Observational Results of LIADA for 2003: Binary Stars Detected

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Abstract: LIADA's (Iberoamerica League of Astronomy) Double Star Section studied 103 neglected visual double stars during 2003. BVIJHK photometries, astrometric and kinematical data were used/ obtained to determine their nature using several criteria and classifying them as optical, physical or common origin pairs. Only 12 % were physical double stars or common origin pairs, i.e. binaries. Their angular separations range from 4.01" to 47.89". In this work I comment in detail on these binaries and determine their expected semimajor axis and orbital period.

Introduction

Nowadays the nature of many double and multiple stellar systems remain unknown and probably several tens of thousands of stellar systems could be optical. This situation hampers a better understanding of the formation of stars and stellar systems. One of the main goals of LIADA's Double Star Section is to determine the nature of visual double stars. BVIJHK photometries, astrometric and kinematical data were used/obtained to determine their nature using several criteria classifying them as optical, physical or common origin pairs. In 2003 we studied 103 neglected visual double stars. Only 12 % were physical double stars (i.e. with components orbiting each other around the center of mass) or common origin pairs (i.e. stars that have born together, travel with the same velocity and direction at the same distance from us, but they don't orbit each other). In this article I will name these two types of double stars as binaries. The angular separation for these binaries range from 4.01" to 47.89". In this work I will describe them in detail and determine their expected semimajor axis and orbital periods.

Notes about wide binaries detected in 2003

In what follows I comment on the results for each binary under a heading that includes its name and WDS identifier, the position angle and angular separation, the epoch, magnitudes and spectral types. Figures 1-6 show parts of photographic plates from Digitized Sky Surveys where the physical pairs are located. Table 1 shows orbital data for the physical pairs studied. The projected separation (in A.U.), the expected semiaxis major (in A.U.), the orbital period (in years) and the relative motion (in mas/yr) for the system are listed. The details about the process to estimate spectral types and luminosity classes for the members, the nature for the stellar systems, the expected semiaxis major and the orbital period were explained in detail in Rica (2005).

HJ 2075 (WDS 01487+7528): [230.7º and 30.67" (2003.074); 9m98 (G8V) and 11m29 (K6V)]

This system (shown in Figure 1) is composed of two stars with 9.98 ± 0.03 and 11.29 ± 0.09 magnitudes (Tycho-2, Hog et al. 2000). This pair has 6 measures and was discovered by John Herschel (1833) in 1831 (229º8 and 20") and the last in 1999 (230º8 and 30.73").

The annual proper motion for the primary component is μ(a) = +0.142 ± 0.002" and μ(d)= -0.047 ± 0.002" and for the companion μ(a) = +0.143 ± 0.002" and μ(d)= -0.043 ± 0.002". HJ 2075 is a common proper motion pair.

According to the spectral distribution of energy in BVJHK bands and the kinematical data (reduced proper motion) of the components, HJ 2075 is composed of G7/8V and K6V stars. According to several

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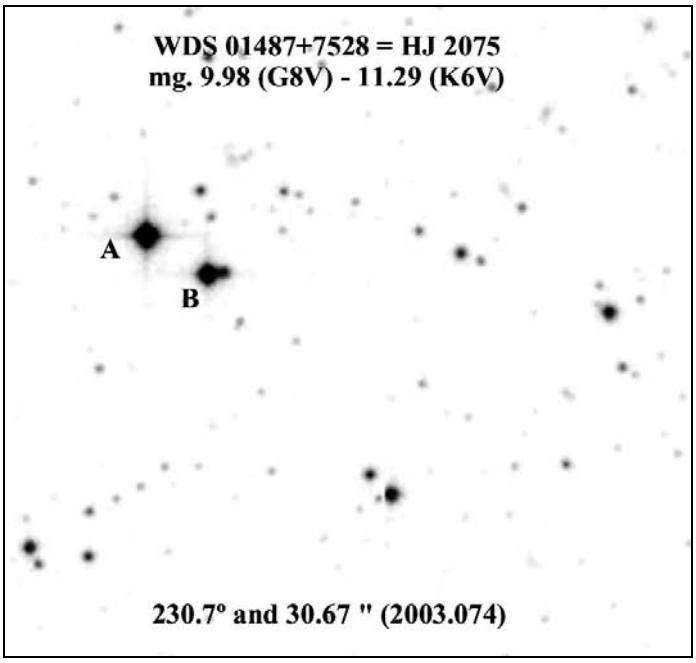

Figure 1: Digitized Sky Survey image of WDS 01487+7528.

criteria HJ 2075 is surely a physical double star.

