A Novel System for Classifying Binary Orbital Solutions

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Abstract A new system for classifying binary star orbital solutions is presented. This system is comprised of seven groups. Stars in a group share a common trait which make the stars interesting targets. The method has aided in the creation of target lists which focus more on improving the grades of orbital solutions published by the Washington Double Star Catalog. The methods are still in their infancy, however the system has been useful for the authors for their recent observation runs.

Introduction

While preparing for several observation runs, we developed a set of categories which partition a large set of binary star systems. These categories have been included in the authors' target lists. The process began while the authors were reviewing possible targets for an upcoming session at Kitt Peak National Observatory. While looking through the Washington Double Star Catalog for interesting systems, there were several factors which piqued our interest, so we decided to make a list of binary star systems categorized by which of these interesting factors was the most prevalent in each system.

As of yet, this classification of orbits is moderately subjective; the authors' judgments have been made by visual inspection of the orbital plots included in the *Sixth Catalog of Orbits of Visual Binary Stars* maintained by the United States Naval Observatory. It is our hope that this method will become standardized and more rigidly defined. Eventually, perhaps a computer code could be developed which would use past observations and the parameters of the orbital solution as inputs to determine which category any binary star belonged to.

Motivations for Classifying Orbital Solutions

The motivations for our method of classifying the orbital solutions were twofold. Our first concern was maximizing the number of targets on an observation list which would most benefit knowledge of double stars. For instance, the category “Bad Orbit” indicates that recent observations of the system deviated from the orbital ephemerides, and one or two more observations could be used to calculate a more accurate orbital solution. It may be a more efficient use of time to observe systems in the “Bad Orbit” category than to observe stars with good agreement between the orbital ephemerides and the subsequent observations.

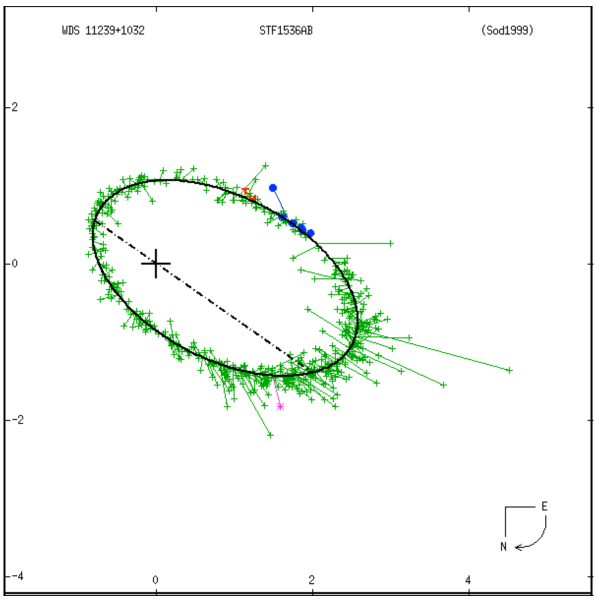
Our second goal was to streamline the observation process. As seasoned observers know, an observation run is never guaranteed to turn out useful results, no matter the amount of time or effort given to preparation. An effective observer needs to be able to think on his or her feet. By categorizing our targets before an observation run, we were able to modify our target list quickly during observations and still maintain a healthy ratio of calibration stars to scientifically interesting systems. For instance, if an observer does not have time to observe all of the systems in a target list, the observer can easily truncate the list by eliminating the less interesting systems.

