About the Relative Proper Motion of 61 Cygni

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Abstract: While both physically connected components are often observed, the different background stars of 61 Cygni are infrequently described. In this paper, 12 new measurements between 61 Cygni and background stars from 2004, 2007 and 2008 are listed. Analyses of the different complete data sets are shown in detail and resulting proper motion were calculated.

Introduction

61 Cygni is a well known double star with high proper motion of both components. Its structure was found in 1753 by James Bradley, its proper motion was found in 1803/1804 by Giuseppe Piazzi (Fodera-Serio, 1990). Friedrich Wilhelm Bessel used 61 Cygni and some background stars to observe the first parallax of a fixed star in 1837/1838. Because of the slow orbital motion of both components, 61 Cygni is often observed.

If we have a look on the data listed in the Washington Double Star Catalog, over 1600 observations described distance and angle of the physically connected main components 61 Cygni AB. But just a few observations described the position between 61 Cygni and some background stars. If we take the 6 background stars AC to AH, a total of only 20 observations are listed in the Washington Double Star Catalog.

The 61 Cygni wide fields

Because of the high proper motion of 61 Cygni AB, the background field changes in time. The field of Piazzi's or Bessel's observations has completely changed. That's why it isn't easy to compare older observations with current values. To get a good overview of the 61 Cygni field, a photo with a common digital camera was shot (Figure 1). Figure 1 is rotated 180 degrees and gives the same orientation as an eyepiece view. On this wide field picture all components expect background stars C and D are marked. The components were identified by the J2000 coordinates given in the WDS catalog. Because of the large reproduction scale the wide field picture was not used in further analyses.

New Measurements

The double star measurements were made with an 8-inch Newtonian telescope with a focal length of 1500 mm. To record the observations a standard webcam was used (Schlimmer 2007a, Schlimmer 2008b). Reproduction scale of the optical system is about 0.794 ± 0.002 arc seconds / pixel. To get the greatest field surround 61 Cygni in 2008, the star was placed in the different corners of the image. Four videos were recorded. The faintest magnitude of stars which can be recorded directly is about 10.5. For components less than 10.5 magnitudes first the frames will be stacked. In this way, signal to noise ratio is improved and components with magnitudes of 11.5 could be detected. For analyses of the webcam records REDUC software package was used.

Table 1 shows my own measurements of 2004, 2007 and 2008. Some components, like AF, were measured for the first time since 1921. Other components near 61 Cygni A not yet listed in WDS catalog are marked with (1).

Calculation of the proper motion

To calculate the relative proper motion, the complete data set of the measurements from WDS (Mason et al., 2008) and the current measurement of the author are used. The different measurements will not

(Continued on page 104)

About the Relative Proper Motion of 61 Cygni

Name	RA+Dec	Mags		PA	SEP	Date	N
STF2758AB	21069+3845	5.35	6.10	151.3	31.00	2008.689	68
STF2758AE	21069+3845	5.35	9.63	271.4	305.89	2008.689	23
STF2758AF	21069+3845	5.35	11.32	241.5	329.14	2008.689	1
STF2758AG	21069+3845	5.35	10.84	237.6	198.03	2004.782	1
STF2758AG	21069+3845	5.35	10.84	236.7	212.85	2007.706	1
STF2758AG	21069+3845	5.35	10.84	236.7	217.69	2008.689	1
STF2758AH	21069+3845	5.35	10.89	302.0	73.12	2004.782	
STF2758AH	21069+3845	5.35	10.89	291.1	79.61	2007.706	
STF2758AH	21069+3845	5.35	10.89	288.2	82.33	2008.689	21
STF2758A1	21069+3845	5.35		47.7	40.89	2004.782	1
STF2758A1	21069+3845	5.35		45.0	25.99	2007.706	1
STF2758A1	21069+3845	5.35		43.9	20.64	2008.689	1

Table 1: Measurements by the author, N = 1 stacked frame was analyzed, N > 1 Number of analyzed single frames.