LDS 9084 (= WDS 00023+0732): [127.9º and 15.25" (1991.699); 18m1 and 18m2]

This double star was discovered by Luyten (1962) with a separation of 15" in direction 128º. The year of the discovery is not listed in the WDS catalog. According to the WDS catalog (Mason, Wycoff, & Hartkopf 2003), it is composed of two stars with 18.1 and 18.2 magnitudes. The last measurement was performed in 1992 (Jaworski 2006), 127.8º and 14.8" .

The annual proper motion for the primary component is $\mu(\alpha)$ = -0.106" and $\mu(\delta)$= -0.060"; for the secondary it is $\mu(\alpha)$ = -0.108" and $\mu(\delta)$= -0.060". Using the USNO-B1.0 proper motions, the relative proper motion was calculated: $\mu(\alpha)$ = +2 mas. So, LDS 9084 is a common proper motion pair. If the Jim Jones measures are used then the relative motion is 10 m.a.s. which seems too large. The 1955 measure performed by Jim Jones, in the LIADA group, using DSS plates must be confirmed.

We could not obtain more astrophysical properties due to the lack of photometric data.

HJ 435 (= WDS 08020+2532): [284.5º and 12.86" (2003.364); 10m8 (F3/4) and 11m2 (F4)]

This double star was discovered by John Herschel (1829) in 1820 (θ = 295º and ρ = 12" with magnitudes of 11.1 and 11.1). It is composed of two stars with magnitudes of 10.84 and 11.24 (Tycho-2). WDS lists 6 measures performed between 1820 and 2000.

The annual proper motion for primary component (from Tycho-2) is $\mu(\alpha)$ = +0.005" and $\mu(\delta)$ = +0.002"; for the secondary is $\mu(\alpha)$ = +0.006" and $\mu(\delta)$ = +0.003". Using the measures made by LIADA, in addition to the historical data from WDS which cover 105 years, we calculated the relative proper motion for this system: $\mu(\alpha)$ = -2.0 mas.* yr^{-1} and $\mu(\delta)$ = -2.0 mas. * yr^{-1}.

According to the spectral distribution of energy in BVJHK bands and the kinematical data, HJ 435 is composed of F3/4 and F4 stars (if they belong to the main sequence). Astrometric and photometric data suggest that there are possibilities that both components be giant stars.

The kinematics is very similar for both members and the photometric distances for both components could be the same, within the error margins. If we take into account several criteria used by us, this system HJ 435 likely is a common origin pair.

LDS 201 AB (= WDS 08039-3133): [236.9º and 47.89" (2000.236); 8m73 (G4V) and 9m64 (G6V)]

This double star was discovered by Luyten (1941). It is a common proper motion pair found by comparison of Bruce proper motion plates. First and second plates epochs were 1898-1904 and 1928-1936, so a "default" mean date of 1920 was assigned to all measures.

It is composed of two stars with magnitudes of 8.73 and 9.64 (Tycho-2). WDS lists 7 new measures performed between 1911 (237º and 47.7") and 2000 (236.5º and 47.86").

The annual proper motion for the primary component (from Tycho-2) is $\mu(\alpha)$ = -0.074" and $\mu(\delta)$ = +0.149"; for the secondary is $\mu(\alpha)$ = -0.073" and $\mu(\delta)$ = -0.146". Using the measures made by LIADA in addition to the historical data from WDS, which cover 89 years, we calculated the relative proper motion for this system: $\mu(\alpha)$ = +2.0 mas.* yr^{-1} and $\mu(\delta)$ = -7.0 mas. * yr^{-1}. So this system is a common proper motion pair.