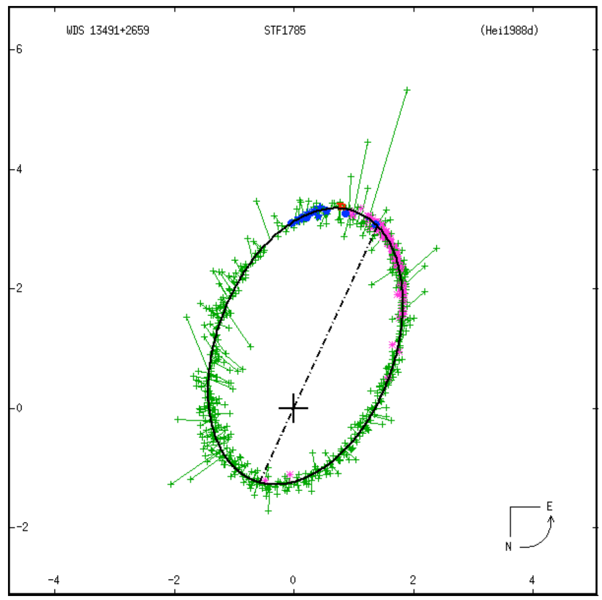
Overview of Orbital Categories

In a first cut at a classification scheme for binary orbits, we came up with the seven categories below:

CB Calibration Binaries
BO Bad Orbits
FS Few Speckles
NS No Speckles
SP Strings of Pearls
LC Late Component
SR Special Request

Calibration Binaries – CB



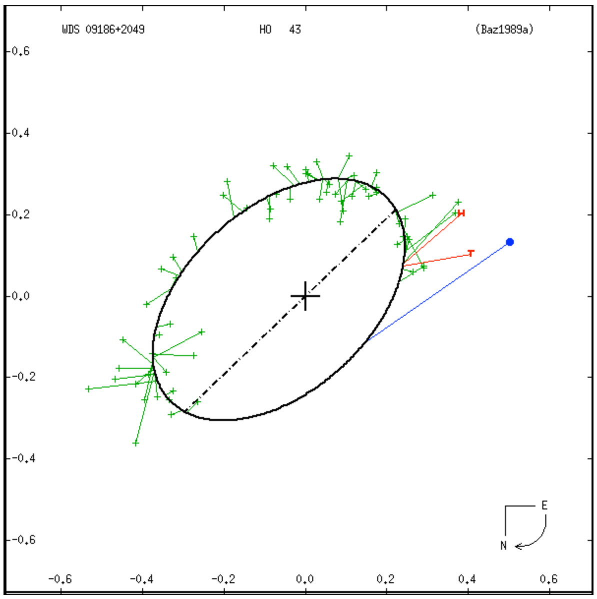


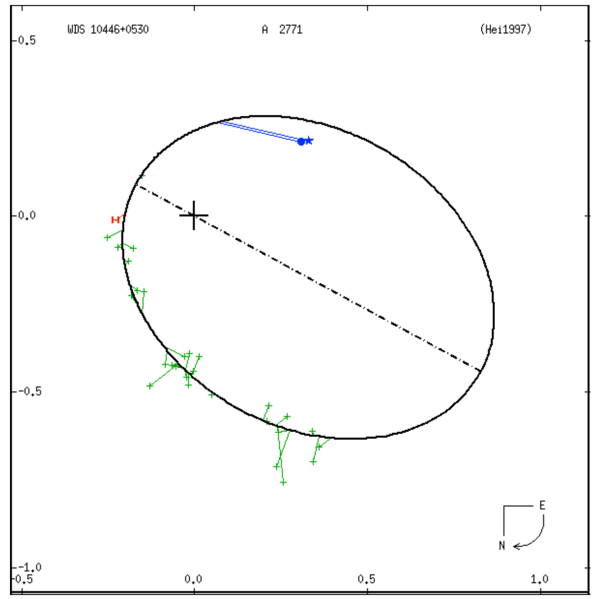
Above left is a Grade 2 system. Speckle observations suggest it is decently on track. Current separation is about 2 arc seconds, perhaps a bit close for smaller telescopes with wider fields-of-view. Other things being equal, it is good to have the separation approaching half of the camera's fov, perhaps not so wide that it won't fit in a 256x256 pixel RoI. The components are bright, 4.0 and 6.7 magnitude. Bright is good for calibration (high S/N), but the delta mag of this binary is really too great, 2.7, for it to be a good calibration binary.

Above right is another Grade 2 calibration binary. Recent speckles appear right on orbit. This one is wider. Other calibration doubles that could be observed could be systems with published rectilinear elements, although most tend to be too wide for use in calibration. Also, somewhat lower grade binaries could be used where plenty of recent speckles right on the orbit really pin things down, but there is not enough orbital coverage to give the system a high grade.

