Double Stars Studied by LIADA in 2002

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Abstract: In this article we report the observational results of LIADA's Double Star Section in 2002. BVIJHK photometric, astrometric and kinematic data were studied for 67 visual double stars to obtain astrophysical data (spectral types, photometric distances, etc) and their nature, classifying them as optical, physical or common origin pairs.

Introduction

LIADA's Double Star Section reports 367 individual relative measurements averaged into 135 mean positions for 67 visual double stars. The angular separation ranges from 4.6" to 114.5". The mean internal errors were 0.2° and 0.09". CCD cameras, micrometric eyepieces, DSS (Digitalized Sky Survey) and 2MASS (Two Micron All Sky Survey) images were used. These measurements, in addition to BVIJHK optical-to-infrared photometric data (from Tycho-2 and 2MASS), and historical relative astrometry (from WDS), allowed us to obtain spectral types, photometric parallaxes, relative motion and other astrophysical data to classify visual double stars as physical (11%), common origin (6%), or optical (74%). We used several professional criteria to make the classification.

Spectral types were estimated using professional spectral-type relations and several professional reduced proper motion diagrams. Preliminary study results in a mean difference of only 0.5 subclasses of spectral type with respect to professional results.

In Romero (2005) we reported a new binary discovered by LIADA (GSC 1753-1506: [294.4° and 4.62" (1997.831); magnitude 12.0 (G9V) and 13.5 (K5V)]) with a crude period of 35,000 years.

Of the 67 double stars measured, 47 of them have been confirmed. A double star is confirmed when an observer made the second historical measure. Some have remained unconfirmed for quite a while, including many discoveries of John Herschel from 1820 and 1830. Five unconfirmed double stars could not be identified. Table I lists those double stars not identified using photographic surveys and astronomical catalogs using Guice 8.0 and Aladin from CDS.

Relative Astrometry

The relative astrometry measurements were made using CCD cameras, micrometric eyepieces, Digitized Sky Survey plates (DSS) and Two Micron All Sky Survey CCD images (2MASS). Guide 6.0/7.0, Astrometrica for Windows and FitsView software were used for documentation and astrometry.

Observational data are shown in Table 2. In the first and second columns, the WDS identifier and discoverer code with their sequential numbers are listed; in the following columns, from left to right, the V magnitude of primary and secondary is listed (if the magnitude listed has two decimal numbers these came from Tycho-2 or else they came from calibrated GSC-I photometry); the spectral type and luminosity class in column (5) and (6); the epoch of the last relative astrometry made by LIADA in column (7); the position angle and the angular separation for the epoch of the measure in columns (8) and (9); the number of measurements in column (10); the observer code as follow: FMR = Francisco Rica -- Astronomical Society of Mérida --, ARU, --, Alejandro Russo, amateur from Argentina--, JRY, John Ryan -- "Spirit of 33"; amateur from Spain-- and BVD -- Rafael Benavides -- Astronomical Society of Córdoba (Spain)) in column (11); the observation methods are listed in the next column (CCD: CCD camera; MCG: MicroGuide eyepiece; 2MASS: 2MASS project images; DSS: Digitized Sky Survey; AC2000: Astrographics Catalogue 2000).

In column (12) the nature of the double star code is as follow: PHY = Physical; OPT = Optical; CO = Common Origin; "¿?" = unknown; "--" = nature not studied. A "?" character means that the nature listed is not con-

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(1) WDS No.	(2) Designation	(3) Mag. A	(4) Mag. B	(5) Epoch	(6) ρ	(7) θ
03064+3153	HJ 5456	9.0	11.0	1823	14.0	300
05301+5327	HJ 2263	11.0	11.0	1830	4.0	311
05514+3535	HJ 710	10.0	10.0	1820	10.0	335
03503-0011	HJ 667 AC	10.5	18.0	1820	15.0	300
04429-0629	HJ 26	9.0	11.0	1820	10.0	305

Table 1: Non-Identified, Uncomfirmed Double Stars

firmed. In the last column the confirmed double stars show a "C" letter; a number indicates the years since the last measure. "#" character followed by a number refers to a note number.

