Double and Multiple Stars

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Approximately 85% of stars are found in double or multiple systems. While the first detection of these double systems dates back to the early 17th century, it was not until systematic work with large-aperture telescopes was done (notably by William Herschel) that the physical rather than the optical nature of these systems was ascertained. The larger the aperture of the telescope, the closer the stars that can be separated under good conditions. The resolving power in arcseconds can be estimated as 120/D, where D is the diameter of the telescope objective in millimeters. Astronomers using long-baseline optical interferometry have measured double-star separations less than a milliarcsecond ($0\farcs001$).

The double stars in the table were selected to cover a wide variety of interests. While wide or slowly moving pairs are good for evaluating optical performance or estimating seeing, with the preponderance of inexpensive, large-aperture telescopes and the availability of interferometry for the amateur (see the *Journal for Double Star Observations*[1], hereafter, JDSO, Vol. 4, 111, 2008, by R. Caloi) as well as access to larger magnitude difference systems (see JDSO **3**, 159, 2007 by J. Daley), closer systems, some with larger magnitude difference, have been added to the list.

The list, much larger than in past versions, covers many decades of separation with small and large Δm. Of the 135 listed systems, 19 have separations less than one arcsecond and 19 more between one and two arcseconds. At more moderate separations there are 21 between two and three arcseconds, 20 between three and five, 22 between five and seven, 25 between seven and ten, and 9 with separations greater than ten arcseconds. Of these more moderate separations, those with both small and large magnitude difference are well-represented. The pairs are well distributed in right ascension. A third of the objects are found south of the equator giving adequate coverage of southern declinations. Since many of the stars selected exhibit significant motion, the predicted position angles and separations are given for both 2010.0 and 2011.0. P.A. (Position Angle) is the angular direction of the fainter star (B) from the brighter (A), measured counterclockwise from north (clockwise in an optical system having an odd number of reflections). Note that data for 2010.0 have been changed for some systems due to improvements in orbit calculations or more recent measurements. For systems with no orbit determination the most recently measured position is tabulated. Also included are notes on selected systems. If no 2011.0 data is provided, there is no calculation (orbit or linear) of the motion (if any) of this double. The 2010.0 data is the most recent published measure.

Notes on some double and multiple stars in the table:

ζ **Phe:** The AB-C pair listed here is rather difficult to observe due to the moderate magnitude difference at a relatively close separation. The AB pair ($\rho = 0\farcs5$, Δm = 2.8, P = 210y) is also a challenge.

γ **Per:** A favorite of astronomers, the brightest eclipsing binary in the sky, Algol, has been known to be variable for hundreds of years. The second brightest eclipsing binary, γ Per, was not known until it's first observed eclipse in 1990! This system, also seen spectroscopically and interferometrically, is also a visual double, and is near maximum separation. It is observable with a large telescope, and a significant color difference should be noted for this pair consisting of a cool giant and a hot dwarf. The June 1991 Sky and Telescope article by Roger Griffin, while older, is an excellent astronomical adventure tale of the first

[1]The Journal of Double Star Observations is a good source for free information on double and multiple see `http://www.jdso.org/`.

observed eclipse.

β **Ori:** Rigel has a very slow moving companion. This, and the very small proper motion, make it difficult to determine physicality, but the spectral types are consistent.

α **CMa:** The companion to Sirius is a difficult target, usually observable only during periods of exceptional seeing when you can use the highest magnification and move the primary off the field of view. The white dwarf secondary, predicted by Bessel and first observed by Alvan Clark, remains a challenging target for visual observers.

α **CMi:** Like Sirius, Procyon has a white dwarf companion. It was first detected in 1840 by the variation in the proper motion of the star, but not resolved until 1896 by Shaeberle with the $36''$ refractor of Lick Observatory.

ξ **UMa:** Many "firsts" are associated with this system. It was one of the first discovered systems (Herschel), one of the first systems whose motion led to the discovery of the physical (rather than optical) nature of double stars (Struve), and the first to have an orbit calculated for it (Savary). Always relatively wide and with an obvious position angle change of $6°$ per year, this is a system that will never fail to please, observing season to observing season.