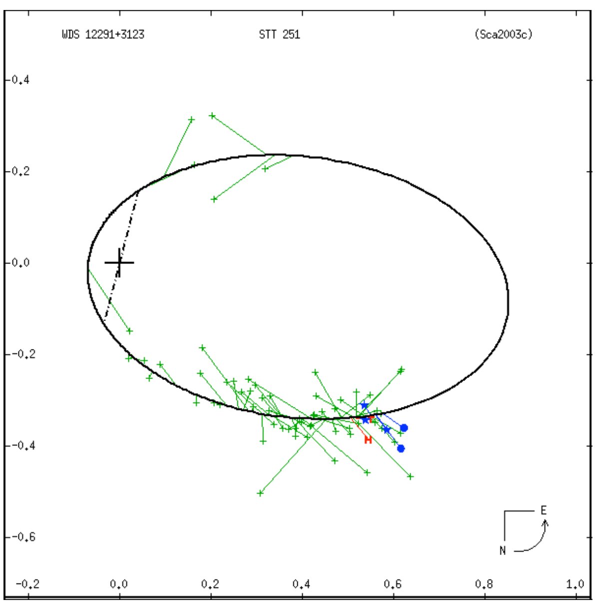
Bad Orbits – BO

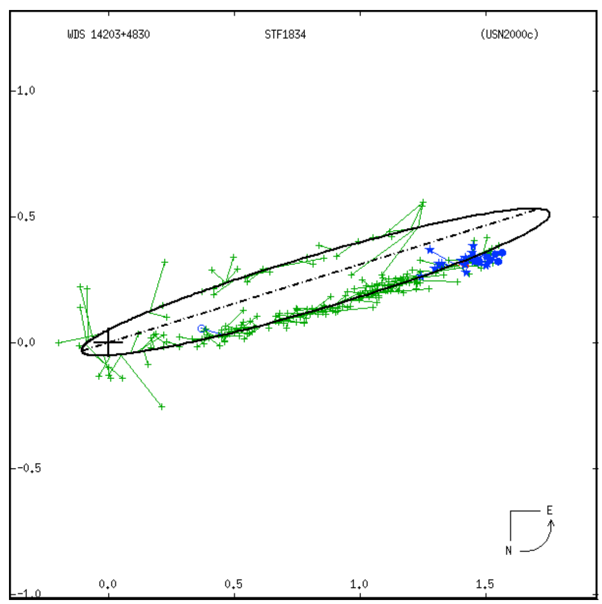
Most of the "BO" binaries are Grade 4 or 5, and as such are prime candidates for additional observations, especially speckle, moving them up to Grade 3 or better where they can then be used in evolutionary models. BOs are especially fun. One can often see how an original orbit with visual observations is often brought into serious question with recent, more accurate speckle observations. One is tempted to add another speckle observation or so and calculate a new orbit.



