

The U.S. Naval Observatory Double Star Program: Frequently Asked Questions

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Abstract: We present from the U.S. Naval Observatory's web site Frequently Asked Questions on double star observations, the Washington Double Star Catalog, and other products and services provided by the U.S. Naval Observatory Astrometry Department.

Introduction

Over the past dozen years, questions about double stars and the work of the USNO Double Star group have been asked by a variety of astronomers and other interested parties. The highlights of these, which have been posted to our website (<http://www.usno.navy.mil/USNO/astrometry/optical-IR-prod/wds/faq/>), are listed below. We hope that these questions will generate others, which the authors will be happy to entertain for possible inclusion on our faq page.

Glossary of Terms and Acronyms

- - **ADS:** The "New General Catalogue of Double Stars within 121 degrees of the North Pole" (a.k.a., "Aitken Double Star Catalog"; Aitken, 1932). When Burnham retired, he gave all his double star catalog information to W. Hussey of Lick Observatory, with the intent that he publish an updated version of the BDS. Hussey died before this could be accomplished, however, and the task was assumed by Robert Grant Aitken, also of Lick. Lick later obtained the files of the SDS and merged all these data to create the IDS.
- **BDS:** The "General Catalogue of Double Stars within 121 degrees of the North Pole" (a.k.a., "Burnham Double Star Catalog"; Burnham 1906). Based on S.W. Burnham's observing notes collected over three decades, this was the first attempt to collect all published double star measurements.
- **DM3:** The "USNO Third Photometric Magnitude Difference Catalog". Currently maintained by the USNO. Earlier published versions were DM2 (2006.5) and DM (2001.0, Worley et al.).
- **DSL:** The "Double Star Library". This is the official webpage of IAU Commission 26 (Double and Multiple Stars).
- **IAU:** The International Astronomical Union. This is a professional organization for astronomers around the world. Most of our work is centered around IAU Commission 26: Binary and Multiple Stars.
- **IDS:** Lick Observatory's "Index Catalogue of Visual Double Stars, 1961.0" (Jeffers & van den Bos, 1963). This catalog by Hamilton Jeffers and Willem van den Bos combined data from the ADS and SDS into the first all-sky compilation of double star data. Due to its size, individual measures were maintained on computer punch cards and only the first and last observations were published. These boxes of punch cards were brought to the USNO by Charles Worley soon afterward to form the basis of the WDS.
- **INT4:** The "Fourth Catalog of Interferometric Measurements of Binary Stars". Currently maintained by the USNO. An earlier version

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published at the USNO was INT3 (2001.0, Hartkopf et al.). INT2 and INT1 were published by Georgia State University's Center for High Angular Resolution Astronomy (CHARA) in 1988 and 1984, respectively. Initially created to keep track of observations made at CHARA and elsewhere using the technique of speckle interferometry, the catalog was later expanded to include other high-resolution techniques (Hipparcos, adaptive optics, etc.) as well as infrared methods.

- **LIN1:** The "Catalog of Rectilinear Elements". Currently maintained by the USNO.
- **ORB6:** The "Sixth Catalog of Orbits of Visual Binary Stars". ORB5 was published in 2001 (Hartkopf et al.). Earlier versions, ORB4 (Worley & Heintz 1983), ORB3 (Finsen & Worley 1970), ORB2 (Finsen 1938) and ORB1 (Finsen 1934) were printed publications.
- **SDS:** The "Southern Double Star Catalogue, -19 to -90 degrees" (Innes, 1927). This catalog by R.T.E. Innes was the southern equivalent to the BDS and ADS and was later incorporated into the IDS.
- **WDS:** The "Washington Double Star Catalog". Currently maintained by the USNO. Major releases were made in 1984 (Worley & Douglass), 1996 (Worley & Douglass), 2001 (Mason et al.) and 2006.5, with additional incremental releases over the years.
- **WMC:** The "Washington Multiplicity Catalog". Currently in preparation, it will be maintained by the USNO.

Frequently Asked Questions

1. *The Double Star Library notes that some of the USNO catalogs are "updated nightly". What does that mean?*

At present there are two astronomers at the USNO who make changes to the WDS and associated catalogs. At approximately 2am local time the WDS is re-compiled from the existing data files and put online for users to access. Web versions of other catalogs are usually updated whenever new data are added.

