HJ 4217 - Now a Known Unknown

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Abstract: John Herschel's double, HJ 4217, is a 'neglected double' in the WDS where Herschel's observation of 1837.25 is the only record. The SIMBAD data base suggests UCAC2 497073 as the companion but this is not correct, the true companion is UCAC4 061-008434. This misidentification has come about because of the high proper motion of the primary star.

Introduction

During the evening of March 31, 1837 John Herschel (HJ), son of the equally famous William Herschel who discovered the planet Uranus, recorded the discovery of a double star in the constellation Chameleon. Working from his observing site in Feldhausen at Wynberg, Cape Town, between the years 1834 and 1838, HJ made detailed and extensive observations of the southern sky. However, it was not until nearly 10 years later, in 1847, that he had completed the hand reduction of the many thousands of observations and publishing them in his *Results of Astronomical Observations Made During the Years 1834, 1835, 1836, 1837, 1838, at the Cape of Good Hope; Being the Completion of a Telescopic Survey of the Whole Surface of the Visible Heavens, Commenced in 1825*; hereafter referred to as *Observations*.

Better known for its record of southern nebulae, *Observations* also contains a catalogue of around 5500 double stars, most of which were newly discovered by HJ.

The Double Star HJ 4217

As an introduction to a new study of southern doubles, we have undertaken a review of neglected doubles in the Washington Double Star Catalog (WDS, Mason, *et al*., 2012) south of declination -30°. The Herschel pair HJ 4217 is represented in the WDS by only HJ's observations of 1837. It is evident that the reason for the neglect of this double is that its modern appearance does not look anything like the HJ description. Indeed, an observation reported in 1922 'Agrees with Herschel's place but not his description' (Dawson, 1922).

Figure 1 is a reproduction of part of HJ's reduced observations of HJ 4217, taken from Chapter II of *Observations*. HJ reduced his observations to equinox and equator B1830.0. The catalogued North Polar Distance (N.P.D.) corresponds to declination -77° 10' 04". The Position Angle (PA) and distance (ρ) were measured using the Twenty-Foot Reflector in survey mode, in this case on sweep 782 made 1837-3-31 (1837.25). The catalogued PA of 278.9° and separation of 20" is thus for equinox and equator B1830.0 reduced from epoch 1837.25. In the last column HJ identifies this pair as being star 3941 of Lacaille's

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No.	R A. 1830.0. h. m. s.d.	N P D. 1830.0. ° ′ ″	Position.	Dist.	Magnitude.	Remarks.	Synon.	Sweep.
4216	9 23 24.6	159 13 35	335.5	10	10 10′	R A ::	.....	429
——	9 23 28.4	121 10 13	209.9	8	7′ 8	ζ Antliæ; pos 209.7, 210.1, marked as double in B. ? if Δ 78, as his position is 88° 53′.	B. 2515 Δ. 78?	678
4217	9 25 38.2	167 10 4	278.9	20	7 13	.....	L. 3941	782
4218	9 26 5.4	125 37 54	28.9	3	8′ 12	Neat double star.....	.....	787
	8.3	39 25	25.9	4	8 12	.....	.....	541
——	9 26 34-7	74 52 11	82.8	45	7 9	7 *Leonis*	σ. 350	688

Figure 1: John Herschel's Observations for HJ 4217.

1763 *Coelum Australe Stelliferum* (de La Caille, 1763; Henderson, 1847).

As for the accuracy of his observations, in the descriptive prelude to the table of Chapter II, HJ expressed confidence with the precision of the PA but considered the ρ values to be "generally somewhat too small in the closer stars ... and are of course in a very high degree vague and precarious serving little more than general classification". We return to this description below.

It is obvious that the WDS data is taken directly from *Observations*, with the addition of a WDS number (09234-7753), a spectral type for the primary (F9V), a revised magnitude of the primary (7.06), a 'precise' J2000.0 position, and a cross reference to CPD -77 507. The WDS invokes similar proper motions for the two stars.

The SIMBAD data base identifies a magnitude 12.6 star, UCAC2 497073, as the companion. At equinox and epoch J2000, this star is at PA = 317° and ρ = 47.5" relative to the primary, not in good agreement with what HJ observed. Star UCAC2 497073 is Star B in Figure 2 below and Star UCAC4 061-008429 in our Table 2.

In our search for an understanding of HJ 4217 we made reference to the HIPPARCOS Input Catalogue (HIC) (Annex 1 Double and Multiple Stars, Turon, *et al.* 1993). Our understanding is that this catalogue resulted from a revision of bright double stars, demanded by the potential of multiple and moving stellar images to degrade the astrometric precision of the final astrometric catalogue. Their entry for HJ 4217 identifies the pair as HIC 46046, gives accurate (but pre HIPPARCOS) J2000 positions, and records the PA and ρ as 282° and 20.1" respectfully. We assume these values to be HJ's B1830.0 (epoch 1837.25) values precessed to Equinox J2000. The HIC also identifies the primary star as HD 82114 and SAO 256614, and, again, ascribes the same proper motions to both members.

