HJ 1853: Old Companion Lost, New Companion Found

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Abstract: The double star HJ 1853 is a neglected double with only one measurement dated in 1905. The large proper motion of the A component allows checking that the pair registered in 1905 was optical. However, inspection of the photographic plates shows a new component which could constitute a physical pair with the A component of the old pair.

A Missing Old Companion

Located in Andromeda, the double star HJ 1853 should be an easy target for small telescopes: according to the *Washington Double Star Catalog* (WDS, Mason *et al.* 2003) it consists of two components of magnitudes 7 and 7.7 separated by 33".2. However, pointing the telescope to the corresponding coordinates (23108 +4531) shows only a seventh magnitude star, with no noticeable companion nearby. Checking the WDS again, we find that this is a pair with only one recorded measure in 1905. The plates of the 2MASS, POSSI and POSSII surveys confirm that the A star is surrounded only by a few faint stars (magnitude 12 and below). As an example, Figure 1 shows the corresponding J plate of the 2MASS survey.

Finding a missing component in the WDS is not always easy, but in this case the catalog provides additional information suggesting a solution: the proper motion of the A component is quite large (-81 mas in RA, -285 mas in DEC), and this could mean that the B component registered originally was an optical companion which is now far away.

Mystery (almost) Solved

Tracing back the position of the star to the year 1905, leads us to an area where, again, there is no star of magnitude 7.7. At this point I asked for help in the binary-stars-uncensored Yahoo group and W.I. Hartkopf kindly browsed the WDS data and found that the 1905 measurement was obtained by S.W. Burnham. The original observations from J. F. W. Herschel were dated in 1828 with PA 265.4º, sep. 15", and mags. 8-9 and 12.

The position of the A star in 1828 was such that there was a 12 magnitude star roughly at the position angle and separation recorded by Herschel. This star is now at PA 325.0 deg., sep. 40".14, mags. 7.07 and 12.3 (see Figure 1). The very small proper motion of the B component implies that it was an optical pair.

Burnham observed the star 77 years after Herschel and, due to the effect of the large proper motion, could not find the companion. Although he suspected that the Herschel measurement corresponded to the A and B star indicated above, he also thought that the double star could be another nearby pair (later designated BU 1528), and the data of this pair (PA: 191 deg, sep: 33".2) ended up as the WDS record for HJ 1835 (Hartkopf, 2008).

This explains most of the story, although some details are not completely clear, as the origin of the magnitude attributed to the B component, 7.7, which is mentioned neither by Herschel nor by Burnham.

The New Companion

Using the RGB facility of Aladin (Bonnarel, 2000) for color composition, I observed the large proper motion of the A star combining the plate of the POSSI

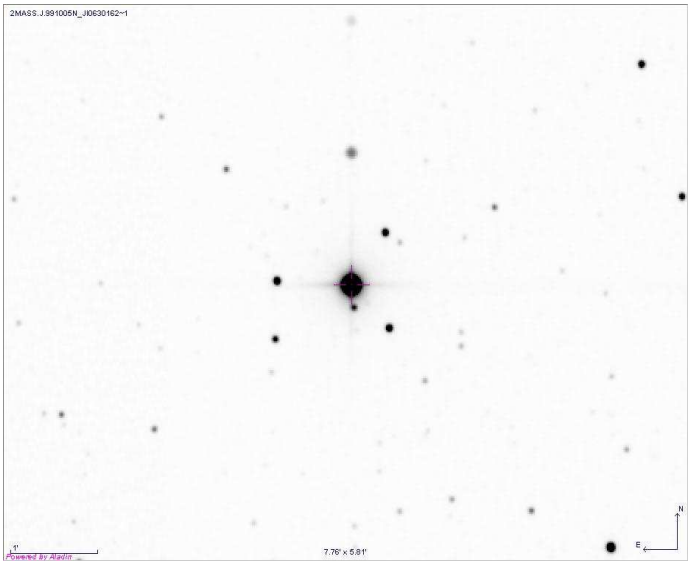

Figure 1: Photographic J plate of HJ 1853 from the 2MASS survey with zoom 2x in Aladin. The A component is the brightest star. The star pointed by the arrow corresponds to the B component observed by Herschel.