Spectral Types and luminosity classes estimates.

In column (5) and (6) of Table II are listed, for both components, the spectral types and luminosity classes estimated by the LIADA group. When the luminosity class is unknown, then the spectral type matches with the main sequence dwarf is listed.

To estimate the spectral type and luminosity class for a star the following data is used:

- Photometric data: B, V and I optical photometry from Hipparcos and Tycho-2 catalogs and J, H and K infrared photometry from Two Micron All Sky Survey (2MASS).
- Kinematical data: Proper motions of the components with their errors are taken from Tycho-2, UCAC2 or USNO-B1.0 catalogs.

Photometric data were transformed to the spectral type and, when the stars are very red, to the luminosity class using J-H vs H-K two-color diagrams and several tables that relate photometric data with spectral data used by professionals (*M.S.Bessell & J. M. Brett (1988)* and *Gerald E. Kron (1988)* Several useful tables are from *Handbook of Space Astronomy and Astrophysics of the Harvard University.)*. The process transforms the magnitudes of the problem-star in energy in Jy (1 Jy = 10^{-23} erg * sec^{-1} * cm^2 * Hz^{-1}) and compares the spectral distribution of a component with those of the empirical tables.

When the star is not red enough to obtain the luminosity class using only photometry data, then we must use Reduced Proper Motion Diagrams (Eric M. Jones, 1972; C. A. Nelson, 2003; Salim Salir, 2002). These diagrams relate the observational photometric data and proper motions with a parameter that is characteristic of a population star (dwarfs, giants, subdwarfs, white dwarfs...).

Of the double stars studied by the LIADA group there are 19 components (13 dwarfs and 6 normal giants) with spectral types and luminosity classes obtained by professionals and published in the astronomical literature. These components are listed in Hipparcos/Tycho-2 and 2MASS catalogs so the BVJHK photometry and proper motions are also known. We have compared our spectral data with those obtained by professionals using spectroscopy. The mean difference was 0.5 spectral subclasses, and the luminosity class was estimated correctly in the 19 components.

Figure 1 shows the results of the comparison between the spectral types published in the professional astronomical literature with those estimated photometrically and kinematically by the LIADA group.

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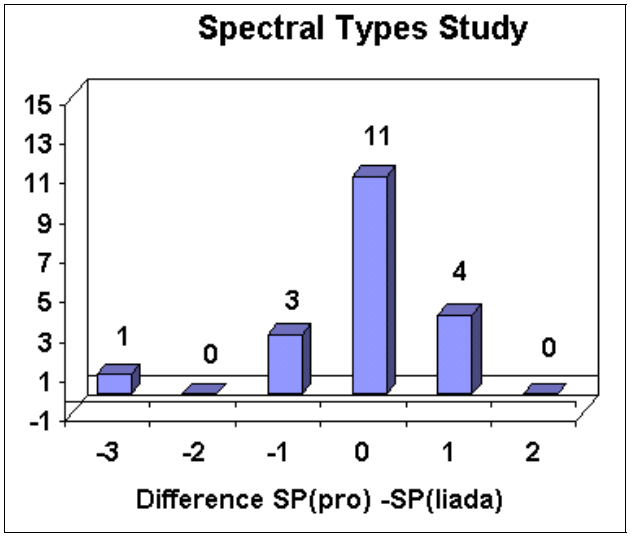

Figure 1: Comparison between the spectral types published in the professional astronomical literature [SP(pro)] with those estimated photometrically and kinematically by LIADA group [SP (liada)].

