The Demise of POP 1232 and New Measures of HLM 40 and POP 201

John Nanson
Star Splitters Double Star Blog
Manzanita, Oregon

Steven C. Smith
Castle Rock, Colorado
ssmith9831@aol.com

Abstract: This paper discusses our effort to determine why POP 1232 disappeared from the WDS Catalog as well as how that search led to new measures of two obscure double stars.

It was a cool November night in 2011 when I pointed a telescope at Cygnus' east wing in search of STT 437. According to the data I had pulled from the WDS, I was looking for a triple star, one component of which was itself a double (Table 1). With magnitudes ranging from 7.2 to 11.2, and separations running from 2.4" to 79.9", I didn't expect much of a problem for my five inch refractor. Much to my surprise, the component that was double refused to split, although I thought I might have glimpsed some elongation in it. That pair was POP 1232, the CD components of STT 437. A return visit a week later with a six inch refractor failed to produce the "D" companion, which I wrote off as being the result of very poor seeing conditions. And that was that, and probably would have remained that, if it hadn't been for a non-sighting of "D" by Steve Smith almost a full two years later.

After you've spent a few years working with double stars, you begin to realize strange things happen sometimes in the heavens. Stars aren't always where their discoverer said they were and measurements aren't always what the records say they are. Measuring double stars is an occupation that requires constant vigilance, a demanding requirement even for people without the distraction of a daytime job. For those who do have daytime employment, the effort can sometimes be beyond demanding, especially when energy begins to flag. Errors occur. No one is immune from them no matter how many times they check and re-check their own efforts. Things happen in the dark that aren't supposed to happen.

Table 1. 2011 Data for STT 437

NAME	RA DEC	MAGS		PA	SEP	DATE
STT 437AB	21208+3227	7.2	7.4	19	2.4	2010
STT 437AC	21208+3227	7.2	11.2	142	79.9	1998
POP1232CD	21208+3227	11.2	11.2	21	15.0	1990

So when Steve sent me a photo of STT 437 and the surrounding area taken with an 80mm refractor, pointing out there was no sign of the "D" component of the CD pair (Figure 1), I became curious. He had also discovered that POP 1232 no longer existed in the WDS, which piqued my curiosity even more. Because it had been almost two years since I wrote the piece which included STT 437 and hadn't looked at it since, I went back and re-familiarized myself with what I had written and wondered if I had made some kind of mistake. I did the same searches Steve had done, with the same results – listings for POP 1232 were nowhere to be found. Still in the dark as to what had happened, I began searching for POP 1232 in the software I use for double star data and locations.

My first search was in SkyTools 3, which produced the same result for STT 437 – no mention of POP 1232 or of a companion to "C." Then I turned to an older program I still use from time to time, MegaStar 5, and

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Figure 1. 80mm Refractor Photo of STT 437 Area (Measurements are from the WDS catalog)

ran headlong into another mystery. It associated a POP 232 with STT 437, and showed the following data for it: magnitudes of 1.1 and 11.2, a position angle of twenty-one degrees, and a separation of fifteen arc seconds. The magnitude of 1.1 was clearly a typographic error, but the POP 232 designation puzzled me. Had I made a typographic error when I wrote about it, adding a "1" that wasn't there? I ran a search for POP 232 in Stelladoppie and found it didn't exist either. (If you haven't used this web site, it does an excellent job of presenting a variety of WDS data in a very accessible format).

The most valuable piece of information I gained from MegaStar was an observation date of 1990, which matched the data for POP 1232 included in my 2011 article. The POP identifier refers to G.M. Popović, so I launched an internet search and found he was associated with the University of Belgrade and published his measurements in their journal, the *Bulletin Astronomique de Belgrade*. Next I turned to the SAO/NASA Astrophysics Data System web site to search for his publications. Since his observation of POP 1232 was made in 1990, I concentrated on 1991, but came up empty-handed. The only entry for that date was a short abstract which provided me with no useful information. I went back to the internet and tried a variety of searches, and just as I was about to give up, I found what I was looking for. It was a January 8th, 2003, document entitled "The Survey of the Double Star Measurements Discovered in Belgrade with Zeiss Refractor 65/1055cm (v. 2003.0)", which lists all the double star discoveries made with the 650cm Zeiss refractor at Belgrade between about 1954 and 2000 by six observers, including G. M. Popović.

