory, Greenwich.

The Modern Era

The A and B stars have similar proper motions and parallaxes and must be regarded as being physically linked. Star C has a similar proper motion but appears to be about three times further away than the bright pair, according to DR2. The derived parallax is 2.97 ± 0.03 mas whilst DR1 gives the parallax of C as 6.38 ± 0.69 mas. The radial velocity of A has a considerable scatter, which might indicate higher multiplicity.

60. δ VEL = I 10 = WDS J08447−5443AAABB

Table 9.60 Physical parameters for δ Vel

I 10	RA: 08 44 42.227	Dec: −54 42 31.75	WDS: 1283(65)		
V magnitudes	A: 1.99	B:	C: 11	D: 13.5	F: 5.70
$(B-V)$ magnitudes	A: +0.05	B: 5.5	F: +0.47		
μ(A)	28.99 mas yr^{-1}	± 0.50	−103.35 mas yr^{-1}	± 0.54	
π(A)	40.49 mas	± 0.39	80.6 light yr	± 0.8 (Hipp.)	
π(A)	39.8 mas	± 0.4	81.9 light yr	± 0.8 (dyn.)	
μ(F)	24.32 mas yr^{-1}	± 0.18	−91.71 yr^{-1}	± 0.15 (DR2)	
π(F)	41.22 mas	± 0.09	79.1 light yr	± 0.2 (DR2)	
Spectra	Aa: A1V	Ab: A4V	B: F8V	F: F6V	
Masses ($M_\odot$)	Aa: 2.43	Bb: 2.27	C: 1.35		
Radii ($R_\odot$)	Aa: 31.7	Bb: 2.02	B: 1.39		
Luminosities ($L_\odot$)	A: 80	B: 3	F: 2.5		
Catalogues (A/F)	HR 3485/3570	HD 74956/76653	SAO 236232/236405	HIP 42913/43797	
DS catalogues	KEL 1 (AaAb)	I 10 (AB)	HJ 4136 (AC)	SHY 49 (AF)	
Radial velocity	+2.2 km s^{-1}	± 1.78			
Galactic coordinates	272°.079	−7°.371			

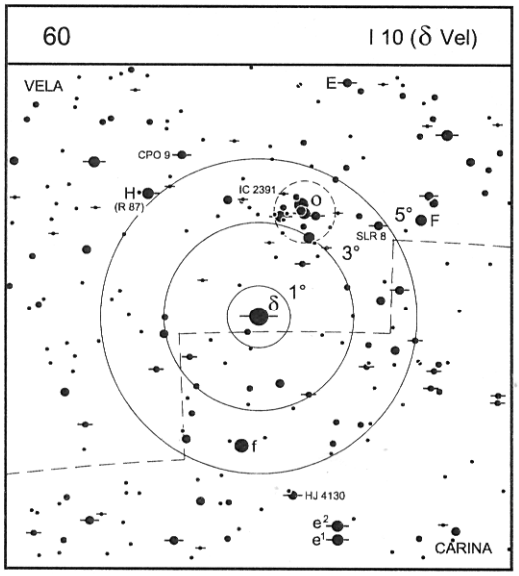
History

In 1835 John Herschel noted a faint companion (now called C) to δ Vel at a distance of about 80″, and he estimated its magnitude on two occasions as 10 and 12. About a century later, W. H. van den Bos added a maguitude 13.5 companion to C at a distance of 5″. In 1894, Solon Bailey [248], using the 13-inch Harvard refractor which had been set up at Arequipa in Peru, discovered a close companion of maguitude 5 at a distance of 3″. Robert Innes came across it a year later during one of his early sweeps for new double stars whilst living in Sydney and as he published his observation first, the pair was given the catalogue number I 10. Owing to the relative difficulty of measuring the system, early measures were scattered and estimates of the brightness of B varied wildly. In 1897 See made it 12 whilst in 1912 Innes estimated 4. The apparently slow motion resulted in only an occasional measure being made of the two stars over the next 60 years or so.

The Modern Era

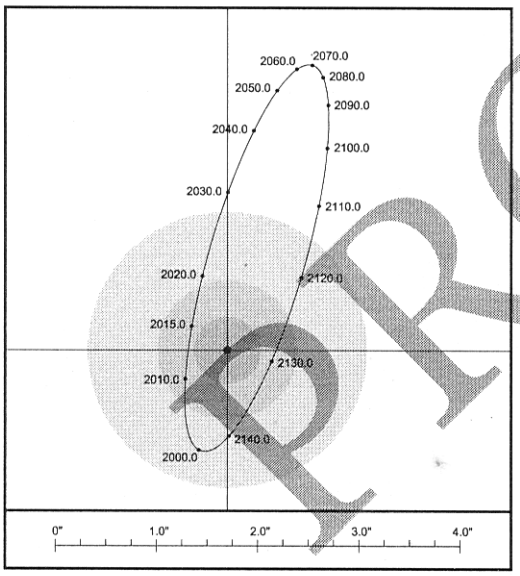
No measures were made at all between 1953 and 1978, when Tango *et al.* [311] announced the discovery of a third star in the system using speckle on the *Anglo Australian Telescope*. It later transpired that this was not an extra component; rather it was the Innes companion, which had closed in considerably. Using Hipparcos observations and a speckle measure from 1999 Andreas Alzner [310] calculated an apparent orbit with

Finder Chart



08h 44.7m -54° 43'

Orbit



Ephemeris for I 10 AB (2016 to 2034)

Orbit by Msn (2011b) Period: 146.97 years, Grade: 4

Year	PA(°)	Sep(")	Year	PA(°)	Sep(")
2016.0	224.4	0.48	2026.0	184.5	1.27
2018.0	208.3	0.61	2028.0	181.9	1.42
2020.0	198.6	0.77	2030.0	179.9	1.57
2022.0	192.2	0.94	2032.0	178.1	1.71
2024.0	187.8	1.11	2034.0	176.7	1.84

a period of 142 years. In 1997 Sebastian Otero *et al.* [312] noticed visually a series of drops in magnitude of up to 0.3 magnitude, whilst Paul Fieseler had independently found similar behaviour whilst examining data from the Galileo satellite star tracker. They found that the star underwent primary and secondary eclipses with a period of 45.15 days. The primary of δ Vel is thus the brightest known eclipsing variable. More recently, a group of astronomers, including Pribulla, Kervella, Kellerer *et al.* [314], dedicated four papers to the system and, using the NACO adaptive optics instrument on the VLT, determined an astrometric orbit for the eclipsing pair. Using star B as a reference they measured the wobbles in the motion of A with an accuracy of 50 microarcseconds, and found that the orbit of AaAb is 2 mas in diameter. They also recalculated the AB orbit, obtaining values of the elements similar to those of Alzner but with much smaller errors. More recently, Shaya and Olling [270] showed that the nearby bright star HIP 43797, which is 90′ to the SE has a similar proper motion to δ, and they report that it is almost 100% certain that the connection is physical.

Observing and Neighbourhood

The resolution of δ Vel requires considerable aperture owing to the brightness of the primary, the difference in magnitude between A and B, and the current small separation. No visual sightings of B have been recorded for more than 60 years, but the stars are now separating quite quickly. The open cluster NGC 2391 can be found 2° NNE. There are a number of fine pairs in this field. The brightest is H Vel = R 87 (4.7, 7.7, 333°, 2″.6, 2008). Just 1° NW is CPO 9 (6.6, 8.2, 83°, 2″.9, 1991). A good test for 15-cm is SLR 8 (6.1, 7.1, 281°, 0″.8, 2014). Finally, 3° S and slightly W is HJ 4130 (6.5, 8.0, 240°, 4″.0, 1998).

Measures

Early (I)	173°.2	2″.45	1900.19
(Orbit	169°.5	2″.52)	
Recent (TOK)	262°.9	0″.37	2013.13
(Orbit	263°.8	0″.38)	

Observing and Neighbourhood

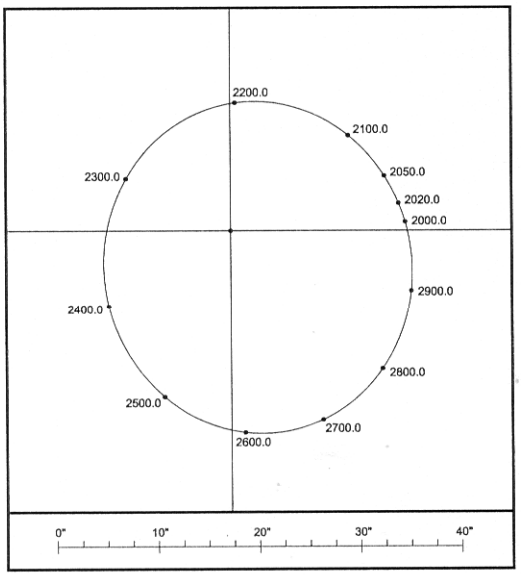
One of the brightest and best double stars in the winter sky, ι Cnc is sometimes referred to as the Winter Albireo. Greg Stone sees the colours as pale yellow and deep sky blue and therefore he considers that it is not a rival to Albireo. Easily a naked-eye object, it is located 14° N and slightly following Praesepe. Alternatively, it is 15° following Pollux. The object 57 Cnc = STF 1291 is a fine close pair of stars with magnitudes 6.09 and 6.37 just 2°.5 NW of ι. One of William Herschel's discoveries, it has slowly widened from 1″ to the current position of 310°.0, 1″.53 (Prieur 2012.24). STF 1298, also known as σ^4 Cnc, magnitudes 5.95, 8.96 is a fairly tough test for the small aperture. RWA found it at 137°.8, 4″.66 on 2016.37. Less than half a degree W in the same low-power field is σ^3 Cnc, also known as SHJ 100, with a deep yellow primary and faint distant companion (5.32, 8.97 115°.7, 88″.26, 2016.37). Just over 1° due S is CBL 32 (7.4, 10.7, 174°, 41″.0, 2010).