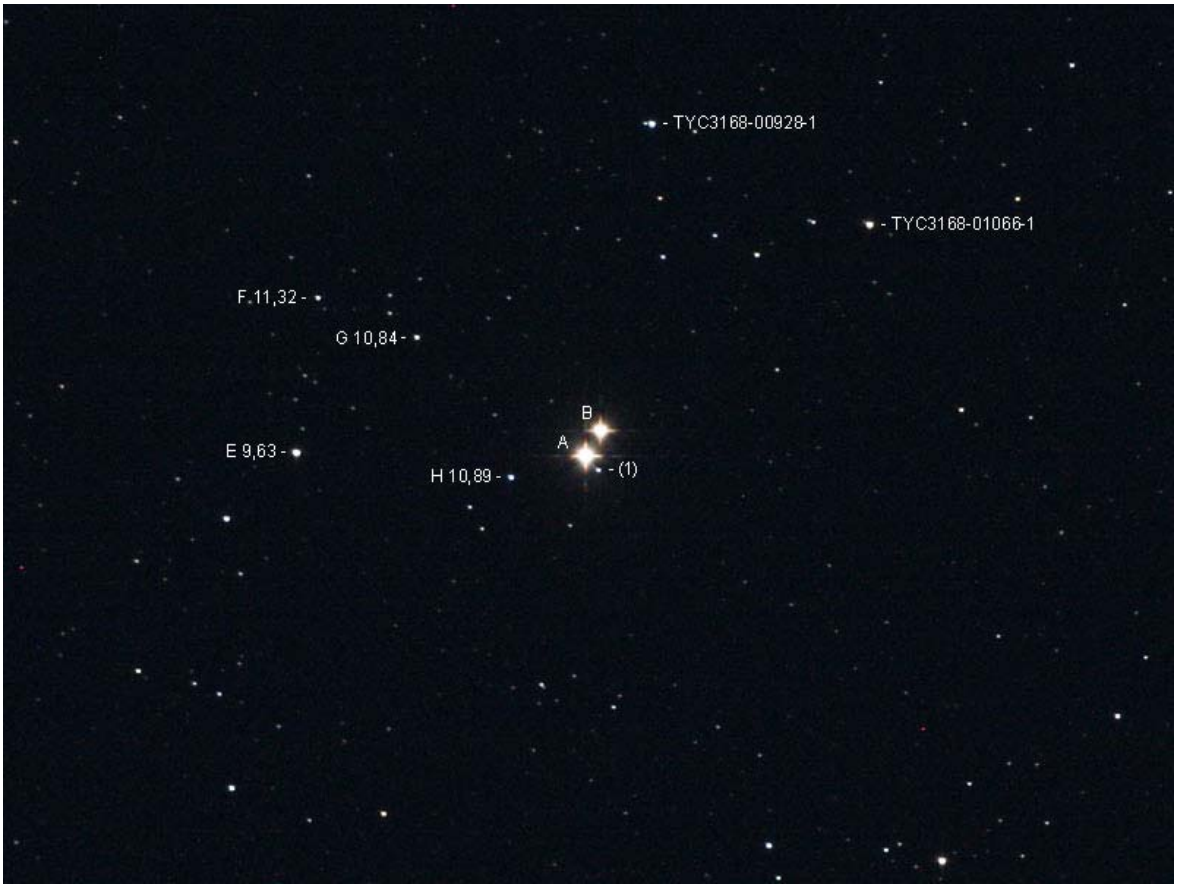

Figure 1: 61 Cygni wide field image, Canon EOS 400D, 30 s.

About the Relative Proper Motion of 61 Cygni

(Continued from page 102)

be weighted. For plotting the relative proper motion the measurements will be transformed from polar to Cartesian coordinates by following formulae:

$$x = d \sin (PA)$$
$$y = d \cos (PA)$$

in which d is the distance or separation in arc seconds and PA is the position angle. A linear fit will be calculated with the Gaussian method of least squares. The x value of the proper motion, which represents the motion in right ascension, will be taken directly from Cartesian coordinates. To calculate the proper motion in declination, the y value from linear fit (y = mx + b) will be used.

