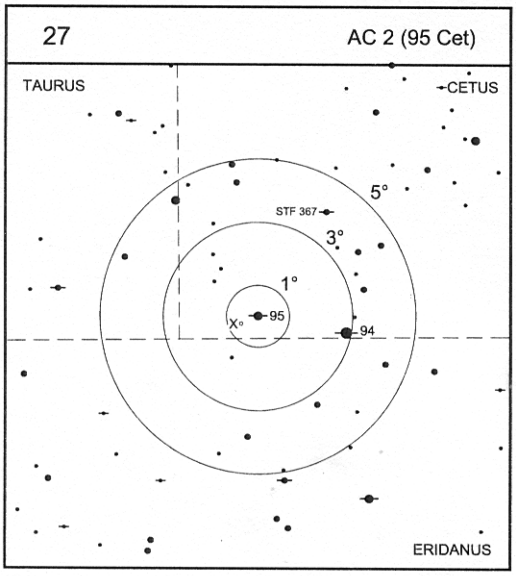
Finder Chart



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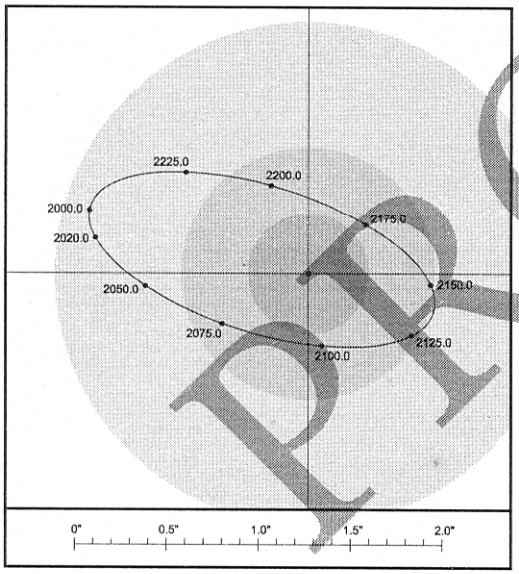
Orbit



Ephemeris for AC 2 AB (2015 to 2060)

Orbit by Pop (1997f) Period: 282.42 years, Grade: 4

Year	PA(°)	Sep(")	Year	PA(°)	Sep(")
2015.0	258.7	1.20	2040.0	268.8	1.01
2020.0	260.5	1.17	2045.0	271.4	0.95
2025.0	262.4	1.14	2050.0	274.4	0.89
2030.0	264.3	1.10	2055.0	277.8	0.82
2035.0	266.5	1.06	2060.0	281.8	0.76

systems, notes a magnitude 16.2 star at 30° and 49″ sharing the same space motion as AB. This is a DA white dwarf (LP 592-50) and physically connected to AB. Olin Eggen [190] also noted a nearby star, BD, at −01° 474, some 11′ distant, which also has a common proper motion.

A-D
mag 10.1, PA 101°

Observing and Neighbourhood

The present time gives a good opportunity to resolve this pair. The stars have just passed widest separation and in 2020 will be at 261°, 1″.2. If the orbit by Popovic [193] is correct, and it is graded as preliminary, they will close slowly until the end of the current century, when the distance reaches 0″.4. Six degrees due S of 95 Cet are a wide pair of sixth maguitude stars. The southwestern component is β 84 (6.4, 7.9, 9°, 1″.0, 2013) which is slowly widening. Five degrees ENE is 10 Tau (V = 4.30) and lying just 10′ N of that star is the fine pair STF 422 (6.0, 8.9, 274°, 7″.1, 2013), which has a premature orbit of 2101 years calculated for it. The primary is an RS CVn star (V711 Tau) and an SB. A good test of resolution and light gathering is STF 367, 2° NW. The stars of magnitudes 8.1, 8.2, are orbital with a period of 420 years. The 2020 position is 130°, 1″.27.

Measures

Early measure (DA)	73°.2	0″.73	1854.81
(Orbit	71°.2	0″.71)	
Recent measure (TOK)	260°.9	1″.12	2015.03
(Orbit	258°.8	1″.20)	

28. STF 425 PER = WDS J03401+3407AB

ADD 40 07.19 +34 06 59.3

Table 9.28 Physical parameters for STF 425 Per

STF 425	RA: 03 00 52.18	Dec: +52 21 06.5	WDS: 184(236)		
V magnitudes	Aa: 7.60	Ab: 14.5	C: 7.60		
$(B-V)$ magnitudes	A: +0.56	B: +0.58			
μ(A)	-66.99 mas yr^{-1}	$\pm$ 0.10	8.08 mas yr^{-1}	$\pm$ 0.08 (DR2)	
μ(B)	-78.78 mas yr^{-1}	$\pm$ 0.11	17.60 mas yr^{-1}	$\pm$ 0.08 (DR2)	
π(A)	21.84 mas	$\pm$ 0.07	149.3 light yr	$\pm$ 0.5 (DR2)	
π(B)	21.77 mas	$\pm$ 0.06	149.8 light yr	$\pm$ 0.4 (DR2)	
Spectra	Aa: F5	Ab: ?	B: ?		
Masses ($M_\odot$)	Aa: 1.5	Ab: 0.02	B: 1.5		
Luminosities ($L_\odot$)	Aa: 2	Ab:	C: 2	(DR2)	
Catalogues	HD 22692	SAO 56613	HIP 17129		
DS catalogues	H 3 36 (AB)	STF 425 (AB)	BDS 1799	ADS 2668	RBR 26Aa,Ab
Radial velocity	-5.7 km s^{-1}	$\pm$ 0.5			
Galactic coordinates	158°.440	-16°.879			

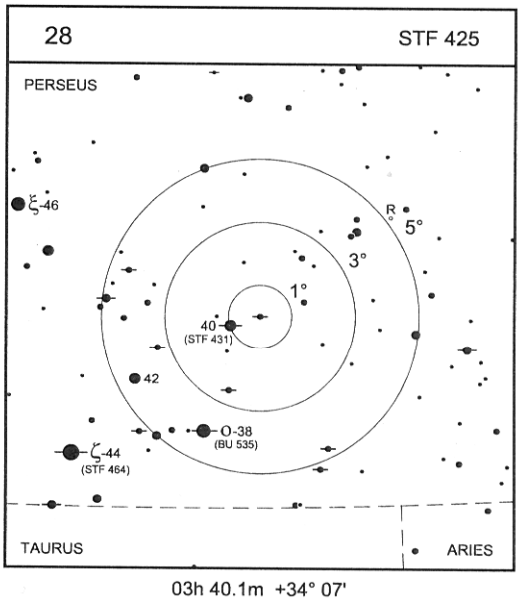
History

This pair was discovered by Sir William Herschel on 7 September 1782. It was noticed by Lewis [194], who commented that 'the motion shown by the micrometer measures is very curious'. Over the nineteenth century the companion gradually approached A, closing from about 3″ to 2″.5, but after about 1870 the distance then remained constant. Neither Burnham nor Aitken, in their respective catalogues, noticed any unusual behaviour.

The Modern Era

In 2014 Zirm and Rica Romero [196] laid out similar orbital parameters for the putative third body but they were unable to say around which of the two visual components this body rotated. In 2014 Russell Genet *et al.* [195] published an analysis of the motion and sub-motions within the

Finder Chart



REPLACE FINDER CHART

29. 32 ERI = STF 470 = WDS J03543−0257

Table 9.29 Physical parameters for 32 Eri

STF 470	RA: 03 54 17.49	Dec: −02 57 17.0	WDS: 434(138)	
V magnitudes	A: 4.45	B: 5.86		
$(B-V)$ magnitudes	A: +0.68	B: +0.19		
μ(A)	25.89 mas yr^{-1}	± 0.37	−0.23 mas yr^{-1}	± 0.36 (DR2)
μ(B)	26.93 mas yr^{-1}	± 0.10	0.85 mas yr^{-1}	± 0.09 (DR2)
π(A)	10.11 mas	± 0.24	322.6 light yr	± 7.7 (DR2)
π(B)	9.65 mas	± 0.06	338.0 light yr	± 2.1 (DR2)
Spectra	A: G8III	B: A2V		
Luminosities ($L_\odot$)	A: 130	B: 40		
Catalogues (A/B)	HR 1212/1	HD 24555/4	SAO 130806/5	HIP 18255
DS catalogues	H 2 36	STF 470	BDS 1939	ADS 2850
Radial velocity (A/B)	26.9 km s^{-1}	± 0.2	17.6 km s^{-1}	± 2
Galactic coordinates	192°.094	−40°.099		

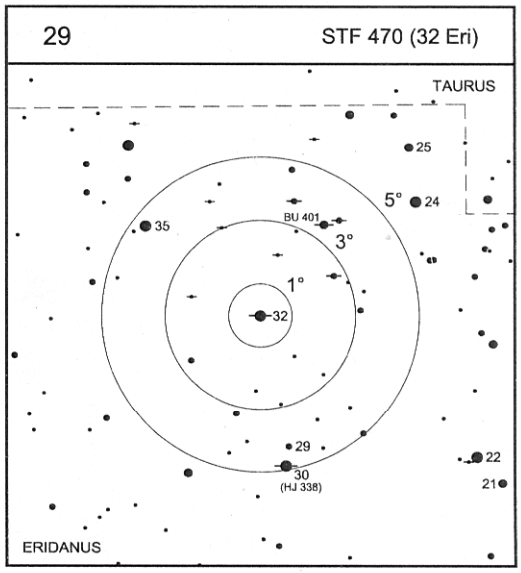
History

This double star was noted by William Herschel on 22 October 1781. 'Double. Considerably unequal. L(arge). reddish w(hite).; S(mall). blue. Distance 4″ 19‴. Position 73° 23′ n(orth). preceding.' In 1886, J. Baillaud [198] noted a distant star of maguitude 10.5 at 5°, 165° which shows little or no change.

The Modern Era

SIMBAD gives the spectral type of the primary star as G8III and A1IV.