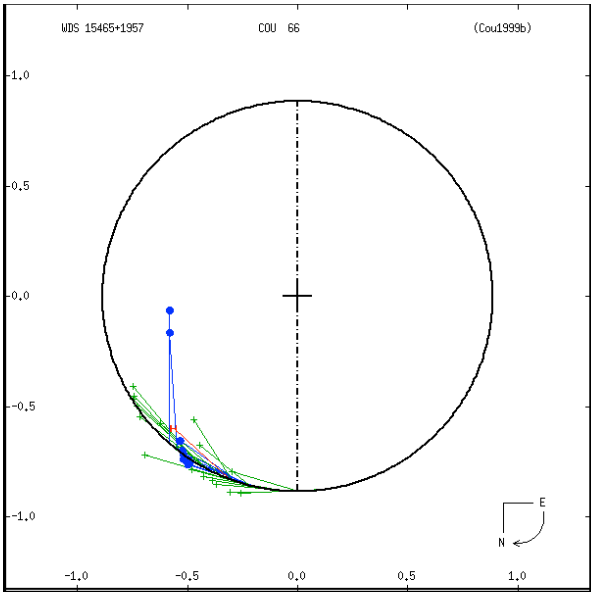


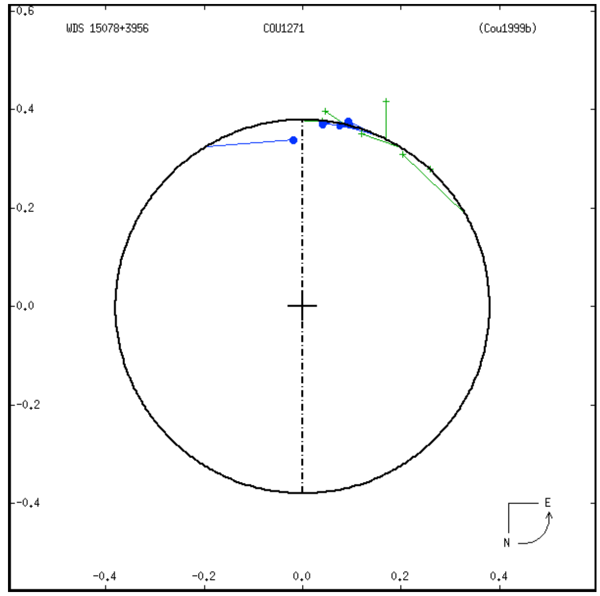
The original orbit on the left was thrown off by several of the last visual points, while other visual observations which, at the time, must have looked errant, are supported by Hipparcos and Tyco and one lone speckle observation made by Jay Farihi with a 2.4-m telescope. On the right, two speckle observations, one by the USNO, suggest the actual orbit may be quite different.





The observations on the left appear to be headed off the orbit, while the ones on the right are only doing so modestly.

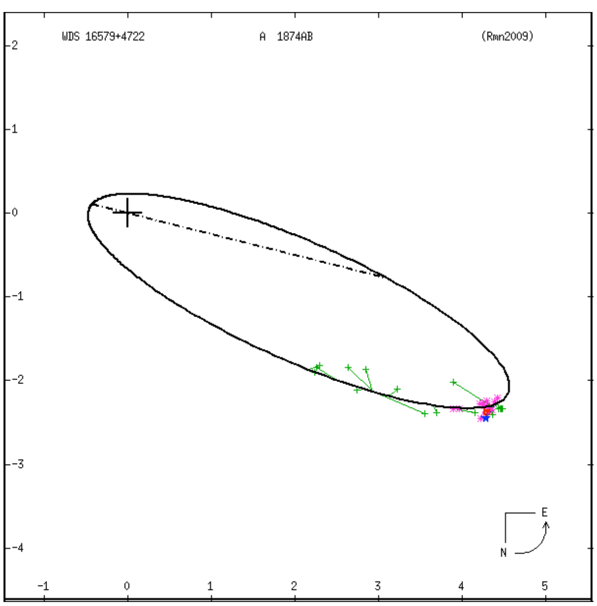


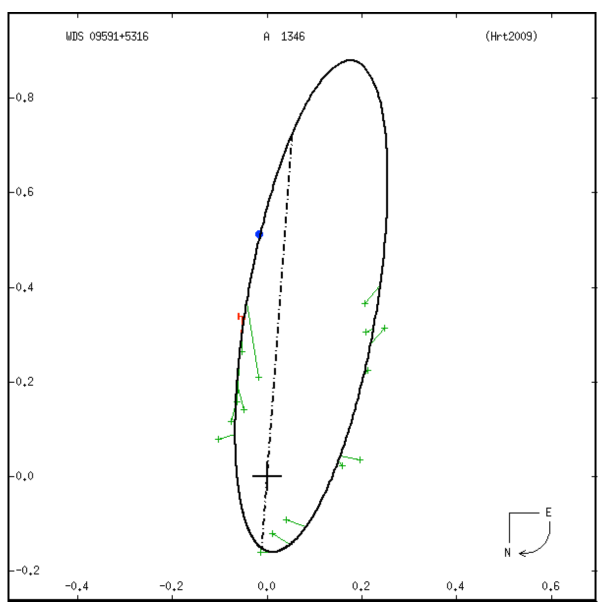


Perhaps the system on the left isn't a binary at all, just an optical double? On the right, the observations may appear to be on orbit at first glance, but clearly their timing is way off and the true orbit may be highly elliptical.