NE

Measures

Early measure (STF)	307°.1	30″.46	1828.04
Recent measure (WSI)	307°.6	30″.40	2014.25

Orbit



Ephemeris for STF 1321 AB (2000 to 2180)

Orbit by Chg (1972) Period: 975 years, Grade: 4

Year	PA(°)	Sep(")	Year	PA(°)	Sep(")
2000.0	93.0	17.21	2100.0	128.9	14.94
2020.0	99.4	16.76	2120.0	137.5	14.48
2040.0	106.1	16.31	2140.0	146.6	14.02
2060.0	113.3	15.86	2160.0	156.3	13.57
2080.0	120.9	15.40	2180.0	166.8	13.11

the companion moved some 40° in position angle. The resulting elements are therefore uncertain but, as of 2015, they still seem to reflect the motion of the two stars fairly well. The ephemeris for this orbit is given below. In 1973 Abt Levy [321] published a paper in which they reported that the radial velocities of both components of STF 1321 had led them to the conclusion that each star was itself a spectroscopic binary of small amplitude. Star A had a period of 44.11 days and an eccentricity of 0.3 whilst B had a period of 16.47 days and an eccentricity of 0.76. Some years later Morbey and Griffin [322] re-observed both stars using the radial velocity spectrometer at Cambridge and reached different conclusions. They were not able to see any significant variation in either star at a level greater than about 0.1 km per second. K. Ward-Duong *et al.* [323] used the *VLT* and an adaptive optics system, in combination with archive astrometric plates, to look for companions of both stars in the range 1 AU to 10,000 AU and found no evidence for further bodies. By the time of writing, Gaia had measured the fainter component. The difference in accuracy in parallax and proper motion determination between Gaia and Hipparcos is clearly shown in the table.

Exoplanet Host?

More recently, Gagné *et al.* [324] observed each component in a cell in a search for exoplanets and found a scatter in radial velocity of about 50 metres per second.

Observing and Neighbourhood

To be found 4° WNW of θ UMa, this is an easy pair for most telescopes but a larger aperture will show the colours better. Using a 60-mm refractor Sissy Haas found both stars 'peach-white' whilst Webb noted yellow and Struve thought both stars 'yellowish'. Within 2° are two STT systems: STT 199 is 2° SE (6.2, 10.0, 140°, 5″.7, 2008) and a magnitude 7.9 at 230″ forms ARN 71 AD. Thirty minutes of arc NE is STT 200 (6.5, 8.6, 337°, 1″.2, fixed).

FORTY

Measures

Early measure (STF)	48°.5	20″.03	1833.54
(Orbit	48°.3	20″.20)	
Recent measure (CTT)	97°.2	17″.22	2015.28
(Orbit	97°.9	16″.87)	

above

64. 38 LYN = STF 1334 = WDSJ 09188+3648AB

Table 9.64 Physical parameters for STF 1334

STF 1334	RA: 08 18 50.644	Dec: +36 48 09	WDS: 259(192)		
V magnitudes	A: 3.92	B: 6.09			
$(B - V)$ magnitudes:	A: +0.05	B: +0.49			
μ(A)	-36.29 mas yr^{-1}	$\pm$ 0.96	-121.77 mas yr^{-1}	$\pm$ 0.95 (DR2)	
μ(B)	-26.51 mas yr^{-1}	$\pm$ 0.19	-127.26 mas yr^{-1}	$\pm$ 0.23 (DR2)	
π(A)	27.80 mas	$\pm$ 0.79	117.3 light yr	$\pm$ 3.3 (DR2)	
π(B)	24.47 mas	$\pm$ 0.12	133.3 light yr	$\pm$ 0.7 (DR2)	
Spectra	A1V				
Luminosities ($L_\odot$)	A: 30	B: 5			
Catalogues	HR 3690	HIP 45688	HD 80081	SAO 61391	
DS catalogues	H 1 9 (AB)	STF 1334 (AB)	BDS 5014	ADS 7292	CHR173 (BaBb)
Radial velocity	4.0 km s^{-1}	$\pm$ 2 km s^{-1}			
Galactic coordinates	186°.810	+44°.471			

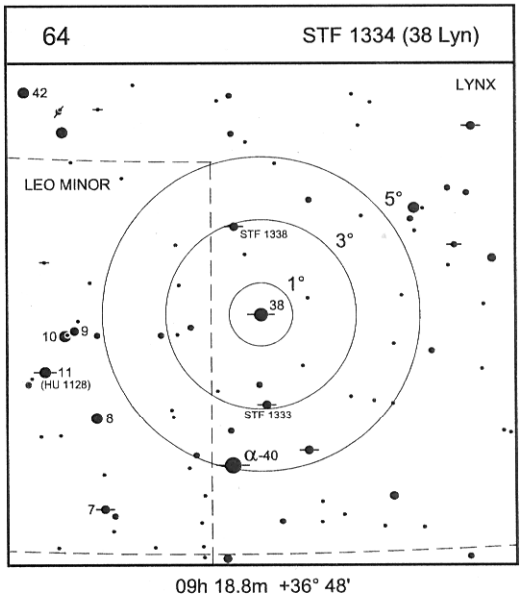
History

William Herschel resolved 38 Lyn on November 24, 1780 and he noted that the colours were white for the primary and inclining to red for the secondary. He also called it 'a very fine object' but added that 'a proper motion is suspected in one of the stars'.

The Modern Era

In 1988 McAlister *et al.* [482] found that star B was itself a close double star (CHR 173BaBb). The apparent separation in 1988.17 was 0″.06. No further interferometric observations were made until 2004, when Hartkopf *et al.* [332] found the companion double at 266° and 0″.24. The difference in separation alone indicates a pair in fairly rapid motion and, if the quadrants are correct then the period cannot be more than about 30 years. De Rosa *et al.* [330], in an investigation

Finder Chart



of X-ray-emitting A star systems within 75 parsecs of the Sun, found that the radiation was emanating from a magnitude 14 companion star (E), which they found 98″.7 (or 3778 AU) away from the bright star.

Observing and Neighbourhood

The double star 38 Lyncis lies at the extreme eastern edge of Lynx and can be found about 2.5° N of the V = 3.1 maguitude α Lyncis. Smyth noted that the colours were silvery white and lilac, an observation that Webb repeated in the first edition of *Celestial Objects* (1859). In his revision of this work, Espin notes yellow and tawny in 1850 and 1852, presumably reporting Webb's own observations, and adds greenish-white and blue, presumably Espin's own impression. The significant proper motion of the A component appears to be mirrored by the B star, so this is a binary star of long period. Just 1°.5 S of 38 is the fine pair of white stars STF 1333 (magnitudes 6.63 and 6.69, and measured by RWA on 2015.37 at 50°.2, 1″.78) whilst the same distance N is the beautiful binary STF 1338, which is described elsewhere (p. xx). About 3°.5 E and slightly S is 11 LMi (HU 1128), a visual binary but also a very stiff visual test. Hussey gave the magnitudes as 5.5 and 14.0 but B, whilst very faint, is not as faint as magnitude 14: The stars have magnitudes 4.8 and 12.5 (WDS) and, according to the orbit, derived by Heintz [540], giving a period of 201 years with an eccentricity of 0.88, the companion lies at 49° and 6″.6, 2020, but recent observations disagree with the predictions. John Nanson [126] glimpsed B at ×152 with a 6-inch f/10 refractor, whilst ×253 gave a slightly better view. The star 11 LMi was for many years used as a photometric standard but Skiff & Gatewood [328] concluded that it was a low-amplitude (0.033 maguitude) variable, the cause of the variation being proposed as star spots. It is known as SV LMi.

Measures

Early measure (STF)	240°.2	2″.79	1829.17
Recent measure (ARY)	224°.4	2″.61	2013.39

65. STF 1338 LYN= WDS J09210+3811AB

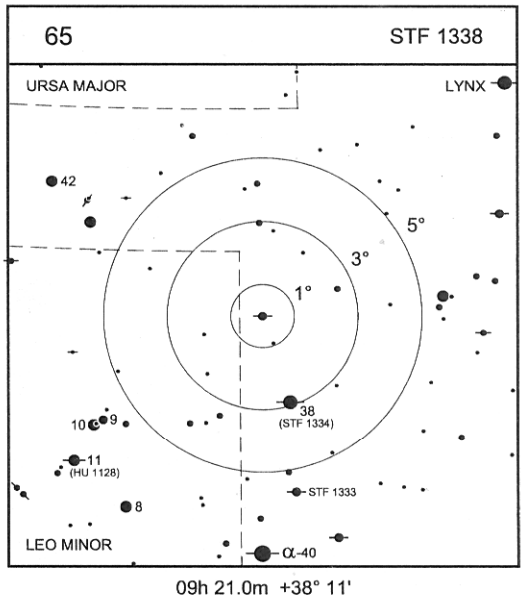
Table 9.65 Physical parameters for STF 1338 Lyn