(1) WDS Id.	(2) Discoverer	(3) V_A	(4) V_B	(5) Sp(A)	(6) Sp(B)	(7) Epoch	(8) θ(°)	(9) ρ(")	(10) N	(11) Observer	(11) Method	(12) Type	(13) Notes
00003+1642	HJ 318	9.44	12.8			1999.830	61.6	26.62	3	FMR	2MASS	OPT	
00046-7745	LDS 832	12.2	12.2	K6V	K6V	1998.601	184.1	9.31	3	FMR	2MASS	OC/FIS	C, ¿40?
00037+1252	HJ 3235	10.3	11.30	K2III	K0V	2002.852	87.5	22.33	5	BVD	MCG	OPT	C, 173
00194+3108	HJ 620	10.36	12.5	F4V	G5V	1997.910	190.2	14.05	3	FMR	2MASS	?	C, 183, #20
00196-2057	HJ 1954	9.82	12.5	M0III	K4V	1996.682	115.0	31.23	1	BVD	DSS	OPT	C, 172
00224-1432	HJ 1958	11.8	12.8	F6V	G6III	1998.604	67.6	14.18	3	FMR	2MASS	OPT	C, 172
00254+4419	HJ 1963	8.70	12.7	A1V:	K0III:	1998.842	51.2	27.02	3	FMR	2MASS	OPT?	C, 173, #21
00290-1817	HJ 1974	11.5	13.5	G5V	G5V:	2000.740	159.0	23.74	3	FMR	2MASS	?	C, 173
00357-0604	HJ 1039	9.64	14.1	F7V	F9V	1998.822	268.3	53.69	3	FMR	2MASS	OPT	C, 175, #22
01072-6834	HDS 147	9.27	10.40	K3III	G/KIII	1998.803	323.7	26.50	3	FMR	2MASS	OPT	C, 11, #1
01116+2823	FMR 5	12.0	13.5	G9V	K5V	1997.831	294.4	4.62	2	FMR	2MASS	FIS/OC	New, #3
01126+2825	HJ 635	10.85	11.29	G5V	G7V	1997.831	127.3	15.00	3	FMR	2MASS	FIS?	C, 182, #2
01518-0750	HJ 2092	11.3	11.7	F6V	F5V:	1998.809	77.1	13.35	3	FMR	2MASS	OPT?	C, 172
01241+4522	HJ 2041	12.7	12.7	G5	G7	1998.899	335.7	4.99	3	FMR	2MASS	?	C, 172, #23
01572+2618	HJ 3243	10.43	10.77	M3III	G5V	1997.842	68.1	29.27	2	FMR	2MASS	OPT	C, 172
03404+3022	HJ 335	11.9	12.1	K2III	G7V	2002.184	251.6	15.34	3	JRY	CCD	OPT	C, 172
03465-1631	HDO 63	11.4	12.0	F6V	G1V	1998.672	294.1	22.65	3	FMR	2MASS	OPT	#4
03475+2406	STFA 8 CD	8.20	8.68	A7V	F6V	2002.184	224.5	54.50	4	JRY	CCD	FIS	#5
04009-1027	STF 487 AB	9.44	9.91	F1V	G7IV:	1998.855	9.8	12.11	3	FMR	2MASS	FIS?	
04009-1027	STF 487 AC	9.44	10.47	F1V	F5V	1998.855	229.8	20.20	3	FMR	2MASS	OPT	
04009-1027	STF 487 BC	9.91	10.47	G4V:	F5V	1998.855	215.1	30.39	3	FMR	2MASS	OPT	C, 159
04166-7030	STF 496 AB	11.13	10.83	M5III	F5V	1994.025	56.6	30.86	1	BVD	DSS	OPT	
04166-7030	STF 496 AC	11.13	11.92	M5III	K0	2002.117	23.0	38.72	3	BVD	MCG	OPT?	C, 172
04166-7030	STF 496 BC	10.83	11.91	F5V	K0	1994.025	329.2	21.40	1	BVD	DSS	OPT?	
04312-0726	HJ 24	10.50	14.0	M1III	F5V	1998.790	57.2	26.78	3	FMR	2MASS	OC?	C, 182, #6

Table 2: Relative astrometry, photometry, spectral data, and nature of measured double stars.