Finder Chart



REPLACE FINDER CHART

30. o^2 ERI = STF 518 = WDS J04153−0739BC

Table 9.30 Physical parameters for o^2 Eri

STF 518	RA: 04 15 07.57	Dec: −07 38 41.5	WDS: 280(181)		
V magnitudes	A: 4.51	B: 10.02	C: 11.47		
$(B-V)$ magnitudes	A: +0.93	B: +0.11	C: +1.68		
μ(A)	−2240.52 mas yr^{-1}	± 0.45	−3421.43 mas yr^{-1}	± 0.42 (DR2)	
μ(B)	−2250.12 mas yr^{-1}	± 1.59	−3408.28 mas yr^{-1}	± 0.55 (DR2)	
π(A)	198.57 mas	± 0.51	16.43 light yr	± 0.04 (DR2)	
π(B)	199.46 mas	± 0.32	16.35 light yr	± 0.03 (DR2)	
Spectra	A: K1V	B: DA4	C: M4.5Ve		
Masses ($M_\odot$)	A: 0.9	B: 0.57	± 0.02	C: 0.204	± 0.006
Radii ($R_\odot$)	A: 0.81	± 0.01			
Luminosities ($L_\odot$)	A: 0.3	B: 0.002	C: 0.0005		
Catalogues (A/B)	40 Eri	HD 26965	HR 1235	SAO 131063/5	HIP 19849
DS catalogues	H 2 80(BC)	STF 518 (BC)	STFB1 (AB)	BDS 2109	ADS 3093
Radial velocity (A/B)	−42.32 km s^{-1}	± 0.08	−21 km s^{-1}	± 10	
Radial velocity (A)	−42.62 km s^{-1}	± 0.42 (DR2)			
Galactic coordinates	200°.753	−38°.048			

History

Another binary star, discovered by William Herschel, which has been subsumed into the Struve Dorpat catalogue, o^2 Eri was first seen by Herschel on 31 January 1783 as a difficult object. 'Very unequal. Both d(usky)r(ed). With 227, hardly visible; with 460, very obscure'. This was the only pair in its class in the *Mensurae Micrometricae* that Struve was unable to measure – he estimated the position angle only. It was left to Otto Struve in 1850 to commence a series of accurate measures, which quickly showed that the stars formed a binary system. Herschel also noted the bright nearby star 40 Eri and measured AC as 107°.9 and 89″. The earliest measures of F. G. W. Struve were quite scattered but for the last 175 years or so the distance has remained almost fixed at around 82″, reflecting the almost identical and large proper motions of A and BC, which amount to more than 4″ per annum. This is the amount by which the distant faint stars D (maguitude 12.6) and E (maguitude 13.0) are being left further behind each year. This is therefore a physical triple star, which is located a little over 16 light years from the Sun.

The Modern Era

The system 40 Eri itself is a bright orange star whilst the brighter of the two stars in the binary system BC is the fifth nearest white dwarf known and is the easiest of the five to observe, whilst its partner is a red dwarf and a flare star (DY Eri). Tokovinin [177] estimates the period of A-BC to be about

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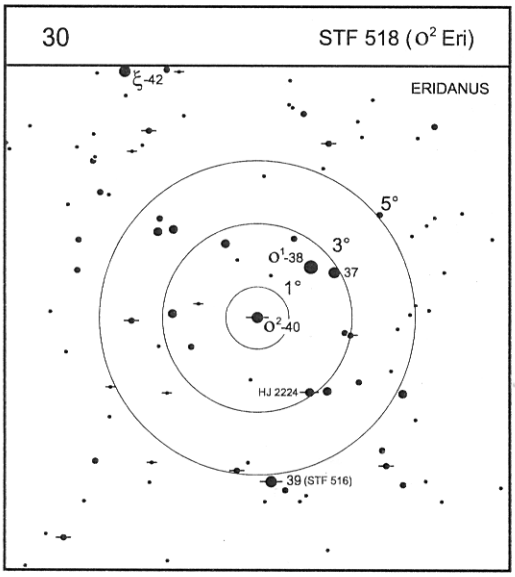
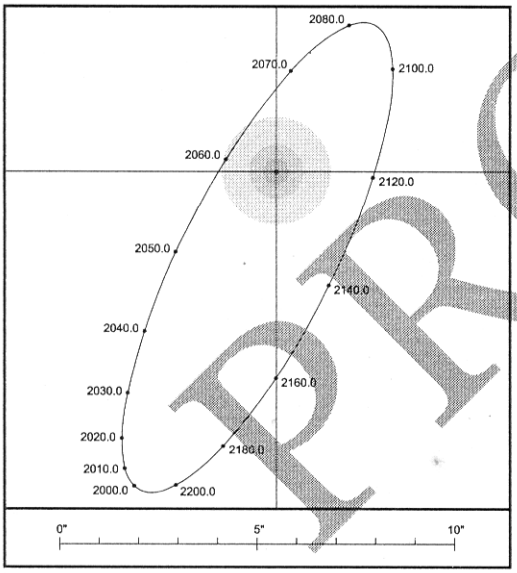
Finder Chart



04h 15.3m -07° 39'

Orbit



Ephemeris for STF 518 BC (2015 to 2060)

Orbit by Msn (2017a) Period: 224.28 years, Grade: 3

Year	PA(°)	Sep(")	Year	PA(°)	Sep(")
2015.0	331.7	8.23	2040.0	320.7	5.29
2020.0	330.1	7.86	2045.0	316.3	4.34
2025.0	328.4	7.39	2050.0	309.1	3.28
2030.0	326.3	6.81	2055.0	294.7	2.17
2035.0	323.9	6.11	2060.0	256.2	1.31

6100 years, whilst the recent orbit by Mason *et al.* [201] gives a periodic time of 230.09 years for BC. The stars were widest in 1995 at 8″.9 and will close up to 1″.3 in 2060. The stars in the BC system have been examined for any sign of exo-planets [199]. The angular diameter of the star was determined by Boyarjian [200] and colleagues and found to be 1.504 ± 0.006 mas, equivalent to 0.8 $R_\odot$. The Gaia DR2 data gives a parallax for stars A and C (but not B) which is in close agreement with the results from Hipparcos.

Observing and Neighbourhood

Starting at Rigel, move the telescope 15° due W and you will alight on a naked-eye pair of stars called o^2 and, 70′ further W and N, o^1 Eri. The star o^1 is an F giant of visual maguitude 4.0 whilst its neighbour is a an orange star at $V = 4.4$. The BC pair is located 83″ away in PA 107°. Hartung notes that both B and C can be seen in 7.5-cm and that the separation is favourable for the smaller aperture for at least the next 20 years or so. Observers in northern Europe are at a disadvantage because of the low declination. Any attempt to use field illumination in the 20-cm at Cambridge renders star C invisible. Moving 3° due S of this star brings you to 39 Eri (STF 516), magnitudes 5.0 and 8.5, at 144° and 6″.3, 2011, with the primary an early K giant. One point five degrees N and slightly W of 39 is HJ 2224, whose components are of magnitudes 6.6 and 9.8 at 306° and 57″, 2011.

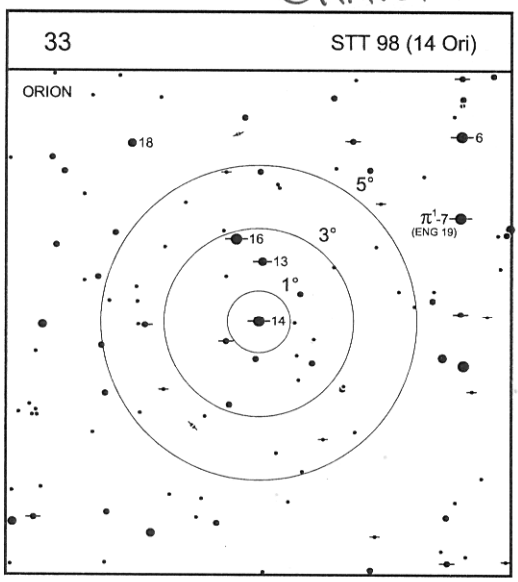
Measures

BC			
Early measure (STT)	158°.0	4″.11	1855.06
(Orbit	153°.6	4″.06)	
Recent measure (WSI)	332°.8	8″.68	2010.72
(Orbit	333°.8	8″.48)	
A-BC			
Early measure (STF)	107°.3	83″.48	1836.04
Recent measure (FYM)	103°.7	83″.49	2011.89

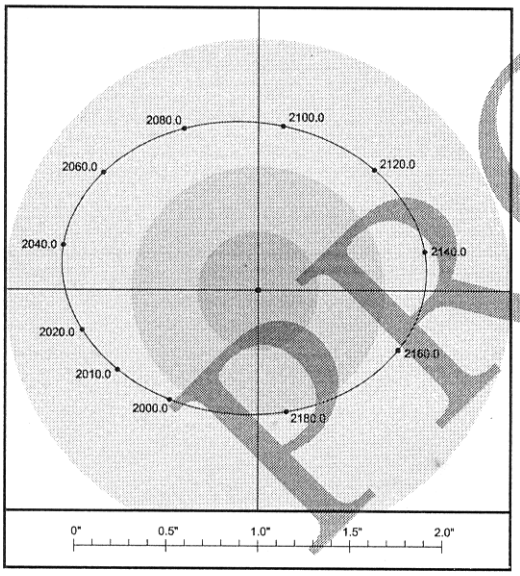
This does not match the Ephemeris. Msn(2017d) is 230.30 yrs. Leave the Orbital plot as it is?

Finder Chart

REPLACE FINDER CHART



Orbit



Ephemeris for STT 98 (2015 to 2060)

Orbit by Sca (2008d) Period: 197.45 years, Grade: 2

Year	PA(°)	Sep(")	Year	PA(°)	Sep(")
2015.0	290.8	0.94	2040.0	256.7	1.09
2020.0	283.0	0.98	2045.0	250.6	1.09
2025.0	275.8	1.02	2050.0	244.6	1.09
2030.0	269.1	1.06	2055.0	238.4	1.08
2035.0	262.8	1.08	2060.0	232.1	1.06

Observing and Neighbourhood

The pair 14 Ori has been followed for a large portion of the orbit, which is relatively open. The separation varies between 0″.7 and 1″.1 and so will be within reach of 15-cm for much of the time and certainly for the next century or so. 14 Ori lies between γ Orionis (Bellatrix) and a vertical stream of stars, all of which are called π Orionis and represent the Hunter's arm. Two of these, π^1 and π^3, are coarse doubles. The pair π^1 Ori was found by Engelmann (ENG 19); the primary is maguitude 5.7 and it has a magnitude 9.9 companion at 254° and 172″, 2011. Three degrees NW is S 463 (7.2, 10.1, 29°, 32″.7, 2013), whilst 2° directly E is STF 664 (7.8, 8.4, 177°, 4″.7, 2011).