According to the spectral distribution of energy in BVJHK bands and the kinematical data, LDS 201 AB is composed of a primary G4V (in good agreement with the G3V spectral type from literature) and a

secondary G6V.

The HIPPARCOS (ESA 1997) obtained trigonometric parallaxes for the components corresponding to 79 and 75 pc. We obtained a photometric distance of 71 pc for the primary. The HIPPARCOS absolute magnitude for the primary is 0.8 magnitudes brighter for its spectral type so LDS 201 A could be an unresolved pair composed of stars of similar magnitudes.

The kinematics are very similar for both members and the photometric distances for both components could be the same (if the primary was a binary star). According to several criteria used by our group this system it is not a bounded system and then we can conclude that LDS 201 AB surely is a common origin pair.

B 2164 CD (= WDS 08039-3133): [58.9º and 4.01" (2000.236)]; 10m9 (B9) and 11m5 (A4V)]

This double star discovered by van den Bos (reference unpublished, manuscript or reference not found) in 1828. It is composed of two stars with magnitudes of 10.9 and 11.5 (inferred by JHK photometry). WDS lists four measures performed between 1913 and 1983. θ and ρ seems not to change during 87 years.

The annual proper motion for primary component (from Tycho-2) is $\mu(\alpha)$ = -0.002" and $\mu(\delta)$ = +0.002". Using the measures made by LIADA in addition to the historical data from WDS, which cover 87 years, we calculated the relative proper motion for this system: $\mu(\alpha) = 0.0$ mas * yr^{-1} and $\mu(\delta) = -2.0$ mas * yr^{-1}.

According to the spectral distribution of energy in BVJHK bands and the kinematical data, B 2164 CD is composed of B9 and A3.5V stars located at about 900 and 1200 pc.

According to several criteria that tested the binarity of this system we can conclude that B 2164 CD likely is a common origin pair.

ES 2569 (= WDS 18107+3903): [274.0º and 9.77" (1989.505); 11m0 (F6) and 12m6 (G8)]

ES 2569 (see Figure 2) is composed of two stars with magnitudes of 11.04±0.11 (Tycho-2) and 12.5. The V magnitude for the secondary was inferred using 2MASS JHK photometry (Cutri et al. 2000). No information about proper motion was found in the literature. Using the measures made by LIADA, in addition to the historical data from WDS, we calculated the relative proper motion for this system: $\mu(\alpha)$ = 4.0 mas* yr^{-1} and $\mu(\delta) = 0.0$ mas * yr^{-1}.

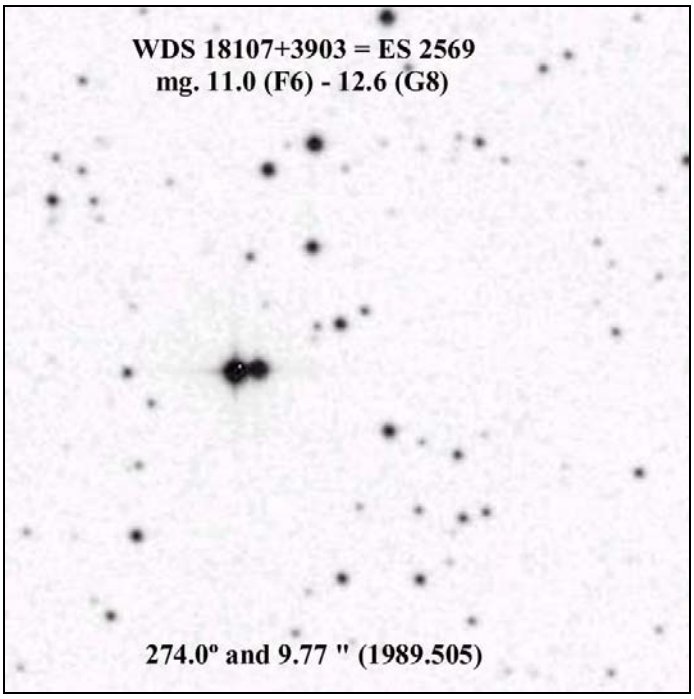

Figure 2: Digitized Sky Survey image of WDS 18107+3903.