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(1) WDS Id.	(2) Discoverer	(3) V_A	(4) V_B	(5) Sp(A)	(6) Sp(B)	(7) Epoch	(8) θ(°)	(9) ρ(")	(10) N	(11) Observer	(11) Method	(12) Type	(13) Notes
05032+2921	HJ 354	11.1	12.1	M III	F9V	1996.050	296.6	11.45	2	BVD	DSS	OPT?	C, 182
05175+3312	CTT 4 AB	7.73	12.1	A2V		2002.184	105.0	108.84	4	JRY	CCD	OPT	C, 5
05175+3312	CTT 4 AC	7.73	11.0	A2V	M1III	1998.088	282.7	111.99	2	FMR	2MASS	OPT	#9
05175+3312	CTT 4 AD	7.73	11.2	A2V	K2III	2002.184	270.7	94.34	4	JRY	CCD	OPT	C, 5, #9
05175+3312	CTT 4 AE	7.73	12.2	A2V	K4V:	2002.184	269.1	114.30	4	JRY	CCD	OPT	C, 5
05413+5329	ENG 22 AB	6.20	9.69	K0V	M1V	2002.184	71.3	98.15	4	JRY	CCD	FIS	
05445-2227	H 5 50 BC	6.16	11.33	K2V	F6V	1999.011	8.1	112.53	3	FMR	2MASS	OPT	170, #7
11045-6332	HDS1581 AB	9.95	11.67	G4III	F4V	1994.268	3.0	8.72	1	BVD&ARU	DSS	?	#10
11045-6332	FAB 10 AC	9.95	11.51	G4III		1994.268	350.4	19.57	2	BVD&ARU	DSS	OPT	#10
11075+2203	HDS1586	8.22	11.27	G1V	K1V	2002.373	211.8	14.35	4	JRY	CCD	OPT	C, 11, #11
11091+1105	HJ 176	10.85	12.9	G5V	G9V	2002.336	33.6	18.71	5	BVD	MCG	OPT?	#12
11258+2704	HJ 497	9.49	12.7	K0III:	G5V	2002.373	53.8	34.77	3	JRY	CCD	OPT	C, 182, #13
11330-7055	HDS1638	9.32	12.34	F5.5V	K0V	2001.118	189.9	8.57	3	FMR	2MASS	FIS?	C, 11
11368+2923	HJ 2579 AB	11.59	12.3			2002.373	351.4	14.33	4	JRY	CCD	OC	99, #14
11404+3003	HJ 507	9.44	14.0	G1V	M1.5V	2002.381	29.2	34.18	4	JRY	CCD	FIS/OC	C, 182
12003+1136	HJ 197	12.9	13.0	F9V	G6V	1996.304	273.7	15.14	1	BVD	DSS	OPT?	C, 182, #15
12089-0317	HJ 1211	10.61	13.4	F5:	K3	1999.077	150.4	11.46	3	FMR	2MASS	OPT	C, 174
12190-0138	HJ 206	13.2	11.8	K2	G0	2002.373	298.2	18.35	2	FMR	CCD	OPT	C, 182, #8
12266-1336	HJ 2611	12.4	12.4	G0	F6	1984.179	219.4	13.27	1	ARU	DSS	OPT?	C, 173
13254+5649	HJ 2652	11.5	12.5	G5V	K0V	2002.523	251.8	20.55	5	BVD	MCG	OPT	C, 172, #16
13313+2857	HJ 531	9.19	13.5	K2III	K0V	2002.507	41.5	35.98	2	BVD	MCG	OPT	C, 182, #17
13345+2503	HJ 2660	10.61	13.4	K0III	G5V	2002.373	143.1	28.26	4	JRY	CCD	OPT	C, 172
13419-1418	HJ 2669	11.2	12.5	K2III	F9V	1998.217	79.8	27.43	3	FMR	2MASS	OPT	C, 173
13469+3307	HJ 2681	12.8	13.1	F8V	F6	1998.185	262.6	13.80	3	FMR	2MASS	OPT?	C, 173
13492+0630	HJ 2686	9.29	13.7	F6V	F6V	2002.373	114.7	22.82	4	JRY	CCD	OPT	C, 172, #18
14123+3646	HJ 542	12.8	13.8	G1V	G0	2002.594	246.5	12.52	4	JRY	CCD	OC?	C, 183