STF 1338	RA: 09 20 59.37	Dec: +38 11 17.7	WDS: 65(428)	
V magnitudes	A: 6.72	B: 7.08	C: 12.59	
$(B-V)$ magnitudes	A: +0.42	B: +0.44		
μ	-44.5 mas yr^{-1}	$\pm$ 0.97	-23.9 mas yr^{-1}	$\pm$ 0.45
π	23.44 mas	$\pm$ 1.08	139 light yr	$\pm$ 6.4
μ(A)	-51.60 mas yr^{-1}	$\pm$ 0.79	-26.45 mas yr^{-1}	$\pm$ 0.73 (DR2)
π(A)	14.90 mas	$\pm$ 0.59	219 light yr	$\pm$ 8.7 (DR2)
Spectra	F2V	F4V		
Luminosities ($L_\odot$)	A: 8	B: 5		
Catalogues	HR 3701	HD 80441	SAO 61411	HIP 45858
DS catalogues	STF 1338	BDS 5030	ADS 7307	
Radial velocity (A/B)	0.6 km s^{-1}	$\pm$ 2	-1.9 km s^{-1}	$\pm$ 2
Galactic coordinates	184°.892	+44°.964		

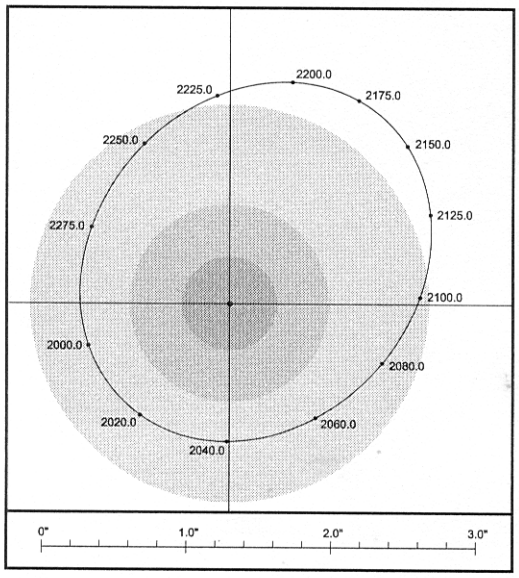
History

This object was found at Dorpat by F. G. W. Struve. component C (maguitude 12.6) at 167° and 143″ was added by Robert Ball in 1879 [333]. Ball was observing stars in certain star fields with the hope of identifying those with a significant or measurable parallax. His argument [326] was based on Schiaparelli's assertion that stars near the Sun may be moving in a stream parallel to the Sun and that the proper motion would not necessarily be an indicator of distance. He also included some red stars and variable stars, in the belief that both were (at the time) held to be small and therefore must be nearby to be seen at all. Neither his initial paper (42 objects) nor the more substantial paper later on (368 stars) showed any sign of a significant parallax, but in the course of this work he found several faint, distant, companions to double stars. As well as holding the Lowndean Chair of Astronomy and Geometry at the Institute of Astronomy, Cambridge, from 1892, Ball (1840–1913) was a great popularizer of astronomy and wrote copiously on astronomical topics.

Finder Chart



Orbit



Ephemeris for STF 1338 AB (2010 to 2100)

Orbit by Sca (2002b) Period: 303.27 years, Grade: 3

Year	PA(°)	Sep(")	Year	PA(°)	Sep(")
2010.0	304.2	1.01	2060.0	36.6	1.00
2020.0	321.8	1.00	2070.0	53.5	1.06
2030.0	340.0	0.98	2080.0	69.4	1.13
2040.0	358.9	0.96	2090.0	81.2	1.23
2050.0	18.0	0.97	2100.0	92.2	1.32

The Modern Era

The components of STF 1338 have now completed almost half a revolution since discovery. In 1953 an orbit was calculated by S. Arend [334] based on an observed arc of 90°, and he obtained a period of 389 years and an eccentricity of 0.29. The current orbit is by M. Scardia in 2002 and shortens the period to 303 years.

208

Observing and Neighbourhood

About 3° S and slightly preceding is 38 Lyn (p. xx). Continuing another 3° in the same direction brings you to STF 1333, described in our entry for 38 Lyn. John Nanson [126] resolved AB with ×253 in a 6-inch refractor in September 2015, with both main component stars appearing white. On that occasion he noted that he saw the C component (magnitude 12.6 at 166°, 144″) better at ×152.

Measures

First measure (STF)	121°.1	1″.76	1829.53
(Orbit	119°.9	1″.57)	
Recent measure (ARY)	314°.0	1″.08	2018.28
(Orbit	318°.2	1″.00)	

66. ω LEO = STF 1356 = WDS J09285+0903AB

DELETE

Table 9.66 Physical parameters for ω Leo

STF 1356	RA: 09 28 27.41	Dec: +09 03 24.4	WDS: 24(656)	
V magnitudes	A: 5.69	B: 7.28		
$(B-V)$ magnitudes	A: +0.75	B: +0.52		
μ	36.98 mas yr^{-1}	± 2.30	5.78 mas yr^{-1}	± 0.70
π	30.15 mas	± 1.45	108 light yr	± 5
Spectra	F9IV			
Luminosities ($L_\odot$)	A: 5	B: 1		
Catalogues	HR 3754	HD 81858	SAO 117717	HIP 46454
DS catalogues	H 1 26	STF 1338	BDS 5103	ADS 7390
Radial velocity (A/B)	0.6 km s^{-1}	± 2	−1.9 km s^{-1}	± 2
Galactic coordinates	223°.657	+38°.896		

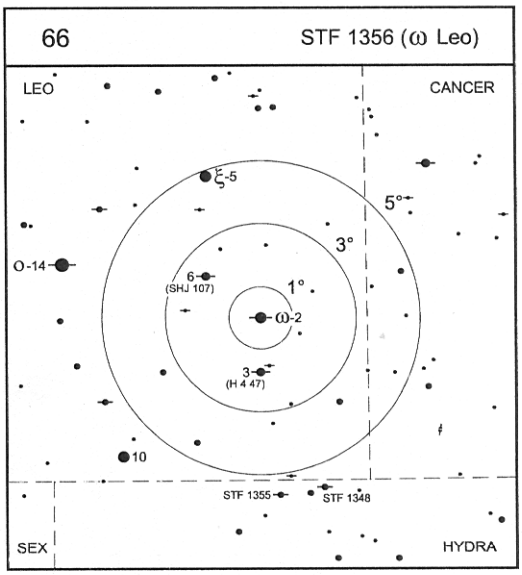
History

Found by William Herschel on 8 February 1782. He records 'With 227 there is not the least suspicion of its being double; with 460 it appears oblong, and, when perfectly distinct, we see 3/4 of the diameter of a small star as it were emerge from behind a larger star; with 932 they are more clear of each other, but not separated; …' Herschel also thought that, between the beginning of 1782 and the end of that year, he was able to discern that the two stars were getting further apart. The modern orbit predicts that the motion in distance during this period would have been only 0″.02.

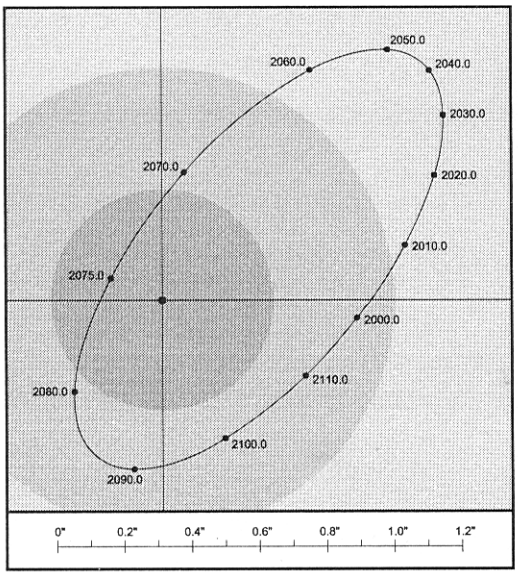
The Modern Era

The current orbit for ω Leo was derived by Muterspaugh *et al.* [620] and incorporates some very accurate astrometry, derived from observations of the star with the PHASES

Finder Chart



Orbit



Ephemeris for STF 1356 (2015 to 2060)

Orbit by Mut (2010b) Period: 117.974 years, Grade: 2

Year	PA(°)	Sep(")	Year	PA(°)	Sep(")
2015.0	109.3	0.82	2040.0	130.7	1.05
2020.0	114.6	0.89	2045.0	134.3	1.04
2025.0	119.2	0.95	2050.0	138.0	1.00
2030.0	123.3	1.00	2055.0	142.1	0.93
2035.0	127.1	1.03	2060.0	147.2	0.81

(Palomar High-Precision Astrometric Search for Exoplanet Systems) instrument. This ground-based interferometer ceased operation in late 2008 but when in use utilised three 40-cm mirrors, with one 110-metre and two 87-metre baselines, and was capable of determining the positions of stars to 35 microarcsecond. The pair does not appear in DR2.

Observing and Neighbourhood

Smyth thought that the colours of the stars were pale yellow and greenish at the time the system was below his telescope resolution limit (1843). Hartung considered the pair to be bright yellow, but again the separation was such that he only saw the stars apart occasionally in his 30-cm reflector (1962). RWA could not resolve the pair until the mid-1990s with the 20-cm at Cambridge. At present, they are a real test for apertures of 15- to 20-cm. The stars are currently still below 1″ but the substantial magnitude difference makes resolution more difficult. In the Cambridge 20-cm only the best nights show the stars separated at ×450. About 1° ENE of ω is 6 Leonis (SHJ 107). This is a wide unequal pair with a fifth magnitude K3 giant primary star and a ninth magnitude companion. Greg Stone [126] noted colours of deep orange and violet in a 80-mm f/5 refractor at ×132, agreeing with W. S. Franks, who in 1877 recorded pale orange and purple. Two degrees due S of ω is 3 Leo (H 4 47) – a William Herschel discovery, which escaped Webb but appears in Smyth, where it is described as 'delicate' and the magnitudes as 6.5 (pale yellow) and 13 (blue). The WDS has 5.8, 11.1 at PA 80° and separation 24″.8. Proceed a further 2° SSE and the two rather similar pairs STF 1348 and 1355 (1° apart) can be found: STF 1348 (7.5, 7.6, 313°, 1″.9, 2017); STF 1355 (7.1, 7.8, 354°, 1″.8, 2017).