Figure 2 is a 'modern' view of the field. This is a 3.5 x 3.0 arc minute image from the 2MASS J (Skrutskie *et al.*, 2006) survey and is typical of many such images that are available on *Aladdin* (Bonnarel *et al.*, 2000) from various surveys taken over epoch 1970 to 1999. Here the primary star is of the correct brightness (details are in Table 3) but there is no obvious companion at the HJ position. The J images of

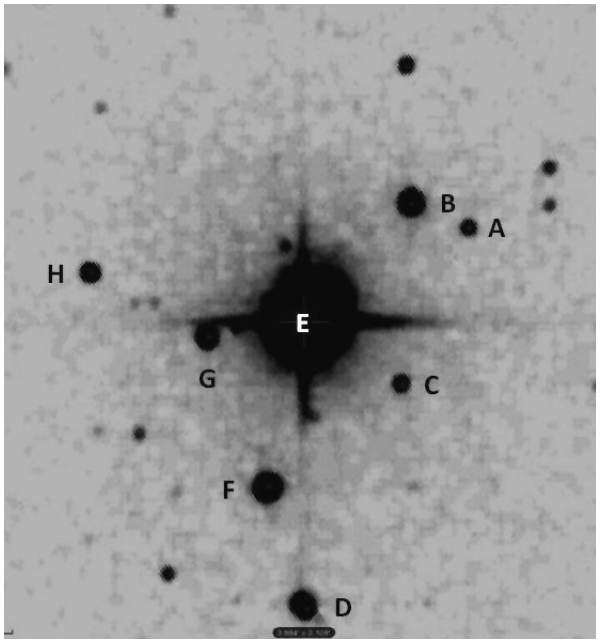

Figure 2: The 2MASS J image of HJ 4217. Stars A to H are catalogued in the UCAC4 and given in Table 2. Some faint objects close to the bright star are Filter Glints. The field is 3.5 arcmin tall and 3.0 arcmin wide. North is up and east is to the left.

Table 1: Astrometric Data for Stars Within 90 arcsec of HJ 4217 Adopted From UCAC4.

Our Label	UCAC4	RA J2000.0	Dec J2000.0	V mag	μ_α mas/yr	μ_δ mas/yr
A	061-008427	09 23 09.046 ± 37 mas	-77 52 58.40 ± 34 mas	-	-23.9 ± 3.9	-17.5 ± 2.8
B	061-008429	09 23 14.579 ± 12 mas	-77 52 50.98 ± 12 mas	12.468 ± 0.02	-39.5 ± 1.2	51.8 ± 1.2
C	061-008431	09 23 15.484 ± 35 mas	-77 53 43.76 ± 37 mas	-	-3.8 ± 4.3	-0.3 ± 4.3
D	061-008432	09 23 24.605 ± 35 mas	-77 54 49.68 ± 45 mas	15.937 ± 0.03	1.3 ± 2.8	10.5 ± 4.9
E HJ 4217	061-008433	09 23 24.809 ± 2 mas	-77 53 25.87 ± 2 mas	8.717 ± 0.01	-251.4 ± 1.0	354.3 ± 1.0
F	061-008434	09 23 28.260 ± 14 mas	-77 54 14.11 ± 22 mas	12.499 ± 0.02	-18.1 ± 1.3	16.6 ± 1.2
G	061-008438	09 23 34.011 ± 16 mas	-77 53 30.09 ± 14 mas	-	55.0 ± 1.5	97.0 ± 1.5
H	061-008441	09 23 45.118 ± 23 mas	-77 53 11.52 ± 22 mas	14.500 ± 0.06	2.7 ± 1.9	0.4 ± 1.9

the 2MASS represent the near infrared (1.25 μm) but approximate the visual appearance. In addition to the obvious stars in this image, there are a small number of star-like artefacts called filter glints (http://irsa.ipac.caltech.edu/applications/2MASS/IM/interactive.html) but we concentrate our discussion here only on the brighter catalogued stars. North is approximately up and east is to the left.

Reduction and Further Discussion

Table 1 lists the UCAC4 stars (Zacharias, *et. al.*, 2012) within ~90 arcsec of the catalogued position of primary of HJ 4217. Here all positions and proper motions are on the FK5 system and are for equinox and equator J2000.0 and epoch 2000.0. We have labelled the stars A to H in Right Ascension order.

