Study of a new Common Proper Motion Pair at Obsevatorio Kappa Crucis IAU/MPC I26

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Abstract: In this paper we present the results of a study and observations of 2MASS 06062558-4504554 as components of a common proper motion pair. We calculated and compared proper motions for both stars using catalog images and CCD observations. We used the PPMXL catalog's proper motion data to select this system. This pair, most probably not a binary, needs to be observed and imaged with photometric filters in order to have more reliable data than in current catalogs, except 2MASS (Two Micron All Sky Survey).

Halbwachs´ criterion tells us that this is a CPM system. The criterion of Francisco Rica, which is based on the compatibility of the kinematic function of the equatorial coordinates, indicates that this pair has a probability of 94% to be a physical one [Rica, 2007]. On the other hand, with the absolute visual magnitude of both components, we obtained distance moduli 12.22 and 10.54 which put the components of the system at a distance of 2779 and 1282 parsecs. This means, taking into account errors in determining the magnitudes, that the probability that both components are subject to the same distance is 0%, not a binary.

We suggest that this pair be included in the CPMDS catalog and the WDS catalog as calibration double star.

Introduction

Using Aladin Sky Atlas with catalogs and digitized plates of 1979, 1991 and 1992 of an area in the constellation of Pictor, we identified what gives us the impression of being a physical double: 2MASS 06062558-4504554. Table 1 shows the proper motion for the pair given in the PPMXL catalog (a catalog of positions, proper motions, 2MASS, and optical photometry of 900 millions stars).

The main purpose is to study this pair to determine if there is a gravitational tie between both components and its nature.

Mostly, the material used in this paper was catalog information, and our own plates taken from Kappa Crucis Observatory and its astrometries.

The result of this study was achieved by an astrophysical evaluation using kinematic, photometric, spectral and astrometrical data.

Table 1: Proper motion of the pair described in this study.

Component	Proper Motion RA	Proper Motion Dec
A	45.8 ± 2.8 mas/year	-26.7 ± 3.6 mas/year
B	45.2 mas/year	26.2 mas/year

Methodology:

The methodology used in this work was:

- Definition of a region on the southern sky delimited by a 4 degrees radius circle.
- Retrieve all entries in the PPMX catalog in this region.
- Sort by RA proper motion
- Review the list identifying 2 stars with almost the same proper motion in RA and Declination.
- Once a pair is identified visually, retrieve the plates and catalog information with Aladin Sky Atlas. See Figures 1 and 2.
- Check proper motion of these stars in other catalogs (USNO B1.0, UCAC3, etc.).
- Retrieve coordinates of both components from many catalogs and observation dates.
- Retrieve photometry magnitude of both components from 2MASS and other catalogs.
- Calculate visual magnitude, spectral type and absolute magnitude of both components from the catalog information.
- Make astrometry measurements of all catalog images and images taken by Kappa Crucis Observatory on January 2011.
- Evaluate a possibly gravitational tie between both components using different criteria such as: Halbwachs, F. Rica Romero, Aitken and Curtiss.

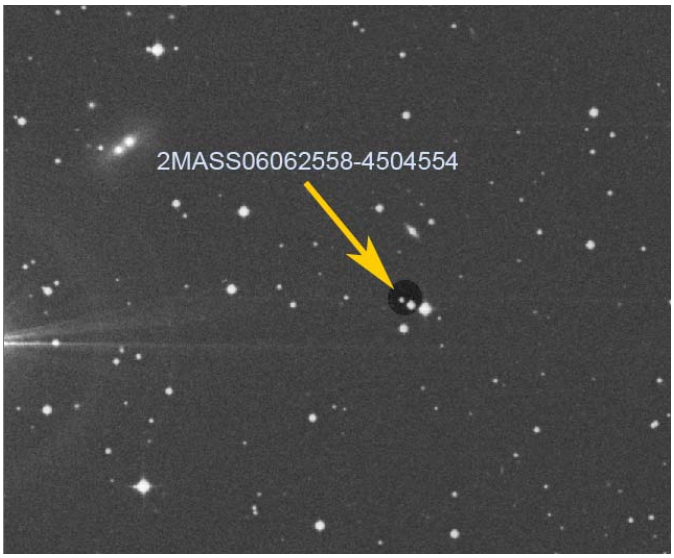

Figure 1: The pair was identified visually and by its proper motion values using Aladin Sky Atlas.

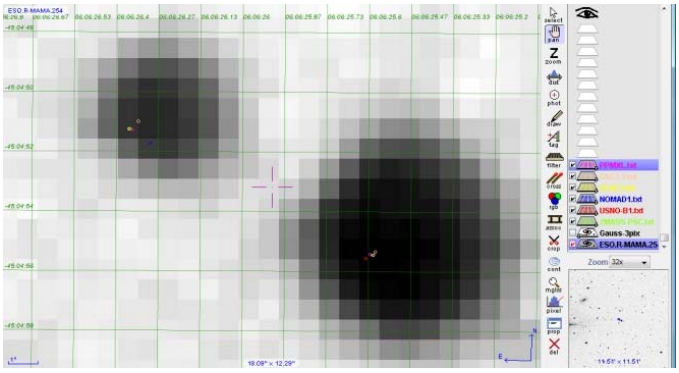

Figure 2: Superposition of the data over the catalog image.