α **Cen:** Our closest neighbor is a quick-moving double star. The brighter component is a near twin of the Sun, while the B component is cooler. The C component, Proxima, which is slightly closer to the Sun, is an extremely faint red dwarf, $2.2°$ away. According to R.G. Aitken, this was discovered by Father Richaud while observing a comet at Pondicherry, India, in December 1689.

ι^1 **Nor:** A small δm and slow motion makes this a good seeing check for high resolution techniques in the southern hemisphere. This pair was resolved first by T.J.J. See with the Lowell $24''$ during the telescope's brief sojurn near Mexico City.

μ **Dra:** This pair of near equal magnitude slow-moving components, is a good seeing test for a more modest resolution detection system.

β **Cyg:** Also known as Albireo. If a neophyte doubts the color of stars, this jewel of the summer sky should change that view. Appearing as brilliant yellow and a deep blue, this wide double has shown no apparent motion. The A component has two close companions, discovered by speckle interferometry, one at a separation of about $0\farcs4$ and the other at $0\farcs1$.

β **Del:** A well-observed close pair, this short period binary has completed over five orbits since the first resolution by S.W. Burnham in 1873. Burnham resolved it with six different Clark refractors with diameters from $6''$ to $40''$.

30 Peg: The large Δm pair needs a dark sky. There is an equally faint companion, at $227°$ and $17\farcs5$.

Table 1. Double Star Parameters

Star	RA h	RA m	Dec °	Dec ′	Magnitudes comb	Magnitudes A	Magnitudes B	2010.0 PA °	2010.0 Sep ″	2011.0 PA °	2011.0 Sep ″	Period years
34 Psc	00	10.0	+11	09	5.0	5.5	9.4	162	7.88			
ζ Phe*	01	08.4	−55	15	4.0	4.0	8.2	242	6.80			
ϕ Psc	01	13.7	+24	35	4.6	4.7	9.1	229	7.75			
κ Tuc	01	15.8	−68	53	4.9	5.0	7.7	319	4.99	318	4.98	857
γ Eri	01	53.5	+19	18	3.8	4.5	4.6	0	7.41			
α Psc	02	02.0	+02	46	4.4	5.1	5.2	264	1.77	263	1.77	933
γ And A-BC	02	03.9	+42	20	2.2	2.3	5.0	63	9.45			
γ And BC	02	03.9	+42	20	4.8	5.1	6.3	100	0.25	98	0.21	64
ι Tri	02	12.4	+30	18	5.0	5.3	6.7	68	3.69			
ι Cas AB	02	29.1	+67	24	4.5	4.6	6.9	229	2.60	229	2.61	620
ι Cas AC	02	29.1	+67	24	4.5	4.6	9.1	116	7.36			
α UMi	02	31.8	+89	16	2.1	2.1	9.1	231	18.21			
ν Cet	02	35.9	+05	36	4.3	5.0	5.1	79	7.50			
84 Cet	02	41.2	−00	42	5.8	5.8	9.7	306	3.30			
γ Cet	02	43.3	+03	14	3.4	3.5	6.2	298	2.32			
ϵ Eri	02	59.2	+21	20	4.6	5.2	5.6	212	1.35			
γ Per*	03	04.8	+53	30	2.7	2.9	4.4	245	0.21	245	0.23	15
α For	03	12.1	−28	59	3.9	4.0	7.2	300	5.23	300	5.26	269
94 Cet	03	12.8	−01	12	5.1	5.1	11.0	197	2.20	196	2.19	1420
HR 997	03	18.7	−18	34	5.8	5.9	8.2	122	7.94	122	7.95	
32 Eri	03	54.3	−02	57	4.5	4.8	5.9	348	6.91			
HR 1230	04	10.0	+80	42	5.2	5.6	6.3	145	0.70	147	0.69	372
14 Ori	05	07.9	+08	30	5.4	5.8	6.7	300	0.88	298	0.89	197
β Ori*	05	14.5	−08	12	0.3	0.3	6.8	204	9.20			
14 Aur	05	15.4	+32	41	5.0	5.0	9.0	9	9.81			
16 Aur	05	18.2	+33	22	4.8	4.8	10.6	56	4.41			
HR 1771	05	21.8	−24	46	5.1	5.4	6.6	97	3.40			
118 Tau	05	29.3	+25	09	5.4	5.8	6.7	208	4.40			
33 Ori AB	05	31.2	+03	18	5.4	5.7	6.7	29	1.89			
λ Ori	05	35.1	+09	56	3.3	3.5	5.5	44	4.44			
ζ Ori	05	40.7	−01	57	1.7	1.9	3.7	166	2.23	166	2.22	1509
52 Ori	05	48.0	+06	27	5.3	6.0	6.0	218	1.00			
β Mon AB	06	28.8	−07	02	4.0	4.6	5.0	133	7.13			
β Mon AC	06	28.8	−07	02	4.2	4.6	5.4	126	9.86			
β Mon BC	06	28.8	−07	02	4.4	5.0	5.4	108	2.89			
HR 2384	06	29.8	−50	14	5.3	6.0	6.2	261	0.61	260	0.58	53
α CMa*	06	45.1	−16	43	−1.5	−1.5	8.5	91	8.81	89	9.16	50
12 Lyn AB	06	46.2	+59	27	4.8	5.4	6.0	69	1.88	68	1.88	908

