Chapter 11

Considering Proper Motion in the Analysis of Visual Double Star Observations

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Introduction

When performing an analysis of theta/rho shifts in double and multiple star listings, the effects of proper motion need to be taken into account. Otherwise, it is possible for erroneous conclusions to be drawn regarding the causes for such shifts. Oftentimes, the double star researcher may have the desire to focus upon performing theta/rho measurements from the neglected double star list that is generated from the *Washington Double Star Catalog*. Such a listing usually includes double stars with very few measurements, or those that have not been measured for at least ten years. Because of the amount of time that has usually elapsed since the last measurements were published, the effects of proper motion by the components might cause dramatic shifts in a given set of theta/rho parameters. In order to demonstrate the effects of this phenomenon, the star system STF 2758 (61 Cygni), as listed in the WDS Catalog, has been selected as the focus for this chapter.

Orbital Motion Causes Shifts in the STF 2758 AB Configuration

To begin with, the "A" and "B" components comprise a well known visual binary star that has been thoroughly studied for decades. Theta/rho shifts occur from the effects of orbital motion.

However, besides displaying an orbital motion of significance, proper motion by the "A" and "B" components is also very noteworthy. In fact, the common proper motion shifts in right ascension and declination contribute to a total composite shift of about 6.25 arc seconds per year, which is an extremely high value. The reasons for this are a distance of only 11 light years from earth and a high velocity through space, relative to the sun, for components "A" and "B" (Burnham 1978).

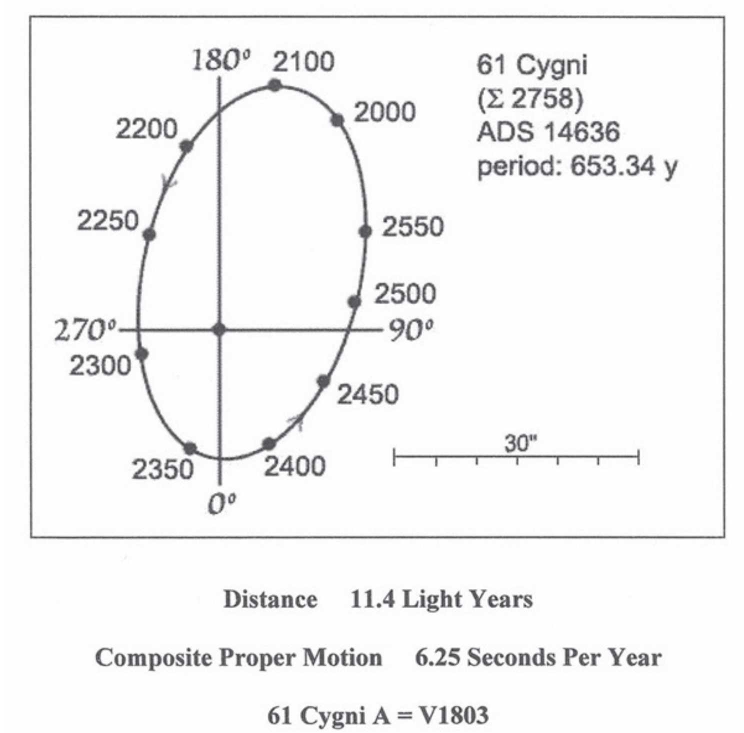

Figure 1: The orbital configuration for the "AB" components. As can also be seen here, the wide separation of these components, and a period of 653 years, are factors that are conducive to constant monitoring, even by researchers with small telescopes.

Proper Motion Causes Theta/Rho Shifts for Configurations "AC" Thru "AH"

The scenario is vastly different when a study of components "C" through "H" is undertaken. The effects of proper motion by the "AB" components, relative to the positions of components "C" through "H," are extreme. Figure 2 shows the magnitude and direction of the proper motion vectors for "AB" over a period of 1,000 years. When compared against the proper motion vectors of the other stars in this one degree field of view, the significance of this 6" shift per year is even more astounding. It becomes obvious from this figure that the "AB" components are the only ones that are physically connected. Components "C" through "H" are obvious optical components that form part of the array of background stars in this part of the sky. Hence, it is easy to see how these optical components can become "lost" if no measurements for these components are made for several decades.