According to the spectral distribution of energy in BVJHK bands and the kinematical data, this pair is composed of F6 and G8 stars (if they are on the main sequence). It is likely that both components could be at the same distance.

According to several criteria that tested the binarity of this system we can conclude that this pair could be a physical pair.

LDS 624 (= WDS 18091-6154): [269.7º and 19.30" (2000.512); 15m3 (K7VI) and 15m7 (K8VI)]

LDS 624 is composed of two stars with magnitudes of 15.3 and 15.7. The V magnitude for the secondary was inferred using GSC-II B and R photometry (Morrison et al. 2001). This double star was discovered by Luyten (1941). It is a common proper motion pair found by comparison of Bruce proper motion plates. The first and second plates' epochs were 1898-1904 and 1928-1936, so a "default" mean date of 1920 was assigned to all measures. WDS lists only 2 measures, the last one in 2000. We think that the magnitudes listed are blue sensitive.

The component that Luyten observed, like the

brightest one, is really about 0.3/0.5 magnitudes weaker in BVRIJHK photometric bands. We reversed the quadrant listed in the literature. According to the measures performed by LIADA since 1975, θ is fixed and ρ seems to increase about 0.3".

The annual proper motion for the system, from "*LDS Catalogue: Doubles with Common Proper Motion"* (Luyten 1940-1987), is μ(α) = -0.158" and μ(δ)= -0.064". Proper motions for the individual components were not known in the literature, so we decided to determine them using Digitized Sky Survey (hereafter DSS) photographic plates. The result was a proper motion for the primary of μ(α) = -0.184" and μ(δ) = -0.054" and for the secondary of μ(α) = -0.184" and μ(δ) = -0.043". Using the measures made by LIADA, which cover 25 years, the relative proper motion was μ(α) = +13 mas* yr^{-1} and μ(δ) = +1 mas * yr^{-1}.

The spectral types were obtained from the spectral distribution of energy in BVIJHK bands and the kinematical data (reduced proper motion) of the components. We are not completely sure about the luminosity class of both components, but likely this pair is composed of two subdwarfs of K7VI and K8VI spectral types. The photometric distance of both components is about 275 pc.

According to several criteria, LDS 624 is surely a common origin pair.

The accurate coordinates for LDS 624 listed in WDS catalog identify a primary component of a pair composed by weak stars separated by 32" in direction of 100º. But the small proper motion for both components don't match the high proper motion listed in the WDS for the primary (-158 and -64 mas*yr^{-1}).

The true high common proper motion pair is located at 35.5 arcsecs east of the WDS accurate position. See Figure 3.

The corrected position from 2MASS for 1999 epoch is RA: 18h 09m 05.34s and Dec: -61º 54' 14.5". Due to the large motion of both components they have moved about 1.2 arcsecs from 1999 to 2007.

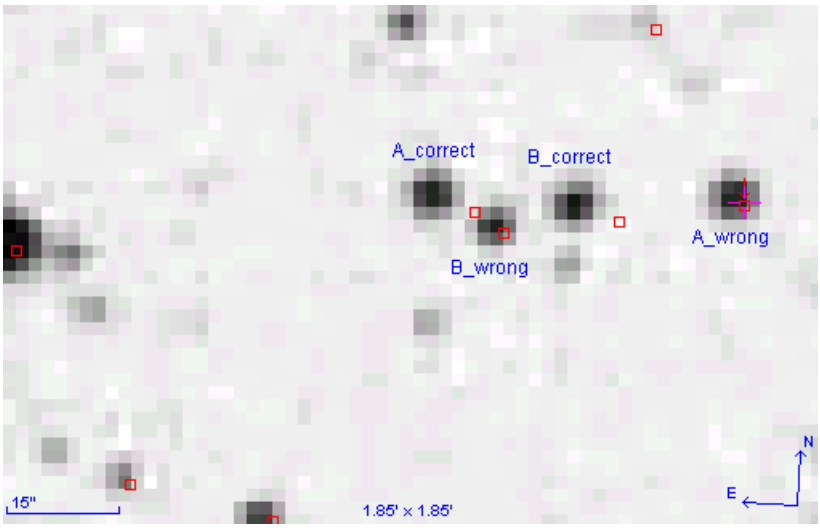

Figure 3.- Photographic plate taken in 1975.659 (DSS). LDS 629 components are marked by *A_correct* and *B_correct* labels. Red square are 2MASS position for 1999 which show the motion for both component in direction SW.