Measures

Early measure (STT)	248°.9	1″.12	1844.53
(Orbit	254°.3	1″.09)	
Recent measure (ARY)	290°.6	1″.02	2017.16
(Orbit	287°.4	0″.96)	

34. β ORI = RIGEL = STF 668 = WDS J05145–0812AB

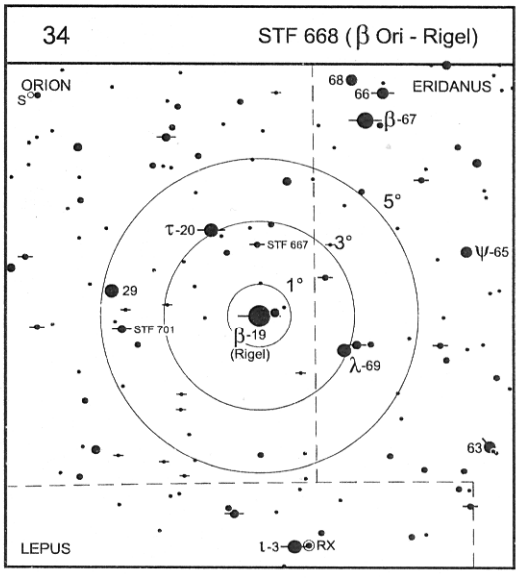
Table 9.34 Physical parameters for ~~Rigel~~ β Ori

STF 668	RA: 05 14 32.27	Dec: −08 12 05.9	WDS: 526(120)		
V magnitudes	A: 0.13	B: 6.8			
$(B-V)$ magnitudes	A: −0.03	B: 0.0?			
μ(A)	1.31 mas yr^{-1}	± 0.40	0.50 mas yr^{-1}	± 0.30	
π(A)	3.78 mas	± 0.34	860 light yr	± 80	
μ(B)	−0.40 mas yr^{-1}	± 0.14	−0.15 mas yr^{-1}	± 0.12 (DR2)	
π(B)	2.92 mas	± 0.08	1120 light yr	± 31 (DR2)	
Spectra	A: B8Iae	B: B9V + B9V?			
Masses ($M_\odot$)	A: 23 $M_\odot$				
Radii ($R_\odot$)	A: 79	± 0.3			
Luminosities ($L_\odot$)	A: 43000	B: 185			
Catalogues (A)	19 Ori	HD 34085	HR 1713	SAO 131907	HIP 24436
DS catalogues	H 2 33 (AB)	STF 668 (AB)	BU 555 (BC)	BDS 2605	ADS 3823
Radial velocity (A)	17.80 km s^{-1}	± 0.4			
Galactic coordinates (A)	209°.241	−25°.245			

History

This binary was found by William Herschel on 1 October 1781. He noted 'Extremely unequal. L(arge). w(hite). S(mall) inclining to (r)ed. With 227 $2\frac{1}{4}$ or $2\frac{1}{2}$ diameters of Rigel. With 460, more than 3 diameters of Rigel'. He never attempted to measure the distance to the magnitude 6.8 companion star but it seems that since then the distance between A and B has changed very little in any case. The B star was also independently found by Fearon Fallows at the Cape of Good Hope around 1830. In 1846, using the Cincinnati 11-inch refractor, O. M. Mitchel noted a very faint star 44″ distance from the primary, which was recovered independently by Burnham, who made it magnitude 13.5. The WDS gives V = 15.4. In 1875 Burnham noted an elongation in B using his 6-inch Clark refractor, thus initiating a mystery that has survived to this day. Details can be found in Chapter 5.

Finder Chart



35. STF 634 CAM= WDS J05226+7914AB

Table 9.35 Physical parameters for STF 634 Cam (ADP)

STF 634	RA: 05 22 33.53	Dec: +79 13 52.1	WDS: 797(90)		
V magnitudes	A: 5.14	B: 9.14			
μ(A)	−78.39 mas yr^{-1}	± 0.23	162.12 mas yr^{-1}	± 0.30 (DR2)	
μ(B)	51.91 mas yr^{-1}	± 0.19	−156.20 mas yr^{-1}	± 0.29 (DR2)	
π(A)	47.70 mas	± 0.17	68.4 light yr	± 0.2 (DR2)	
π(B)	5.17 mas	± 0.19	631 light yr	± 23 (DR2)	
Spectra	F6Ve				
Masses ($M_\odot$)	A: 1.25				
Luminosities ($L_\odot$)	A: 3	B: 7			
Catalogues	19H Cam	HR 1686	HD 33564	SAO 5486	HIP 25110
DS catalogues	STF 634	BDS 2548	ADS 3864		
Radial velocity	−10.8 km s^{-1}	± 0.3			
Radial velocity (A/B)	−11.03 km s^{-1}	± 0.23	−46.11 km s^{-1}	± 0.35 (DR2)	
Galactic coordinates	133°.735	+22°.648			

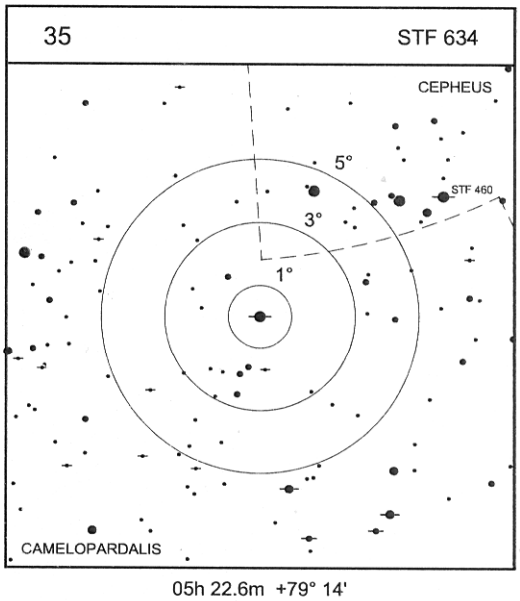
Introduction

With its location only 10° from the Celestial Pole, STF 634 is an awkward star to find for the equatorially-mounted-refractor user but it can be found by locating the pretty, wide, pair β Cam and then moving due N by two-thirds of the distance to Polaris.

History

This star appears in the catalogue of Hevelius as 19 Cam and the nomenclature was carried forward by Admiral Smyth, but when transferred to Webb's *Celestial Objects for Common Telescopes* it became P IV 269. In the sixth version of *Celestial Objects* it was simply called 19 but should not be confused with Flamsteed 19 Cam, which is a different star; as luck would have, that star is also double but much more difficult to resolve. Smyth considered that its observed motion up to 1840

Finder Chart



represented orbital motion with a period of 'not less than 1000 or 1200 years'. In fact the stars are completely unassociated and the relative motion is due to the large proper motions of A and B, each amounting to 0″.18 per year and in virtually opposite directions on the sky.

The Modern Era

The stars are now separating quite quickly. The closest approach occurred in 1929 when they were 9″.55 apart in position angle 66°. Gaia DR2 indicates that the companion is twice as far away, as measured by Hipparcos, and the radial velocities confirm that the two stars are totally unconnected.

Exoplanet Host?

Observations in 2005 using the Élodie echelle spectrograph on the 1.9-metre reflector at Haute-Provence [212] revealed that there was a variation in the radial velocity of the primary star with a period of 388 days, due to the presence of an exoplanet whose minimum mass is estimated at 9.1 Jupiter masses assuming that the mass of the host stars is 1.25 $M_{\odot}$.

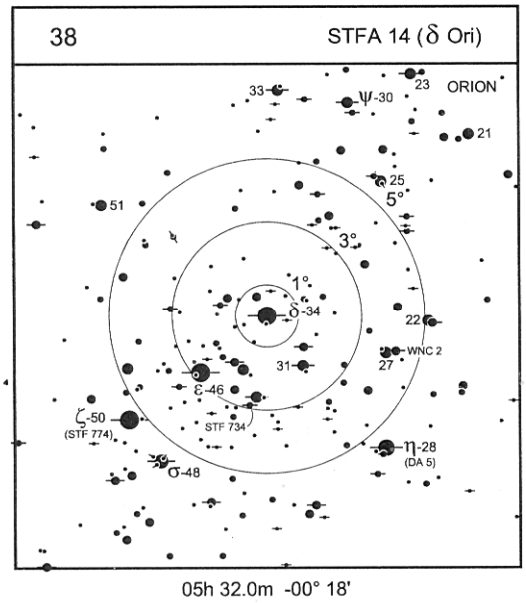
Observing and Neighbourhood

This is a fine, if very unequal, pair for the small telescope. Smyth noted colours of light yellow and pale blue though the companion is sufficiently faint for its colour not to be obvious. There is a good resolution test for a 15-cm aperture 3°.5 to the NW. This is the 372-year orbital pair STF 460 with components of magnitudes 5.6, 6.3, to be found at 159°, 0″.67, 2020.

Measures

Early measure (STF)	348°.2	34″.53	1832.10
(Linear prediction	347°.8	34″.59)	
Recent measure (ARY)	140°.8	30″.32	2013.30
(Linear prediction	138°.7	30″.07)	

Finder Chart



The Modern Era

The system δ Orionis is a group of massive, luminous, hot, and rapidly rotating B and O stars. The distance to this system is still rather uncertain. The Hipparcos parallax, which equates to a distance of 212 pc, has a nominal error of about 15% and the complex nature of star A no doubt contributes to this uncertainty. However, Shenar *et al.* [223] argue that the masses which they derive in their investigation make sense only if the true distance to δ is much greater, nearer the value 380 pc for the massive σ Orionis cluster. The HST and the STIS spectrograph have been used to obtain radial velocity curves of the close P = 5.7 day binary for the first time (Richardson *et al.* [224]. Such is the breadth of the lines due to fast rotation, though, that only the largest radial velocity shifts can be clearly measured, at the extrema of the orbit. The orbit of this pair is also edge-on to the line of sight, leading to Algol-like eclipses. The primary eclipse is about 0.1 magnitude whilst the secondary eclipse is 0.04 magnitude. The rotation period of HEI 42 has been estimated at 326 years. Interpolating back to 1892, the stars would have been just 0″.21 apart, which possibly explains why Burnham did not see them at that time. Star C is also an SB2 and Tokovinin [177] gives a period of 29.96 days for C. The brightness and complexity of δ Ori A has kept it from inclusion in DR2 but the C component is included and appears to be at a very similar distance to the A star as that found by Shenar.

Observing and Neighbourhood

Easily found as the westernmost star in the Belt of Orion, δ is almost on the celestial equator and hence has often provided a means of determining telescopic eyepiece fields by allowing it to drift from one side of the field of view to the other, noting the time taken in seconds, and dividing by 4 to get the eyepiece field in arcminutes. The relatively small motion between the stars A and C also mean that this star can be used as an astrometric calibrator. The current separation is 52″.4 and the position angle is 0°. Another fine binary can be found in ζ = STF 774 (p. xx), the easternmost star in the belt. Also worth a look is WNC 2 – a binary pair – magnitudes 6.9, 7.0 at 158° and 3″.1 (2020). One point five degrees SSE is STF 734, a fine triple in a beautiful field (6.7, 8.2, 357°, 1″.7, 2008) with magnitude 8.4 at 244°, 29″, 2014.

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Measures

Early measure (STF)	359°.2	52″.58	1835.75
Recent measure (SMR)	0°.3	52″.7	2010.17

39. ζ ORI = STF 774 = WDS J05408–0156AB

Table 9.39 Physical parameters for ~~STF 774~~ ζ Ori

STF 774	RA: 05 40 45.52	Dec: −01 56 33.3	WDS: 154(257)		
V magnitudes	Aa: 2.0	Ab: 4.0	B: 3.7	C: 9.6	
$(B-V)$ magnitudes	Aab: −0.11	B: −0.20			
μ	3.19 mas yr^{-1}	± 0.59	2.03 mas yr^{-1}	± 0.26	
π	4.43 mas	± 0.64	736 light yr	± 106	Hipparcos
π	2.58 mas	± 0.36	1264 light yr	± 176	Photometric
μ(C)	2.36 mas yr^{-1}	± 0.11	−2.02 mas yr^{-1}	± 0.10 (DR2)	
π(C)	2.62 mas	± 0.07	1245 light yr	± 33 (DR2)	
Spectra	A: O9.5Ibe	Ab: B0.5IV	B: B0III		
Masses ($M_\odot$)	Aa: 19.6	Ab: 9.9	B: 10.9		
Luminosities ($L_\odot$)	Aa: 19600	Ab: 3100	B: 4100	C: 18	
Catalogues (A/B)	50 Ori	HR 1948/9	HD 37742/3	SAO 132444	HIP 26727
DS catalogues	H 4 21 (AC)	STF 774 (AB)	BDS 2902	ADS 4263	NOI1(AaAb)
Radial velocity	18.50 km s^{-1}	± 1.3			
Galactic coordinates	206°.452	−16°.585			

History

William Herschel noted a distant 9.6 magnitude star associated with ζ Ori on 10 October 1780, noting that the two stars were extremely unequal and that the distance between them was about 25″. By late 1781 he had found a PA of 7° and a distance of about 60″. Eleven years later he re-examined ζ and prounounced the primary star 'distinctly round'. It seems strange that he did not see the close-in companion found by F. G. W. Struve in 1822 during the course of his first survey for visual double stars. Over the last 200 years the pair has remained close to 2″.5. The angular motion in that time amounts to only 15° but this has not prevented an orbit being calculated for it.