Few Speckles – FS

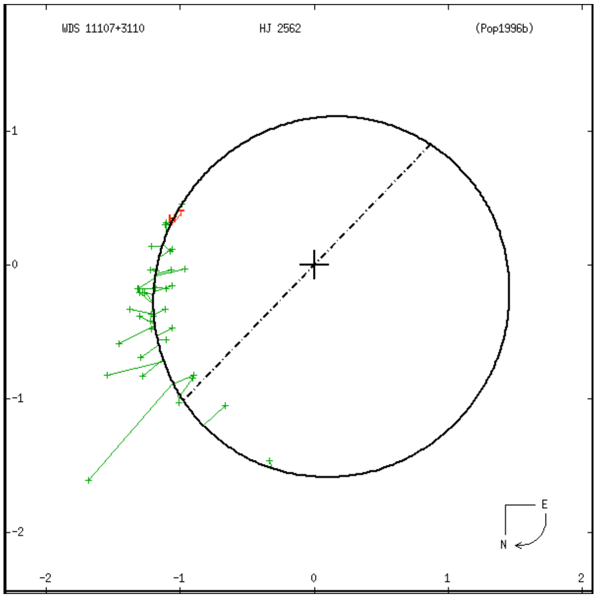
Orbits with few speckle, FS, observations tend to be Grade 4 and 5, mostly 5. The primary difference between them and "Bad Orbits" is that while the orbits are low grade, they do not appear to be grossly off. Adding accurate speckle observations can up their grade, especially if the period is short enough for the added observation(s) to be somewhat spaced out.

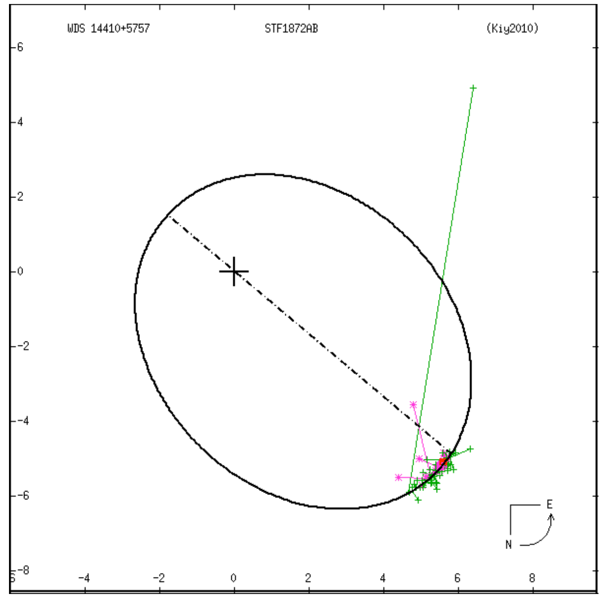




No Speckles – NS

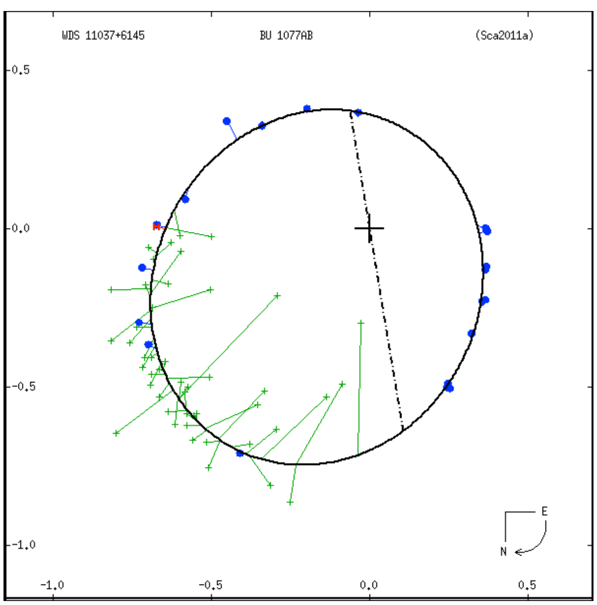
These binaries tend to be Grade 4 or 5, perhaps mainly 5. Speckle observations could upgrade their orbit. Shorter periods are likely to be more amenable to upgrading.