LDS 735 (= WDS 21141-5428): [61.2º and 15.30" (1999.852); 12m3 (K9V) and 13m2 (M1V)]

This system (shown in Figure 4) is composed of two stars with magnitudes of 12.3 and 13.2 (inferred from 2MASS JHK photometry). It was discovered by Luyten (1941). It is a common proper motion pair found by comparison of Bruce proper motion plates. First and second plates epochs were 1898-1904 and 1928-1936, so a "default" mean date of 1920 was assigned to all measures. WDS lists only two measures, the last one in 1958. We think that the magnitudes listed are blue sensitive.

The annual proper motion for the primary is μ(α) = -0.203" and μ(δ) = +0.020". The motion for the secondary is μ(α) = -0.202" and μ(δ) = +0.016". The secondary proper motion was calculated from the relative motion of the secondary to a near star with known proper motion, while the primary proper motion was calculated from the relative motion of LDS 735 and the secondary proper motion previously calculated. Using 9 measures made by LIADA which cover 24 years, the relative motion of the system was determined: μ(α) = -1 mas* yr^{-1} and μ(δ) = +4 mas * yr^{-1}.

According to the spectral distribution of energy in BVIJHK bands and the kinematical data (reduced proper motion) of the components the spectral types were obtained. LDS 735 is composed by K9V and M0.5V stars.

The Halbwachs' criterion determined that the probability to be physical is about 95%. The photometric distance of both components (55 pc) are very similar. According to other several criteria, LDS 735 is surely a physical pair.

The projected separation is 840 A.U. and the expected semiaxis major is of 21.4". The orbital period is about 42,000 years (assuming circular and face-on orbit).

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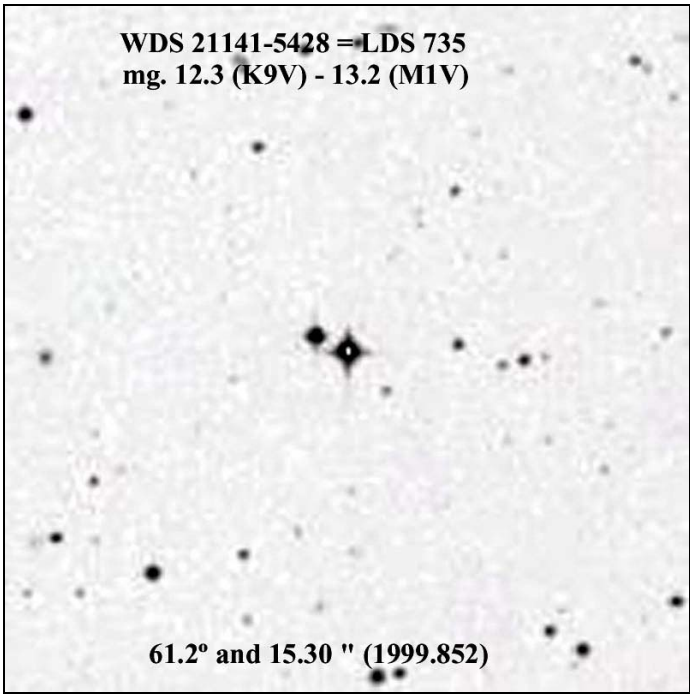

Figure 4: Digitized Sky Survey image of WDS 21141-5428.

This system seems to have an erroneous identification in WDS catalog. The WDS identification is located 10.5 minutes of arc west of the correct position while the accurate WDS position is at 15 minutes of arc. So an update of the accurate coordinate for this binary must be done in WDS catalog. The position of LDS 735 is 21h 12m 55.12s and –54º 28' 14.3".