Calculation of the residuals

61 Cygni AC

Component C is outside of the CCD and wide field image and was not measured. Three measurements between 1907 and 1924 are listed in the WDS catalog. Two of these measurements are faulty or one measurement is faulty and component C has also a significant proper motion. No linear fit and no residuals can be calculated.

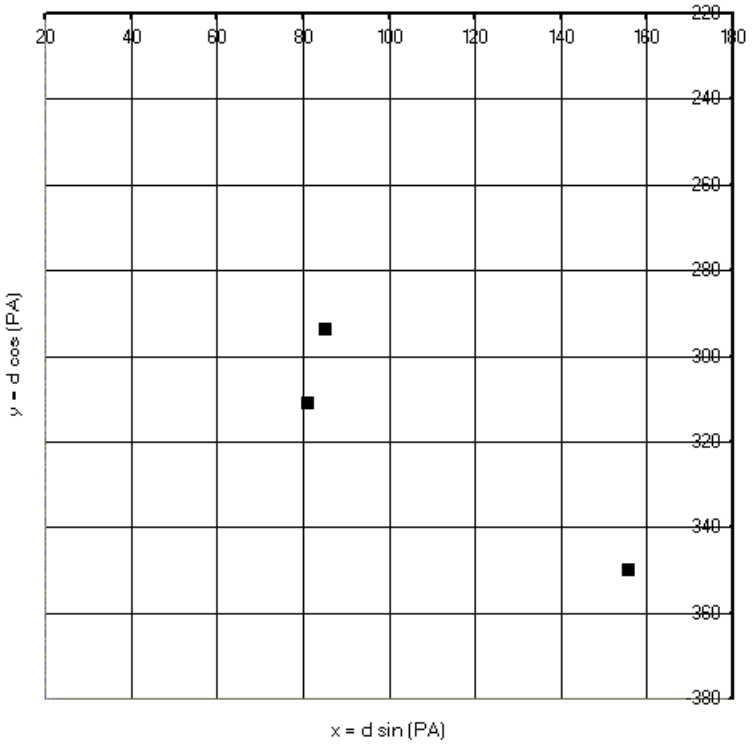

Figure 2: xy plot of 61 Cygni AC.

About the Relative Proper Motion of 61 Cygni

61 Cygni AD

Same situation as component C. Component D is outside of the CCD and wide field image. Three measurements between 1918 and 1991 are listed in the WDS catalog. Component D is outside of the CCD image. Three measurements between 1918 and 1991 are listed in the WDS catalog. Two of these measurements are faulty or one measurement is faulty and component D has also a significant proper motion. No linear fit and no residuals can be calculated.

