POU 5641 (WDS 22077+2521). A Binary Composed of a Red dwarf and a White Dwarf

F. M. Rica

Double Star Section of Liga Iberoamericana de Astronomía (LIADA)
Astronomical Society of Mérida
frica0@gmail.com

Abstract: The Double Star Section of the LIADA have studied many long neglected double stars during 2006-2010. These yet unpublished results start to see the light with this article. The main aim of this work is present one of the more interesting long neglected pairs studied in the last years by our group: POU 5641 (= WDS 2207+2521). In the time of our study, it was only measured in 1899. This pair is composed of common proper motion star (a K2V dwarf and a previously known hot white dwarf) with 11.2 and 14.5 magnitudes at 58 parsecs of distance and separated by 7.89". Astrophysical basic parameters were determined analyzing and consulting the data from the literature. Eight astrometric measures (position angles and angular distances) were performed using astrometric catalogs and photographic plates from public surveys. No significant relative velocity was detected. A dynamical study (comparing the relative velocity with the escape velocity) showed that POU 5641 likely is a gravitationally bound pair.

1. Introduction

During the last years, the LIADA Double Star Section have measured and studied many neglected double stars. In the fourth observational program of 2008 we listed POU 5641 (= WDS 2207+2521), one of many unconfirmed and neglected double stars not resolved since before 1900. Most of these double stars are pairs of unrelated stars, that is optical in nature, which have no astrophysical interest. But POU 5641, composed of stars with magnitude 11.2 and 14.5 separated by 7.9 arc seconds, surprised us not only for the physical relation of the stellar members, but also by the astrophysical interest of the component stars.

The organization of this paper is as follows. Sections 2 and 3 presents the astrometric observations and the astrophysical characterization. The dynamic study is detailed in Section 4. The conclusions are detailed in Section 5.

2. Astrometric Observations

When LIADA members measured and studied POU 5461 in 2008, it was an unconfirmed and neglected pair only measured in 1899 by Pourteau. Recently the WDS catalog has added 5 astrometric measures more, confirming this object. LIADA Double Star section performed 8 astrometric measures spanning from the year 1950 to 2008, a 58 year baseline. For this astrometric work, Digitized Sky Survey plates and astrometric catalogs (2MASS and AC2000) were used. In addition to this, one measure was performed using a CCD camera. Rafael Benavides, a well-known double star observer in Spain, used a 0.3 m telescope with an Atik 16HR CCD camera with an image scale of 0.995 arcsecond/pixel (see Figure 1).

Table 1 shows the relative astrometry (the epoch of observation, the angular separation and distance, the origin of the measure and the observer are listed) used in this work.

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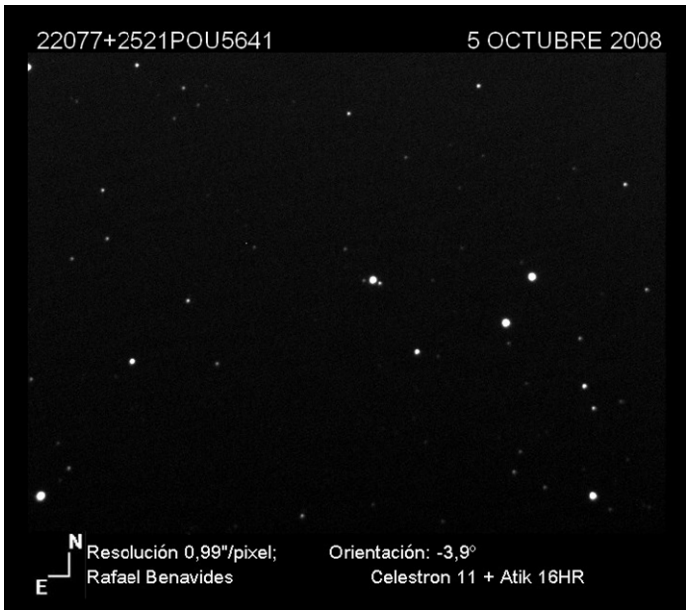

Figure 1. WDS 22077+2521 = POU 5641. Taken by Rafael Benavides in 2008.760.