Table 2 (cont.): Relative astrometry, photometry, spectral data and nature of measured double stars.

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(1) WDS Id.	(2) Discoverer	(3) V_A	(4) V_B	(5) Sp(A)	(6) Sp(B)	(7) Epoch	(8) θ(°)	(9) ρ(")	(10) N	(11) Observer	(11) Method	(12) Type	(13) Notes
14189+3220	HJ 2709	11,42	14,6	F8V	G8V	1998,340	84,6	27,46	3	FMR	2MASS	OPT	C, 173
14226+1159	HJ 236	12,6	12,8	F9V	G5V	2002,597	285,4	23,01	4	JRY	CCD	OPT?	
14226+1159	FMR 2 BC	12,8	18,2	G5V	M1V:	2000,256	105,9	8,32	2	FMR	2MASS	OPT?	
14296+1040	HJ 237	11,6	13,8	K1III	F9V:	2002,597	47,4	20,76	3	JRY	CCD	OPT?	C, 183
16540-4148	JC 23 AF	5,42	6,54	B0.5Ia	O6III	1995,422	20,1	56,72	1	ARU	DSS	OPT	#19
18004+4611	J 756	11,8	12,3	G4V		2002,589	181,7	3,37	3	BVD	MCG	¿?	
18020+3153	SEI 555	11,5	12,5	F8V:	G3	2002,597	109,5	19,37	4	JRY	CCD	OPT	C, 104
18093+5945	STF2300 AB	9,22	11,08	A8	F2	2002,597	43,4	13,80	4	JRY	CCD	--	
18093+5945	STF2300 AD	9,22	12,64	A8	K0	2002,597	88,9	24,70	4	JRY	CCD	OPT	
18093+5945	STF2300 BC	11,08	12,2	F2		2000,275	186,4	3,49	2	FMR	2MASS	OPT?	
18213+3920	HJ 1321	10,10	12,0	K0III	K1III	2000,259	77,2	9,66	3	FMR	2MASS	OPT	
22388+3000	MLB 725	11,7	12,8	G7V	G7	2002,695	13,2	8,25	4	JRY	CCD	OPT?	C, 72
23033+0653	HJ 3161	10,67	13,1	G9III:	G6V:	2000,685	251,7	12,08	3	FMR	2MASS	¿?	C, 173, #24
23224-1259	HJ 310	9,79	10,62	K0III	G3	1999,513	337,3	10,41	3	FMR	2MASS	OPT	#25
23246+0617	HJ 3190	11,6	13,0	K3V	G2	2000,494	3,8	21,75	3	FMR	2MASS	OPT	
23324+1229	HJ 312	12,7	13,5			1997,743	90,0	18,37	3	FMR	2MASS	--	C, 183

Table 2 (cont.): Relative astrometry, photometry, spectral data, and nature of measured double stars.

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Notes to Table 2:

(# 1) HDS 147: In CCDM it is catalogued as RSU measured in 1973 (324º and 26"9)

(# 2) HJ 635: Suspected to be physical according to our analysis of astrometry and BVJHK photometry; it is located 13' West of the WDS coordinate.

(# 3) FMR 5: This object is composed of two stars separated by 4.62" and they are suspected to be physical according to photometric parallaxes using BVJHK bands.