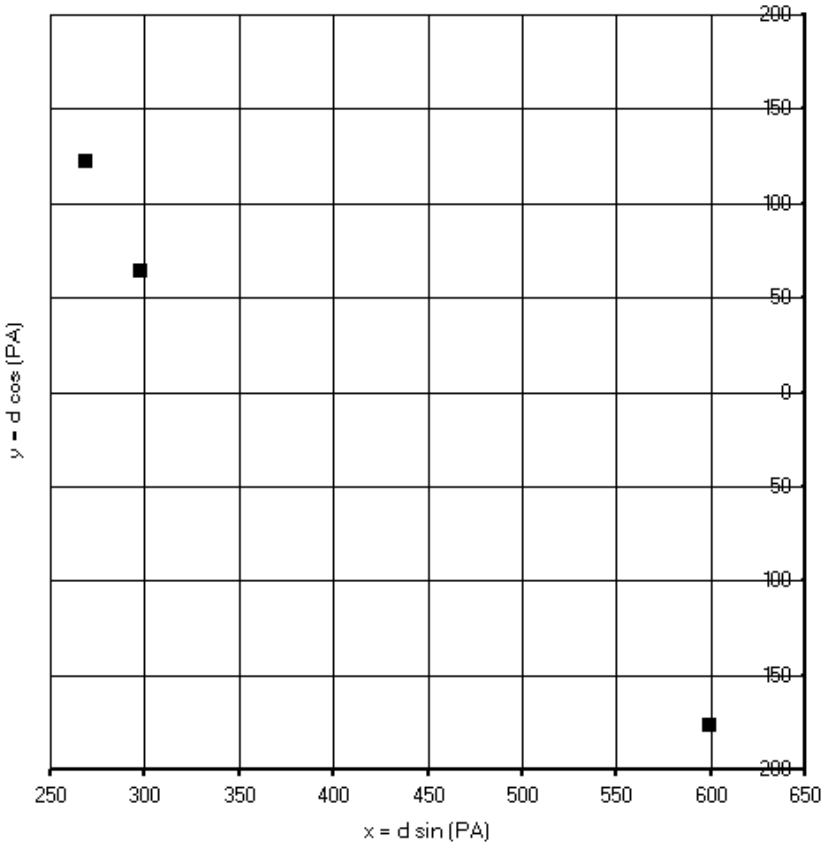

Figure 3: xy plot of 61 Cygni AD.

About the Relative Proper Motion of 61 Cygni

61 Cygni AE

Historic measurements of 61 Cygni AE are given in Table 2 along with measurements by me and results of a linear fit. Note that the observation of 1983 was not used in calculating the linear fit.

Ref. Code	Date	PA Observed	PA Calculated	PA residual	Sep. Observed	Sep. Calculated	Sep. Residual
VvS1919	1918.820	12.30	12.30	0.00	305.970	305.900	0.07
Tob2006c	1983.614	359.40	359.30	0.10	288.300	245.812	42.49
TYC2002	1991.680	284.50	284.96	-0.46	245.140	245.660	-0.52
Arn2002a	2001.688	277.00	276.45	0.55	280.450	280.135	0.32
Arn2003c	2002.625	276.00	275.65	0.35	284.400	284.225	0.18
Schlimmer2008	2008.741	271.44	271.90	-0.46	305.892	305.963	-0.07