The Modern Era

The binary ζ Ori sits in the Orion OB1 association and in common with the stars in this group it is very young, hot, and luminous. Its spectral classification is O9.5Ibe, making it a rare example of an O-type supergiant. In 2000, observations with the Navy Prototype Optical Interferometer (NPOI), revealed [226] that the bright star was a close pair with a companion, some 2.2 magnitudes fainter in the V band, resolved at a distance of 0″.040. Even better, it turned out that the period was only seven years, and an astrometric orbit was obtained for it [227], giving a handle for the first time on the mass of an O supergiant. The orbit yields a dynamical parallax of 3.4 mas, corresponding to 294 pc, but this does not agree

40. θ AUR = STT 545 = WDS 05597+3713AB

Table 9.40 Physical parameters for ~~STT 545~~ θ Aur

STT 545	RA: 05 59 43.24	Dec: +37 29 45.9	WDS: 518(122)		
V magnitudes	A: 2.7	B: 7.2	C: 11.1	D: 10.10	
$(B-V)$ magnitudes	A:	B:			
μ	47.63 mas yr^{-1}	± 0.21	−73.79 mas yr^{-1}	± 0.08	
π	19.70 mas	± 0.16	165.6 light yr	± 1.4	
Spectra	A0pSi				
Luminosities ($L_\odot$)	A: 180	B: 3			
Catalogues	37 Aur	HIP 28380	HD 40312	SAO 58636	
DS catalogues	H 5 89 (AC)	H VI 34 (AD)	STT 545 (AB)	BDS 3074	ADS 4566
Radial velocity	29.30 km s^{-1}	± 1.7			
Galactic coordinates	174°.338	+6°.729			

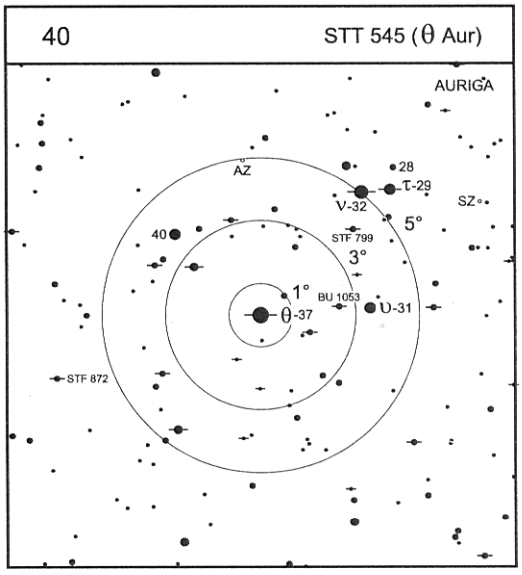
Introduction

Although θ is the eighth letter of the Greek alphabet, the star itself is the fourth brightest in the constellation of Auriga, although strangely missing from the list of 200 brightest stars in the book by Bakich [228]. It is easily found, being the next star around the pentangle of Auriga, anticlockwise from Capella.

History

William Herschel added a star at a 'distance about 2.5 min' from θ Aur on 26 September 1780 (now C) and later, when he was engaged on his second survey, noted the star now called D, on September 5th, 1782: 'distance with 460 35″ 18‴, narrow measure'. It was not until 1871 that Otto Struve found the close companion at 2″.1 and included it in his *Pulkova Catalogue*. This seems to indicate

Finder Chart



41. η GEM = BU 1008 = WDS J06149+2230AB

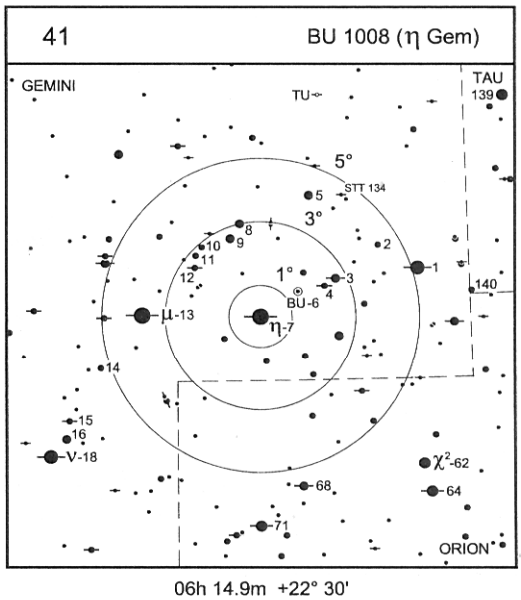
Table 9.41 Physical parameters for BU 1008

BU 1008	RA: 06 14 52.69	Dec: +22 30 24.6	WDS: 52(474)	
V magnitudes	A: 3.15 - 3.90	B: 6.15		
$(B-V)$ magnitudes	A: +1.94	+1.21		
μ	-62.46 mas yr^{-1}	$\pm$ 1.06 mas yr^{-1}	-12.12 mas yr^{-1}	$\pm$ 0.70 mas yr^{-1}
π	8.48 mas	$\pm$ 1.23 mas	385 light yr	$\pm$ 56 light yr
μ(A)	-59.52 mas yr^{-1}	$\pm$ 1.45	-7.77 mas yr^{-1}	$\pm$ 1.39 (DR2)
π(A)	4.73 mas	$\pm$ 1.02	690 light yrs	$\pm$ 150 (DR2)
Spectra	M2III			
Radius ($R_\odot$)	A: 317	$\pm$ 1		
Luminosities ($L_\odot$)	A: 1000 – 2000	B: 125		
Catalogues	7 Gem	HIP 29655	HD 42995	SAO 78135
DS catalogues	BU 1008 (AB)	BDS 2796	ADS 4841	
Radial velocity (A/B)	22.39 km s^{-1}	$\pm$ 0.36 km s^{-1}		
Galactic coordinates	188°.853	+2°.519		

History

Gilliss [231] in 1852 observed an occultation of η Geminorum and saw a double event, which he ascribed to the star disappearing behind a projecting lunar mountain. Gilliss also observed the occultation of η on another occasion, according to Tatlock [232]. The companion of η Gem was first seen by S. W. Burnham using the 12-inch refractor at Mount Hamilton in 1881. His measure showed the stars to be just below 1 arcsecond apart, and Burnham gave magnitudes of 3 and 8.8. About nine years later he assigned magnitudes of 10.5 and 10.7 to B. When he found very unequal and close pairs, it seems that Burnham would tend to underestimate the brightness of the companion. A similar case is α UMa (BU 1077), another subarcsecond pair, for which Burnham gave the discovery magnitudes as 2.0 and 11.1. The current WDS has 2.02 and 4.95. Another is example is BU 648 – the discovery magnitudes assigned by Burnham were 6.0 and 9.5 - the current WDS gives 3.52 and 6.15.

Finder Chart



42. 4 LYN = STF 881 = WDS J06221+5922AB

Table 9.42 Physical parameters for STF 881 (4 Lyn)

STF 881	RA: 06 22 03.57	Dec: +59 22 19.5	WDS: 387(148)	
V magnitudes	A: 6.43	B: 7.52		
$(B-V)$ magnitudes	A: +0.16	B: +0.18		
μ	-5.85 mas yr^{-1}	$\pm$ 0.66	0.03 mas yr^{-1}	$\pm$ 0.56
π	6.57 mas	$\pm$ 0.67	496 light yr	$\pm$ 51
μ(A)	15.33 mas yr^{-1}	$\pm$ 0.50	-15.56 mas yr^{-1}	$\pm$ 0.60 (DR2)
π(A)	8.22 mas	$\pm$ 0.50	397 light yr	$\pm$ 24 (DR2)
Spectra	A3V			
Luminosities ($L_\odot$)	A: 33	B: 12		
Catalogues	HD 43812	SAO 25678	HIP 30272	
DS catalogues	STF 881	BDS 3277	ADS 4950	CHR 128 (AaAb)
Radial velocity	-20.70 km s^{-1}	$\pm$ 1 km s^{-1}		
Galactic coordinates	155°.354	+19°.537		

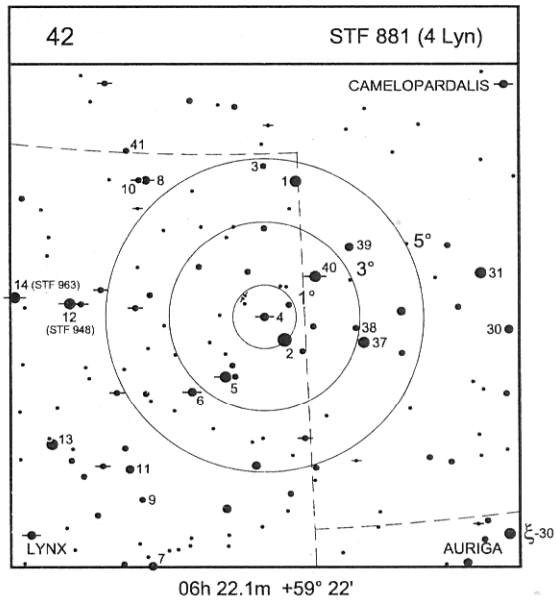
History

Burnham [238], in 1908, whilst carrying out his proper motion project; measured a maguitude 12.9 star at 96° and 26″. Previously Robert Ball[347] had observed a more distant maguitude 11.9 at 100″ separation and almost due N. Wallenquist added a third faint star of magnitude 12.2 at 32° and 75″.

The Modern Era

Observations of 4 Lyn with a speckle interferometer on a 3.8-metre telescope by McAlister *et al.* [240] showed that A was a very close and rather unequal pair (CHR 128), the separation being 0″.187 in PA 109°.5. No subsequent measures have been made of this pair. The orbit by Zirm [243] of the STF pair is based on 60° of direct motion in the apparent orbit and the stars closing from around 0″.9, so it is only a preliminary attempt until the stars pass periastron.