HJ 1637 (= WDS 21226+3158): [104.0º and 13.55" (1998.461); 8m63 (F6V) and 12m0 (K3V)]

This double star (Figure 5) was discovered by John Herschel (1826) in 1828 (106º and 8" with magnitudes of 8.7 and 11.7). How can it be measured in 1828 and published in 1826? I think that there is an error in WDS database. It is composed of two stars with magnitudes of 8.63 (Tycho-2) and 12.0 (inferred by JHK photometry). WDS lists 4 measures, the last one performed by James Daley (2004) in 2003 (103.2º and 13.29"). Since 1910, θ has decreased one degree and ρ has increased about 0.2". James Daley (2004) found a weak companion of 14.4 magnitude at a separation of 8.52" in direction 142.9º. The new pair AC was named DAL 15 AC.

The annual proper motion for primary component (from Tycho-2) is μ(α) = +0.011" and μ(δ) = -0.038"; for the secondary is μ(α) = +0.015" and μ(δ) = -0.040" (from UCAC-2, Zacharias et al. 2004). Using the measures made by LIADA, which cover 93 years, we calculated the relative proper motion for this system: $\mu(\alpha) = +4.0$ mas* yr^{-1} and $\mu(\delta) = +2.0$ mas * yr^{-1}.

According to the spectral distribution of energy in BVJHK bands and the kinematical data, the primary is surely a dwarf F6V, in good agreement with literature which lists F5. The secondary is a K3V star.

The kinematics is very similar for both members

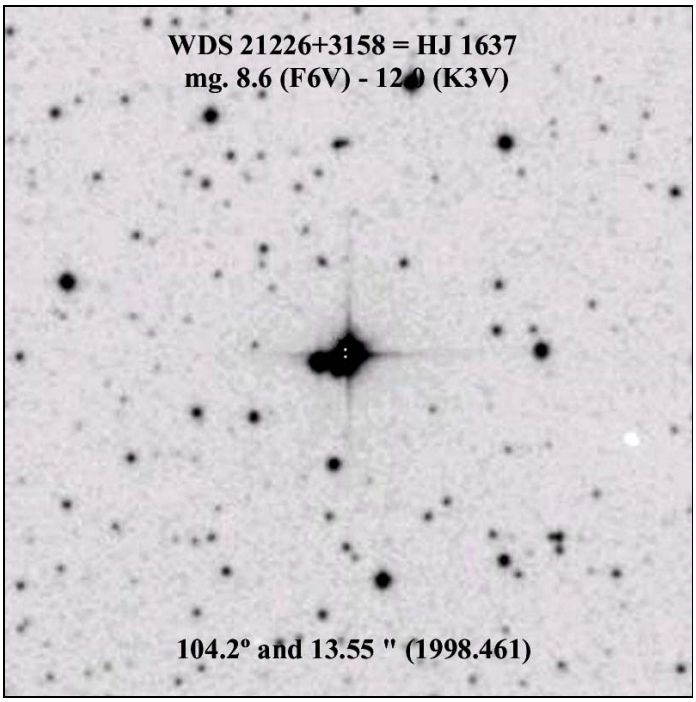

Figure 5: Digitized Sky Survey image of WDS 21226+3158.

and the photometric distances for both components could be the same (111 and 115 pc), within the error margin. The modified Halbwachs' criterion indicates a probability to be physical of 76 %. If we take into account the other criteria we used, HJ 1637 likely is a physical pair.

The projected separation is 1,485 A.U. and the expected semiaxis major is of 18.4". The orbital period is about 67,000 years (assuming a circular and face-on orbit).

HJ 3036 (= WDS 21337-1444): [91.7º and 6.04" (1999.412); 12m1 (K3V) and 12m1 (K3V)]