Changes are made in a sporadic fashion. Some days, like over the weekend, there may be no changes. Other days the changes may be significant. Some new papers may take only minutes to add, while others may yield many days' work.

2. *I am interested in making some double star observations but don't know what doubles are appropriate for my telescope or need observing. Can you help me?*

Yes. The Observing List Request form http://ad.usno.navy.mil/wds/obslist_request.html is designed for people to make requests for observing lists. While typical questions to make the list are provided, the field is free form and you can specify exactly what you want or ask the sorts of questions that can guide us in helping you generate an observing list.

3. *Are there actually doubles that still need to be observed?*

Quite a few. Naturally, the ones that most need observation are those which are hardest to observe and those that are easiest to observe do not typically need more. The number of pairs needing observation that are accessible to you depends on your capabilities.

4. *What sort of parameters are needed for a double star observation?*

Typically date, position angle and separation. If the magnitude difference is estimated, providing that is helpful, too. For publication the aperture of the telescope, method of data collection, etc., would be needed.

5. *What about calibration?*

Ah, yes. An uncalibrated measure is worthless. Independent methods for determining your calibration parameters, such as looking at a single star with a slit-mask and performing Young's experiment, are preferred. However, should you be unable to do this we provide a set of calibration quality orbits (<http://ad.usno.navy.mil/wds/orb6/orb6c.html>). The presumably differential proper motion linear solution targets (<http://ad.usno.navy.mil/wds/lin1.html>) should also be good for this.

6. *I have made some double star observations. How do I get them into the WDS?*

The easiest way to get data in the WDS is to have them published in a refereed journal. Those will then be added as time permits. A faster way to get them into the WDS is to also send us a flat ascii file which includes the tabular information from the publication.

The fastest way is to get in touch with us (wds@usno.navy.mil) and let us provide you with the "ready to fold into the catalog" format.

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7. *Who maintains all the USNO double star catalogs?*

The oldest catalog, the WDS, was created when Charles Worley brought the IDS from Lick Observatory in the early 1960s. It then is the "great grand-catalog" of the first comprehensive double star catalog, the BDS (BDS ---> ADS, ADS+SDS ---> IDS, IDS ---> WDS). For over thirty years it was maintained by him with help mainly from Geoff Douglass. Over this time, Charles painstakingly went through the enormous resources of the USNO library adding measures by hand. While intermediate versions were periodically released, Charles made two major releases in 1984 and 1996. As he compiled the WDS he also collected accurate magnitude difference measures in his own internal "Delta-M Catalog."

Shortly thereafter, Charles began collaborating with W.S. Finsen in producing the "Third Catalog of Binary Orbits." He later made the 4th Catalog with W.D. Heintz. The Interferometric Catalog was first compiled at Georgia State University. When two of those authors came to the USNO the Catalog came with them.

In 2001 new versions of all four catalogs were released on the first USNO double star CD. In 2006.5 the second double star CD was released with these four plus the new linear elements catalog for likely optical pairs. This catalog also included a html history of USNO double star work.

Currently the USNO catalogs are maintained by two astronomers in the Cataloging Division of the Astrometry Department at the US Naval Observatory. In addition to cataloging double stars we have observing and other responsibilities as assigned --- in actual work spent cataloging, probably from one to two FTE (i.e., "full-time equivalents") depending on circumstances.

8. *Is it possible to get a copy of the most recent double star CD?*

Yes. Fill out the form at http://ad.usno.navy.mil/wds/cd_request.html and one will be mailed to you.

9. *Why is there also an interferometric catalog? Aren't all these data in the WDS?*

No, not all of it. The interferometric catalog contains a subset of WDS data, but may contain additional photometric information. It also contains one-dimensional results (e.g., data from lunar occultations) not found in the WDS, as well as single-star information from large surveys for duplicity.

10. *Why are there separate catalogs of interferometric measurements and magnitude differences? Aren't all those data in the WDS?*

Much of the data in the Magnitude Difference Catalog is also found in the Interferometric Catalog. However, a large number of measures that were made by techniques not classified as "High Angular Resolution" are in the Magnitude Difference Catalog, such as measures from 2MASS.