I scanned the list looking for POP 232 (the list is sorted by discoverer first and then numerical designation) and found the POP numbers suddenly jumped from POP 223 to POP 1219 and then became sequential again. Holding my breath, I continued down the list and found what I was looking for, which is shown in Table 2.

One thing was immediately clear: the POP 232 designation in MegaStar was the result of an error. The WDS number on the first line of the listing, 21208+3227, matches that of STT 437, which confirmed POP 1232's association with it, and the ADS number (14489) also matches that of STT 437. The numbers in the second line contain the position angle and separation for POP 1232 that I had listed in my earlier piece on STT 437. Next on that line is the number of observations (1) followed by two magnitudes (10.0, 10.0), which puzzled me since they were not what I had found two years prior. However, the third line, which is the listing as it appeared in the WDS, did include the two magnitudes of 11.2 I had previously found, leading me to guess the magnitudes on the second line were estimates.

There's also a reference to a note on that line (1n), so I scrolled down to the bottom of the document and found this note: "*POP1232 Magnitude for component C in WDS is wrong: instead of 1.12, needs to be 11.2.*" And that explained the magnitude error I had found in MegaStar.

It took a while longer for the last light to come on, but I later realized that "Pop1994" at the end of the second line was a bibliographic reference. Again holding my breath, I searched once more through the listings in

Table 2. Data from Zeiss Survey at Belgrade

POP1232	CD	21208+3227=ADS14889CD						
POP1232	CD	1990.750	21.1	15.01	1	10.0	-10.0	Pop1994
POP1232	CD	1990	21	15.0	1n	11.2	-11.2	WDS

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MICROMETER MEASUREMENTS OF DOUBLE STARS (Series 48)

Table 1 (continues)

ADS	Disc. IDS Mag	Mult.	Epoch 1900+	P	ρ	Est.Mag.	Weight	Obs.	Notes
14889	STT 437	AB	90.746	25°.3	2″.22	0.5	1+1		
	21166N3202		90.750	23.0	2.32	7.0−7.7	2+3		
	6.9 − 7.6		**90.749**	**23.7**	**2.29**	**0.6**	**2n**	**POP**	$\Delta\theta/146y = +44°$
	6.4 − 11.2	AC	90.750	142.0	80.72	7.0−10.0	2+2		
			90.750	**142.0**	**80.72**	**7.0−10.0**	**1n**	**POP**	
	-	CD	90.750	21.1	15.01	10.0−10.0	2+2		The position related to AB:
			90.750	**21.1**	**15.01**	**10.0−10.0**	**1n**	**POP**	$\Delta\alpha = +6^s$, $\Delta\delta = +3'$.
									The first measurements.

Source: 1994BABel.150..109P

Figure 2. Listing for POP 1232 in Bulletin Astronomique de Belgrade, 1994, p. 115.

the SAO/NASA Astrophysics Data System site, looking for a 1994 publication by G.M. Popovich. Eventually I found a 1994 *Bulletin Astronomique de Belgrade* publication entitled "Micrometer Measurements of Double Stars", opened it, and began scrolling through several pages of double star observations until I struck gold on page 115 (Figure 2).