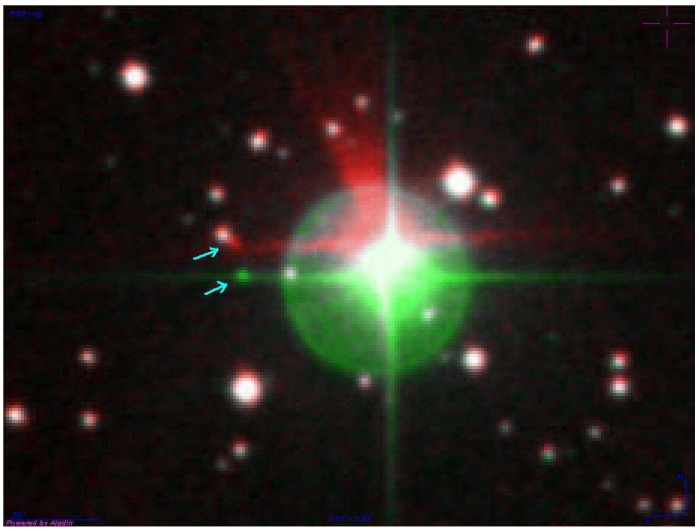

Figure 2: Color composition in Aladin of two plates from 1953 (red) and 1993 (green). Zoom 4x. The positions of the new component C are pointed by arrows.

survey (year 1953) in the red channel and one of the plates of the POSSII survey (year 1993) in the green channel. The result can be seen in Figure 2. The stars with small proper motion appear almost white, while the large proper motion stars as HJ 1853 A show two different images, one in red and another one in green.

Apart from the movement of the A component, the image shows that another star seems to be moving at the same pace as A. It is a new component not known before, which will be denoted by C in the rest of this paper. A rough measurement using the dist feature of Aladin shows that the C component is at about 90 degrees and about 50" from the primary.

Table 1 shows the proper motion data for both stars at the USNO-B1.0 catalog (Monet et al., 2003). The numbers after the ± symbol represent the mean error of the measure. Using these data we can check the Halbwachs (Halbwachs, 1983) selection criteria for distinguishing physical and optical pairs from its proper motion:

(1) $(\mu 1 - \mu 2)\ 2 < -2\ (\sigma 12 + \sigma 22)\ \ln(0.05)$

(2) $\mu \geq 50 \times 10^{-3}$ "/yr

(3) (3) $\rho/\mu < 1000$ yr

With μ1, μ2 the two proper motion vectors, σi, the mean error of the projections on the coordinate axes of μi, μ the smaller proper motion vector module between μ1 and μ2, and ρ the angular separation of the two stars. In the A-C system the three criteria hold, indicating that the two stars are probably physically attached.

USNO-B1.0	HJ 1853 A	HJ 1853 C
Id.	1355-0521782	1355-0521821
Epoch	2000.0	1992.3
pm RA	-86 ± 0	-50 ± 14
pm DE	-288 ± 0	-322 ± 75

Table 1: Proper motion data for HJ 1853 A-C

Old and New Measurements of the HJ 1853 A-C System

In order to obtain more precise data for the separation and position angle, it is convenient to look for the coordinates of both components in the available catalogs and also to obtain new images if possible. Unfortunately, the C component is not in the UCAC2 catalog (Zacharias *et al.*, 2004), and the data for the two stars in the other catalogs such as the USNO-B1 correspond to different epochs. An exception is the 2MASS catalog, where both stars can be found with measurements corresponding to the same date (1999-10-05). The first row of Table 2 show the data obtained from the coordinates in this catalog.

This measurement was complemented by images taken by the author on July, 3, 6, and 7, 2008. The reduction phase relied on the program Astrometrica (Raab, 2008) using the catalog UCAC-2, following the

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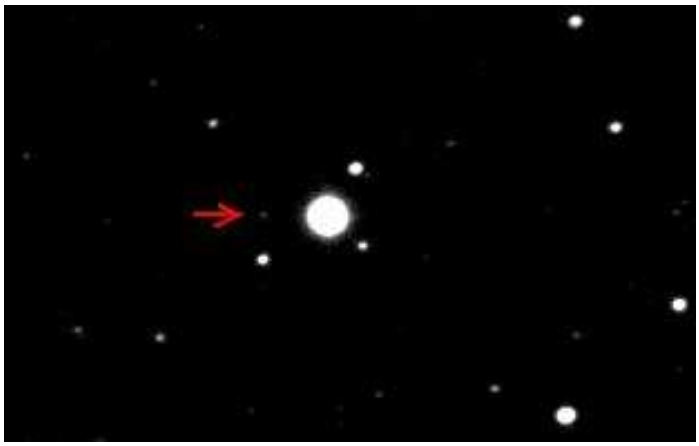

Figure 3: Image of the AC system with a DSIPro camera in a 4" refractor. The C component is pointed by an arrow.

next procedure:

- First every individual image was reduced using Astrometrica.
- All the images with residuals greater than 0.11" (either in Dec or in RA) were discarded.
- The rest of the images were stacked and reduced by Astrometrica to obtain the data.