Measures

Early measure (STF)	153°.9	0″.97	1825.21
(Orbit	148°.7	0″.78)	
Recent measure(ARY)	108°.9	0″.85	2014.94
(Orbit	109°.1	0″.82)	

67. ψ VEL = COP 1 = WDS J09307–4028

delete '0'

-.3'

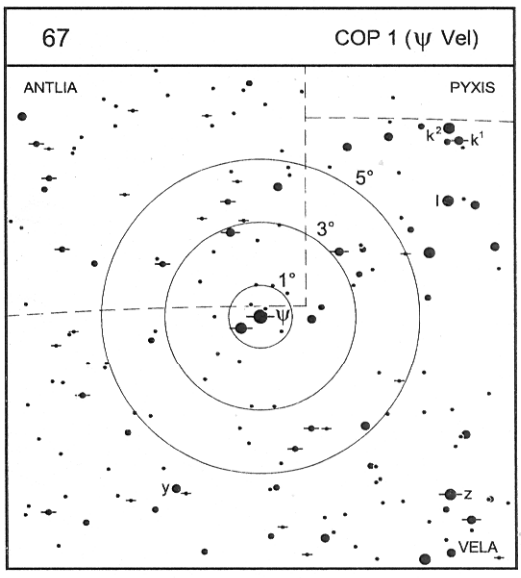
Table 9.67 Physical parameters for ψ Vel

COP 1	RA: 09 30 42.000	Dec: −40 28 00.26	WDS: 368(152)	
V magnitudes	A: 3.91	B: 5.12		
$(B-V)$ magnitudes	A: +0.34	B: +0.53		
μ(A)	−178.49 mas yr^{-1}	± 0.66	93.50 mas yr^{-1}	± 0.81 (DR2))
μ(B)	−203.95 mas yr^{-1}	± 0.57	44.27 mas yr^{-1}	± 0.60 (DR2)
π(A)	54.61 mas	± 0.45	59.7 light yr	± 0.5 (DR2)
π(B)	54.31 mas	± 0.33	60.1 light yr	± 0.4 (DR2)
Spectra	A: F0IV	B: F3IV		
Masses ($M_\odot$)	A: 1.56	B: 1.26		
Radii ($R_\odot$)	A: 1.6	B: 1.2		
Luminosities ($L_\odot$)	A: 7.5	B: 2.5		
Catalogues	HR 3786	HD 82434	SAO 221234	HIP 46651
DS catalogues	COP 1			
Radial velocity	8.80 km s^{-1}	± 1.8		
Galactic coordinates	266°.777	+7°.910		

History

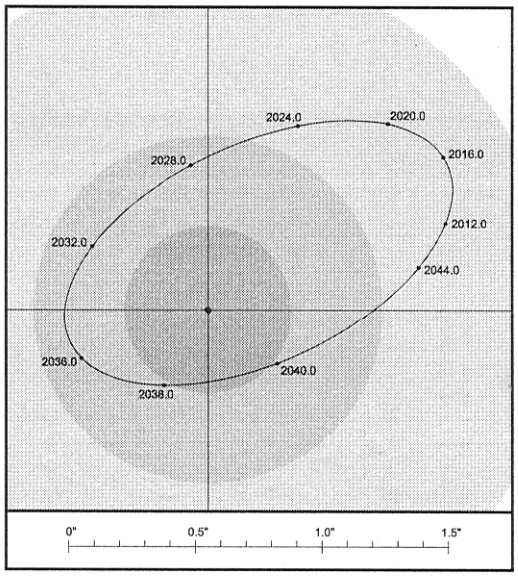
Ralph Copeland (1837–1905) was the third Astronomer Royal for Scotland. He worked at Dun Echt Observatory in Ireland for the 26th Earl of Crawford and was a frequent traveller on worldwide astronomical expeditions, which included seeing transits of Venus, in 1874 from Mauritius, and in 1882 from Jamaica. After the latter event, he made his way through Ecuador and into Peru in March 1883, where he made observations with a 6-inch refractor from sites higher than 12 500 feet [336]. Whilst at Puno from March to June 1883 he recorded the observation of 13 double stars, some of which he was able to attribute to earlier discoverers. The third star on his list was ψ Vel and his journal noted 'ψ Argûs = Stone 5124, 45° 0″.8, 4 and 6 magnitudes; both white; nova?' The last comment is the Latin word for new, as indeed it was and thus became COP 1. On the same night he also resolved the brighter component of the wide pair ϵ Lupi (COP 2).

Finder Chart



REPLACE FINDER CHART

Orbit



Ephemeris for COP 1 (2016 to 2034)

Orbit by Msn (2001c) Period: 33.95 years, Grade: 2

Year	PA(°)	Sep(")	Year	PA(°)	Sep(")
2016.0	123.1	1.11	2026.0	167.6	0.69
2018.0	129.3	1.08	2028.0	186.8	0.58
2020.0	136.1	1.02	2030.0	212.8	0.51
2022.0	144.0	0.93	2032.0	241.5	0.52
2024.0	154.0	0.81	2034.0	267.0	0.56

The Modern Era

The object ψ Vel is a binary of relatively short period, for a visual system, which can be seen with medium aperture when at its widest. The WDS notes that the primary is a spectroscopic binary but gives no details. The primary is a fast rotator ($v \sin i = 160$ km s^{-1}) and Fuhrmann & Chini [337] have derived the masses given in the table above. About 4° SW of ψ lie a couple of John Herschel pairs – z Vel (HJ 4191) is an unequal couple (5.1, 9.1, 13°, 6″, 2008) whilst 30′ SW again lies HJ 4188, 6.0, 6.8, 281°, 2″.9, 2015. One of the entries in the small catalogue of Captain Jacob can be found at 1°.5 NNE (JC 21, 6.5, 8.2, 205°, 56″, 2010). The current orbit by Mason has a period of 33.95 years and is assigned Grade 2 in the USNO Sixth Orbital Catalog. Recent observations show that the star is falling behind the predicted position angle, indicating that the period is perhaps too short.

Observing and Neighbourhood

This pair should be comfortably within range of 20-cm for the next few years, and is probably accessible to 15-cm on a good night. It is one of the shortest-period visual binaries that can be seen with small apertures.

Measures

Early measure (A)	275°.0	0″.72	1899.3
(Orbit	279°.5	0″.56)	
Recent measure (ANT)	121°.6	1″.02	2016.34
(Orbit	124°.2	1″.11)	

be an inadvertent duplicate entry. Of the 26 real systems, the WDS gives credit to Dunlop for five of them, but as Dunlop and Rümker were contemporaneous it is not clear who had precedence in time for the first observation of each pair. One further object appears to have been independently found later at Cordoba Observatory.

The Modern Era

A study by Mandrini & Niemela in 1986 [339] gives a distance of 1333 light years and from this they derive a linear distance of 2000 astronomical units between the stars. With masses of 13 and 8 $M_\odot$ this implies a rotation period of 19500 years. Gaia (DR2) has announced astrometry results for both components and the proper motions and parallxes are given above. The uncertainty on the primary's distance is no doubt due to its brightness. If the pair is physical, the best estimate of the distance to the system is that of the secondary star.

Observing and Neighbourhood

'Very fine pair' (Hartung) but the significant magnitude difference and small separation requires sufficient magnification to separate the two stars and move the companion away from the glare of the primary. Gould notes that the double star 'dominates a quite starry field'. An 18-cm refractor shows it as an easy and beautiful pair at ×180. There has been virtually no apparent motion since discovery, supporting the great distance to these stars implied by the DR2 parallaxes. Ten arcminutes to the SE is HJ 4252 (9.3, 9.5, 303°, 12″, 2010). To the NE at 3°.6 distance is HRG 47 (6.3, 7.9, 353°, 1″.1, 2014). Four degrees NW is HJ 4213 (5.8, 9.6, 330°, 8″.8, 2000).

Measures

Early measure (JC)	126°.6	5″.08	1851.21
Recent measure (ANT)	126°.1	4″.98	2010.28

opposite

69. γ SEX = AC 5 = WDS J09525–0806

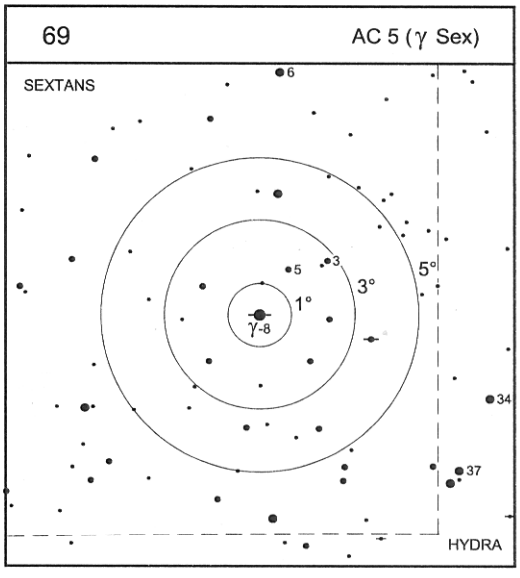
Table 9.69 Physical parameters for γ Sex