Table 2: Measurements, linear fit and residuals of 61 Cygni AE

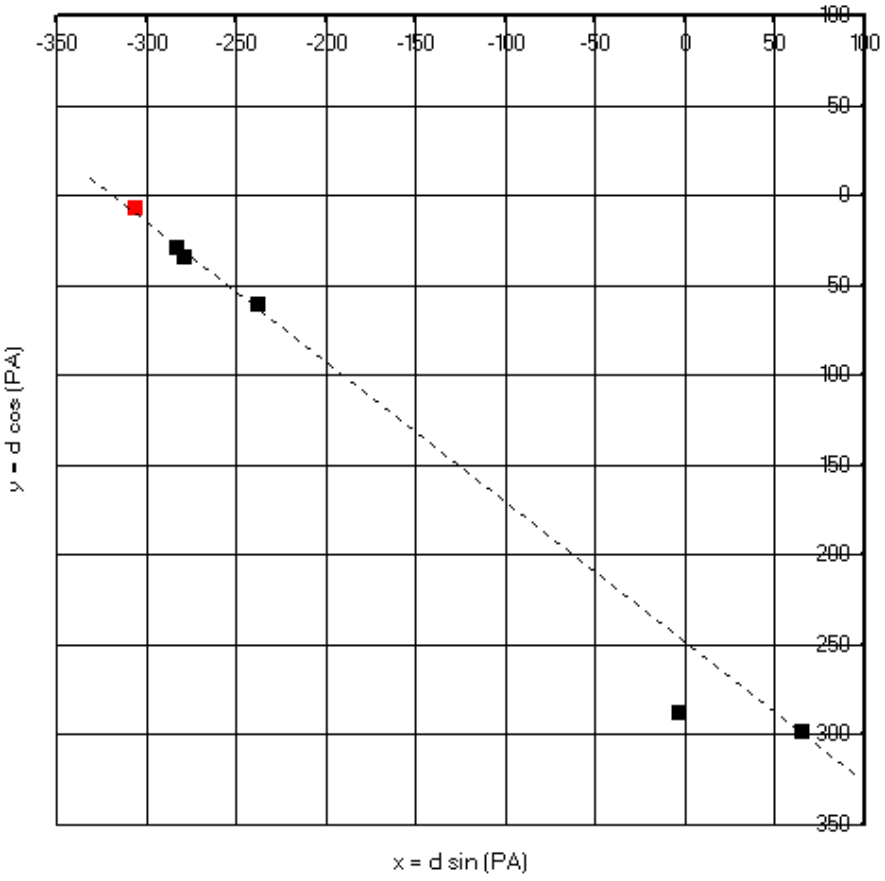

Figure 4: Measurements of 61 Cygni AE. The red square is the measurement by the author.

About the Relative Proper Motion of 61 Cygni

61 Cygni AF

Historic measurements of 61 Cygni AF are given in Table 3 along with measurements by me and the results of a linear fit. The measurements and fit are shown graphically in Figure 5.

Ref. Code	Date	PA Observed	PA Calculated	PA residual	Sep. Observed	Sep. Calculated	Sep. Residual
VvS1919	1918.660	31.100	31.42	-0.32	157.130	155.685	1.45
Abt1922	1921.680	29.700	29.35	0.35	140.560	142.079	-1.52
Schlimmer2008	2008.689	241.520	241.51	0.01	329.141	329.167	-0.03

Table 3: Measurements, linear fit and residuals of 61 Cygni AF

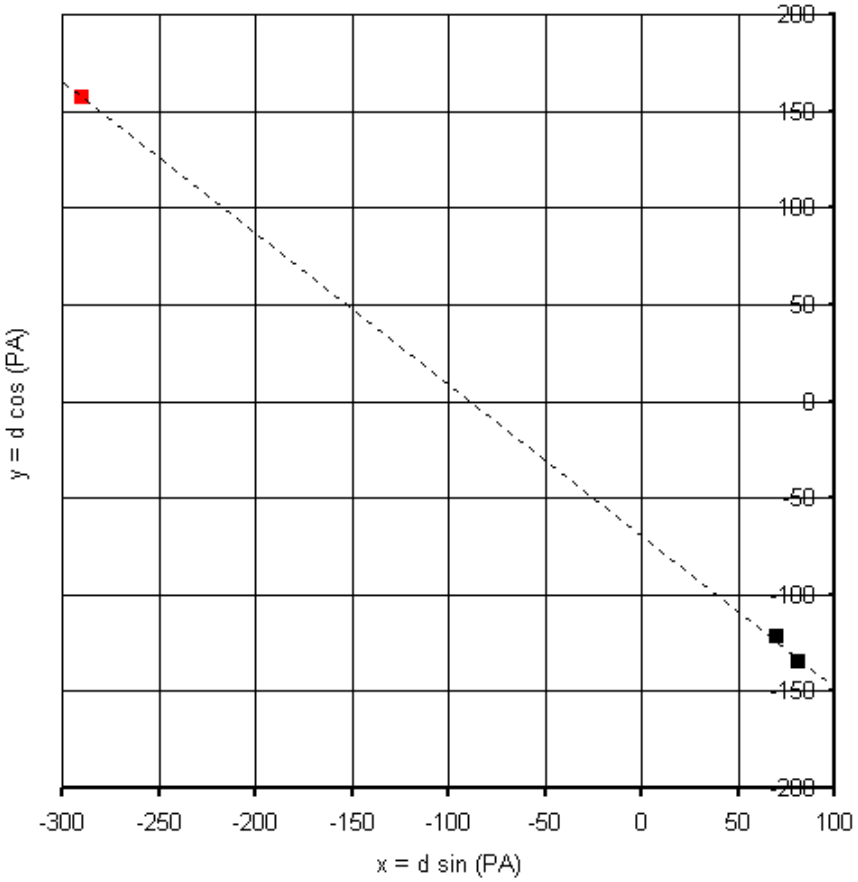

Figure 5: Measurements of 61 Cygni AF. The red square is the measurement by the author