11. *What is the difference between the WMC (Washington Multiplicity Catalog) and the WDS (Washington Double Star Catalog)?*

The WMC is an IAU-mandated catalog to hierarchically assign designations to pairs discovered by all double star techniques. While the vast majority of these will be resolved pairs from the WDS, the final WMC will also include spectroscopic, photometric and other unresolved companions. Also, these companions are not necessarily stellar, so it will include Brown Dwarfs and exoplanets.

12. *Why do astronomers care about double stars?*

The majority of stars in the sky are part of double or multiple star systems. The only way to determine stellar mass, the most fundamental property of a star, is through analysis of binary star systems. While stars similar to the Sun are known well, the most common stars, Red Dwarfs and those that have the greatest impact on Galactic Evolution, the Massive OB stars, are not well determined.

While double or multiple stars are broadly characterized as more abundant than single stars, how different subsets, either based on stellar type or environment, may be enhanced or not can have significant implications for the evolution of the Galaxy.

The coeval nature of binary stars makes them an insulated set which can be studied together. While the individual stars may be different, they are of at least approximately the same age and have the same chemical composition.

Binary stars are not only the predominant stellar evolutionary track, but they are a boon to astronomers for the plethora of data that can be determined from them.

13. *I am interested in a particular binary star, but the WDS only lists the first and last observations. How do I obtain all the data?*

The Data Request form (http://ad.usno.navy.mil/wds/data_request.html) will return to you all data,

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notes and references we have for double stars. If it has an orbit we will also provide elements, ephemerides and an orbit plot. These typically are returned within 24 hours.

14. What are "discoverer designations"?

Historically, each discoverer of a pair would provide a list of his "new" discoveries in his publications. When a pair was resolved and published for the first time it was added to the catalog with that designation. In more recent years pairs discovered, but not resolved, for the first time (by, for example, spectroscopy) were credited to someone sometimes many years later.

Generally speaking, the discovery designation can tell you something about the difficulty of seeing the pair. For example, STF pairs (first seen by F.G.W. Struve) are easier to split than BU pairs (first seen

by S.W. Burham). Also, the discovery designation helps personalize the star and can make it a little more interesting.

The current plan of the more comprehensive WMC is to not use the discovery designation if alternate designators of greater usage are available. Coordinates and components will be the primary identifiers, instead.

15. *Some double-star names include components such as AB or AC, while others have Aa,Ab or Ba,Bb and still others have no components listed at all. Why?*

When a component designation is given the relative position is of the secondary relative to the primary. For example, for an AB pair at 90 deg and 3", in a polar coordinate system the A component is at the origin and the B component is at a position angle of 90 deg (i.e., due east of the A component) at a separation of 3".

By default a simple binary has no components explicitly listed; the primary is understood to be A and the secondary to be B.

Another common arrangement, such as AB-C or AB,C indicates that C is measured relative to the center of light (or photocenter) of the AB system. This is often measured when the AB pair is beyond the capability of one observer, but they can measure C.

More complex hierarchical arrangements follow a strict set of rules. More details are available at <http://ad.usno.navy.mil/wds/wmc.html>.

16. Which is the primary?

It depends on how much information we have. If

we have a full characterization of the system, it is the most massive component. If not, it is the brightest component (considering bolometric magnitude).

If we don't know the magnitudes in many bands it is the brightest component as assigned by observers (most commonly in the visual band).

If the magnitude difference is zero or unknown the primary is arbitrarily assigned such that the angle of position is less than 180 deg.

In some cases other techniques, such as spectroscopy, can assist in assigning the primary.

17. Do you have any information on spectroscopic binaries?

While the WMC will contain information about spectroscopic binaries when fully populated, none of the all-sky USNO double star catalogs contains a comprehensive list of spectroscopic binaries. The notes file to the WDS contains some information and the orbit catalog has some other information as well, but these are not comprehensive. The best source for spectroscopic binaries is the 9th Catalogue of Spectroscopic Binary Orbits: <http://sb9.astro.ulb.ac.be/>.