AC 5	RA: 09 52 30.437	Dec: −08 06 18.13	WDS: 111(309)		
V magnitudes	A: 5.63	B: 6.11	C: 12.3		
$(B-V)$ magnitudes	A: +0.02	B: +0.11			
μ	-57.28 mas yr^{-1}	$\pm$ 1.38	$-$ 49.26 mas yr^{-1}	$\pm$ 0.36	
π	11.75 mas	$\pm$ 0.63 mas	278 light yr	$\pm$ 15	
Spectra	A: A0/A1	B:			
Luminosities ($L_\odot$)	A: 35	B: 20			
Catalogues	8 Sex	HR 3909	HD 5558	SAO 137199	HIP 48437
DS catalogues	H N 49 (AB,C)	HJ 4256 (AB,C)	AC 5 (AB)	BDS 5235	ADS 7555
Radial velocity	12.20 km s^{-1}	$\pm$ 2.4			
Galactic coordinates	245°.565	+34°.170			

History

The star γ Sex was observed by William Herschel and, on February 22nd, 1787, he noted that it had a very faint companion. During his work at the Cape in South Africa, John Herschel re-oberved γ and in late 1835 was able to glimpse the B star between clouds. He did not refer to his father's previous observation, and gave the stars the number HJ 4256. In April 1852, Alvan Clark [342] was testing a 4.75-inch objective and noticed that the primary star was double. This observation intrigued W. R. Dawes, who wondered why Struve had not seen it at Dorpat. He suspected that there had been orbital motion and the star was then too close for the 9.3-inch Fraunhofer telescope. (The current orbit gives a separation of 0″.48 for 1825). The stars were close to maximum separation (0″.56) when John Herschel looked at them in admittedly less than perfect conditions. The discovery by Clark is remarkable and demonstrates the quality of even the smaller objectives. The *Aitken Double Star Catalogue* (*ADS*) gives AB-C as HJ 4246, which is incorrect.

Finder Chart



70. I 173 VEL = WDS J10062–4722

11.22 -47 22 12.1

Table 9.70 Physical parameters for I 173 Vel

I 173	RA: 10 06 10.53	Dec: −41 45 34.8	WDS: 2282(42)	
V magnitudes	A: 5.38	B: 7.11		
$(B-V)$ magnitudes	A: +1.17	B: +0.45		
μ(A)	−10.36 mas yr^{-1}	± 0.36	−49.99 mas yr^{-1}	± 0.29 (DR2)
μ(B)	−9.02 mas yr^{-1}	± 1.89	−53.47 mas yr^{-1}	± 1.93 (DR2)
π(A)	12.19 mas	± 0.15	268 light yr	± 3 (DR2)
π(B)	8.34 mas	± 1.06	391 light yr	± 50 (DR2)
Spectra	A: K1III	B: G		
Luminosities ($L_\odot$)	A: 40	B:15		
Catalogues	HR 3976	HD 87783	SAO 221773	HIP 49485
DS catalogues	I 173			
Radial velocity	+21.20 km s^{-1}	± 0.8		
Radial velocity (A)	25.89 km s^{-1}	± 0.28		
Galactic coordinates	276°.175	+6°.734		

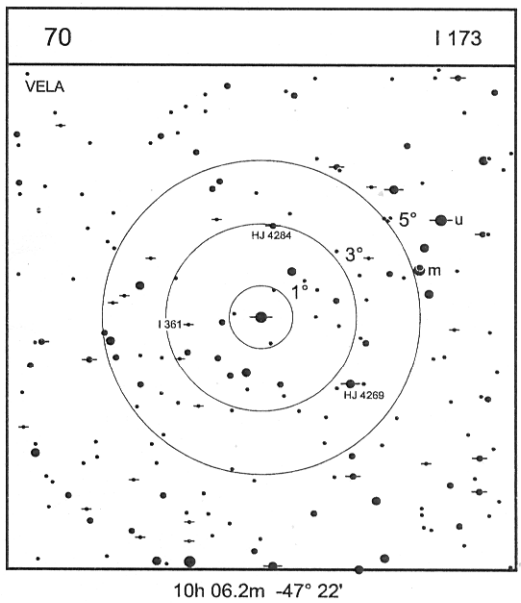
History

Innes found this star using a 7-inch refractor at the Royal Observatory at the Cape and observed it occasionally until 1925, when van den Bos found that it had closed in considerably from its discovery separation. During the 1930s the pair was essentially unresolved in the large refractors at Johannesburg and Bloemfontein. Since then it has slowly widened and is currently close to maximum separation, which will be reached in 2034 when the stars will be 1″.0 apart. The separation will then remain above 0″.9 until around 2065, when the stars close again.

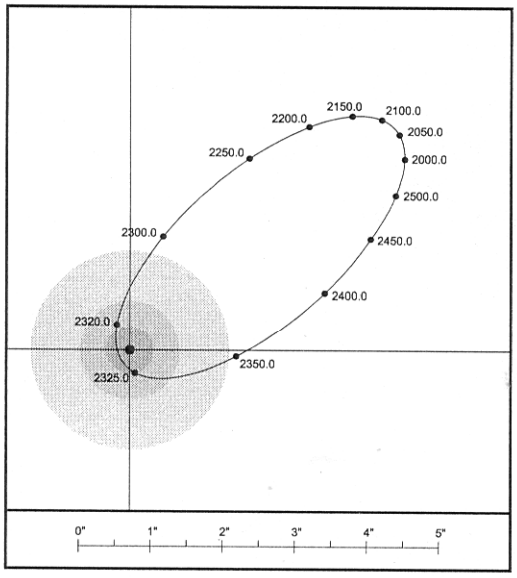
The Modern Era

Although DR2 has observed this pair, the results are unsatisfactory; the fainter star gets a very poor parallax

Finder Chart



Orbit



Ephemeris for STF 1424 AB (2000 to 2180)

Orbit by PkO (2014c) Period: 554 years, Grade: 4

Year	PA(°)	Sep(")	Year	PA(°)	Sep(")
2000.0	125.0	4.65	2100.0	132.6	4.75
2020.0	126.6	4.73	2120.0	134.2	4.67
2040.0	128.1	4.78	2140.0	135.8	4.56
2060.0	129.6	4.80	2160.0	137.5	4.41
2080.0	131.1	4.79	2180.0	139.4	4.22

interest. It is an M0 flare star, known as AD Leo, and a parallax by DR2 (0″.20137) puts it 16.197 light years away, with an error of 0.006 light years). It has its own large proper motion of 0″.5 per year. In 1943, Dirk Reuyl [538] analysed a series of photographic plates of AD Leo covering a baseline of 27 years and found a perturbation amounting to about 0″.1 with an apparent period of 26.5 years. In 1968, S. L. Lippincott [346], using plate material taken with the Sproul 24-inch refractor between 1938 to 1966, found that 'no definite analysis of the variable proper motion in terms of Keplerian motion is possible at this time'. In 1981, using the 6-metre reflector at the Special Astrophysical Observatory, Yuri Balega [347] detected a companion at 750 nm at a distance of 0″.07. Four years later, at two closely spaced epochs, he noted that the pair were 'resolved but uncertain'. Since then no further direct observations of B have been made, so the question of duplicity is still uncertain.

Exoplanet host?

An exoplanet accompanying star A, period = 428 days, M_J = 8.8, was discovered in 2009 [344].

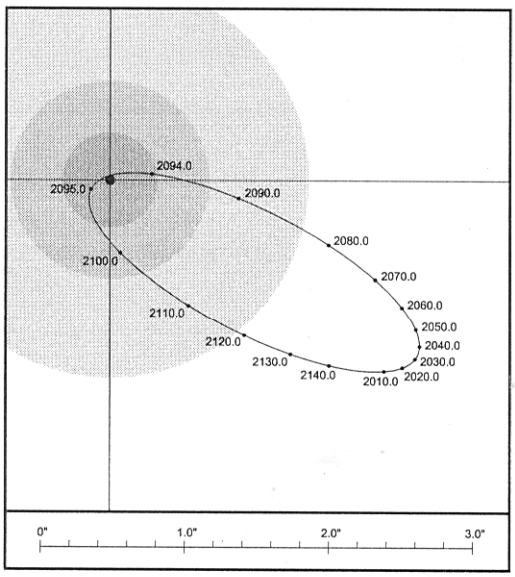
Observing and Neighbourhood

The object γ Leonis is observable in the smallest apertures. Smyth noted bright orange and greenish-yellow, whilst Struve called them both golden. The writer found both stars to be orange using a 21-cm reflector at ×96, whilst from Australia the ASNSW group called them pure yellow and yellow or yellowish. Just 2°.2 SSW is the binary STT 215. The stars of magnitudes 7.3 and 7.5 rotate around each other in 670 years, according to Zaera [343] but a glimpse at the astrometric history shows that they are beginning to deviate from this orbit. The stars are currently 1″.5 apart and, on the basis of the current orbit, are expected to widen until they reach 2″, two centuries hence. Star D, magnitude 10.62, is 371″ away and the distance is reducing. Due N 3°.5 can be found the wide binocular pair ζ Leonis (STFA 18) (3.5, 6.0, 338°, 335″). The star 39 Leo is a good light-gathering test. The stars in STT 523 are 5.8, 11.3, 300°, 7″.9, 2017. Both have a large and common proper motion and the comes is an M dwarf star. DR2 confirms both stars are 73 light years away.