About the Relative Proper Motion of 61 Cygni

61 Cygni AG

Historic measurement of 61 Cygni AG are given in Table 4 along with measurements by me and the results of a linear fit. The measurements and fit are shown graphically in Figure 6.

Ref. Code	Date	PA Observed	PA Calculated	PA residual	Sep. Observed	Sep. Calculated	Sep. Residual
Ole1977a	1975.560	255.800	255.94	-0.14	48	47.970	0.03
Schlimmer2004	2004.782	237.620	237.28	0.34	198.033	198.788	-0.76
Schlimmer2007	2007.706	236.690	236.91	-0.22	212.851	212.309	0.54
Schlimmer2008	2008.689	236.720	236.78	-0.06	217.693	217.533	0.16

Table 4: Measurements, linear fit and residuals of 61 Cygni AG

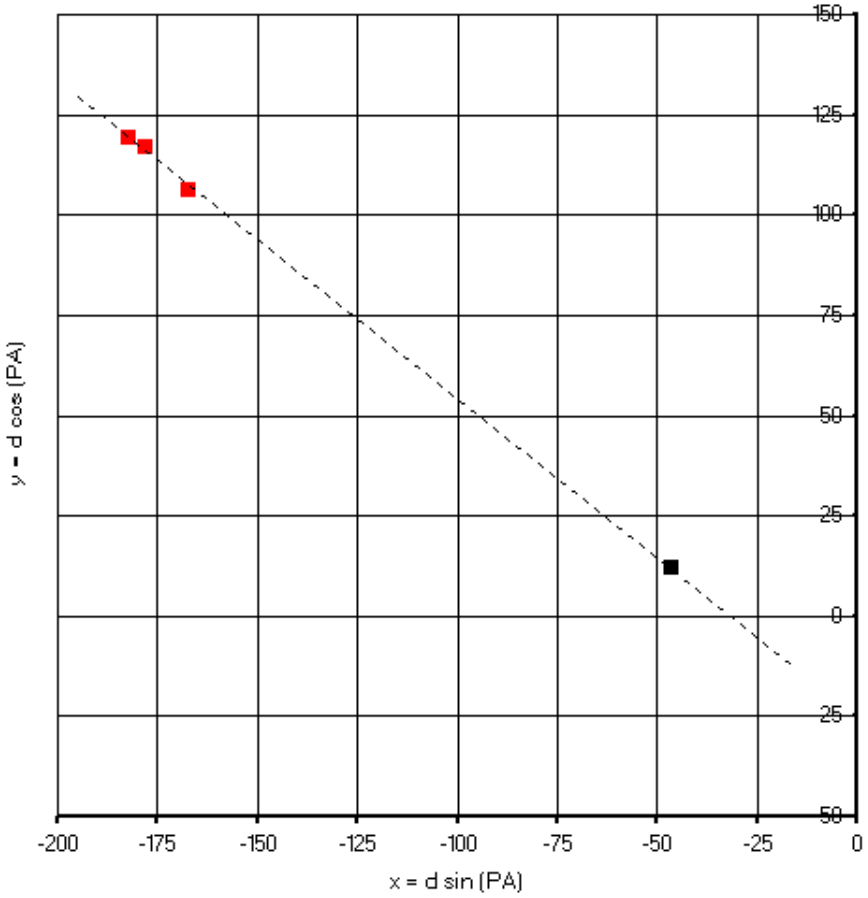

Figure 6: Measurements of 61 Cygni AG. The red squares are the measurements by the author

About the Relative Proper Motion of 61 Cygni

61 Cygni AH

Historic measurement of 61 Cygni AG are given in Table 5 along with measurements by me and the results of a linear fit. The measurements and fit are shown graphically in Figure 7.