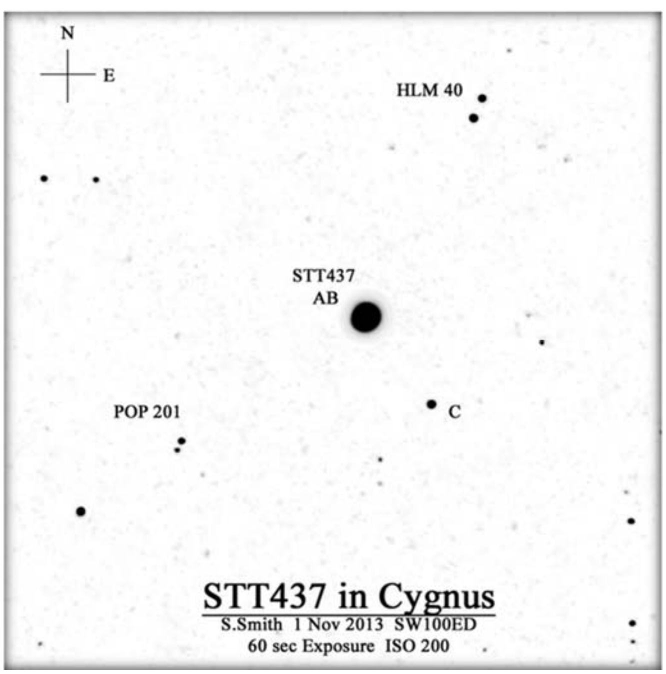

Figure 3. 100mm Refractor Photo of STT 437 area looking for "D"

There, finally, was the original observational data I had been searching for – and it contained the estimated magnitudes of 10.0 for both components that I had found in the 2003 Zeiss Refractor document.

Now that I knew for sure POP 1232 had actually existed, I was left with the next big question: *What happened to it?*

As I sat mulling that question over on a cloud-covered night, I was looking at the most recent photo Steve Smith had sent me, which went a bit deeper because it was taken with a 100mm refractor (Figure 3). Other than a few faint field stars in the general location of 'C", it was obvious there was no "D" that came anywhere near to matching the catalog data. Maybe it was because the field of view in the second photo was smaller than the first, but suddenly my eyes were drawn to the pair of stars northeast of the STT 437 primary, HLM 40. Both stars appeared to be about the same magnitude as STT 437 C, the position angle was similar to POP 1232's twenty-one degrees, and the distance between the two stars appeared to be close to the 15 seconds of arc listed for POP 1232.

On a hunch, I entered HLM 40 in the search box of Stelladoppie and found it was listed with a separation of 15.2" and a position angle of twenty-three degrees, both matching closely with the POP 1232 data. The magnitudes listed there caused me to hesitate – 11.8 and 12.6 – but I scanned down to the WDS notes section of the screen and found this:

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21218+3230 HLM 40   Also appears to be POP1232CD
       which is not related to 21208+3227. WDS po-
sition of HLM 40 far off and is corrected here.
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Just to make certain, I switched over to the WDS and double-checked the data and notes. Everything matched the Stelladoppie screen. My next step was to send a request to Brian Mason at the WDS for the observational data on HLM 40. What I found was the 1990 observational data for POP 1232 had also been entered under HLM 40 for 1990 (Table 3).

So there it was. POP 1232 hadn't disappeared – it had been HLM 40 all along!

I passed my new found discovery onto Steve immediately, along with a question: would it be possible to measure the position angle and separation of HLM 40 using the existing data for STT 437 AC as a basis for calibration? I had seen Steve use AutoCAD to measure position angles and separations, and it looked like it should be possible to do it in this case as well. HLM 40 hadn't been measured since 2000, so it would be well worth the effort. *Eight separate photos were measured* and the results averaged. One of the photos showing the AutoCAD measurements of HLM 40 is shown in Figure 4, along with the measure of nearby POP 201, which hadn't been measured since 2002. A comparison of those measures with existing measures for HLM 40 and POP 201 are shown in Table 4.

Now obviously we weren't the first to discover POP 1232 is actually HLM 40. In our blissful unawareness of someone else's effort, we probably wandered down the same labyrinthine paths they did. Nevertheless, the

Table 3. HLM 40 WDS Data File and 1990 POP 1232 Observation

NAME	RA DEC	MAGS	PA	SEP	DATE
HLM 40	21218+3230	10.7 11.0	18.0	13.48	1925
HLM 40	21218+3230	10.0 10.0	21.1	15.01	1990
HLM 40	21218+3230	11.8 12.6	22.7	15.16	2000
POP1232 CD	21218+3230	10.0 10.0	21.1	15.01	1990