Table 1—Continued

Star	RA h	RA m	Dec °	Dec ′	Magnitudes comb	Magnitudes A	Magnitudes B	2010.0 PA °	2010.0 Sep ″	2011.0 PA °	2011.0 Sep ″	Period years
12 Lyn AC	06	46.2	+59	27	4.8	5.4	7.1	310	8.89			
38 Gem	06	54.6	+13	11	4.7	4.8	7.8	325	6.98	325	6.98	1944
HR 2674	07	03.3	−59	11	5.5	5.8	6.8	86	1.41			
δ Gem	07	20.1	+21	59	3.5	3.6	8.2	227	5.59	227	5.58	1200
α Gem	07	34.6	+31	53	1.6	1.9	3.0	57	4.65	57	4.72	445
HR 2949	07	38.8	−26	48	3.8	4.4	4.6	318	9.80			
α CMi*	07	39.3	+05	14	0.4	0.4	10.8	221	2.34	241	2.63	41
κ Gem	07	44.4	+24	24	3.7	3.7	8.2	241	7.03			
ζ Cnc AB	08	12.2	+17	39	4.9	5.3	6.3	38	1.06	34	1.07	60
ζ Cnc AB-C	08	12.2	+17	39	4.6	4.9	6.3	68	5.92	68	5.92	1115
HR 3432	08	37.3	−62	51	5.5	5.5	11.0	237	5.76			
ι Cnc	08	46.7	+28	46	4.0	4.1	6.0	307	30.45			
ϵ Hya	08	46.8	+06	25	3.4	3.5	6.7	305	2.89	306	2.89	990
ι UMa	08	59.2	+48	03	3.1	3.1	9.2	198	2.64	200	2.69	818
σ^2 UMa	09	10.4	+67	08	4.8	4.9	8.9	350	4.15	350	4.18	1141
38 Lyn	09	18.8	+36	48	3.8	3.9	6.1	225	2.70			
HR 3752	09	25.5	−61	57	5.8	5.8	9.6	330	8.77			
ψ Vel	09	30.7	−40	28	3.6	3.9	5.1	101	0.85	106	0.93	34
11 LMi	09	35.7	+35	49	4.8	4.8	12.5	51	6.20	51	6.24	201
γ Sex	09	52.5	−08	06	5.1	5.4	6.4	50	0.57	49	0.57	78
γ Leo	10	20.0	+19	50	2.1	2.4	3.6	126	4.62	126	4.62	510
μ Vel	10	46.8	−49	25	2.7	2.8	5.7	56	2.58	56	2.59	138
54 Leo	10	55.6	+24	45	4.3	4.5	6.3	113	6.91			
ξ UM*	11	18.2	+31	32	3.8	4.3	4.8	211	1.61	204	1.61	60
ν UMa	11	18.5	+33	06	3.5	3.5	10.1	149	7.35			
57 UMa	11	29.1	+39	20	5.3	5.4	10.7	354	5.48			
α^1 Cru	12	26.6	−63	06	0.6	1.3	1.6	114	3.96			
24 Com	12	35.1	+18	23	4.8	5.1	6.3	271	19.98			
γ Vir	12	41.7	−01	27	2.8	3.5	3.5	24	1.39	19	1.59	169
β Mus	12	46.3	−68	06	3.0	3.5	4.0	52	0.97	54	0.95	194
θ Vir	13	09.9	−05	32	4.4	4.4	9.4	342	6.94			
α Com	13	10.0	+17	32	4.4	4.9	5.5	12	0.65	12	0.63	26
ζ UMa	13	23.9	+54	56	2.0	2.2	3.9	153	14.42			
84 Vir	13	43.1	+03	32	5.5	5.6	8.3	228	2.84			
tau Boo	13	47.3	+17	27	4.5	4.5	11.1	60	1.37	66	1.24	2000
HR 5386	14	23.4	+08	27	4.8	5.0	6.8	194	6.16			
ϕ Vir	14	28.2	−02	14	4.9	4.9	10.0	112	5.26			
α Cen*	14	39.6	−60	50	−0.2	0.1	1.2	245	6.80	251	6.09	80