Measures

Early measure (STF)	102°.0	2″.46	1828.24
(Orbit	103°.0	2″.54)	
Recent measure(ARY)	128°.3	4″.78	2018.33
(Orbit	127°.4	4″.74)	

Orbit



Ephemeris for R 155 (2010 to 2100)

Orbit by Tok (2014a) Period: 149.3 years, Grade: 4

Year	PA(°)	Sep(")	Year	PA(°)	Sep(")
2010.0	55.0	2.32	2060.0	66.5	2.21
2020.0	57.3	2.41	2070.0	69.4	1.97
2030.0	59.5	2.45	2080.0	73.6	1.58
2040.0	61.7	2.44	2090.0	82.1	0.90
2050.0	64.0	2.36	2100.0	8.0	0.51

Sydney Observatory, then under the leadership of its founding director, William Scott. Russell rose to become Government Astronomer in New South Wales in 1870 and in the following year was appointed Director at Sydney. At that time the Observatory had a fine 7.25-inch Merz refractor with micrometer, which was used to re-measure some of John Herschel's double stars. In 1874 an 11.5-inch Schroder refractor of 12ft 6in focal length was added. It was fitted with a micrometer and powers ranging from 100× to 1500× and used for the discovery of new double stars; Russell himself accumulated a list of 350 objects. Number 155 in this list is μ Vel, which was found in 1880. Russell noted that the colours were pale yellow and pale green and that the magnitudes were 3 and 9.

The Modern Era

The modern value for the visual magnitude of B is 5.65, as derived by Hipparcos. Observation of the star was part of a monitoring programme carried out by Ayres *et al.* [354] with the *Extreme Ultraviolet Explorer*, and they observed a significantly intense flare from the primary star which lasted 1.5 days. Yellow giants are not expected to produce such outbursts unless they happen to be in an RS CVn binary system. The WDS catalogue indicates that A is a spectroscopic binary but there are no references to the source of this information.

Observing and Neighbourhood

The apparent orbit of the visual pair has an eccentricity of almost 0.97 – one of the largest known. The two stars are 80 times closer together at periastron (0″.03 in 1945) than at apastron (2″.45 in 1880). The large difference in magnitude suggests that a night of good seeing would be advantageous and then 15-cm should show it well. The stars will remain near widest separation for several decades. The system μ Velorum lies 10° due N of the η Carinae nebula, and the sky between the two is filled with a range of visual double stars including DUN 95 (p. xx) and DUN 102 (p. xx). For a real challenge there is p Vel (SEE 119), one of T. J. J. See's most interesting discoveries. This pair has a period of only 16.65 years and is therefore correspondingly close. The minimum distance will be 0″.14 in 2020, the widest separation of 0″.44 occurring in 2030. The stars are magnitudes 4.1 and 5.8. The star t Vel is also HJ 4330 (5.2, 8.6, 163°, 40″, 1999). Star A is again a close pair, also called YSJ 1 (0″.4). Close by in the field is HJ 4332 (7.0, 9.8, 163, 25″, 2010).

Measures

Early measure (I)	61°.7	2″.72	1900.36
(Orbit	63°.6	2″.37)	
Recent measure (TOK)	56°.9	2″.28	2016.34
(Orbit	56°.5	2″.39)	

78. ξ UMA = STF 1523 = WDS J11182+3132AB

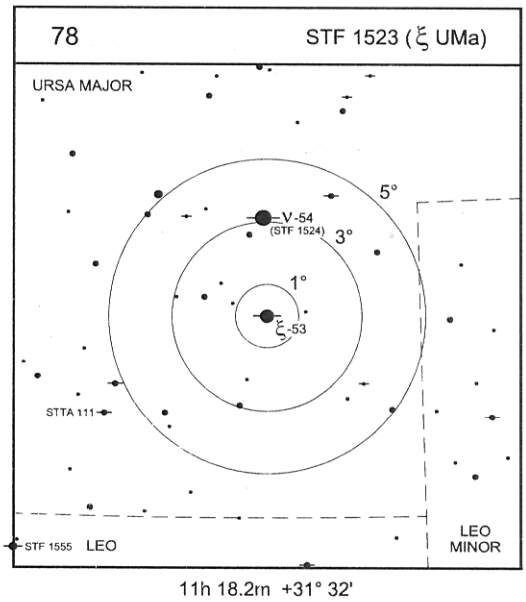
Table 9.78 Physical parameters for ξ UMa

STF 1523	RA: 11 18 10.90	Dec: +31 31 45.0	WDS: 3(1617)	
V magnitudes	Aab: 4.33	Bab: 4.80		
$(B-V)$ magnitudes	Aab: +0.59	Bab: +0.73		
μ	-453.7 mas yr^{-1}	± 2.0	-591.4 mas yr^{-1}	± 2.0
π	119.7	± 0.8	27.2 light years	± 0.2
μ(B)	-339.40 mas yr^{-1}	± 0.78	-607.89 mas yr^{-1}	± 0.76 (DR2)
π(B)	114.49 mas	± 0.43	28.5 light yr	± 0.1 (DR2)
Spectra	F9V	G9V		
Luminosities ($L_\odot$)	A: 1.2	B: 0.8		
Catalogues	HD 98230J	SAO 62484	HIP 55203	
DS catalogues (AB)	H 1 2	STF 1523	BDS 5734	ADS 8119
Radial velocity (A/B)	-18.2 km s^{-1}	± 2.7		
Galactic coordinates	195°.107	+69°.246		

Introduction

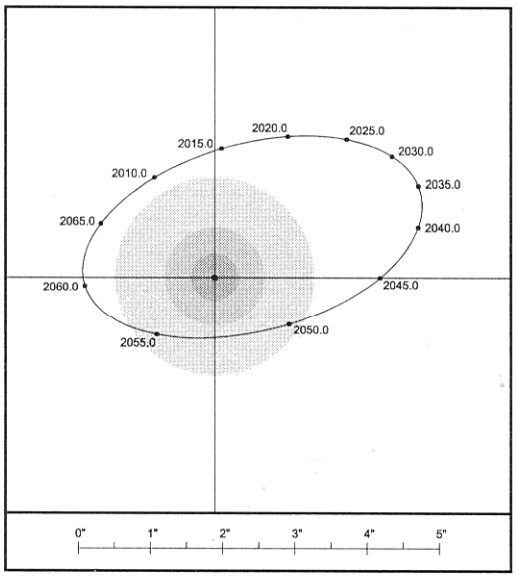
The second entry in Sir William Herschel's catalogue of 1782, ξ UMa, has attracted much attention from double observers since its discovery on 2 May 1780. Herschel recorded 'Double. A little unequal. Both w(hite). and very bright. The interval with 227 is 2/3 diameters of L(arge).; with 222, 1 diameter of L(arge).; with 275, near $1\frac{1}{2}$ diameter of L(arge). Position 53° 47′ s(outh). following.' In 1804, Herschel [363] used it, along with a number of other stars, as an example of the existence of gravitational attraction outside the Solar System and as confirming Herschel's belief in the existence of binary systems (double stars that are gravitationally connected). In 1827 ξ UMa was also the first visual binary to have its orbit computed, by Felix Savary [364]. The title of Savary's paper is 'Sur la détermination des orbites que découvrent autour de leur centre de gravité deux étoiles très raprochées l'une de l'autre'. Lick Observatory spectra taken with the 36-inch refractor by Campbell & Wright [360] showed radial velocity

Finder Chart



REPLACE FINDER CHART

Orbit



Ephemeris for STF 1523 AB (2018 to 2036)

Orbit by Msn (1995) Period: 59.878 years, Grade: 1

Year	PA(°)	Sep(")	Year	PA(°)	Sep(")
2018.0	161.0	2.01	2028.0	128.7	2.86
2020.0	152.4	2.19	2030.0	124.3	2.97
2022.0	145.2	2.38	2032.0	120.1	3.05
2024.0	139.0	2.55	2034.0	116.1	3.09
2026.0	133.6	2.72	2036.0	112.1	3.08

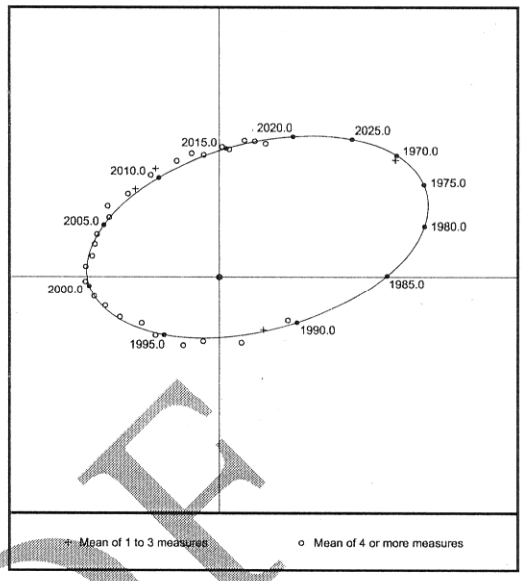
variations in the system. In 1905, Norlund [359], in calculating a new visual orbit for AB, discovered a systematic run of residuals amounting to an amplitude of 0″.05 and a period of 1.8 years. Abetti, at Lick, confirmed that the radial velocity of star A varied periodically in 1.8 years, thus identifying the source of the effect found by Norlund. Radial velocity measurements of star B began in 1902, but it was not until 1918 that it was shown by Lick observers that this star too was a spectroscopic binary. A comprehensive study of the astrometry and radial velocities of the system was carried out by van den Bos in 1928 [366], and there the matter largely rested until Roger Griffin's [358] thorough analysis.