(# 4) HDO 63: PGC 13821 galaxy, of 14 magnitude, is 3' at SE. "HDO" double stars were discovered by Harvard Observatory. According to a lineal fit using Hipparcos, USNO-A2.0 and LIADA data the discover's measure of 1863 is in great error of about 3".

(# 5) STFA 8 CD: In the Pleiades open cluster. C is the d scuti V647 Tau (8,25-8,30 mg., P=0,05 days)

(# 6) Spectral types corrected by interestellar absortion.

(# 7) H5 50 B is at 9.0 pc (Hipparcos) with a radial velocity of – 8 km/s ("3er. Bibliog. Cat. Of Stellar Radial Vel.", Barbier-Brossat, 1994). It has a spectral type of K2V according to Michigan Catalogue of HD stars (Houk, 1989) and "Spectra of Sourthen late-type dwarfs" (Cincunegui, 2004) which is in excellent agreement with LIADA result. LIADA searched for unknown companion but no candidate was found.

(# 8) HJ 206: The star that John Herschel observed as the main component really is 1.2 magnitudes weaker than the secondary.

(# 9) CTT 4: Components C and D seem to be a suspected common origin pair.

(#10) Spectral type is corrected by interestellar extinction.

(#11) HDS 1586 : A search for unknown companions was carried out. No candidate was found; we studied the professional astronomical literature: Jaschel (1978), Duflot (2004). Tycho-2 proper motion for secondary are in great error.

(#12) HJ 176: A weak star of 16ª magnitude was observed by Rafael Benavides at 10"3 of separation in direction 52º. According to JHK photometry it is a G/K star that surely is not bounded to the A or B components.

(#13) HJ 497 A is a K0 star (PPM catalog).

(#14) HJ 2579: Primary is a G5p star according to Skiff (2003) in "Catalogue of Stellar Spectral Classifications"; located at 2' West to WDS position.

(#15) HJ 197: This pair is located 9' East of WDS position.

(#16) HJ 2652: Both components have the same distance moduli but different proper motions.

(#17) HJ 531 A: spectral type K3III (Jaschek, 1978 and Kennedy, 1983); Mv = + 0,1 (Corbally and Garrinson, 1984); Av=0.29, distance = 571 pc; (B-V)o=+1,16 (J. Guarinos, 1992).

(#18) HJ 2686 A: It is HD 120406 a F0 star according to Henry Draper Catalog; Hipparcos parallax p = 0"005±0"001 and Mv = +2,8±0,6. BVIJHK correspond with a F6V star.

(#19) JC 23 AF: In NGC 6231: A = NSV20804; B = NSV8021.

(#20) HJ 620 : Components have very similar photometric parallaxes and different proper motions.

(#21) HJ 1963: Primary is HD 2091 an A2 star (Henry Draper Catalog) located at 385 pc (Hipparcos). Photometric distance calculated by LIADA is 350 pc.

(#22) HJ 1039: Primary is a F7V star (Michigan Catalogue).

(#23) HJ 2041: If both components are dwarfs then the photometric parallaxes are very similar. Is this pair a binary star?

(#24) HJ 3161: Primary is a K0 star (PPM and Simbad)

(#25) HJ 310 : Discovered in 1820 and confirmed in 1831 by John Herschel. Primary is HD220259 with spectral type of G8/K2 III ("*Michigan Catalogue*"); a spectral type of K0(III) is listed in "*13th General Catalogue of MK Spectral Classification"* (Buscombe, 1988). UBV for both components was obtained by D. Sinachopoulos and E. L. Van Dessell (1996) concluding that they are not physically bound.

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The difference is expressed in spectral subclass. In 95% of the stars studied (18 of 19 stars) the difference is less or equal to 1 spectral subclass. In Table II there are many spectral types that were estimated using only JHK photometry due to the star component not being listed in Tycho-2, so their results are of lower accuracy than those obtained using BVJHK photometry. Table III shows the stars used to test the accuracy of the spectral type estimate procedure.