Figure 3 is a schematic of the field constructed from the UCAC4 data. The primary is Star E and this figure shows good agreement with the 2MASS image of Figure 2.

Resolution

A clue as to the correct nature of HJ 4217 comes from the fact that it is cross referenced in the SIMBAD data base (http://simbad.u-strasbg.fr/simbad/) as being star 3476 in the LTT catalogue (as well as being listed in 26 other catalogues). The LTT (Luyten Two Tenths (Luyten, 1957)) is a compilation of high proper-motion stars, all of which have proper motions greater than 0.2 arcsec per year.

All stars in the UCAC4 have detectable proper motions, however, the proper motion of the primary HJ 4217, (Star E) is particularly high (μ_α = -251.4 ± 1.0 mas/yr, μ_δ = 354.3 ± 1.0 mas/yr) and larger than the other stars in the field. This is a new consideration as both the WDS and the HIC assume that the proper motion of the secondary star is/will be the same as that of the primary.

To emulate what HJ saw, in Table 2 we have precessed stars A to H from the J2000.0 equinox and

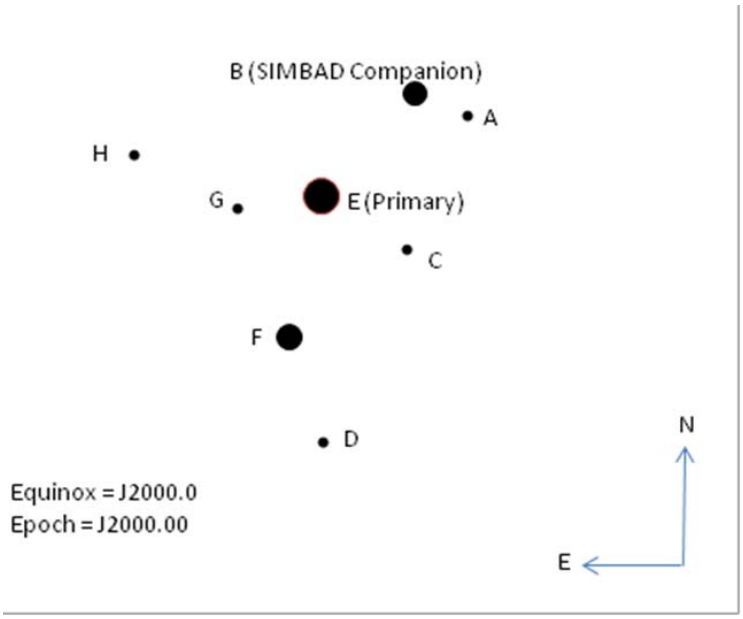

Figure 3: The year 2000 view of the HJ 4217 field based on the accurate UCAC4 data in Table 1. We have used *Polar Plot 2*, an add-in for Microsoft Excel, written by Andy Pope (http://www.andypope.info/charts/polarplot3.htm) to construct Figures 3 and 4.

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Table 2: Positions for the Stars in Table 3 Precessed to Equinox B1830.0 and Epoch 1837.25.

Label	UCAC4	PA (θ°) J2000.0 Epoch 2000.0	Sepⁿ (ρ") J2000.0 Epoch 2000.0	RA B1830.0 Epoch 1837.25	Dec B1830.0 Epoch 1837.25	PA (θ°) B1830.0 Epoch 1837.25	Sepⁿ (ρ″) B1830.0, Epoch B1837.25
A	061-008427	298.98	56.70	09 25 13.03	-77 08 44.3	312.7	123.4
B	061-008429	317.30	47.47	09 25 19.06	-77 08 47.1	318.9	107.4
C	061-008431	238.63	34.37	09 25 18.81	-77 09 31.5	297.1	80.2
D	061-008432	180.44	83.81	09 25 28.13	-77 10 37.8	233.6	50.2
E HJ 4217	061-008433			09 25 40.26 ± 170 mas	-77 10 08.0 ± 170 mas	Primary	Primary
F	061-008434	167.31	49.45	09 25 32.02 ± 210 mas	-77 10 02.5 ± 200 mas	281.3 ± 0.6	28.0 ± 0.3
G	061-008438	98.29	29.26	09 25 33.43	-77 09 31.3	328.2	43.2
H	061-008441	77.34	65.50	09 25 45.96	-77 08 55.1	14.6	75.3

epoch 2000.0 to the equinox B1830.0 and epoch 1837.25 as observed by HJ. Precession was undertaken using the STARLINK web-based precession routine. The simulated 'HJ view' is shown in Figure 4.

Pleasingly, our precessed position for the primary and that of HJ are in exceptional agreement. The differences in RA and declination are an amazing 6.7 and 4.0 arcsec respectively - an indication of the care HJ took in recording his astrometric observations.