The Modern Era

The object ξ UMa is one of the most observed visual binary systems known. The WDS lists more than 1600 observations of position angle and separation, and the pair with its period of just under 60 years has now been observed through more than three revolutions. The current orbit (the ephemeris of which appears below) is classified as Grade 1.

above

Measure with 8″ Refractor



Year	PA(°)	Sep(")	No.	Year	PA(°)	Sep(")	No.
1970.35	123.7	2.91	1	2004.30	250.5	1.79	7
1990.28	56.5	1.13	4	2005.34	241.4	1.73	7
1991.27	38.7	0.97	1	2006.34	237.4	1.83	6
1992.42	18.0	0.98	5	2007.34	227.5	1.71	5
1993.48	346.2	0.94	5	2008.43	223.5	1.68	3
1994.29	332.7	1.09	5	2009.37	213.8	1.70	6
1995.35	313.2	1.21	6	2010.30	207.0	1.74	3
1996.35	301.6	1.26	5	2011.41	200.1	1.71	4
1997.37	292.8	1.49	5	2012.40	192.6	1.75	4
1998.38	284.8	1.63	5	2013.35	187.3	1.70	6
1999.31	279.3	1.75	5	2014.42	178.8	1.80	6
2000.35	272.1	1.85	6	2015.38	175.6	1.77	5
2001.32	265.5	1.85	6	2016.43	169.7	1.92	5
2002.31	260.4	1.78	5	2017.40	165.5	1.94	6
2003.42	254.9	1.78	6	2018.44	161.0	1.95	4

According to Griffin, the period of Aa is 670.24 ± 0.09 days with a significant eccentricity (0.532) whilst B has a circular orbit of period 3.980507 days (known to an accuracy of half a second). In 1995 Mason *et al.* [361] noted an additional companion star to B during speckle interferometric observations, but a positive detection was noted in only one out of 27 attempts. Since no confirming observations have been made, the reality of this star must be in some doubt. In addition, Daniel Bonneau [365] questioned its existence on dynamical grounds. In 2013, Wright *et al.* [362] announced the discovery of a common proper motion companion to the quadruple system, located 511″ away. This star is a T8.5 dwarf which appears to be a single object. It is some 16 magnitudes fainter than AB in the *K* band. Gaia DR2 gives only the position and *G* magnitude of the A component.

Observing and Neighbourhood

The system is easily found by starting at δ Leo. Move 11° in declination: ξ is the southerly of two bright stars, the more northerly of which is the V = 3.5 mag ν. It will be easy to resolve ξ in 7.5-cm apertures for several decades to come. At the last periastron in 1995, the stars closed in to just under 1″. As the two components widen the angular motion will reduce – at present it is about 5° per year. The nearby ν (STF 1524), one of William Herschel's last discoveries, is also known as H N 53, and is much more of a challenge. The primary is a K3 giant and the companion is 7″.8 away in PA 145° but it is of magnitude 10.1. For a resolution test, try STF 1555, which lies 5° SE of ξ and is described at greater length elsewhere (p. xx).

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Measures

Early measure (STF)	238°.8	1″.75	1826.20
(Orbit	240°.3	1″.71)	
Recent measure (ARY)	161°.0	1″.95	2018.44
(Orbit	159°.0	2″.05)	

79. STF 1527 LEO = WDS J11190+1416

ADD

Table 9.79 Physical parameters for STF 1527 Leo

STF 1527	RA: 11 18 59.91	Dec: +14 16 06.9	WDS: 138(270)	
V magnitudes	A: 7.01	B: 7.99		
$(B-V)$ magnitudes	A: +0.57	B: +0.88		
μ	-453.7 mas yr^{-1}	$\pm$ 2.0	-591.4 mas yr^{-1}	$\pm$ 2.0
π	32.53 mas	$\pm$ 1.39	100 light yr	$\pm$ 4
Spectra	F9V			
Luminosities ($L_\odot$)	A: 1.2	B: 0.5		
Catalogues	HD 98354	HIP 55254	SAO 99551	
DS catalogues	H N 142	STF 1527	BDS 5739	ADS 8128
Radial velocity (A/B)	21.80 km s^{-1}	$\pm$ 0.2		
Galactic coordinates	239°.123	+64°.918		

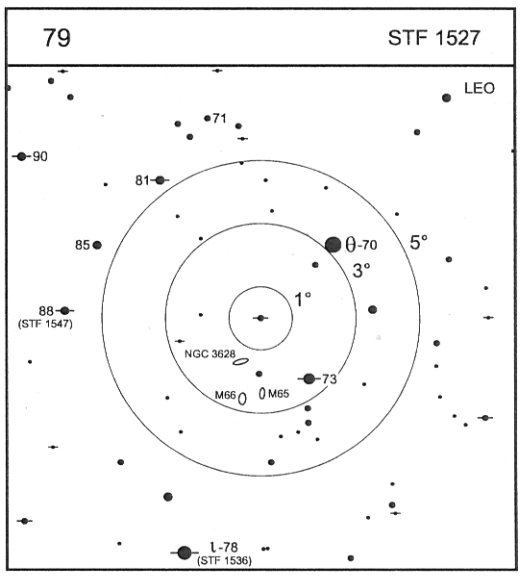
History

Herschel noted the separation as 4± whilst Thomas Lewis [194] stated that the star was a binary although at that time the apparent motion since discovery had amounted to just +10° in PA and $-0''.6$ in separation. The significant proper motion would have separated the stars rapidly had they been unassociated.

The Modern Era

This pair has attracted some attention from observers with large apertures and a number of orbits have been computed. The form of the apparent orbit will be much clearer once the stars begin to separate, as they will do from 2015 or so. If the current orbit is correct, they will reach apastron in around 2200, when the separation will again be $4''$. In 2012 Prieur *et al.* [504] obtained a dynamical parallax of 31.2 mas, in good agreement with the revised Hipparcos value. This paper also concluded that the spectral type of B was around G3V on the basis of the observed magnitude difference.

Finder Chart



80. ι LEO = STF 1536 = WDS J11239+1032 AB

AB

Table 9.80 Physical parameters for ι Leo

STF 1536	RA: 11 23 55.37	Dec: +10 31 46.9	WDS: 39(541)	
V magnitudes	A: 4.06	B: 6.71		
$(B-V)$ magnitudes	A: +0.44	B: +0.91		
μ(A)	149.41 mas yr^{-1}	± 0.72	−90.70 mas yr^{-1}	± 0.69 (DR2)
μ(B)	177.27 mas yr^{-1}	± 0.50	−52.97 mas yr^{-1}	± 0.84 (DR2)
π(A)	42.36 mas	± 0.40	77.0 light yr	± 0.7 (DR2)
π(B)	41.50 mas	± 0.36	78.6 light yr	± 0.7 (DR2)
Spectra	F3	F3s		
Luminosities ($L_\odot$)	A: 11	B: 1		
Catalogues	HR 4399	HD 99028	SAO 99587	HIP 55642
DS catalogues	STF 1536	BDS 5765	ADS 8148	
Radial velocity (A/B)	−11.80 km s^{-1}	± 0.2		
Galactic coordinates	247°.600	+63°.548		

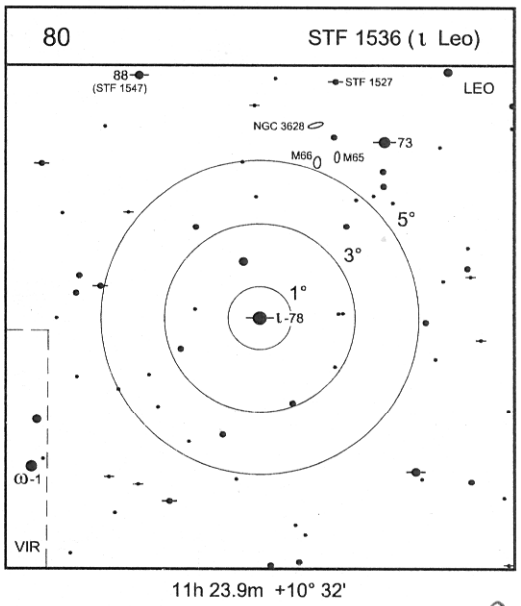
History

Found by F. G. W. Struve in 1827, this pair showed little motion during the remainder of the century, with maximum distance occurring around 1874. From 1910 or so the stars began to close up quickly, and a close approach occurred in 1943 when they were 0″.63 apart.

The Modern Era

In 1976 Abt & Levy [369] used radial velocities of the A star in combination with visual measures to derive a period of 191 years. The period was reduced by five years in the analysis by Staffan Söderhjelm [370]. The stars are now almost back at the discovery position.

Finder Chart



REPLACE FINDER CHART

81. STT 235 UMA = WDS J11323+6105AB

Table 9.81 Physical parameters for STT 235 UMa

STT 235	RA: 11 32 20.76	Dec: +61 04 57.9	WDS: 96(334)	
V magnitudes	A = 5.69	B = 7.75		
$(B-V)$ magnitudes	A: +0.51	B: +0.75		
μ	-16.48 mas yr^{-1}	$\pm$ 0.51	-96.10 mas yr^{-1}	$\pm$ 0.43
π	35.73 mas	$\pm$ 0.54	91.3 light yr	$\pm$ 1.4
μ(A)	-24.23 mas yr^{-1}	$\pm$ 0.52	-67.23 mas yr^{-1}	$\pm$ 0.62 (DR2)
π(A)	34.84 mas	$\pm$ 0.38	94 light yr	$\pm$ 1 (DR2)
Spectra	F7V			
Masses ($M_\odot$)	2.05	$\pm$ 1.10 (dyn.)	2.34 (phot.)	1.10 (spec.)
Luminosities ($L_\odot$)	A: 3.5	B: 0.5		
Catalogues	HD 100203	SAO 15542	HIP 56290	
DS catalogues	STT 235	BDS 5811	ADS 8197	
Radial velocity (A/B)	0.6 km s^{-1}	$\pm$ 2	-1.9 km s^{-1}	$\pm$ 2
Galactic coordinates	138°.904	+53°.524		

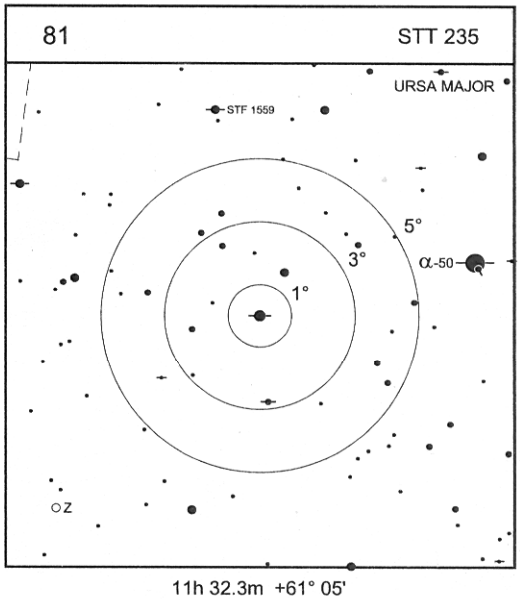
History

Found by O. Struve in 1843, this pair is now well into its third orbital cycle since discovery. Smyth has not observed it and Haas suggested only that a 300-mm aperture should be able to resolve this pair in 2006, when the separation was 0″.7.