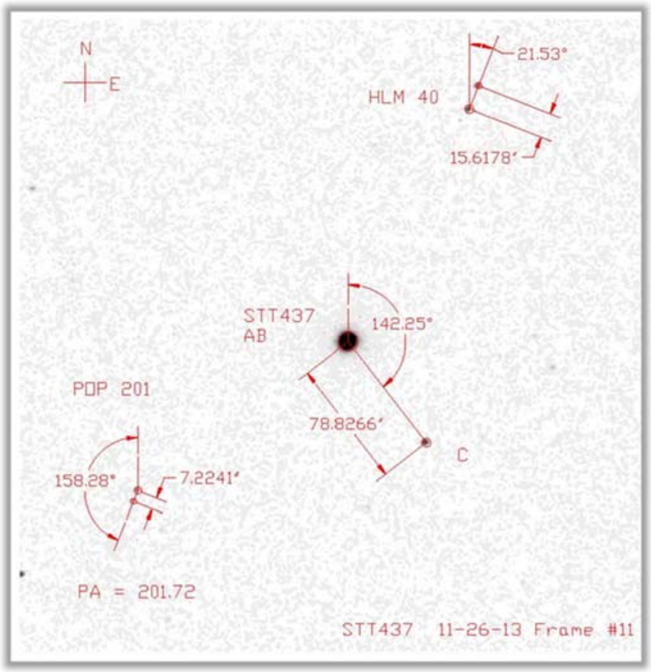

Figure 4. One of Eight Photos Showing Measurements of HLM 40 and POP 201 using AutoCAD (see Note 1 in Table 4).

Table 4. Measures of HLM 40 and POP 201

NAME	RA DEC	MAGS	PA	SEP	DATE	NOTES
HLM 40	21218+3230	10.7 11.0	18.0	13.48	1925	
HLM 40	21218+3230	10.0 10.0	21.1	15.01	1990	
HLM 40	21218+3230	11.8 12.6	22.7	15.16	2000	
HLM 40	21218+3230	11.8 12.6	22.9	15.50	2013.912	1
POP 201	21207+3226	12.5 13.0	204	7.3	1998	
POP 201	21207+3226	12.5 13.0	202	7.3	2002	
POP 201	21207+3226	12.5 13.0	202.8	7.2	2013.912	1

Notes:

1. The 2013 measures shown for both HLM 40 and POP 201 are the result of taking measures from eight separate photos and averaging the results.

process of discovery is still the process of discovery, even for those who come to it unaware they're duplicating a prior effort. The thrill is still the same and it's worth every second of it even when you later realize you're not the first.

And when it culminates in the opportunity to offer new measurements of a pair of obscure double stars not measured for the past ten years, the resulting reward is more than ample compensation for all the effort put forth. So in the same way that old stars give birth to new stars, the demise of POP 1232 gave birth to new measurements for a pair of double stars that otherwise would likely have remained obscure for many years longer.

Notes on Photo Images and Measurement

The photographs of STT 437 were taken through a Skywatcher SW100ED (4"-f9) refractor telescope at prime focus using an Olympus EPL-1 Camera and processed using Adobe Photoshop Elements. The photos were typically 30 to 60 second exposures at ISO 200. Drift timings of stars crossing the camera sensor yield a calibration constant of approximately 1 arc-second per pixel for this particular camera-scope combination. In addition to the guided frames, several 30-second unguided star trail photos were also taken to establish the east-west orientation of the frames for each night's observing session. In order to calibrate the photo frames and imaging system, several photos of the nearby triple star system S790 were also taken. It would have simplified things significantly if the A-C pairing of STT437 could have been used to calibrate the images as it falls in the same field-of-view as HLM 40 and POP 201, but at the exposure times required to image HLM 40 and POP 201, the A-B components of STT 437 could not be resolved as separate objects.