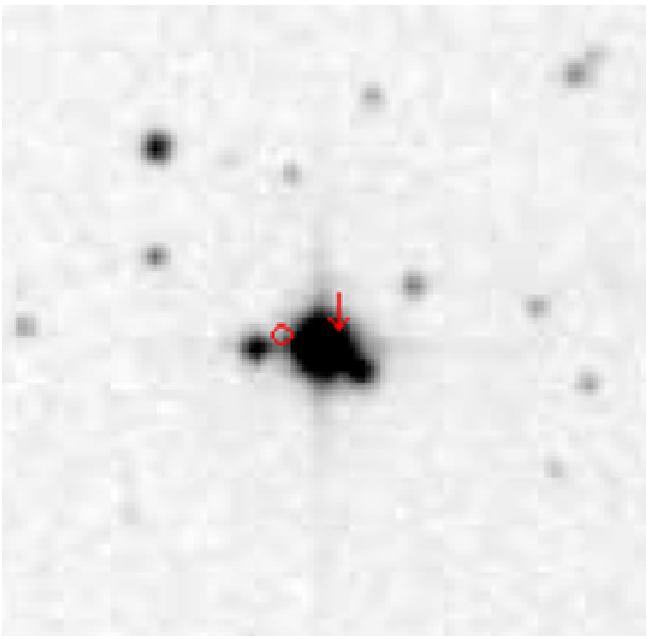

Figure 2. POU5641. The position for the white dwarf is marked with an empty red circle.

3. Astrophysical study

The astronomical literature was consulted searching for astrophysical data for the stellar components of POU 5641[1]. Table 2 lists the multiwavelengh photometric data used in this work. The *AVVSO Photometric All-Sky Survey* (APASS) catalog included in the UCAC4 astrometric catalog (Zacharias, et al. 2012) provides 5 optical bands and it is of great usefulness in our astrophysical characterization. The good accuracy of the *V* band magnitude was confirmed consulting the ASAS catalog[2] (Pojmanski 1997). The astrophysical study was performed following basically the guidelines published in Benavides et al. (2010) and Rica (2012). The interstellar reddening for this pair (galactic latitude of -24.4 deg) determined in this work was of $E(B-V)$ = 0.02.

Table 1. Relative Astrometry

Epoch	θ [°]	ρ ["]	Origin	Observer
1950.609	239.45	8.133	DSS	FMR
1990.776	238.14	7.72	DSS	FMR
1992.734	242.42	7.65	DSS	FMR
1995.557	238.27	7.31	DSS	FMR
1983.772	239.2	8.33	DSS	AOG
1991.231	237.9	7.96	DSS	AOG
1997.84	240.2	7.99	2MASS	AOG_2M
2008.760	239.7	7.99	CCD	BVD

The primary component is a K5V star with a photometric distance of 59 - 60 pc and with a significant proper motion. The UCAC3 and the PPMXL catalogs list similar values ($\mu(\alpha)$ = +88.4 ± 1.6 mas yr^{-1} and $\mu(\delta)$ = -27.7 ± 1.6 mas yr^{-1}). This data was confirmed in this work using plates from Digitized Sky Survey, and the astrometry from the AC2000 catalog (epoch 1894.882) and 2MASS (epoch 1997.840). This is the first time that the spectral type (and the luminosity class) and the distance are determined.

The photo-metric data for the secondary component is very poor. The version of 2008 for the *Spectroscopically Identified White Dwarfs (*McCook & Sion 1999*)* catalog lists a weak and hot white dwarf very near of the primary component with *V* band magnitude of 14.47 (Table 2 lists more photometry data), a *B-V* color of -0.10 and an absolute magnitude in *V*-band of +10.77. While Green, Ali & Napiwotzki (2000) list a *V* band magnitude of 14.58, an effective temperature of 26,129 K and a mass of 0.74 solar mass.

Figure 2 shows the stellar members of POU 5641.

[1]*The Aladin, VizieR and Simbad Virtual Observatory tools were used.* [2]*All Star Atlas Catalogue, http://archive.princeton.edu/asas_main.html*

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Table 2. Photometry

Passband	A [mag]	Ref.	B [mag]	Ref.
B	12.281±0.013	APASS	14.37	McCook & Sion (1999)
g	11.758±0.012	APASS	...	...
V	11.249±0.011	APASS	14.47	McCook & Sion (1999)
r	10.844±0.010	APASS	14.991±0.145	CMC14
i	10.610±0.041	APASS	...	...
J	9.067±0.023	2MASS	14.993±0.131	
H	8.497±0.016	2MASS	...	...
K	8.343±0.018	2MASS	...	...
W1	8.246±0.023	WISE	...	...
W2	8.269±0.021	WISE	...	...
W3	8.161±0019	WISE	...	...