Ref. Code	Date	PA Observed	PA Calculated	PA residual	Sep. Observed	Sep. Calculated	Sep. Residual
Ary2004	2003.028	307.900	307.52	0.38	70.680	70.320	0.36
Ary2004	2003.882	304.300	304.85	-0.55	70.830	71.297	-0.47
Arn2006c	2004.732	300.800	301.63	-0.83	72.090	72.723	-0.63
Schlimmer2004	2004.782	302.020	301.56	0.46	73.119	72.756	0.36
Ary2005	2004.983	300.600	300.01	0.59	73.990	73.548	0.44
Ary2006	2005.878	296.900	297.00	-0.10	75.240	75.304	-0.06
Ary2007	2006.836	294.300	294.22	0.08	77.240	77.191	0.05
Schlimmer2007	2007.706	291.07	291.12	-0.05	79.606	79.635	-0.03
Schlimmer2008	2008.689	288.18	288.18	0.00	82.331	82.333	0.00

Table 5: Measurements, linear fit and residuals of 61 Cygni AH

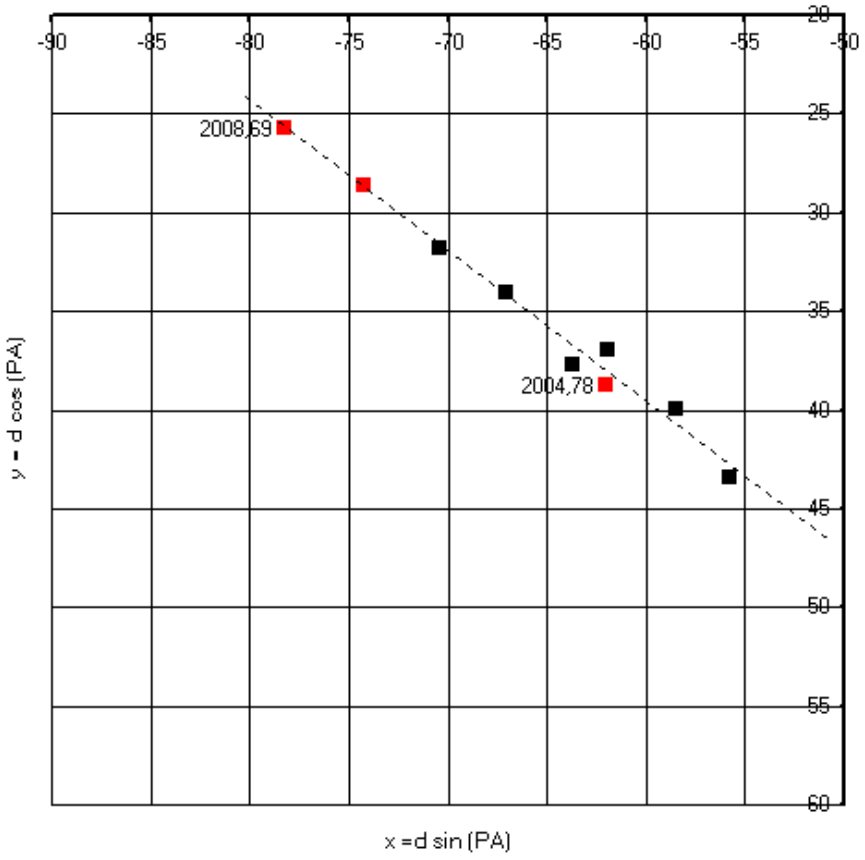

Figure 7: Measurements of 61 Cygni AH. The red squares are the measurements by the author

About the Relative Proper Motion of 61 Cygni

61 Cygni AI

Measurements of 61 Cygni AI made by the author are given in Table along with the results of a linear fit. The measurements and fit are shown graphically in Figure 8.