Studying the Nature of Visual Double Stars

To study the nature of visual double stars and classify them as optical, physical, common proper motion or common origin pairs, BVJHK photometric and astrometric (proper motions and relative astrometry) data were used. The historical relative astrometry (θ corrected by precession and proper motions) in addition to our own measures are plotted in a X ($=\rho*\sin(\theta)$) against Epoch and Y($=\rho*\cos(\theta)$) against Epoch diagrams. A linear fit shows the relative proper motion of B with respect to A. This data is very important because nearly all methods that allow us to know their nature use it. If a double star is physical then this data will give us the projected relative orbital motion and velocity.

The photometric and astrometric data are analyzed using several professional methods that allow us to classify visual double stars according to their nature. We use methods that study if an orbital motion could be possible with the observational astrometric

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Name#1	Name#2	Mg_V	Sp_Lit	Ref.	Sp_LIADA	Differ.
	ARA1597 A	10.27	F8/G0V	1	G0V	-1
	WHC 29 A	7.22	G8/K0III	1	G8III	1
	HDS1595 A	8.87	K2III	1	K2III	0
	HJ 88 A	7.84	K0III	1	K0III	0
	HJ 3037 A	8.75	K1III	1	K1III	0
	HJ 3100 A	9.22	F5/6V	1	F8V	-2.5
	HJ 5025 A	9.34	F5/6V	1,2	F6V:	-0.5
	HLD 32 A	8.37	F7V	1	F8V	-1
	LDS 201 A	8.73	G3V	1-3	G4V	-1
HD 11352		8.62	G5V	1	G4V	1
	STF 222 A	6.06	B9V	4	B9V:	0
	STF 222 B	6.70	A1Vn	4	A1V:	0
HD 9656	STF 136 A	7.31	A6V	6	A6V	0
HD 37394	ENG 22 A	6.20	K1V	2.4	K0V	1
HD233153	ENG 22 B	9.69	M1V	4	M1V	0
HD 38392	H5 50 B	6.16	K2V	1.5	K2V	0
	HJ 531 A	9.19	K3III	4	K2III	1
	HJ 1039 A	9.64	F7V	1	F7V	0
HD220259	HJ 310 A	9.79	K0III	3	K0III	0

Table 3: Comparison between LIADA's and Professional Spectral Types. Ref: 1: Michigan Catalog, 2: Henry Draper Catalog, 3: 13th General Catalog of ML Spectral Type, 4: Selected MK Spectral Types (Jaschek, 1978), 5: Spectra of southern late-type dwarfs (Cincunegui, 2004), 6: Washington Double Star Catalog (WDS).

and photometric data; methods that are based in an empirical study and methods based in a probability theory. Table II shows in column (12) the conclusion of this study. Of the 67 visual double stars measured in 2002, LIADA studied the nature of 65 of them. 74 % (48 visual double stars) were optical or optical suspected while only 11% (7 doubles) were physical or physical suspected. See Figure 2. Of the double stars studied there were pairs with photometric and astrometric data consistent with pairs located at the same distance with the same kinematic but not gravitationally bounded: they are called '*common origin'* and were 6% of all double stars studied.

About 9% of visual double stars have an undetermined nature due to insufficient or no accurate data; thus more astrometric and photometric data are needed. The very low percentage of physical pairs is not surprising. There has been little astrophysical interest in the neglected and unconfirmed visual double stars because a majority of them are optical pairs.

Physical Pairs Orbital Data

Table IV shows some orbital data for the physical pairs studied in this circular. Projected Separation (in A.U.), the expected semi-major axis (in arc second and A.U.), the orbital period and the relative motion is showed in Table IV.

The projected separation in U.A. is calculated using the followed simple formula:

$$\text{Projected\_separation} = \rho / \pi$$

where ρ is the angular separation and π is the mean parallax of the binary. LIADA considered the mean angular separation and the mean photometric parallaxes of the components. The photometric parallaxes were calculated using spectral types and luminosity class estimates and the absolute magnitude obtained from several professional references.