Figure 3 (right) will serve to illustrate this point in more detail. Figure 3 (upper) represents the way that the STF 2758 system appeared in 1918.

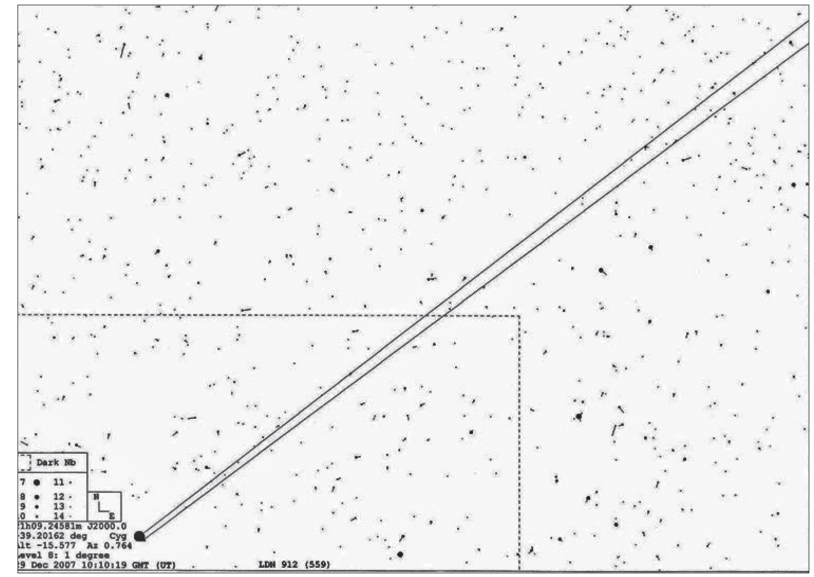

Figure 2: Proper motion vectors for STF 2758 over 1000 years compared to the proper motion vectors for several background stars in the same field of view.

As can be seen, the "AB" components are rather centrally located among components "C" through "H." If one was to utilize the published theta/rho measurements for 1918, during that calendar year, the outlying components could be identified with little difficulty. However, if one had to utilize these same measurements today, all of the optical components would be drastically out of place.

By comparing Figure 3 (lower), which represents this same part of the sky in 2007, with Figure 3 (upper), one can see the effect that the proper motions of "AB" have had on the rest of the system. In fact, compared with the 1918 configuration, the 2007 configuration bears no resemblance. If no intervening published measurements are available, the outlying components can become lost, and hence, neglected. This situation is well illustrated by examining, for example, the data pertaining to STF 2758 AF from the WDS Catalog.

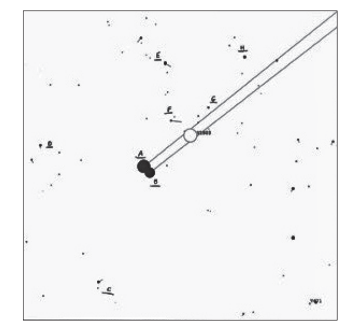

Figure 3 Upper: Position of STF 2758 in 1918.

Figure 3 Lower: Position of STF 2758 in 2007.

WDS Identifier	Discovr Comp	Epoch Frst	Epoch Lst	Theta Frst	Theta Lst	Rho Frst	Rho Lst	Magnitudes Pri	Magnitudes Sec	Spectral Type	Prop Mot RA" Dec"	2nd PM RA" Dec"
21069+3845	STF 2758 AB	1753	2005	35	151	19.6	31.0	5.35	6.10	K5V K7V	+533+326	+527+314
	STF 2758 AC	1907	1924	196	204	306.1	383.2		10.03			+001+001
	STF 2758 AD	1918	1991	282	254	304.9	625.0		10.45			+000-001
	STF 2758 AE	1918	2002	12	276	306.0	284.4		9.63			+001-001
	STF 2758 AF	1918	1921	31	30	157.1	140.6		11.32			+002-000
	STF 2758 AG	1975	1975	256	256	48.0	48.0		10.84			+000-000
	STF 2758 AH	2003	2005	308	297	70.7	75.2		10.89			-000-001

	Theta	Rho	2007.995
AC	219	798	
AD	251	708	
AE	271	307	
AF	241	329	
AG	237	218	
AH	289	82	

Figure 4: Top: A comparison of theta/rho values of all components of STF 2758 between the first and last observations in the WDS Catalog 2006.5. Bottom: Measurements of STF 2758 from B2007.995.