In Photoshop the star trail photos, the S790 calibration photos, and the STT437 photos for each night's observations were copied and pasted as individual layers into a single Photoshop document. The composite image was then rotated until the star trail was parallel to the upper or lower part of the editing window, thus squaring all of the photos and the celestial coordinate system to the edges of the editing window. The full frame photos could then be cropped in unison to a more manageable size. The fields-of -view of the three systems were encompassed in an area of approximately 900 x 900 pixels (15' x 15'). The photos were cropped square (1:1 aspect ratio) in order to reduce the possibility of introducing unwanted distortions or unequal scaling of the image when importing a rectangular image into AUTOCAD.

The double star measurements were made by importing bitmap copies of the photos into AutoCAD, a professional computer based engineering and technical drawing application. A circle was drawn and centered on each star image, the center point of the circle thus establishing the measuring point for each star. A line was then drawn connecting the center points of the circles representing the primary and secondary of each pair of stars. Since the image had previously been rotated and squared, a vertical line passing through the center point of each primary star established the North-South direction.

The dimensioning functions of the CAD Program (Angular and Linear) can then be used to measure the Position Angle (PA) and Separation of the pairs. The angular measurements can be read directly but the linear dimension (separations) will be in whatever default units (feet, inches, mm etc.) that are set by the user. The CAD program can be set to read the separation in arc seconds but requires that the image scale be established.

The nearby triple star system S790 in Cygnus was chosen as a suitable calibration object since the position measurements in the WDS are recent (2012) and have shown little change over the years. According to the WDS the current values are: A-B separation = 34.7" and A-C = 53.3". The image scale factors were then calculated as:

Scale Factor 1 = 34.7 arc-sec / Measured A-B Distance in inches = arc-sec/inch

Scale Factor 2 = 53.3 arc-sec / Measured A-C Distance in inches = arc-sec/inch

Table 5. Average of Measurements and Statistics

	POP 201		HLM 40	
	PA (deg)	Sep (arc-sec)	PA (deg)	Sep (arc-sec)
No. Obs.	8	8	8	8
Avg	202.8	7.2	22.9	15.5
Std Dev	2.06	0.37	0.91	0.23
Std Err Mean	0.73	0.13	0.32	0.08

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The average of the two scale factors for each night's observations were then entered into the Dimensional Properties dialog box and from that point any CAD generated dimensions were directly converted into arcseconds. In all, eight separate frames taken over the course of three nights of observation were measured and averaged to come up with the new measures for HLM 40 & POP 201 presented herein. The averages of the measurements and statistics are presented in Table 5.

This procedure seems to produce reliable measures based on my measures of other systems and the calibration frames used for this project. These new measures for HLM 40 & POP 201 also appear to be in line with the trends of the historical measures for these systems. While the procedure is somewhat time consuming and does not lend itself to the reduction of large amounts of data, it illustrates the procedures and processes used by astrometric software programs such as Reduce and Astrometrica, and has the benefit of producing a permanent visual and graphic record of the measurements.

References

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Nanson, John., 2012, "The Subtleties of Starlight in Cygnus, First Part: Upsilon Cygni (OΣ 433), STT 437 (OΣ 433), and STF 2762 (Σ 2762)", Bestdoubles.wordpress.com: http://wp.me/pVYaT-MO

Popović, G.M., Pavlović, R., 1994, "Micrometer Measurements of Double Stars (Series 48). *Bulletin Astronomique de Belgrade*, **No. 150** (1994), pp. 109-116. http://articles.adsabs.harvard.edu/full/1994BABel.150..109P

Popović, G.M., Pavlović, R., Pakvor, I.,2003, "The Survey of the Double Star Measurements Discovered in Belgrade with Zeiss Refractor 65/1055cm (v. 2003.0)": http://www.aob.rs/old/Science/Beomes.htm

Web Sites

AutoCAD: http://www.autodesk.com (AutoCAD is a Professional Computer Aided Design drawing program but there are other low-cost or shareware/freeware technical drawing software packages available that can provide the same functionality).

SAO/NASA Astrophysics Data System site: http://articles.adsabs.harvard.edu/

Stelladoppie WDS Interface: http://stelledoppie.goaction.it/index2.php?section=1