This double star was discovered by John Herschel

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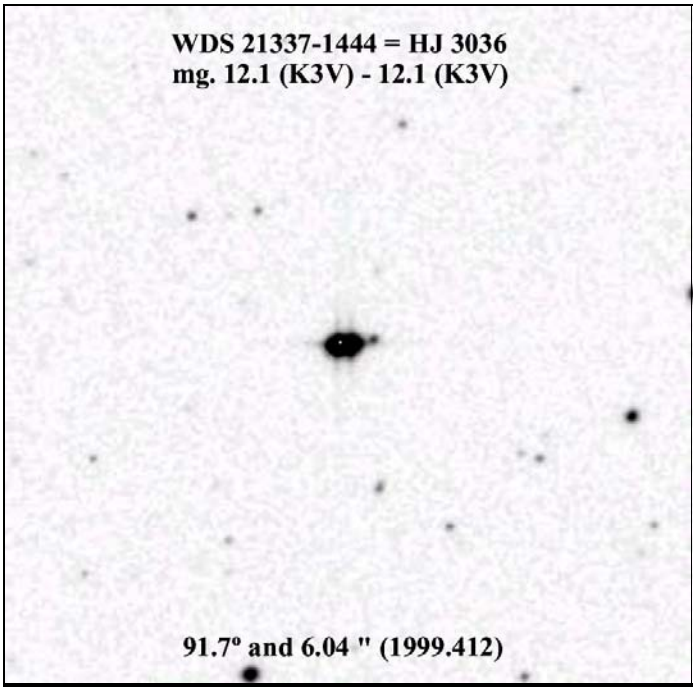

Figure 6: Digitized Sky Survey image of WDS 21337-1444

(1833) in 1830 (90º and 2" with magnitudes of 11 and 11). It is shown in Figure 6. It has been measured two times more, the last one performed by Mason (2001) at 2001.7875 (91.3º and 5.85") using speckle interferometry. It is composed of two stars with magnitudes of 12.1 and 12.1. Since 1905 θ has increased one degree and ρ didn't change significantly.

The annual proper motion for primary component (from Tycho-2) is $\mu(\alpha)$ = +0.064" and $\mu(\delta)$ = -0.011"; for the secondary is $\mu(\alpha)$ = +0.065" and $\mu(\delta)$ = -0.013". The secondary proper motion was calculated from AC2000 (Urban et al. 1998) and 2MASS astrometry for 1905.604 and 1999.412 epochs. Using the measures made by LIADA in addition to the WDS historical measures, which cover 99 years, we calculated the relative proper motion for this system: $\mu(\alpha)$ = -0.4 mas* yr^{-1} and $\mu(\delta)$ = -0.9 mas * yr^{-1}.

According to the spectral distribution of energy in BVJHK bands and the kinematical data, the components are K3V stars located at 115 pc.

According to several criteria used, this pair is likely a physical pair. The projected separation is 672 A.U. and the expected semimajor axis is 8.2" (940 A. U.). The orbital period is about 25,000 years (assuming circular and face-on orbit).

A near star with K magnitude of 14.06 located at 21h33m37s96 and -14º45'49"9 was studied. The J, H and K photometry were consistent with a M5.0/5.5V star at a distance of 107 pc. The distance is very similar with that of the stellar system but the very different proper motion of this third companion suggests that it not related to the system.

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This publication has made use of the Washington Double Star Catalog, UCAC2 and USNO-B1.0 maintained at the U.S. Naval Observatory.

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TABLE I. PHYSICAL PAIRS ORBITAL DATA

WDS identifier	Desig.	θ, ρ (epoch)	mag. spT.	E(a) (A.U.)	Period (yrs)	$\Delta\mu_x$ (mas*yr^{-1})	$\Delta\mu_y$ (mas*yr^{-1})
01487+7528	HJ 2075	230.7 - 30.67 (2003.074)	9.98 – 11.29 G8V – K6V	2,510	106,000	+1	+4
18107+3903	ES 2569	274.0 - 9.77 (1989.505)	11.0 – 12.6 F6 – G8	3,374	139,000	+4	0
21141-5428	LDS 735	61.2 – 15.30 (1999.852)	12.3 – 13.2 K9V – M1V	1,177	42,000	-1.3	+4.1
21226+3158	HJ 1637	104.2 – 13.55 (1998.461)	8.63 – 12.0 F6V – K3V	2,113	67,000	+3	+2
21337-1444	HJ 3036	91.7 – 6.04 (1999.412)	12.1 – 12.1 K3V – K3V	940	25,000	-0.4	-0.9

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