The top part of Figure 4 shows the WDS Catalog 2006.5 listings for all of the components of STF 2758. Looking particularly at the listing for "AF," one sees that the last published measurements were made in 1921. If the present day researcher was to look for component "F" at the listed theta/rho values of 30 degrees and 140 seconds, the star would not be found. In fact, by comparing the configuration of the background stars relative to "AB" in 1918 (Figure 3 upper), with the configuration in 2007 (Figure 3 lower), it is discovered that the theta/rho values for "AF" are 241 degrees and 329 seconds. Increases of 211 degrees and 189 seconds have occurred in that 89 year period!

When examining the more current theta/rho values for the remaining components of STF 2758, which are also listed in the lower part of Figure 4, dramatic shifts continue to be noted when compared with the WDS Catalog entries. In essence, all of these shifts are caused by the proper motions of the "AB" components alone. The proper motion values that are presented for a period of 100 years, which are listed in the two rightmost columns of Figure 4, serve to illustrate the point. The shifts in the values for "AB" are the only ones that can be attributed to orbital motion. Thus, STF 2758 can be regarded as a "textbook" case for some of the ways in which proper motion can significantly alter a listed configuration.

Proper Motion Affects Many Other Cataloged Configurations

STF 2758 is not the only catalog listing that is significantly affected by the dynamics of proper motion. There exists a large number of other double and multiple star listings in the WDS Catalog that are prone to the same difficulties, especially if the entries are actually optical doubles. Even though the shifts may not be as dramatic in these other systems (STF 2758 is a rather exceptional case), they can be significant. In addition, sometimes the outlying

components are the ones that will display large proper motion vectors, rather than the components that have the smaller rho values. Of course, even with a double star system with only two components, one component might appear relatively fixed while the other component displays a large proper motion. The possibilities are many. Figure 5 displays two examples.

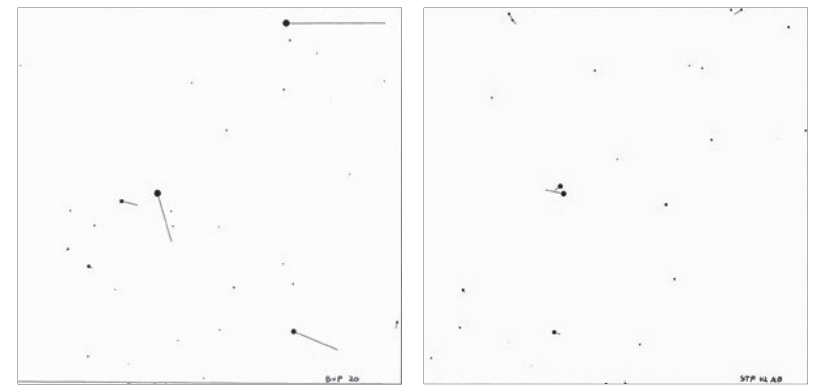

Figure 5: Examples of multiple star systems. The short lines are proper motion vectors.

Conclusion

When the researcher is performing an analysis of theta/rho shifts for a given double or multiple star listing, the possibility should be considered that the magnitudes and directions of the proper motion vectors of the components might be causing significant changes to occur. If these dynamics are not accounted for, erroneous interpretations may follow. In addition, components can appear to become "lost" over time, thereby causing them to appear in the neglected double star list.

Acknowledgements

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Reference

Burnham, R. 1978. *Burnham's Celestial Handbook*, 769.