Ref. Code	Date	PA Observed	PA Calculated	PA residual	Sep. Observed	Sep. Calculated	Sep. Residual
Schlimmer2004	2004.782	47.740	42.31	5.43	40.889	40.921	-0.03
Schlimmer2007	2007.706	44.960	44.75	0.21	25.987	25.855	0.13
Schlimmer2008	2008.689	43.880	46.39	-2.51	20.643	20.744	-0.10

Table 6: Measurements, linear fit and residuals of 61 Cygni AH

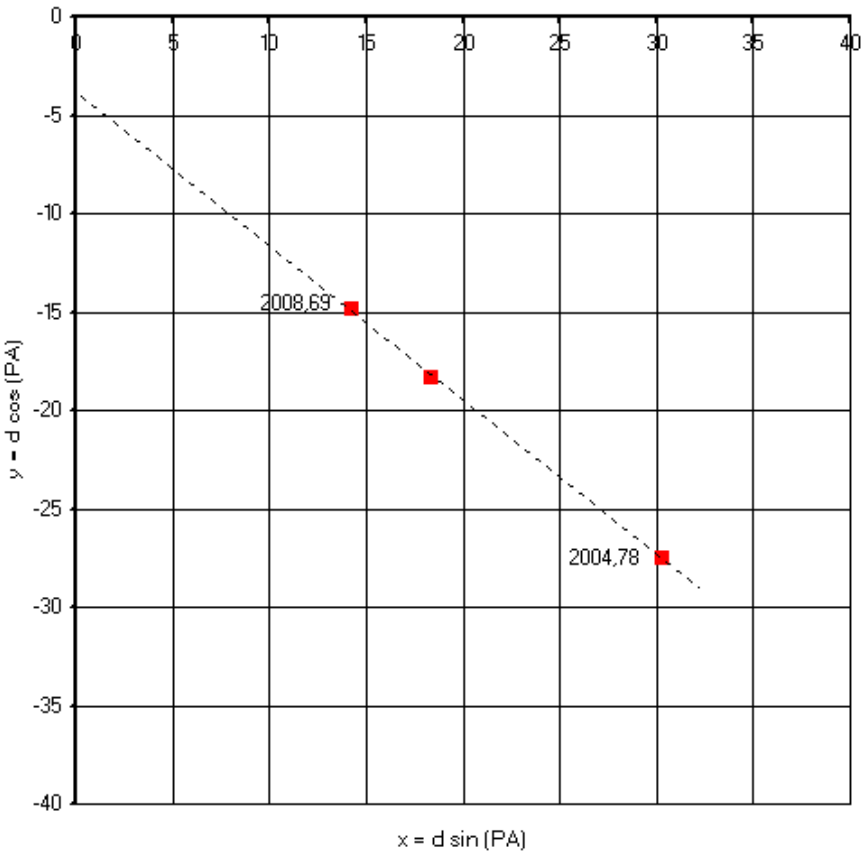

Figure 8: Measurements of 61 Cygnii AI made by the author. The dashed line is a linear fit to the points.

Summary of Results

Table 7 below shows the relative proper motion between background stars and 61 Cygni AB.

At least we compare these proper motion calculated from observation data with results of Hipparcos mission: pm (x)= 4133 mas, Pm (y) = 3202 mas, pm = 5228 mas. As we can see, the results from observation values of AF, AG and AH are close to Hipparcos results.

References

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	pm(x)/ mas	pm (y) / mas	pm / mas
AB	-	-	-
AC	not calculated	not calculated	not calculated
AD	not calculated	not calculated	not calculated
AE	4013	3123	5085
AF	4115	3220	5225
AG	4089	3245	5220
AH	4153	3170	5225
AI	4083	3206	5192
average	**4091**	**3193**	**5189**

Table 7: Results of the Proper Motion