Finder Chart



44. β MON = STF 919 = WDS J06288−0702A,BC

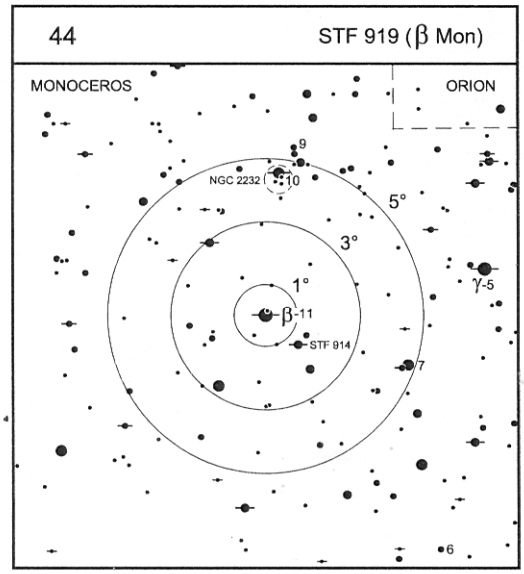
Table 9.44 Physical parameters for β Mon

STF 919	RA: 06 28 49.010	Dec: −07 01 59.03	WDS (AB): 435(138)	
			WDS (AC): 460(132)	
V magnitudes	A: 4.62	B: 5.00	C: 5.39	
$(B-V)$ magnitudes	A: −0.10	B: −0.19	C: −0.11	
μ(A)	−5.02 mas yr^{-1}	± 0.25	−2.86 mas yr^{-1}	± 0.47 (DR2)
μ(B)	−7.36 mas yr^{-1}	± 0.46	−2.27 mas yr^{-1}	± 0.53 (DR2)
μ(C)	−7.25 mas yr^{-1}	± 0.22	−3.77 mas yr^{-1}	± 0.26 (DR2)
π(A)	5.22 mas	± 0.25	625 light yr	± 30 (DR2)
π(B)	4.89 mas	± 0.20	557 light yr	± 23 (DR2)
π(C)	5.05 mas	± 0.13	621 light yr	± 16 (DR2)
Spectra	A: B3Ve	B: B3ne	C: B3e	
Masses ($M_\odot$)	A: 11.0	B: 11.0	Ca: 11.0	Cb: 5.4
Luminosities ($L_\odot$)	A: 430	B: 350	C: 220	
Catalogues (A/B/C)	11 Mon	HR 2356/7/8	HD 45725/6/7	SAO 133316/7
	HIP 30867			
DS catalogues	Mayer 18	H 1 10 (BC)	H 2 17 (AB)	STF 919 (A,BC)
	BDS 3402	ADS 5107	CHR 167 CaCb	
Radial velocity	A: 17.2 km s^{-1}	± 2.9	B: 18 km s^{-1}	± 5
	C: 23 km s^{-1}	± 5		
Galactic coordinates	216°.661	−8°.214		

History

This is one of the earliest telescopic double star discoveries. It was found by Benedetto Castelli on 30 January 1617, using a telescope borrowed from Galileo. It next appeared in the catalogue of Christian Mayer as number 18, and two years later in 1779 William Herschel examined AB and noted the close pair BC. 'A curious treble star; may appear double at first sight; but with some attention we see that one of them is again double'. He noted that all three stars were white and went on to say 'As perfect as I have seen this treble star with 460, it is one of the most beautiful sights in the heavens; but requires a very fine evening'. Burnham [245], using the 18.5-inch Dearborn refractor, added a distant 12th magnitude star (BU 570).

Finder Chart



The Modern Era

In 1988 H. A. McAlister *et al.* [482] found that C was double in PA 141° at a separation of 0″.26 (CHR 167). The motion between the bright stars is very small and any orbital period is bound to be long. Tokovinin, in his MSC, estimates the period of BC, for instance, at 2800 years whilst CaCb could be 100 years; it may well be shorter, but the speckle companion has gone to ground – it has not been resolved since 1988.

Observing and Neighbourhood

Smyth noted 'Golden yellow and lilac', whilst Webb drew attention to 'the glorious low-power field'. More recently Hartung found pale yellow and deep yellow in a rich field with other wide pairs and a red star 5′ away in PA 200°. RWA has always seen the three stars as white, but Greg Stone [126], using a 60-mm f/6 refractor on a night good enough to use a magnification of ×180, resolved the close pair comfortably. He saw a hint of yellow in the primary and light blue in the other two stars. Also on the Star-Splitters website, John Nanson, using 72-mm at ×108 sees three very white stars. North of β Mon by 2.5° is the open cluster NGC 2232, whilst 1° SE is the pair STF 914 (6.3, 9.3, 299°, 21″), which was first seen by William Herschel as (H 3 43). The Burnham companion is as at 55°, 26″.6 (2012).

Measures

AB			
Early measure (STF)	130°.0	7″.25	1831.23
Recent measure (ARY)	132°.2	7″.33	2014.10
AC			
Early measure (STF)	101°.7	2″.46	1831.23
Recent measure (ARY)	108°.9	2″.81	2014.10

45. △ 30 PUP = WDS J06298−5014

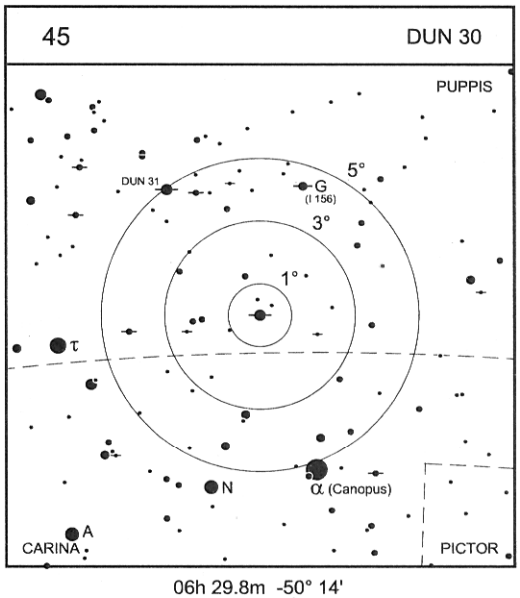
Table 9.45 Physical parameters for △ 30 Pup — ADD

DUN 30	RA: 06 29 49.03	Dec: −50 14 20.7	WDS: 3200(33)	
R 65			WDS: 1093(72)	
HDO 195			WDS: 1497(58)	
V magnitudes	A: 5.97	B: 6.15	C: 7.98	D: 8.73
μ	A: −67.94 mas yr^{-1}	±1.03	B: −49.01 mas yr^{-1}	± 0.72
π	19.44 mas	± 0.66	168 light yrs	± 6
Spectra	A: F2	B: ?	C: K3?	D: ?
Masses ($M_\odot$)	A: 1.54	B: 1.50	C: 0.63	D: 0.63
Luminosities ($L_\odot$)	A: 9	B: 8	C: 1.4	D: 0.7
Catalogues	HR 2384	HD 46273	SAO 234539	HIP 30953
DS catalogues	DUN 30 (AB,CD)	R 65 (AB)	HDO 195 (CD)	
Radial velocity	−3.40 km s^{-1}	± 0.3		
Galactic coordinates	258°.815	−23°.837		

History

Dunlop recorded this pair in 1826. John Herschel observed and measured it in 1834 and 1835 with his 7-foot telescope but did not use the 20-foot. Had he done so he might have seen the duplicity of both components. The primary was divided by Russell [525] in 1879 with the 11.5-inch refractor at Sydney when the separation was 0″7. Again the duplicity of CD was missed – the stars were actually also separated by 0″.58 at that time according to a recent orbit. The pair CD was finally resolved by Solon Bailey [248] at Arequipa in 1894. Using the 13-inch refractor which had been brought from Harvard for photography, Bailey realized the quality of the high-altitude site for the discovery of close and faint double stars and initiated a programme of observation. The first observations were estimates and the group later sent for a micrometer, which arrived a few months later. On 15 April 1894, DUN 30 appeared as a quadruple star to Bailey. The Russell pair were estimated as magnitudes 6.5, 6.5 at 0″.5 whilst C appeared as a new pair, with two 9.5 magnitude components 0″.3 apart.

Finder Chart



46. 15 MON = STF 950 = WDS J06410+0954AB

15 Mon

Table 9.46 Physical parameters for ~~STF 950~~

STF 950	RA 06 40 58.66	Dec: +09 53 44.7	WDS: 901(83)		
V magnitudes	A: 4.37	B: 7.52			
$(B-V)$ magnitudes	A: +0.27	B: +0.27			
μ	-2.61 mas yr^{-1}	$\pm$ 0.50	-1.61 mas yr^{-1}	$\pm$ 0.39	
π	3.55 mas	$\pm$ 0.50	920 light yr	$\pm$ 130	
μ(A)	-4.39 mas yr^{-1}	$\pm$ 0.99	-6.58 mas yr^{-1}	$\pm$ 0.85 (DR2)	
μ(B)	-1.80 mas yr^{-1}	$\pm$ 0.47	-6.55 mas yr^{-1}	$\pm$ 0.40 (DR2)	
π(A)	-0.78 mas	$\pm$ 0.62	- light yr	$\pm$ — (DR2)	
π(B)	-6.36 mas	$\pm$ 0.45	- light yr	$\pm$ — (DR2)	
Spectra	Aa: O7V	Ab: ?	B: B7V	C: B8V	
Masses ($M_\odot$)	Aa: 31.0	Ab: 10.7	B: 7.0	C: 3.0	
Luminosities ($L_\odot$)	A: 10000	B: 550			
Catalogues	S Mon	HR 2456	HD 47839	SAO 114258	HIP 31978
DS catalogues	H 6 65	STF 950	BDS 3542	ADS 5322	CHR 168 (AaAb)
Radial velocity	+22.00 km s^{-1}	$\pm$ 0.3			
Galactic coordinates	202°.936	+2°.199			

History

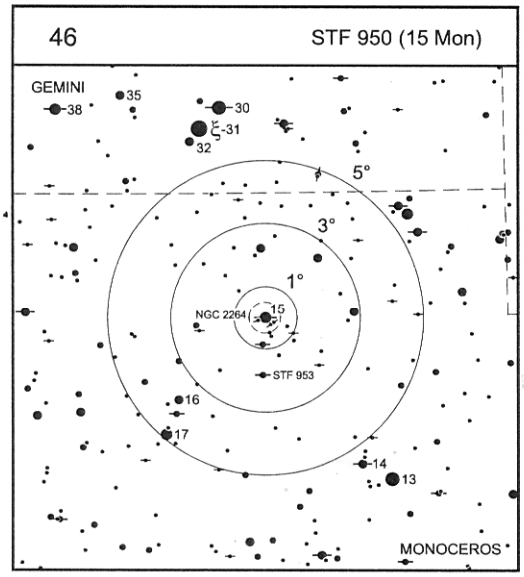
William Herschel observed S Mon on 22 October 1781. He noted 'Multiple. It is one star with at least 12 around it, all within the field of my telescope.'

The Modern Era

Centred within the open cluster NGC 2264, the Christmas-Tree cluster, 15 Mon (also known as S Mon) is a extremely bright and hot O7 star, which dominates the northern part of the stellar group. It is thought to be the source of a bubble of hot gas which influences the kinematic properties of the surrounding gas and stars. Next to the Orion Nebula, NGC 2264 is the nearest significant region of star formation (Tobin *et al.* [250]). The WDS lists 17 components within 190 arc seconds of 15 Mon, whose magnitudes range from 7.8 to 12.8. There is a substantial discrepancy between the accepted distance to the cluster (2500–3000 light years (Sung *et al.* [252], Baxter *et al.* [253]) and the distance to S Mon derived by Hipparcos (920 light years). The duplicity of the A component was found by McAlister *et al.* [482] (CHR 168). The dynamical parallax derived from the orbit of AaAb is 1.2 mas, which is 2700 light years, so this favours the larger value for the distance to S Mon. The results from Gaia DR2 do not settle the argument but indicate that the stars are indeed extremely distant – considerably more so than that found by Hipparcos. STF 953 is a neat pair 1° S (7.1, 7.7, 329°, 7″.1, 2017). The luminosities in the table are based on the 2700-light-year distance.