The expected semi-major axis, E(a), in arcsecond, was calculated using the work of Paul Couteau (1960) by the followed formulae:

$$\text{Log } E(a) - \text{Log } (\rho) = 0.146$$

Where a and ρ are the semi-major axis and the angular separation, respectively. The orbital period was calculated using the following formula derived from the Kepler Laws:

Double Stars Studied by LIADA in 2002

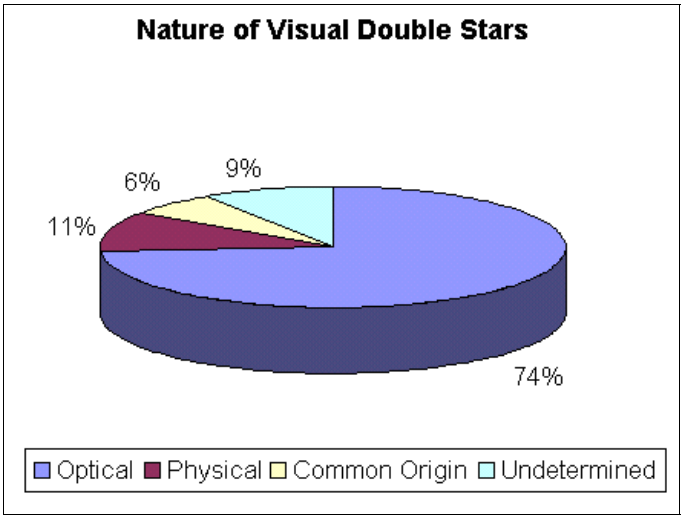

Figure 2: Study of the visual double star's nature. Most of the neglected and unconfirmed viusal double stars are optical pairs with no astrophysical interest.

$$P = \sqrt{\frac{E(a)^3}{\sum M_{\odot}}}$$

Proper motions

The proper motion data of the components is important because they inform us about the kinematics of the system's components and if they travel together in space. A physical pair or a common origin pair travels together in space, and so their proper motions are very similar, nearly the same. In physical pairs the difference in proper motions, that is, the relative proper motion, give the projected relative orbital motion of the binary. This is an important data for the study of the nature of double stars.

LIADA's Double Star Section has compiled proper motions from the astronomical literature. Tycho-2, UCAC2 and USNO-B1.0 catalog are the main reference. The proper motion data for the components of several double stars are not listed in the WDS, so our group has reported them to Brian Mason, who has included them in WDS catalog.

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The Guide Star Catalog-I was produced at the Space Telescope Science Institute under U.S. Government grant. These data are based on photographic data obtained using the Oschin Schmidt Telescope on Palomar Mountain and the UK Schmidt Telescope.

The Guide Star Catalogue–II is a joint project of the Space Telescope Science Institute and the Osservatorio Astronomico di Torino. Space Telescope Science Institute is operated by the Association of Universities

Double Designation	r (A.U.)	E(a) (")	E(a) (A.U.)	Period (years)	Dm_x ($mas*yr^{-1}$)	Dm_y ($mas*yr^{-1}$)
LDS 832	760	13.03	1,064	33,000	+5.8	-5.1
FMR 5	853	6.47	1,194	35,000	---	---
ENG 22 AB	1,027	136.8	1,437	50,000	+4.4	+10.8
HDS1638	1,403	12.51	1,963	59,000	---	---
HJ 507	2,730	48.10	---	190,000	-0.7	-5.5
STF 487 AB	2,615	16.92	3,660	123,000	+0.7	+0.5
HJ 635	2,187	20.97	3,061	125,000	+0.5	+1.8
STFA 8 CD	7,117	75.96	9,960	542,000	+0.6	+0.4

Table 4: Physical Pairs Orbital Data

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