18. *I published a paper of double star measurements and orbits, but it is not in your catalogs or even in your list of references. How can I get it included?*

We may have just missed it (we have a small staff and there are many papers out there!) See question 6 above. At the very least, drop an email to wds@usno.navy.mil and provide the reference or fill out the comment form http://ad.usno.navy.mil/wds/wds_comment.html. Speed of addition is based on how much information is provided.

19. *I found an error in the WDS. How can I get it corrected?*

Just tell us! The online comment form http://ad.usno.navy.mil/wds/wds_comment.html is designed for people to tell us of errors or ask us questions. Like the observing list form, it is free form so prattle on to your heart's content.

20. *Most of the doubles in the WDS have good right ascensions and declinations, but a few are only listed with very imprecise coordinates. Why?*

Historically, double star coordinates were published only to the nearest minute of arc and early double star catalogs did not include proper motion. The result of this is that if it was not followed on a regular basis the pair could become "lost". The pair could also

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be a chance alignment that is no longer there, or the erroneous identification of a "plate flaw" as a real star. There also may have been a printing error in the original paper or a transcription error in entering the object into the WDS or one of its predecessor catalogs. In any event, we have thus far been unable to match it to nearby pairs we have online in the Cataloging Division.

Sometimes it takes only a look through the telescope to see where it is and "find" the pair again. For example, using the 26" in Washington we have confirmed an extensive number of John Herschel's pairs, last seen in 1820 but long lost due to poor coordinates.

When a pair is judged to be false or lost for one or more of the above reasons we add an "X" code for the pair to it in the WDS. Removing the pair entirely might prompt someone to add it back in one day and adding the "X" code is like giving it the "Black Spot of Binaries."

21. If there are bad doubles are there also bad measures?

Yes, there are. When we have thoroughly analyzed a measure and found it to be insufficient we similarly mark it as such. It remains in the WDS but is henceforth not considered when, for example, counting measures of systems or calculating an orbit. It is a marker that lets someone else know that the measure has been added, evaluated and found wanting. If a published measure has an obvious error we will correct it and add a flag indicating a correction has been made.

22. What is the orbit "grade" which is assigned in the orbit catalog?

Both the Third and Fourth orbit catalogs assigned a quality grade to an orbit. This subjective grading was based on many factors as judged by probably the most experienced double star astronomers and catalogers at the time. Since their expertise and experience could not be replicated, in the Fifth Catalog a painstaking method was developed to replicate their grading based on many key parameters: thus objectifying the previous subjective grade. See <http://ad.usno.navy.mil/wds/orb6/orb6text.html> for details.

23. How is this grade assigned?

When an orbit is added, all data are plotted with this new orbit and then evaluated. If the grade is better it becomes the new default orbit. Just adding one measure and re-computing an orbit is rarely justifica-

tion for your orbit being the new "best" orbit, however.

In adding an orbit the weight of each measure in that orbit is considered, which takes into account the method, size of the telescope, separation, magnitude, magnitude difference, N (number of nights in a mean position) and person who made the measure.

24. What are the weights of individual measurers used for orbit grading?

Not all observers are the same. Some get a low weight because they were always working at the limits of their telescope. Some get a low weight because the observations were not as good (due to poor calibration, for example).

Evaluating an observer is a sociologically complex consideration. We do not release these parameters. But, for the record, ours are not the best.

25. Who has observed the most double stars?

It depends on how you count them. Counted by the number of measures, the three top are W.H. van den Bos, W.D. Heintz and C.E. Worley. A full listing of the top twenty-five groups and individuals counted many different ways is on the WDS website.

26. Why aren't all the measures used to compile the WDS published online?

Size is one consideration.

Integrity of the product is another, as it is not completely corrected.

There is also a historical reason. The full database was once taken, repackaged and then presented as a new catalog with no attribution. Given the enormous number of man years spent by USNO personnel over the past decades to maintain this database, that will not be allowed to happen again.

All measures of specific systems are always available via the Data Request form

http://ad.usno.navy.mil/wds/data_request.html.

Bottom line: You can have some of the data on all of the systems or all of the data on some of the systems, but you cannot have all of the data on all of the systems!

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