MOVE TO 'OBSERVING + NEIGHBOURHOOD'

Finder Chart



Observing and Neighbourhood

For the small telescope user, the principal pair is STF 950 itself. The stars differ by more than three magnitudes in the *V* band and the separation has widened a small amount in the last 200 years or so. Between 2008 and 2011, RWA measured a number of the fainter components in the group NGC 226, as in the following table.

NGC 2264

Aa,B	213°.7	2″.87	2008.72	3 nights
Aa,E	139°.9	73″.56	2008.57	2 nights
Aa,H	168°.0	88″.46	2008.57	3 nights
Aa,G	264°.4	39″.35	2010.24	2 nights
Aa,F	223°.5	155″.00	2008.74	2 nights
STF 952 MN	116°.6	14″.02	2011.21	4 nights

Measures of Principal Pair

Aa,B			
Early measure (R)	318°.0	12″.50	1893.12
Recent measure (ANT)	311°.1	12″.03	2014.25

47. SIRIUS = α CMA = AGC 1 = WDS J06451–1643

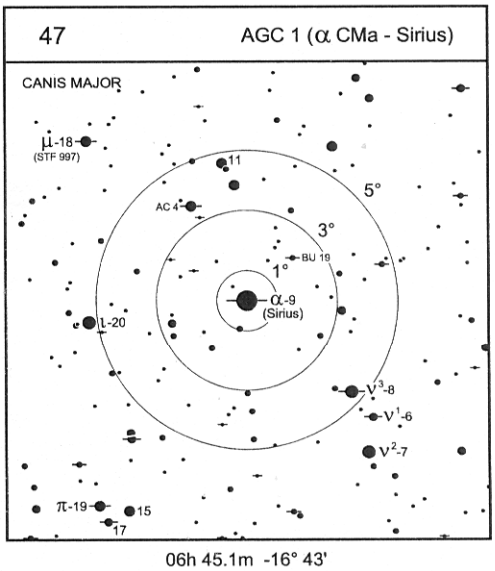
Table 9.47 Physical parameters for Sirius

AGC 1	RA: 06 45 08.92	Dec: −16 42 58.0	WDS: 26(640)		
V magnitudes	A: −1.44	B: 8.44			
$(B-V)$ magnitudes	A: 0.00	B: −0.04			
μ	A: −546.01 mas yr^{-1}	± 1.33	−1223.07 mas yr^{-1}	± 1.24	
π	379.21 mas	± 1.58 mas	8.60 light yr	± 0.04	
μ(B)	−459.68 mas yr^{-1}	± 0.54	−915.02 mas yr^{-1}	± 0.53 (DR2)	
π(B)	376.68 mas	± 0.45	8.66 light yr	± 0.01 (DR2)	
Spectra	A: A1V	B: DA2			
Masses ($M_\odot$)	A: 2.06	± 0.02	B: 1.02	± 0.11	
Radii ($R_\odot$)	A: 1.711	B: 0.0084			
Luminosities ($L_\odot$)	A: 22	B: 0.002			
Catalogues	9 CMa	HR 2491	HD 48915	SAO 151881	HIP 32349
DS catalogues	AGC 1	BDS 3596	ADS 5423		
Radial velocity	−5.50 km s^{-1}	± 0.4			
Galactic coordinates	227°.230	−8°.890			

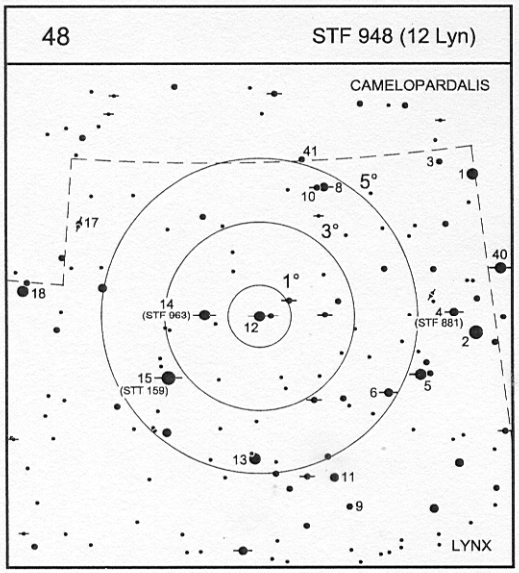
History

In 1834, F. W. Bessel, working at Konigsberg Observatory, noticed that the proper motion of Sirius was variable. Further observations led him, in 1844, to write to Alexander von Humboldt – 'I adhere to the conviction that Procyon and Sirius are genuine binary systems, each consisting of a visible and an invisible star. We have no reason to suppose that luminosity is a necessary property of cosmical bodies. The visibility of countless stars is no argument against the invisibility of countless others [257]'. Sirius B was first measured by G. P. Bond with the Harvard College 15-inch refractor on February 19th, 1862. His report to Astronomische Nachrichten [255] notes that 'An interesting discovery of a companion to Sirius was made on the evening of Jan 31, 1862 by Mr. Clark with his new object-glass of eighteen and one half inches aperture'.

Finder Chart

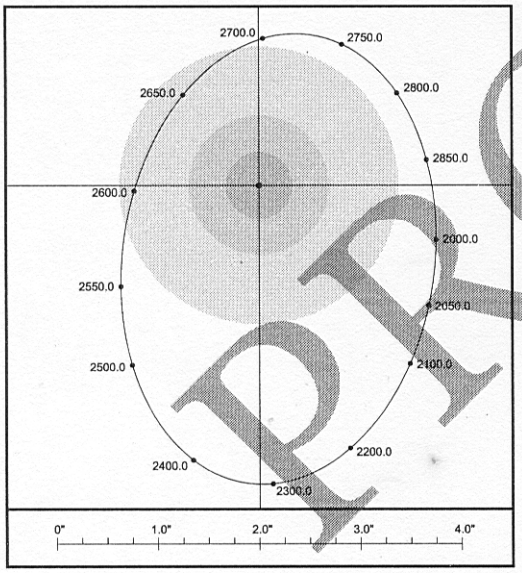


Finder Chart



06h 46.2m +59° 27'

Orbit



Ephemeris for STF 948 AB (2010 to 2100)

Orbit by WSI (2006b) Period: 907.6 years, Grade: 4

Year	PA(°)	Sep(")	Year	PA(°)	Sep(")
2010.0	68.7	1.88	2060.0	51.3	2.11
2020.0	64.9	1.92	2070.0	48.3	2.16
2030.0	61.2	1.96	2080.0	45.4	2.21
2040.0	57.8	2.01	2090.0	42.7	2.26
2050.0	54.4	2.06	2100.0	40.1	2.32

Observing and Neighbourhood

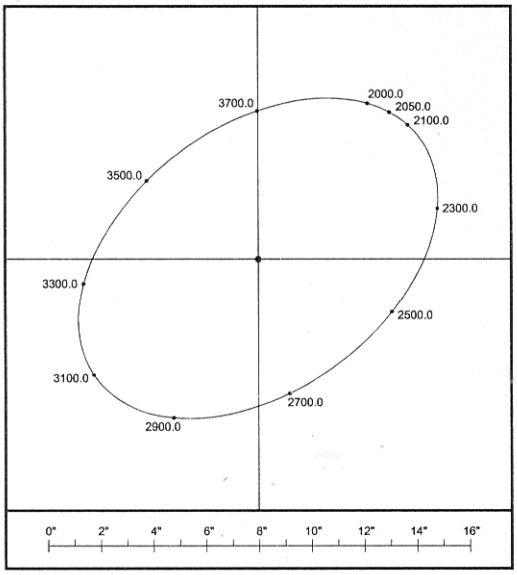
This beautiful triple is visible in 75-mm and above. The close pair has traced out about one-quarter of the apparent orbit and will continue to widen to 3″ in 2300 before closing to 1″.1 in 2630 or so. The triple 12 Lyncis is part of a group of faint naked-eye stars which can be found about 6° NE of δ Aurigae. There is a wealth of testing binaries in the neighbourhood. Nearby are the considerably more difficult pairs 4 (p. xx), 14, and 15 Lyncis (see below). The pair 14 Lyn (STF 963) is given in Webb with the intriguing colours of gold and purple. It has so far escaped the attentions of RWA. It is a 316-year binary which is now slowly widening. In 2020 the relative positions will be 358° and 0″.32 and the stars have visual magnitudes 6.0 and 6.5, making them a severe test for 30–40-cm. Meanwhile, 15 Lyn was a discovery by Otto Struve at Pulkova (STT 159) and needs 20-cm to be seen well. The stars are relatively unequal (4.5 and 5.5) and in 2020 the position will be 236° and 0″.71.

162

Measures

AB			
Early measure (STF)	152°.5	1″.60	1832.60
(Orbit	154°.8	1″.60)	
Recent measure (ARY)	67°.9	1″.95	2016.28
(Orbit	66°.3	1″.90)	
AC			
Early measure (STF)	304°.2	8″.67	1831.10
Recent measure (ARY)	310°.3	8″.70	2016.28

Orbit



Ephemeris for STF 982 AB (2010 to 2100)

Orbit by Msn (2014b) Period: 1898.12 years, Grade: 4

Year	PA(°)	Sep(")	Year	PA(°)	Sep(")
2010.0	143.6	7.28	2060.0	136.9	7.52
2020.0	142.2	7.33	2070.0	135.6	7.55
2030.0	140.9	7.38	2080.0	134.4	7.58
2040.0	139.5	7.43	2090.0	133.1	7.61
2050.0	138.2	7.48	2100.0	131.8	7.63

from white, yellow, or orange for A and white, blue, greenish, red, or purple for B. Star C was first measured by Burnham in 1913 as part of his project to measure proper motions.

The Modern Era

A speckle interferometry study of the primary star by McAlister [482] using the 3.6-metre CFHT reflector on Hawaii concluded that the star was single at the 0″.038 level. The Hipparcos satellite data supplies a distance of 83 light years and shows that the annual proper motion of the two brighter stars is almost exactly 0″.1 per year and that the fainter component C is being rapidly left behind. In 2012, Andrei Tokovinin [261] noted a very faint star (D) some 150″ distant which appears to be moving through space with the same proper motion as AB. This has been catalogued in the WDS as TOK 261AD. Brian Skiff derived position angles and separations for AB and D from both the POSS-R plate from 1950 and the 2010 WISE catalogue and showed there had been no net motion over 60 years.

2.3°E

Observing and Neighbourhood

The pair 38 Gem can be easily found almost 5° E of the $V = 3.4$ star ξ Gem. F. G. W. Struve found colours of yellow and blue, whilst Smyth noted light yellow and purple. Five degrees NE is 45 Gem (STT 165), a very unequal pair which is becoming easier as the stars are separating due to the proper motion of the bright primary (5.5, 10.9, 6°, 16″, 2015). The stars were only 5″ when discovered by Otto Struve in 1847. A maguitude 13.5 star lies at 333°, 60″.

