Requested Double Star Data
from the U.S. Naval Observatory

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United States Naval Observatory
Washington, D.C.

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Abstract: Double star data that can be requested from the U.S. Naval Observatory is described.

In addition to providing various double star catalogs and other double star resources online, astronomers at the U.S. Naval Observatory (USNO) are available as a resource for astronomers worldwide. In addition to answering a plethora of questions, we have prepared several software packages that fill the most common types of requests. These are described below.

Data Request

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

This software package provides all measures we have in the WDS, Orbit Catalog, and Delta-m Catalog at a specified WDS coordinate. The output will be in the form of a text file which starts by listing data from the first entry in the WDS summary line and then lists each measure associated with it from the measurements database. The method and, if present, codes for each measure are described in the accompanying "datarequest.key" file. For multiple stars the 2nd, 3rd, etc., components listed in the WDS follow along with a complete list of its measures. After all measures from the WDS are listed, notes from the WDS follow and then information from the Orbit Catalog: orbital elements and ephemerides for the next ten years. If there is more than one orbit, each is provided. Following information from the Orbit Catalog, information from the Delta-M Catalog is provided and at the end of the document a list of references keyed to measures, orbits, and delta-m measures listed previously.

Accompanying each data request is the previously mentioned "datarequest.key" file which provides note codes, method keys, and details changes or planned changes to the data request.

If the data request contains an orbit system a portable network graphics (png) of the orbit and measures is also sent.

Data Requests are made at the form above with WDS coordinate, Discovery Designation or another designator. The time needed to fill an individual data request is minimal and you shouldn't hesitate to ask for them to be filled. Several thousand data requests are filled every year. Shown are examples of a data request for the multiple system WDS 05272+1758. The close component of this system actually has two orbits depending on the quadrant interpretation of some of the interferometric data. The "datarequest.key" file also is included as well as the figures associated with each of the two calculated orbits.

(Continued on page 33)

file : wds05272+1758.measures

WDS Star No. 05272+1758

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(2000) Number Obs. A B Type RA DEC
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(Continued on page 22)
Requested Double Star Data from the U.S. Naval Observatory

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RA = 05 27 10.0  Dec = +17 57 44.

Note? = yes  Orbit? = yes  DM? = yes  Other? = no

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**Requested Double Star Data from the U.S. Naval Observatory**

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Note? = no  Orbit? = no  DM? = yes  Other? = no

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Dec = +17 57 50.

Note? = no Orbit? = no DM? = no Other? = no

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<th>Sep. Mag-a</th>
<th>Mag-b</th>
<th>#</th>
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WDS Index Catalog Notes

115 Tau. A is an occultation binary which has been resolved by speckle interferometry.
First detected as an occultation binary by Afr1978.

6th Orbit Catalog Orbits

<table>
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<tr>
<th>Refcode</th>
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6th Orbit Catalog Ephemerides

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Delta-M Catalog Measures

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WDS References

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<tr>
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</table>
Requested Double Star Data from the U.S. Naval Observatory

         AJ 83, 1100, 1978
B_1963b  van den Bos, W.H.
         AJ 68, 582, 1963
Bag1985  Balega, Y.Y. & Balega, I.I.
         SvAL 11, 47, 1985
Bag1987  Balega, I.I. & Balega, Y.Y.
         SvAL 13, 208, 1987
Bag1999a Balega, I.I. et al.
         A&AS 140, 287, 1999
         A&A 385, 87, 2002
Bu_1879  Burnham, S.W.
         MemRAS 44, 141, 1879
Bu_1883  Burnham, S.W.
         MemRAS 47, 167, 1883 (= BU 28)
Bu_1913  Burnham, S.W.
         Carnegie Inst. Wash. #168, 1913
D_1883   Dembowski, E.
         Mis. Micrometriche I, 1883
Dool01   Doolittle, E.
         Publ. Univ. Penn. 1, Pt. 3, 1901
Dsc1914  Demetrescu, G.
         AN 199, 53, 1914
Eng1886  Engelmann, R.
         AN 115, 81, 1886
Evn1981  Evans, D.S. & Edwards, D.A.
         AJ 86, 1277, 1981
Heg1983  Hegde, K.K. et al.
         IAU Colloq 62, Lowell Obs Bull 167, v 9, #1, 154, 1983
HIP1997e Hipparcos
         Hipparcos Cat., ESA SP-1200, 1997 (single star systems)
Hrt1994  Hartkopf, W.I. et al.
         AJ 108, 2299, 1994
Hrt1997  Hartkopf, W.I. et al.
         AJ 114, 1639, 1997
Hrt2000a Hartkopf, W.I. et al.
         AJ 119, 3084, 2000
Hu_1901a Hussey, W.J.
         Publ. Lick Obs. 5, 1901
Mad1844  Maeder, J.H.
         Dorpat Observations 11, 3, 1844
McA1982d McAlister, H.A. & Hendry, E.M.
         ApJS 49, 267, 1982
         AJ 114, 1623, 1997
Msn1996b Mason, B.D.
         AJ 112, 2260, 1996
Msn1997a Mason, B.D.
         AJ 114, 808, 1997
Ole1997b Olevic, D. & Jovanovic, P.
Rad1982b Radick, R.R. et al.