The values of the second row of Table 2 show the result. However it must be mentioned that these results are unusually imprecise, with a standard deviation of 0.22 in the separation and of 0.37 in the PA w.r.t. the set of individual images. These deviations are the result of the large difference in stellar magnitude of the two components which can be observed in the image of Figure 3. In particular, the component C is too faint and this makes the reduction less reliable, while the relatively bright primary appears overexposed, which makes calculating the centroid an imprecise task.

Therefore, more reliable measurements of this pair would be useful, perhaps following specific techniques for high delta m doubles such as those described in (Daley, 2007). Also the photometry of C in Table 2 must be considered preliminary since C's visual magnitude cannot be found in the catalogs, and no V filter was used in the author's images. In order to improve the photometry, the images were calibrated with respect to other stars with known visual magnitude. After the calibration a test over another ten stars in the image with similar characteristics (visual mag. between 13 and 16, blue mag.- red mag. > 0) presented a maximum absolute error of 0.4 mags.

Physical Characteristics of the AC System

The A component has a mass of 0.9 solar masses (Allende Prieto, 1999) and with a MK spectral type of G8 V (Gray *et al.*, 2003). Located at only 23.45 parsecs (76.5 light years) from the Sun, it is in the *25pc sample of sun-like stars* catalog (Grether, 2006), but without indicating any known companion, confirming that C had not been noticed up to now. If we assume that C is also at 23.45 parsecs we have that both stars are separated by at least about 1172 AU, and hence probably the pair has a very long period. Finally, combining the distance d=23.45 with the estimated apparent magnitude m=15.25 by means of the formula $M = m + 5 - 5\ Log\ d$, an absolute magnitude M for C of approximately 13.40 is obtained. This visual magnitude corresponds in the HR-diagram either to a white or to a red dwarf, but the B, R magnitudes in the NOMAD catalog are 17.52 and 13.86 respectively and the strong predominance of the red magnitude indicates that C is likely a red dwarf.

Conclusions

The main contribution of this paper is the (serendipitous) discovery of a new possibly physical

Name	RA+DEC	Mags	PA	Sep	Date	N	Notes
HJ1853AC	23108+4531	7.00	87.03	50.31	1999.760	-	1
HJ1853AC	23108+4531	7.00, 15.25	86.82	49.79	2008.506	3	2

Table 2: Measures of the HJ 1853 A-C pair

Table Notes

1. Note 1: Obtained from the coordinates in the 2MASS catalog.
2. Note 2: Images taken with a DSI Pro camera and a refractor ED 100mm/900mm.

binary star formed by HJ 1853 A and a new component C. Some initial measurements of the pair are given, although the high magnitude difference influences the reliability of the author's measurements. From an amateur point of view this paper shows that even novice observers with modest equipment can obtain some results in this field, in particular thanks to the impressive set of resources (catalogs, plates) available on the internet.

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My thanks to Dr. William I. Hartkopf, U. S. Naval Observatory, who taught me the basics of chasing missing doubles in the catalogs, and to Francisco Rica for his invaluable help. In this research I made use of the ALADIN Interactive Sky Atlas and of the VizieR database of astronomical catalogs, all maintained at the Centre de Données Astronomiques, Strasbourg, France. This publication makes use of data products from the Two Micron All Sky Survey, which is a joint project of the University of Massachusetts and the Infrared Processing and Analysis Center/California Institute of Technology, funded by the National Aeronautics and Space Administration and the National Science Foundation.

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When he was a child, Mr. Caballero wanted to be an astronomer. However, his parents thought that computers were more useful for his future so, instead of a telescope, he got a computer for Christmas. Now he works in the field of computer science during the day, but still dreams of being an astronomer while watching the stars at night.