Table 1—Continued

Star	RA h	RA m	Dec °	Dec ′	Magnitudes comb	Magnitudes A	Magnitudes B	2010.0 PA °	2010.0 Sep ″	2011.0 PA °	2011.0 Sep ″	Period years
π^1 Boo	14	40.7	+16	25	4.5	4.9	5.8	112	5.43			
ζ Boo	14	41.1	+13	44	3.8	4.5	4.6	294	0.53	293	0.50	123
ϵ Boo	14	45.0	+27	04	2.4	2.6	4.8	342	2.77			
ξ Boo	14	51.4	+19	06	4.6	4.8	7.0	308	6.03	307	5.96	152
44 Boo	15	03.8	+47	39	4.8	5.2	6.1	60	1.61	61	1.49	206
π Lup	15	05.1	−47	03	3.8	4.6	4.6	67	1.68			
η CrB	15	23.2	+30	17	5.0	5.6	6.0	168	0.60	177	0.63	42
δ Ser	15	34.8	+10	32	3.8	4.2	5.2	173	3.99	173	3.99	1038
ζ^2 CrB	15	39.4	+36	38	4.6	5.0	5.9	305	6.42			
ι^1 Nor*	16	03.5	−57	47	4.7	5.2	5.8	233	0.40	225	0.38	27
ξ Sco AB	16	04.4	−11	22	4.3	5.2	4.9	355	0.93	357	0.96	46
ξ Sco AC	16	04.4	−11	22	3.8	4.3	4.9	45	7.55	44	7.55	1514
11 Sco	16	07.6	−12	45	5.7	5.8	9.8	263	2.79			
κ Her	16	08.1	+17	03	4.8	5.1	6.2	13	27.19	13	27.17	
ν Sco	16	12.0	−19	28	4.0	4.4	5.3	1	1.24			
σ CrB	16	14.7	+33	52	5.2	5.6	6.5	237	7.11	238	7.13	726
ρ Oph	16	25.6	−23	27	4.6	5.1	5.7	336	3.03	335	3.03	
α Sco	16	29.4	−26	26	0.9	1.0	5.4	277	2.64	277	2.63	1218
λ Oph	16	30.9	+01	59	3.8	4.2	5.2	37	1.45	38	1.45	
HR 6246	16	49.6	+13	16	5.7	5.7	10.0	45	5.34			
μ Dra*	17	05.3	+54	28	4.9	5.7	5.7	6	2.36	5	2.38	672
η Oph	17	10.4	−15	44	2.4	3.1	3.3	235	0.58	234	0.58	88
α Her	17	14.6	+14	23	3.3	3.5	5.4	104	4.64	103	4.64	3600
36 Oph	17	15.3	−26	36	3.9	4.3	5.1	143	4.96	142	4.97	471
41 Ara	17	19.1	−46	38	5.6	5.6	8.9	256	9.89	256	9.96	693
95 Her	18	01.5	+21	36	4.3	4.9	5.2	257	6.42			
τ Oph	18	03.1	−08	11	4.8	5.3	5.9	285	1.62	285	1.61	257
70 Oph	18	05.5	+02	30	4.1	4.2	6.2	132	5.72	130	5.86	88
HR 6749-50	18	06.8	−43	25	4.9	5.7	5.7	2	1.72	2	1.72	450
59 Ser	18	27.2	+00	12	5.3	5.4	7.6	320	3.77			
HR 6997	18	36.6	+33	28	5.4	5.4	9.4	204	7.41			
ϵ^1 Lyr	18	44.3	+39	40	4.8	5.2	6.1	348	2.39	347	2.38	1725
ϵ^2 Lyr	18	44.3	+39	40	4.6	5.3	5.4	78	2.37	78	2.37	724
β Cyg*	19	30.7	+27	58	2.9	3.2	4.7	56	37.12			
16 Cyg	19	41.8	+50	32	5.4	6.9	6.2	133	39.70	133	39.72	18212
δ Cyg	19	45.0	+45	08	2.8	2.9	6.3	220	2.68	219	2.69	780
ϵ Dra	19	48.2	+70	16	3.9	4.0	6.9	19	3.16			
π Aql	19	48.7	+11	49	5.8	6.3	6.8	103	1.37			