The position for the white dwarf is marked with an empty red circle. But, what star is the white dwarf? The weak magnitude for the white dwarf suggest me that could be POU 5641 B or the weak star at East of the primary component. This star has a *V* magnitude of about 15.6 with *JHK* colors that matches with a medium -F star. POU 5461 B has a color $r_{CMC} - J_{2MASS} = 0.0$ what is in agreement with the color listed for the white dwarf. If the *V-J* color is plotted in a reduced proper motion diagram, POU 5641 B is located in the white dwarf region. Therefore, white dwarf nature for POU 5461 B is confirmed.

There is an X-ray source very near of POU 5641. Flemming et al. (1996) list the secondary component in the "*Catalogue of ROSAT White Dwarfs*" as the optical counterpart for this X-ray source.

Are the stellar components for POU5641 two stars at the same distance? From the absolute magnitude of the white dwarf, a photometric distance of about 55 pc (distance moduli of +3.77) was determined, in very good agreement with the distance for the primary component (about 59-60 pc and distance moduli of +3.94). Therefore, the stellar components of POU 5641 surely are at the same distance.

Dynamical study

The astrometric data listed in Table 1 were used to determine the relative motion of secondary w.r.t. the primary star, plotting the evolution of the astrometric measures with respect the time. As is usual in this type of neglected binaries, only a few poor-quality measurements can be used. The observational data only allows detecting relative motions greater than 3.0 mas yr^{-1}. The relative motion measured (1.2 ± 3.0 mas yr^{-1}) is smaller than this limit and it is consistent with zero relative motion. This result confirms the common proper motion for both stars. Literature no list proper motion for the secondary component. In this work, the proper motion was determined, for the first time, from the proper motion of the primary component and the relative motion measured:

$\mu(\alpha)$ = +89.6 ± 2.7 mas yr^{-1}
$\mu(\delta)$ = -27.9 ± 2.6 mas yr^{-1}

There are two important pieces of evidence for the binarity of POU 5641: the common proper motion and the very similar photometric distances for both components. The astrometric observations do not yield a determination of a significant relative motion and velocity. The value for the relative velocity determined in this work is 0.33 ± 0.81 km s^{-1} and is therefore consistent with zero. The escape velocity for POU 5641 assuming a face-on[3] orbit is 2.38 km s^{-1}, therefore POU 5641 is likely a gravitationally bound system.

[3]*The calculation of the true escape velocity is not possible because the value of the radius vector (r) is unknown. Thus only the projection of r (that is, the angular separation expressed in physical units, called s) can be used. Like s ≤ r, the escape velocity calculated is the upper value. When the orbit is face-on then s = r.*

Conclusions

POU 5641 (= WDS 2207+2521) is one of the most interesting pair against the long neglected pairs studied by LIADA Double Star Section. This pair is composed of K2V and white dwarf (an X-ray source) stars with common proper motion and common distance with 11.2 and 14.5 magnitudes at 58 parsec of distance and separated by a physical distance of 460 AU. We performed 8 astrometric measures spanning from the year 1950 to 2008, that is, 58 years of time baseline. The dynamic analysis did not detect a significant relative motion and velocity. See Table 3. Likely the relative motion is smaller than the escape velocity of the system and therefore POU 5641 surely be a gravitationally bound system.

Table 3. Astrometric and Dynamic Parameters

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Epoch	1998.503		
θ (deg)	239.8		
ρ (arcsec)	7.99		
x (AU).[E-W]	-397	±	79
y (AU).[N-S]	-231	±	46
dρ/dt (mas yr^{-1})	-0.87	±	2.47
dθ/dt (deg yr^{-1})	-0.006	±	0.018
dx/dt (mas yr^{-1}).[E-W]	1.19	±	2.13
dy/dt (mas yr^{-1}).[N-S]	-0.21	±	2.06
Vx (km s^{-1})…[E-W]	0.32	±	0.58
Vy (km s^{-1})…[N-S]	-0.06	±	0.56
Vz (km s^{-1})		±	
Vxy (km s^{-1})	0.33	±	0.81
Vesc (km s^{-1})	2.38	±	
Mass A (Msun)	0.73	±	0.07
Mass B (Msun)	0.74	±	0.07
Distance (pc)	57.5	±	11.5

Acknowledgements

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