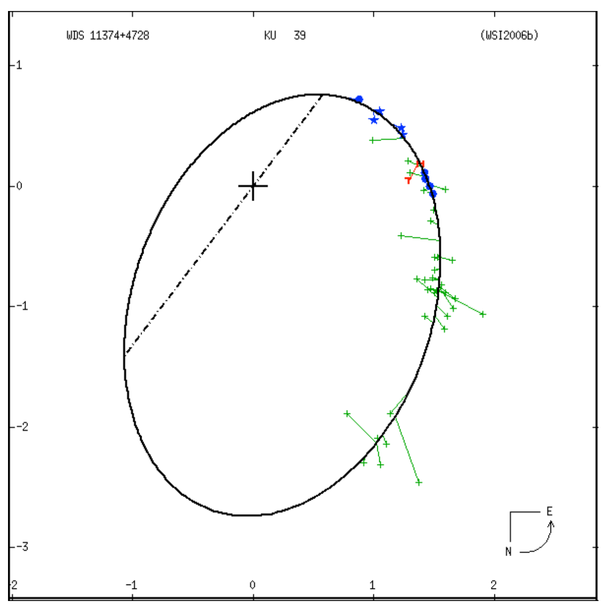




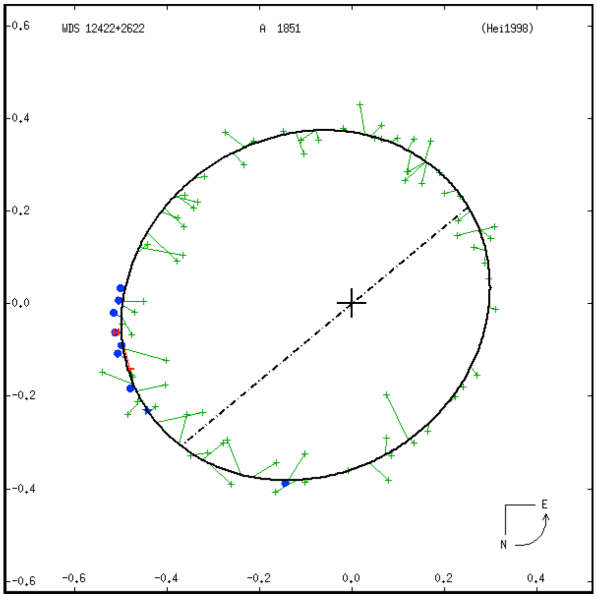
Strings of Pearls – SP

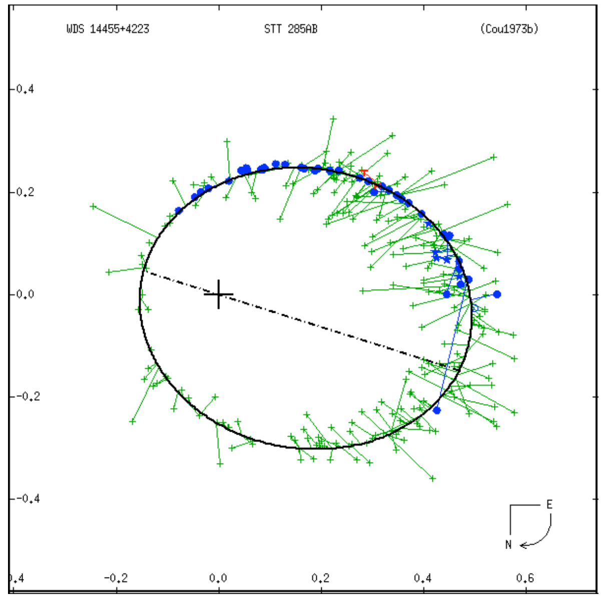
Like their namesakes, these are beautiful orbital plots. They can be almost any grade.