Visual Identification

After the identification of the binary system candidate, we reviewed its proper motion values from PPMXL catalog, and with Aladin software we retrieved all plates with plate resolution around 1 arcsecond/pixel. Then, we retrieved catalog data of the image field from USNO, UCAC3, PPMX, and 2MASS.

Results

Unfortunately, photometry data are not reliable, except from the 2MASS project. The visual photometry is clear from the magnitudes B, R and R USNO-B1.0 catalog. With this set of photometry in bands BVRIJHK and using the spectral energy distribution spectra, we obtained F5 III and K0V for the primary and secondary respectively. The photometry is shown in Table 3.

Regarding kinematics, the proper motion of the system obtained from PPMXL is given in Table 1 with the resulting tangential velocity calculation in Table 2.

Astrometry from the 2011 measurements is consistent with the catalog data (1986 USNO B1.0 and 1999 2MASS). See Table 4.

Observations from Observatorio Kappa Crucis, January 2011

On 17 January 2011, (Besselian Date: 2011.020021), we observed this pair from Observatorio Kappa Crucis, Córdoba- Argentina, with a 20 cm. F/5 Newtonian reflector and a Starlight Xpress SXV-H9f CCD camera. With almost a full moon, we imaged 32 30 seconds exposure time frames.

At this time, the pair was almost in the zenith,

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Table 2: Tangential velocity calculation

Tangential Velocity Calculation	A	B
mu(alpha) =	0.046	0.045
mu(delta) =	-0.027	-0.026
Pi (") =	0.0009	0.0008
Ta (km/s) =	240	275
Td (km/s) =	140	159
Vt (km/s)=	278	318

Table 3: These photometric magnitudes were pulled from 2MASS (infrared) and USNO B1.0 catalogs. Absolute magnitude was calculated using Francisco Rica Romero's astrophysics spreadsheet.

	A	B
Magnitude V	13.62061	16.44056
Magnitude J	13.03	14.879
Magnitude H	12.714	14.284
Magnitude K	12.613	14.264
Color B - V	0.5838	0.6116
Color V - I	0.5706136	1.240555
Absolute Magnitude V	3.4	5.9
Bolometric Correction	-0.2	0.19
Distance Module	10.2206136	10.5405550
Mag R1	13.43	16.14
MagB1	14.48	17.24
Mag I	11.371	13.63

Table 4: Relative Astrometry

	1986	1999	2011
Rho (")	8.143	11.394	**13.354**
Theta (°)	62.184	68.371	**75.86**

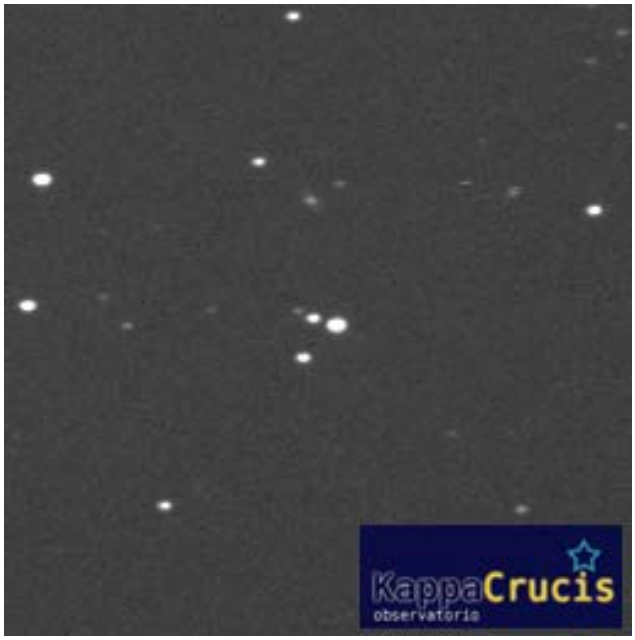

Figure 3: Photo of the pair taken from Observatorio Kappa Crucis.

providing the possibility of obtaining the best possible quality images.

Having identified the star field to image, we obtained 32 images of 20 seconds of exposure and 30 frames of 30 seconds. Finally we chose the 30 seconds ones, since the companion is more clearly identified and the primary is not overexposed. See Figure 3.

Calibration was made with Astrometrica software identifying an effective focal length of 1007.6mm and camera rotation angle = -2.04°.