(Continued on page 26)
Requested Double Star Data from the U.S. Naval Observatory

(Continued from page 25)

AJ 87, 885, 1982
Richichi, A. et al.
A&A 350, 491, 1999
Struve, H.
Pulkova Publ. Ser. 2, 12, 1901
Struve, O.
Pulkova Observations 9, 1878
Tarrant, K.J.
AN 121, 273, 1889
TMA2003
2MASS Catalog
2MASS Point Src Cat., 2003 all-sky release
(http://pegasus.phast.umass.edu/)
Tokovinin, A.A. & Ismailov, R.M.
A&AS 72, 563, 1988
Wallenquist, A.

file: datarequest.key

Version: 09 May 2005

DATA FROM THE WASHINGTON DOUBLE STAR CATALOGS (WDS)

U.S. NAVAL OBSERVATORY
WASHINGTON D.C. 20392

As a result of changes in software and hardware, as well as in the data formats of the WDS and its associated catalogs, information is now provided in a somewhat different format. It is hoped that this presentation is clearer; if it is in any way confusing, or there are omissions, please let me know.

The WDS (and associated catalogs) are at present in a state of flux. At this point the following things have been done:

1. The Orbit Catalog has been updated. The previous version (4th) by Worley & Heintz was out of date (1983). The new version (6th; Hartkopf & Mason) includes more orbits, more complete notes, ephemerides, orbit plots, explanation of orbit grading, and statistics. Data request software now obtains orbital information from this catalog.
2. Ephemeris data from the 6th Catalog are now included as well.
3. Data from the delta-m catalog (previously unavailable) are included in data requests. This is from the new, 2nd magnitude difference catalog, over 200% larger than the first magnitude difference catalog.
4. The codes to the WDS (previously columns 63 and 64) have been updated to a single set of non-redundant codes.
5. Non-numeric position angles (N, NP, SF, etc.), have been converted to the nearest numeric position angle and a code (L) has been added

(Continued on page 27)
6. Measures which are likely to be in error, but cannot be corrected (code "T") are not included in the ensemble of data points for the summary line. Incomplete data (missing date, position angle and/or separation) are also not included in the summary line.

7. Our updating of measures, orbits, and discoveries continues.

8. Data are now referenced to a single note file and single reference file.

9. The magnitude information in the WDS is a hodge-podge of data. Many systems with entries in the delta-m catalog (see the website http://ad.usno.navy.mil/wds/dmtext.html) inexplicably had little or no magnitude information available. These have been updated to be as consistent as possible, taking Tycho V magnitudes when available.

10. The WDS and Delta-m Catalog method files have been combined.

11. Duplicate discovery designations have been removed. Some numbers had been used more than once erroneously. In addition, some discovery designations were given unfortunate additional designations ("1/2", "a", and even the Struves' use of "App"). Some numbers were repeated due to the discoverer having more than one list (Herschel lists I-VI and N come to mind). To make the WDS discovery designation more clear all of these duplicate designations have been corrected.

12. Arcsecond precise coordinates have been provided when available.

13. Secondary proper motion have been provided when available.

14. We are in the midst of correcting many errors in the WDS. This task included examining all measures containing codes G, H, I, and J as well as large outliers in orbit or rectilinear motion calculations. In most cases, this involves going back to the original reference and examining the observation to determine what errors can be ascertained (often a misidentification or a typo) and corrected. We have gone from these four codes to a more generic code "N" (corrected) or "T" (not corrected, while retaining the "I" (identification questionable) code. Code "T" data are not included in the summary line.