More importantly, it can be seen from Figure 4 that HJ's companion was in fact Star F (UCAC4 061-008434) and not star B (UCAC2 497073) as suggested by SIMBAD. Star F is nearest to the primary, and its visual magnitude (12.499) closely matches HJ's recorded 13. This is clearly HJ's double star 4217.

And there is good agreement in PA and ρ. HJ's PA of 278.9° and ρ of 20" are close to our precessed values of 281.3° ± 0.3° and 28.0" ± 0.3" (the formal uncertainties are computed on the uncertainties in the UCAC4 positions and proper motions).

The difference between HJ and us is 2.4° ± 0.3° and 8.0" ± 0.3" in PA and ρ respectively. We are assured of the accuracy of the UCAC4 data and therefore we look at the large-ish discrepancy in the separation. We have examined the distribution of HJ's separations for all southern pairs, and have found there an obvious rounding-off of separation values into multiples of 5 arcsec. Thus we concur that HJ's separation for HJ 4217 is, as above, "somewhat too small ... and a very high degree vague". We offer this as an explanation for the difference between our measured separations.

It is also perhaps appropriate to make a few comments on the magnitudes of the pair. We note that the UCAC4 magnitude is discordant with the other estimates for the primary. The UCAC4 is an astrometric catalogue and is based on CCD images made

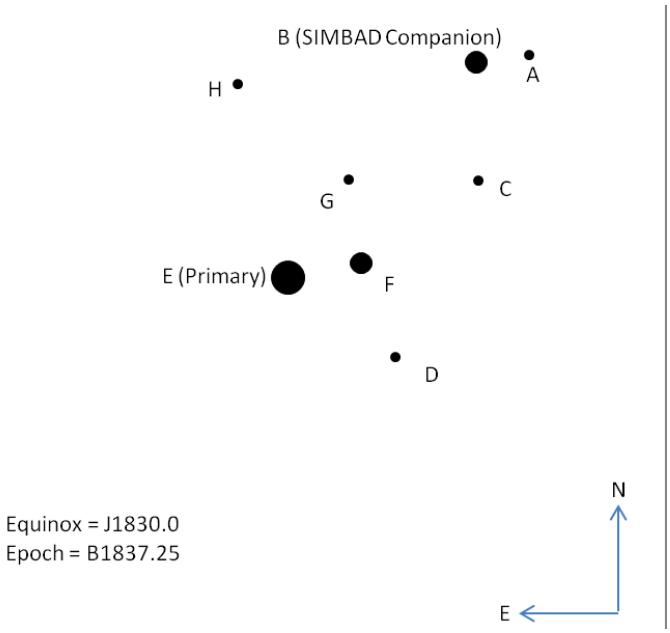

Figure 4: The field of HJ 4217 with the positions precessed to Equinox B1830 and Epoch 1837.25. This approximated what HJ would have seen. The double star is now obvious; being the 7th magnitude primary and our Star F. The PA and ρ are now in agreement with HJ's observations.

on a non-standard photometric scale that is between the V and R. It is, therefore, not consistent with the visual observation by HJ or the SIMBAD V magnitude of 7.06. We have decided to adopt the SIMBAD magnitude estimate for this star and note that this is in good agreement with HJ estimate of 7.

There is also some consideration in *Observations* as to the consistency of HJ's magnitude estimates for fainter stars, where HJ points out a potential bias that may exist between himself and another reputable observer. With no other accurate magnitudes available for the secondary, we are forced to adopt the UCAC4 estimate of 12.5 (12.499) for the companion. This is consistent with HJ's estimate of 13.

Conclusion

HJ 4217 is an unusual double star. Here the 7th magnitude primary has a high proper motion, and the clear double seen by HJ no longer exists due to the movement of the primary by some 67 arcsec relative to the secondary since 1837.25 (to 2000). This movement has lead to the wrong identification of the secondary in SIMBAD and a misrepresentation of the pair in subsequent work. Star UCAC4 061-008434 is the correct companion of HJ 4217 and star UCAC2 497073 (UCAC4 061-008429) is not the companion.

We offer the data given in Table 3 below and recommend an appropriate amendment to the WDS.

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Table 3: Proposed amendment to the WDS.

NAME	RA+DEC	MAGS	PA	SEP	DATE	N	NOTES
HJ 4217	09232-7753	7.1,12.5	167.3	49.5	2000.0	1	1

Note 1
The companion is clearly UCAC4 061-008434, and not UCAC2 497073 (UCAC4 061-008429) as suggested in SIMBAD. Data here is based on the catalogued positions, proper motions and magnitude (of secondary) from the UCAC4 (Zacharias, *et. al.*, 2012). The magnitude of the primary is from SIMBAD.

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