Astrometrica results are given below:

Plate Center Coordinates:
RA = 06h 06m 23.70s
Dec = -45° 04' 58.9"
Focal Length = 1007.6mm
Rotation = -2.04°
Pixel Size: 1.33" x 1.33", Field of View: 30.9' x 23.1'

Photometry
158 of 195 Reference Stars used: dmag = 0.18mag
Zero Point: 26.05mag

Component A:
Coordinates: 06 06 25.582 -45 04 55.44
±0.14 ±0.12 ±0.01
Magnitude: 14.0 V
Component B:
Coordinates: 06 06 26.344 -45 04 51.51
±0.15 ±0.13 ±0.01

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Magnitude: 15.2 V

Next step was relative astrometry with Reduc software using for calibration focal length and camera angle position data obtained with Astrometrica's reduction. Reduc results are given below:

Date : 01/17/2011
Besselian Date: 2011.020021
Location : Cordoba, Argentina
Conditions : Full Moon
Instrument : SXV-H9 CCD Camera
Newtonian 20cm F/5
Camera : SXV-H9 (pixels : 6.48 x 6.48)
30 sec. exposure time bin 1x1" / píxel : 0.5
Delta Matrix : -2.15
75.82 (sigma theta : 0.87) Med: 75.86
5.019 (sigma rho : 0.119) Med: 5.015
deltaM=1.69
Effective Focal Length = 1007.6mm

Spectral Type of the Components

Using the Francisco Rica Romero's "Astrophysics" spreadsheet, we can evaluate and calculate the spectral type of each component from photometric data.

The result was that the primary component as well its companion are main sequence stars: the primary component is F5V and the companion is K0V.

The estimation of the spectral type was made using JHK photometric data from the 2MASS catalog mainly, but to be sure about the nature of each component there is a need to obtain more and more observations with photometric filters.

The reduced proper motions for the companions are presented in Table 5. Reduced Proper Motion Diagram (Figure 4) shows that both components are just above the solid separation line and so could be main sequence sub dwarfs (below the line are degenerate sequence stars).

Table 5: Reduced Proper Motion

BAND	Mag(A)	H(A)	Mag(B)	H(B)
V	13.6206	12.2	16.440555	15.0
K	12.613	11.2	14.264	12.9

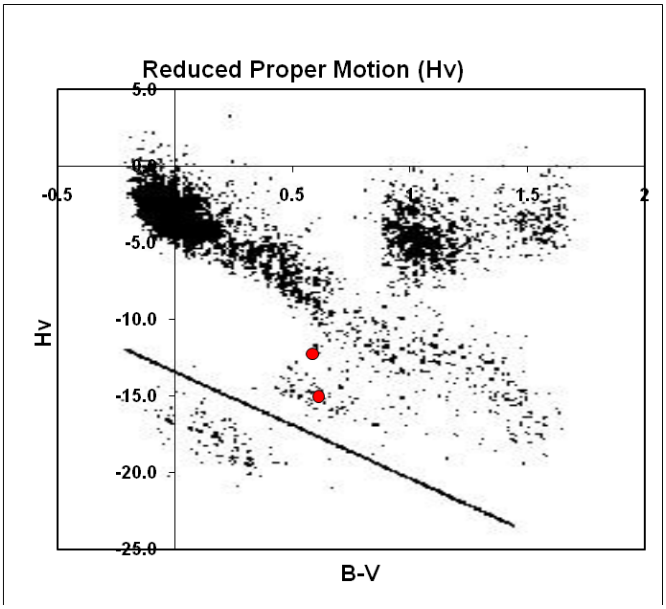

Figure 4: Reduced-Proper Diagrams after II. Luyten's White-Dwarf Catalog (Jones, E. M., Astrophysical Journal, vol. 177, p.245). This diagram shows that both components are just above solid line separation and then could be main sequence sub dwarfs

Conclusions

If we consider reliable the spectroscopy obtained above, we can estimate the sum of the masses to be 2.21 solar masses, at a distance calculated based on the data mentioned above, the criteria of Wilson and Close indicates a physical system.

The absolute visual magnitude of both components allow us to calculate the distance moduli: 10.2206 and 10.5405, which puts us both components of the system at a distance of 1106.9 (primary) and 1282.7 (companion) parsecs, which means that taking into account the errors in determining the magnitudes, we conclude that the probability that both components are at the same distance is more than 52%. Those values are not enouth to say with certainty that this is a binary system, therefore, for now, and until we can obtain more reliable spectral values, we will consider it as a common proper motion system.

Was intended to verify the plate kinematics through digitized and are available as 3 images (1979, 1991 and 1992) is not sufficient to establish the proper motions, but because of the relative astrometry between 1979 and 1992 (13 years) could confirm kinematic values outlined above. Astrometry values for 1992 are: $\theta = 62.7°$ and $\rho = 9.34"$

According to these data, we estimate the parameter (ρ/μ) representing the time it takes the star to travel a distance equal to their angular separation with its motion μ which gives T = 685 years which would give us an interesting likely to be physical. Halbwachs's criterion tells us that this is an MPC system. (An excellent explanation of the Halbwachs'

criterion can be found in Rica Romero, 2007.)

This paper attempts to apply the experience of Rafael Caballero (2009).

In summary, with the present information we could not consider this pair as a binary but only as a common proper motion system and there is need to collect more data in the future in order to confirm or discard it as a binary.

We suggest that this pair be included in the CPMDS catalog and the WDS as a calibration double star (it could be useful to have more calibration double stars in southern celestial hemisphere).

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We used Francisco Rica Romero's "Astrophysics" spreadsheet with many useful formulas and astrophysical concepts.

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