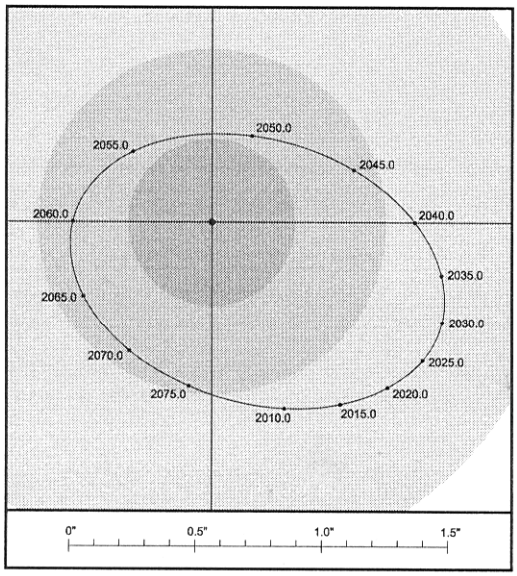
The Modern Era

The pair is amongst those predicted to pass close to the solar system (Bailer-Jones [271]). The orbit is tolerably well known and the period of 72.7 years assigned to it by Söderhjelm has been graded 2 in the USNO Sixth Orbit Catalog.

Finder Chart



Orbit



Ephemeris for STT 235 AB (2015 to 2042)

Orbit by Sod (1999) Period: 72.7 years, Grade: 2

Year	PA(°)	Sep(")	Year	PA(°)	Sep(")
2015.0	34.9	0.89	2030.0	66.5	0.99
2018.0	42.0	0.93	2033.0	72.7	0.96
2021.0	48.5	0.97	2036.0	79.3	0.91
2024.0	54.7	0.99	2039.0	87.1	0.84
2027.0	60.6	1.00	2042.0	96.7	0.73

Observing and Neighbourhood

The object STT 235 can be found 4° ESE of α UMa and for many years this pair has been too close for resolution with the apertures available to the writer, but in the spring of 2017 the companion appeared very closely preceding and slightly S of the primary using the 8-inch refractor at Cambridge. It was difficult owing to the significant difference in brightness, but it was certainly there. The next 10 years now offers the best chance to resolve the system but even then it will require at least 15-cm and a good night, and the significant difference in magnitude makes splitting the pair harder. From the end of the 2020s the stars will close quickly, reaching a minimum separation of 0″.35 in 2052 before widening again to 1″ in 2075. Three point five degrees N and slightly E is STF 1559 (6.8, 8.0, 323°, 2″.0, 2017)

Measures

Early measure (STT)	153°.9	0″.97	1825.21
(Orbit	148°.7	0″.78)	
Recent measure (SCA)	108°.9	0″.85	2014.94
(Orbit	109°.1	0″.82)	

2100

82. STF 1555 LEO = WDS J11363+2747AB

Table 9.82 Physical parameters for STF 1555 LEO

STF 1555	RA: 11 36 17.94	Dec: +27 46 52.7	WDS: 122(294)	
V magnitudes	A: 6.41	B: 6.78	C: 11.7	
$(B-V)$	A: +0.25	B: +0.29		
μ	24.11 mas yr^{-1}	± 1.31	15.83 mas yr^{-1}	± 1.63
π	13.97 mas	± 0.75	233 light yr	± 13
Spectra	F0V			
Luminosities ($L_\odot$)	A: 13	B: 8		
Catalogues	HR 4465	HD 100808	SAO 81893	HIP 56601
DS catalogues	STF 1555 (AB)	HJ 503 (AB-C)	BDS 5841	ADS 8231
Radial velocity	8.00 km s^{-1}	± 3.7		
Galactic coordinates	206°.347	+73°.334		

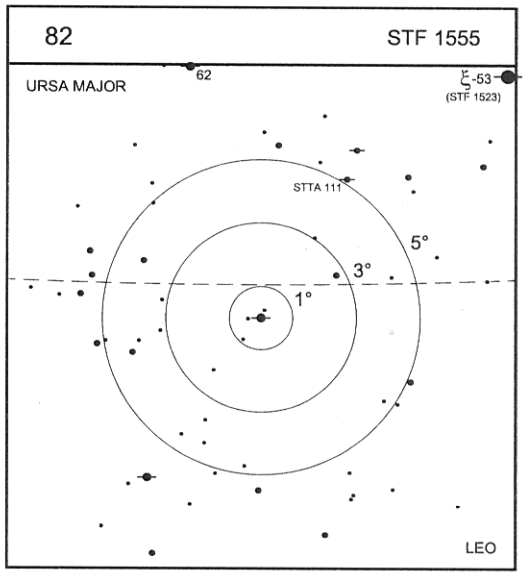
History

Discovered at Dorpat by F. G. W. Struve, this was a relatively easy pair to resolve. It was, nonetheless, missed by John Herschel with his 20-foot reflector at Slough in 1827 when he noted a faint companion (C) of magnitudes 10 some 18″ distant in PA 50° and assigned it number 503 in his catalogue (WDS – mag. 11.7 at 158°, 22″.5 – distance increasing). There is also some confusion over this star as the next entry, number 504, appears to be the same object – it is at slightly different RA and the magnitudes and position are 6 and 12 at 15″ and 50°.

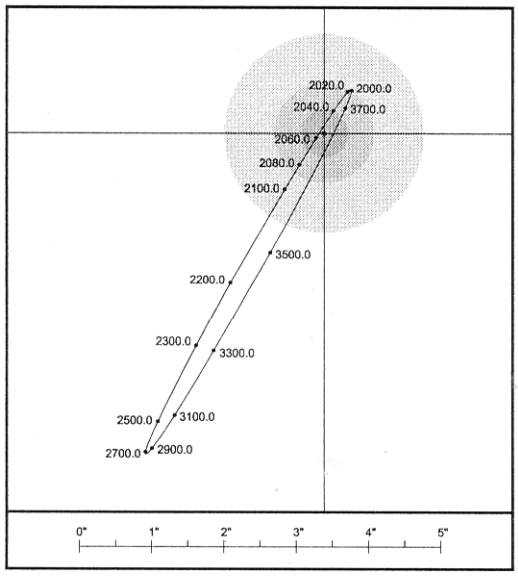
The Modern Era

Some doubt still lingers over the exact nature of the close pair. The early measures were discussed by Burnham in his 1906 catalogue and he said '… at this time the motion is practically

Finder Chart



Orbit



Ephemeris for STF 1555 AB (2010 to 2100)

Orbit by Doc (2017a) Period: 1730 years, Grade: 4

Year	PA(°)	Sep(")	Year	PA(°)	Sep(")
2010.0	149.1	0.72	2060.0	298.7	0.13
2020.0	150.8	0.66	2070.0	317.5	0.34
2030.0	153.1	0.53	2080.0	321.8	0.56
2040.0	157.6	0.34	2090.0	323.8	0.76
2050.0	176.3	0.13	2100.0	324.9	0.95

rectilinear and uniform. It will soon be a difficult pair with a minimum distance of about 0″.1'. Between 1920 and 1945 the distance remained below 0″.2 but measures were scattered. Since then the separation has slowly increased and as at 2015 stands at about 0″.75. This is certainly significantly closer than the distance predicted by the linear ephemeris, whilst the orbit predicts a smaller separation. In the next five or ten years it should be possible to come down on the side of one prediction or the other. One component of the system is a spectroscopic binary.

Observing and Neighbourhood

This is an ideal system for testing the resolution of a 15-cm telescope. The relative brightness and equality of the two stars fit Dawes' criterion well. The pair appears on Map 9 of the *CDSA2*, but it is not labelled, reflecting the linear nature of the system in the opinion of the cartographers. RWA measured this pair in 1995, 2003, and 2014 and has recorded a slow increase in separation with little change in position angle. This is a fairly sparse area of the sky but about 3° NNW is the wide pair STTA 111 of magnitudes 6.95 and 9.49, measured by RWA in 1996 at 33°.2, 67″.52. There is very little motion in this system. The primary star is the W-UMa-type binary AW UMa, which has a period of 0.44 days and an amplitude of 0.25 magnitudes in *V*. Pribulla *et al.* [371] indicated the likelihood of two further components with periods of 398 and 6250 days respectively. Moving another 3° in approximately the same direction will bring you to the beautiful binary ξ UMa (p. xx).

Measures

Early measure (STF)	339°.4	1″.25	1829.12
(Orbit	337°.4	1″.20)	
(Linear	341°.8	1″.17)	
Recent measure (ARY)	148°.2	0″.81	2014.17
(Orbit	150°.1	0″.68)	
(Linear	148°.6	0″.91)	