Measures

Early measure (STF)	174°.9	5″.74	1829.24
(Orbit	174°.3	5″.84)	
Recent measure (ARY)	143°.8	7″.33	2014.86
(Orbit	142°.9	7″.30)	

50. Δ 39 CAR = WDS J07033–5911

ADD

Table 9.50 Physical parameters for Δ 39 CaF

DUN 39	RA: 07 03 15.12	Dec: −59 10 41.1	WDS: 2539(39)	
V magnitudes	A: 5.64	B: 6.79		
$(B-V)$ magnitudes	A: −0.14	B: −0.08		
μ(A)	−9.90 mas yr^{-1}	± 0.26	12.43 mas yr^{-1}	± 0.46 (DR2)
μ(B)	−17.01 mas yr^{-1}	± 0.15	10.13 mas yr^{-1}	± 0.30 (DR2)
π(A)	6.49 mas	± 0.11	503 light yr	± 9 (DR2)
π(B)	4.82 mas	± 0.09	677 light yr	± 13 (DR2)
Spectra	A: B9III + B8V	B: B8V		
Luminosities ($L_\odot$)	A: 110	B: 70		
Catalogues	HR 2674	HD 53921	SAO 234890	HIP 34000
DS catalogues	DUN 39			
Radial velocity	7.00 km s^{-1}	± 4.3		
Galactic coordinates	269°.542	−21.598		

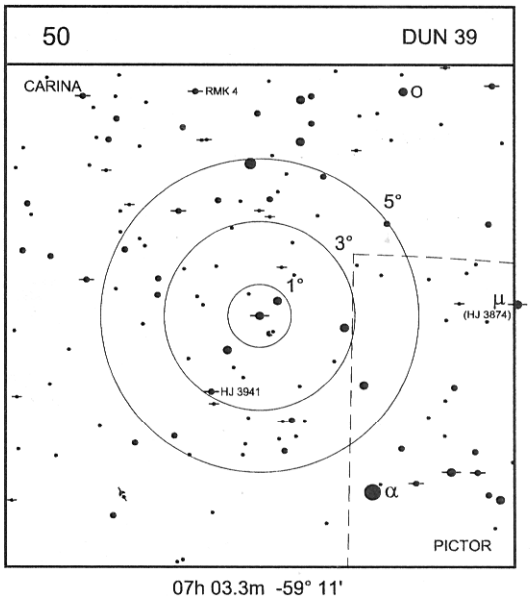
History

This binary was found by Dunlop at Parramatta but his observation was criticized by John Herschel, who first observed the star on sweep 664 at the Cape of Good Hope: 'Fine ∗'. On 1838.110 he notes 'practice wire set to 72° 40′, but it cannot be borne out. The star has certainly changed (Mr Dunlop's position is 11° 12′, which is probably a mistake of reading).

The Modern Era

Gaia DR2 would seem to indicate that the stars are at significantly different distances and that they are merely an optical pair. Star A is the variable star V450 Car, a member of the 53 Per class of B stars which pulsate but in a non-radial fashion. The period is 1.6518 days and the range is between V = 5.45 and 5.47 [265]. de Cat & Aerts [263] found that one component is a single-lined spectroscopic binary with an eccentric orbit, but they did not specify which star.

Finder Chart



REPLACE FINDER CHART

52. 145 CMA = HJ 3945 = WDS J07166–2319AB

Table 9.52 Physical parameters for HJ 3945 CMa

HJ 3945	RA: 07 16 36.84	Dec: −23 18 56.1	WDS: 2023(46)		
V magnitudes	A: 5.00	B: 5.84	C: 9.15		
$(B-V)$ magnitudes	A: +1.92	B: +0.44	C: +0.21		
μ(A)	-3.94 mas yr^{-1}	± 0.25	B: 2.25 mas yr^{-1}	± 0.26 (DR2)	
μ(B)	-33.79 mas yr^{-1}	± 0.08	B: 40.71 mas yr^{-1}	± 0.08 (DR2)	
μ(C)	-29.903 mas yr^{-1}	± 0.021	B: +39.081 mas yr^{-1}	± 0.027 (Hipparchus)	
π(A)	1.43 mas	± 0.16	2280 light yr	± 255 (DR2)	
π(B)	9.46 mas	± 0.06	344.8 light yr	± 2.2 (DR2)	
π(C)	10.83 mas	± 0.46	301 light yr	± 13 (Hipparchus)	
Spectra	A: K3Ib	B: A5m	C: A7m		
Luminosities ($L_\odot$)	A: 4000	B: 40	C: 1.5		
Catalogues (A/B)	145 CMa	HR 2764	HD 56577/8	SAO 173349/53	HIP 35210/3
Catalogues (C)	HD 57527	SAO 173505	HIP 35578		
DS catalogues	HJ 3945 (AB)	SHY 508 (BC)	BDS 3954	ADS 5951	
Radial velocity (A)	29.00 km s^{-1}	± 0.5			
Radial velocity (B)	36.90 km s^{-1}	± 1.78			
Radial velocity (C)	40.60 km s^{-1}	± 0.7			
Galactic coordinates	236°.499	−5°.214			

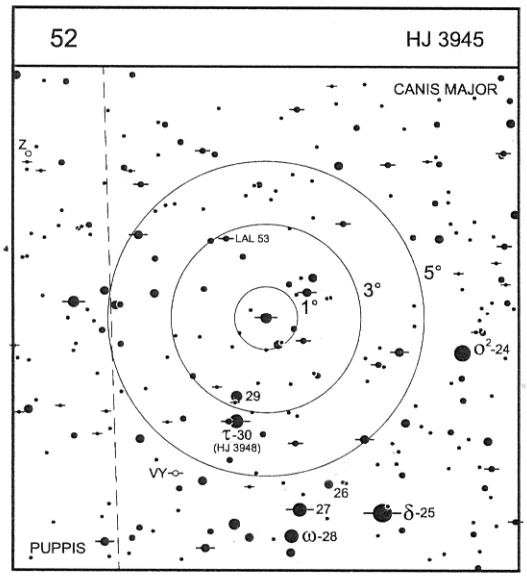
History

This beautiful pair was swept up by John Herschel on 23 January, 1835. He noted 'Large star orange, small pale blue'. Two years later he re-observed it and called the colours very high yellow and contrasted blue. Burnham, in his General Catalogue, notes that Birmingham thought the A component was variable and Aitken also notes that, whilst its radial velocity is small, it may be variable.

The Modern Era

The two bright components of 145 CMa are completely unrelated, as shown by the parallax and proper motion recently obtained by the Gaia satellite for the A and B components. Hartkopf [269] published a linear ephemeris which predicts that A and B are closest together in 2023 and then begin to widen. Component B is actually co-moving with a distant star C (HIP 35578), which is 3°.5 away to the SE. Shaya and Olling

Finder Chart



[270] suggested that there is a near 100% certainty that the two stars are physically connected. Both B and C are metallic-lined late A stars.

Observing and Neighbourhood

HJ 3945 sits in Canis Major, about 2°.5 WNW of the magnitude 3.0 blue supergiant star o^2 CMa. It is a rich area for the telescopic observer. Two degrees S is the luminous star τ CMa (HJ 3948) (4.4, 8.2, 77°, 85″) with additional stars of magnitudes 10.2 and 11.2 much closer, at 9″ and 14″. HJ 3945 is often called the 'Southern Albireo' and indeed there are similarities between the two pairs. Australian observers have also labelled x Vel with the same moniker. Greg Stone [268], however, sees orange going to red with a blue companion and finds this pair more redolent of α Her. Still surviving with its original discoverer's name intact, Lalande 53 (LAL 53) is 1°.5 NNE of HJ 3945. Its stars are 7.6, 7.7 at 165°, 4″.0, 2010.

Meaures

Early measure (DOO)	60°.3	27″.12	1898.20
(Linear:	61°.2	27″.40)	
Recent measure (ANT)	52°	26″.4	2008.86
(Linear:	50°.7	26″.7)	

53. δ GEM = STF 1066 = WDS J07201+2159AB

DELETE '4'

Table 9.53 Physical parameters for δ Gem

STF 1066	RA: 07 20 07.38	Dec: +21 58 56.34	WDS: 152(258)		
V magnitudes	Aa: 3.70	Ab: 5.50	B: 8.18		
$(B-V)$ magnitudes	A: +0.36	B:			
μ(A)	-31.20 mas yr^{-1}	± 1.34	-15.51 mas yr^{-1}	± 1.08 (DR2)	
μ(B)	-28.23 mas yr^{-1}	± 0.11	13.00 mas yr^{-1}	± 0.09 (DR2)	
π(A)	57.74 mas	± 0.81	56.5 light yr	± 0.8 (DR2)	
π(B)	53.98 mas	± 0.07	60.42 light yr	± 0.08 (DR2)	
Spectra	Aab: F2IV	B: K3V			
Masses ($M_\odot$)	Aa: 1.65	Mb: 1.10	B: 0.75		
Luminosities ($L_\odot$)	A: 8	B: 0.15			
Radii ($R_\odot$)	A: 1.1	B: 2.0			
Catalogues	55 Gem	HR 2777	HD 56986	SAO 79294	HIP 35550
DS catalogues (AB)	H 2 27	STF 1066	BDS 3970	ADS 5983	
Radial velocity	+4.1 km s^{-1}	± 2			
Galactic coordinates	195°.985	+15°.885			

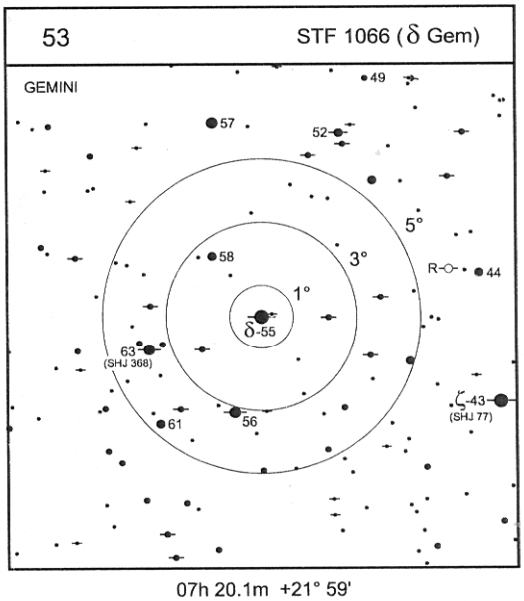
History

The duplicity of δ Geminorum, also known as 55 Gem, was found by the elder Herschel on March 13, 1781, the same night as that when he discovered Uranus. Intriguingly, δ Gem was also on the discovery plate of Pluto which was taken by Tombaugh at Lowell Observatory in 1930. Herschel's notes say 'Double. Extremely unequal. L(arge). w(hite). inclining to r(ed).; S(mall). r(ed). With 227, about 2.5 full diameters of L., with 460, 4 or 5 diameters. Position 85° 51′ s(outh). preceding'.