Table 1—Continued

Star	RA h	RA m	Dec °	Dec ′	Magnitudes comb	Magnitudes A	Magnitudes B	2010.0 PA °	2010.0 Sep ″	2011.0 PA °	2011.0 Sep ″	Period years
ζ Sge	19	49.0	+19	09	5.0	5.0	9.0	311	8.11			
ψ Cyg	19	55.6	+52	26	4.9	5.0	7.5	178	2.96			
16 Vul	20	02.0	+24	56	5.2	5.8	6.2	125	0.94			
κ Cep	20	08.9	+77	43	4.4	4.4	8.3	120	7.12			
β Cap	20	21.0	−14	47	3.1	3.2	6.1	267	206.00			
β Del*	20	37.5	+14	36	3.7	4.1	5.0	24	0.37	35	0.29	27
52 Cyg	20	45.6	+30	43	4.2	4.2	8.7	69	6.41			
γ Del	20	46.7	+16	07	3.9	4.4	5.0	265	9.07	265	9.05	3249
HR 8040	20	58.5	+50	28	5.5	5.9	6.8	26	1.93			
ϵ Equ	20	59.1	+04	18	5.4	6.0	6.3	284	0.50	284	0.46	101
12 Aqr	21	04.1	−05	49	5.6	5.8	7.5	201	2.39			
τ Cyg	21	14.8	+38	03	3.7	3.8	6.6	234	0.77	227	0.79	50
μ Cyg	21	44.1	+28	45	4.5	4.8	6.2	316	1.66	317	1.64	789
λ Oct	21	50.9	−82	43	5.4	5.6	7.3	63	3.50			
ξ Cep	22	03.8	+64	38	4.3	4.5	6.4	274	8.34	274	8.35	3800
30 Peg*	22	20.5	+05	47	5.4	5.4	11.5	15	5.97			
ζ^2 Aqr	22	28.8	−00	01	3.7	4.3	4.5	171	2.14	170	2.16	487
δ Cep	22	29.2	+58	25	4.0	4.2	6.1	191	40.80			
o Cep	23	18.6	+68	07	4.8	5.0	7.3	222	3.34	222	3.34	1505
72 Peg	23	34.0	+31	20	5.1	5.7	6.1	104	0.53	105	0.53	246
σ Cas	23	59.0	+55	45	4.9	5.0	7.2	327	3.16			

$\star$: System with note above.