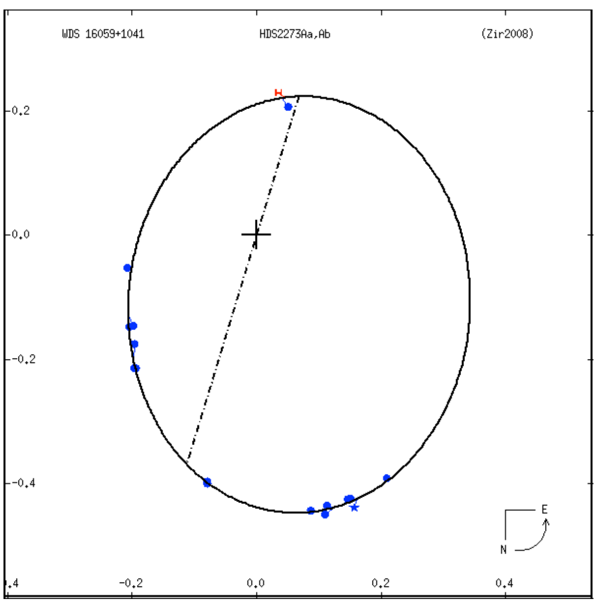


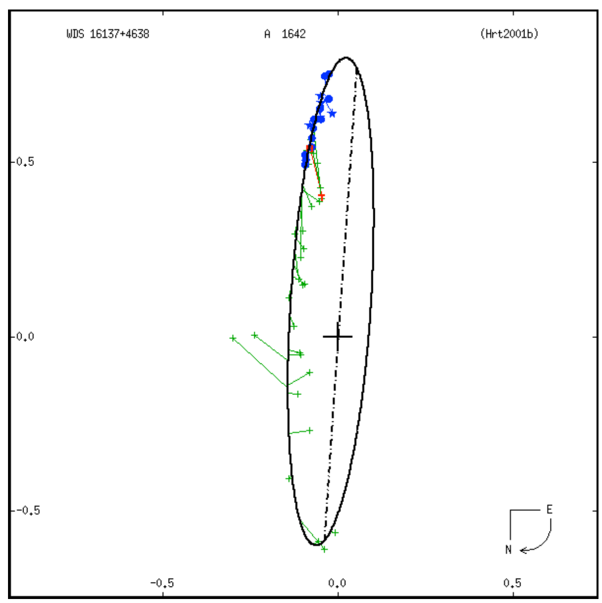
On the left is a short period, 44 year, Grade 3 binary. A few additional speckle observations could move it up to Grade 2. On the right, the period is a much longer 278 years, and it is only a Grade 5. Observations over the next several decades might move it up to a Grade 4 or even 3, perhaps, but generally adding observations to shorter period systems may be more useful.





On the left (above) is a 61 year Grade 2 orbit with a rather large gap between many speckle observations and one lone speckle observation. Another Grade 2 orbit is on the right with an 88 year period and many more speckle observations.





The orbit on the left is only a Grade 4 (although it looks very nice). The period is just 33 years and it has no visual observations. On the left is a much longer period, 188 years, a system with a Grade 4 rating.

Late Component – LC

Binaries with a late spectral-type component are especially valuable to observe, as masses on that end of the HR diagram are not as well known.

Special Request – SR

When we go on an observation run at a large telescope we ask our collaborators in the double star community if there are any special systems they want observed. This designation is added to those systems in our target list to ensure we fulfill our friendly duty.

Conclusion

The classification method that the authors have developed, while in its early stages, has proven to be a useful tool. More categories may be added as our interests broaden and our knowledge deepens. We look forward to creating a streamlined process which is more standardized and time efficient, thus enabling us to create more diverse target lists in a shorter time.

Acknowledgments

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