The Modern Era

Abt [469] in 1965 gave a list of 17 spectroscopic binaries in which the primary is an A star. For δ Gem he combined early radial velocities from Lick Observatory with later ones

Finder Chart



54. Δ 47 CMA = WDS J07247–3149AB

ADD

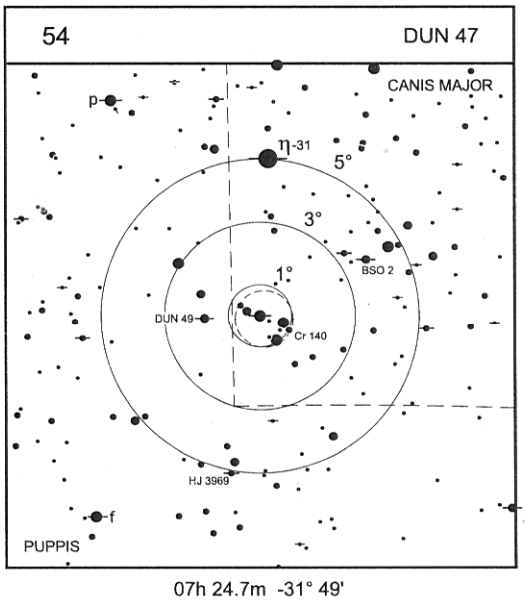
Table 9.54 Physical parameters for Δ 47 CMa

DUN 47	RA: 07 24 43.87	Dec: −31 48 32.1	WDS: 9144(16) (AC)	
V magnitudes	A: 5.40	B: 7.48	C: 7.58	D: 10.8
$(B-V)$ magnitudes	A: +1.26	B: −0.11		
μ(A)	−21.18 mas yr^{-1}	± 0.17	9.19 mas yr^{-1}	± 0.20 (DR2)
μ(B)	−7.72 mas yr^{-1}	± 0.11	5.42 mas yr^{-1}	± 0.11 (DR2)
μ(C)	−20.17 mas yr^{-1}	± 0.33	14.74 mas yr^{-1}	± 0.72 (DR2)
π(A)	5.14 mas	± 0.11	635 light yr	± 14 (DR2)
π(B)	2.68 mas	± 0.07	1217 light yr	± 32 (DR2)
π(C)	5.45 mas	± 0.21	598 light yr	± 23 (DR2)
Spectra	A: K1+III	B: B	C: B8V	
Luminosities ($L_\odot$)	A: 240	B: 115	C: 25	
Catalogues	HR 2834	HD 58535	SAO 197964	HIP 35957
DS catalogues	DUN 47 (AB-CD)	DAW 129 (AB)	B 1540 (CD)	
Radial velocity	19.90 km s^{-1}	± 0.8		
Galactic coordinates	244°.921	−7°.519		

History

The wide field view of this pair contains the cluster Collinder 140. It was first observed by Lacaille in 1751. In 1922 B. H. Dawson [277] found A was double and seven years later van den Bos [278] doubled the C component. Bernhard Hildebrande Dawson was an Argentine astronomer who was born in Kansas City in 1891 and who worked initially at La Plata Observatory in Argentina. He was perhaps best known as the discoverer of Nova Puppis in 1942. His double star discoveries were made using the 17-inch refractor at La Plata Observatory and were orginally denoted by a small greek delta; number 31 is perhaps his most interesting find – a visual pair with a period of 4.56 years.

Finder Chart

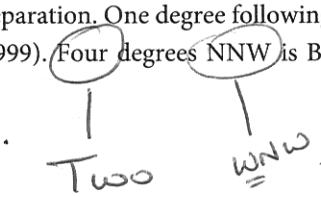


The Modern Era

Simbad says 'Star in cluster', Collinder 140 – distance 410 ± 30 pc = 1337 light years. Dr Floor van Leeuwen, using Hipparcos data, reported [279] that the cluster distance was 376 pc (1276 light years), so DUN 47 A and C, which appear to be physically connected, happen to lie in the line of sight of the cluster but significantly in front of it, whilst the B star appears to be just a line-of-sight coincidence and actually belongs to the cluster.

Observing and Neighbourhood

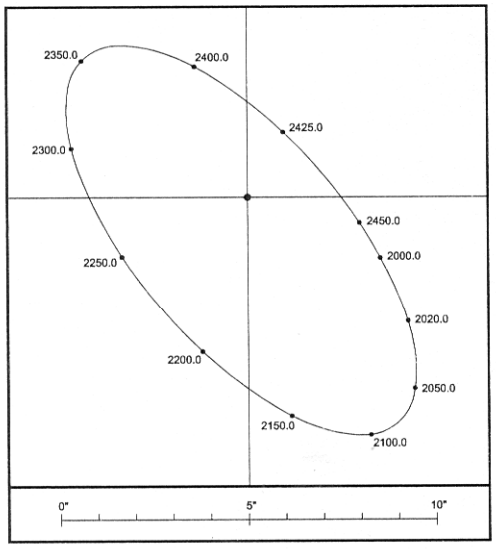
This pair can be found 2°.5 south of η CMa, and is visible in 8 × 50 binoculars. Ross Gould reports that both components are white. This is a difficult quadruple for 20-cm, and probably needs more aperture than that. Andrew James noted that the CD pair was easier to see than AB even though it has only half the separation. One degree following is DUN 49 (6.3, 7.0, 54°, 9″, 1999). Four degrees NNW is BSO 2 (6.6, 7.8, 183°, 38″, 2015). Two point five degrees S, a little following, is HJ 3969 (7.1, 8.1, 227°, 17″.5, 2010) – a pair of stars which is moving at about 0″.3 per year together and which may constitute a quadruple system.



Measures

AB			
Early measure (DWS)	309°	2″.17	1922.58
Recent measure (HIP)	311°	2″.12	1991.25
CD			
Early measure (B)	206°	1″.04	1929.22
Recent measure (B)	205°	0″.85	1965.16
AB-CD			
Early measure (BSS)	341°.3	100″.35	1898.20
Recent measure (TMA)	342°.9	98″.49	1999.09

Orbit



Ephemeris for STF 1110 AB (2015 to 2060)

Orbit by Doc (2014g) Period: 459.8 years, Grade: 3

Year	PA(°)	Sep(")	Year	PA(°)	Sep(")
2015.0	54.6	5.04	2040.0	44.1	6.43
2020.0	52.1	5.38	2045.0	42.4	6.62
2025.0	49.8	5.69	2050.0	40.9	6.78
2030.0	47.7	5.96	2055.0	39.4	6.92
2035.0	45.8	6.21	2060.0	37.9	7.03

of Gemini was so nearly parallel to a line through κ and σ of Gemini that, after many trials, we could scarce determine on which side of σ the line from κ parallel to the line of direction tended; if on either, it was towards β.' Unfortunately they did not attempt to measure or estimate the distance. In 1896 Bélopolsky [282], using a prism spectrograph on the 30-inch Pulkovo refractor, took some spectra of Castor four nights apart. He noted that the radial velocity on each occasion was significantly different and made some further observations to try to determine the cause of this effect. He found that the variation in velocity arose in the fainter component B and that there was a periodic variation over 2.91 days. In 1895 H. D. Curtis [283] determined that the brighter component was also a spectroscopic binary, with a period of nine days. Star C too is a spectroscopic binary. Its periodic variability was found by Adams & Joy [285] in 1917 whilst the spectroscopic orbit was first determined in 1926 by Joy & Sanford [286]. The orbit of the star is close to the line of sight and leads to regular eclipses, resulting in the allocation of the variable star name YY Gem.

The Modern Era

Measures of AB now cover almost 300 years but it will be some years yet before the orbit of this pair can be regarded as definitive, as the apastron end of the apparent ellipse has not yet been observed. Nevertheless, a number of orbits published in recent years give periods in the range 445 to 467 years. The distance to the system was rather poorly defined by Hipparcos possibly because of the combination of star brightness and orbital motion. Torres & Ribas [280] reworked the distance of C, and hence AB, as 66.90 ± 0.63 milli-arcseconds. Recent photometry of YY Gem by Butler*et al.* [281] put the period at 19.54 hours. A fine light curve can be found on Bruce Gary's website [289] Recent measurements appear to show that the secondary eclipse is now deeper than the primary, leading to suggestions that there has been a change in star spot activity. Castor is a member of a loose group of bright stars which are moving through space with a similar velocity and direction. The group also includes Vega and Fomalhaut and the visual binaries ψ Vel and μ Dra. The age of this group has been estimated at 400 million years. If the total mass of the Castor system is taken to be 7.1 $M_\odot$, and the separation between AB and C is 70″, then the projected rotation period of Castor C around AB is about 13,200 years.

Observing and Neighbourhood

Castor and Pollux are the bright leaders of the constellation of Gemini. They are easily distinguished, as Castor appears brilliant white whilst Pollux glows orange red. Castor is one of the most spectacular and visited pairs in the sky (more than 1400 measures to date). The companion, having passed within 2″ of A around 1970, is now heading out to the point in the orbit where the two stars are at maximum separation (7″.2 in 2080 or so). The pair is thus visible in small telescopes at all times. Castor C, a ninth magnitude red star 70″ away in PA 166° is also visible in 7.5-cm. I RWA has measured Castor AB every year since 1990, and the results are shown on the orbital diagram. In spring 2016, the position of the stars were as given below. Three point five degrees ENE is the 5th magnitude star π Gem, which the elder Herschel found to be double (H 4 53) and which is also catalogued at STF 1135. There are two maguitude 11 comites (11.4 at 214°, 19″.6, 2016, and 11.2 at 343°, 92″, 2016).

Measures

Early measure (STF)	262°.6	4″.42	1826.26
(Orbit	261°.7	4″.52)	
Recent measure (ARY)	52°.8	5″.38	2018.30
(Orbit	53°.0	5″.27)	

56. STF 1126 CMI = WDS J07401+0514AB

Table 9.56 Physical parameters for STF 1126

STF 1126	RA: 07 40 06.994	Dec: +05 13 51.89	WDS: 144(268)	
V magnitudes	A: 6.55	B: 6.96		
$(B-V)$ magnitudes	A: −0.02	B: −0.07		
μ(A)	−0.15 mas yr^{-1}	± 0.29	−17.76 mas yr^{-1}	± 0.18 (DR2)
μ(B)	−3.16 mas yr^{-1}	± 0.61	−16.55 mas yr^{-1}	± 0.43 (DR2)
π(A)	4.96 mas	± 0.22	658 light yr	± 29 (DR2)
π(B)	2.33 mas	± 0.37	1400 light yr	± 222 (DR2)
Spectra	A0III			
Luminosities ($L_\odot$)	A: 80	B: 250		
Catalogues	HR 2950	HD 61563	SAO 115773	
DS catalogues	H 1 23	STF 1126	BDS 4193	ADS 6263
Radial velocity (A/B)	17.0 km s^{-1}	± 5		
Galactic coordinates	213°.790	+13°.203		

History

William Herschel discovered this pair on 21 November 1781, and he noted that it was 'a most minute double star'. He measured the position angle but simply estimated the distance in terms of the diameter of the stars. Its likely that the stars were closer then than they are today, and a measure of separation would have helped to define the modern orbit by Zirm [288], which gives a predicted separation of 1″.33. Herschel thought the stars closer than those in η CrB, which at the time were 1″.03 apart, but he recognised that the separation estimated in this way depended upon the brightness of the stars. Herschel added a fainter star some 120″ away, preceding the pair. This is not star C (magnitude 11.99) as given in the WDS at a distance of 43″ for 2009. F. G. W. Struve measured the pair in 1820 and it has been followed regularly until today and, whilst the observed motion in angle is but 50°, with little change in separation, Lewis [194] *op cit.* believes that a maximum distance was reached around 1840.

Finder Chart