15. X codes have been added in column 80 when the pair is questionable. Generally these are unconfirmed systems. Called alternatively dubious doubles or bogus binaries, these pairs may represent positional typos in the original publication (thus we're looking in the wrong location), an optical double going away due to radically different proper motions, plate errors, or may be simply not at the magnitude, separation, etc., where the first measure was added (too faint, too close, etc.). We would certainly like to know about circumstances where you have found or have ascertained the mystery behind these pairs.

16. To facilitate those of you who make data requests on a regular basis I've added a "version number" to the top line so that it is known when this file is modified. Typically a user can just check these numbered notes and look for new ones.

17. The format of the WDS has been changed slightly. We anticipate that this will be the last format change for some time. The changes are:

a. The column for number of measures has been increased to four digits. Therefore, the 607 systems which previously had "99" measures (indicating N greater than or equal to this number) now
have the actual number of measures. Ten systems have more than
1000 measures with the largest being 70 Ophiuchus with 1640.
b. The secondary proper motion, formerly at the end of each record,
have been moved next to the primary proper motion.
c. An additional notes column has been added. The actual notes
codes have not changed, however, many cases have been found
where a note has either been not included or put in the notes
file. Adding the additional column will eventually decrease the
size of the notes file.
d. The precision of the arc second precise coordinate has been
improved by an order of magnitude in each digit, i.e., tenths of
a second of arc and hundredths of a second of time. At the
present time, this digit is most often blank but as stars are
matched to this higher standard they will filter into the WDS.
e. Spaces and decimals have been added are removed, where
appropriate, for consistency and to improve readability.

18. The p code has been removed from the summary line codes in columns
108-111. This code referred to "Coordinates and proper motions from
ACRS, PPM, IRS, FK5 catalogs".

19. Data request software modified so that png images of orbits and
data will be returned. Figure captions are described below.

The delta-m catalog is an eclectic collection of differential magnitude
values collected over a long timebase. Many of them are visual estimates
while others are photographic corresponding (approximately) to broadband V
or B, respectively. More recent additions to the delta-m catalog include
filter information (typically, central wavelength & FWHM) and errors. Also,
the delta-m catalog gives information about components which have no
differential measurements and are, thus, not found in the WDS.

The WDS catalogs (measures, orbits, delta-m, speckle) have in the past
included four separate note and reference files, as well as four separate
formats for discoverer designation. While discoverer designations and
reference codes have been made uniform across the four catalogs there are
still four note files. These will be merged into a single file for each.
Future changes are listed below.

1. Many systems were listed in the IDS (the parent catalog of the WDS)
with only a summary line. These may have indicated one, two, or more
observations. We are attempting to locate and add all of these
observations. At present, summary line measures have been added to
the data lines with a "9999" (not found) reference number. These
references codes will be updated as original publications are found.

2. In addition, plots of available data will be provided. Similar to
the orbit plots, these will give a visual representation of all
available rho and theta values.

The aperture of the telescope (in inches) which obtained the observation
is provided. Below, you will find keys to the observing method and the codes
given for individual observations.
Requested Double Star Data from the U.S. Naval Observatory

(Continued from page 28)

Sometimes you will find that the reference is listed as "unpublished". If you use such data, as a common courtesy dictates that you obtain the permission of the author. This permission is implicitly given by me by inclusion of my own unpublished measures in the data base. Also, if you make use of data supplied by us, we would appreciate an acknowledgement in your published report or paper.

Brian D. Mason
Project Manager, Washington Double Star Program
Astrometry Department
U. S. Naval Observatory
3450 Massachusetts Avenue NW
Washington DC 20392-5420
phone: 202-762-1412
df: 202-762-1516
email: bdm@usno.navy.mil
WDS web page: http://ad.usno.navy.mil/ad/wds/wds.html

WDS INDEX CATALOG NOTES, COLUMNS 108-111.

B Summary line gives blue (Johnson U or B, blue photographic, etc.) magnitudes
C Orbit and Linear solution. A published orbit exists and this system has a Linear Solution as well. A "C" code, then, indicates both an "O" and an "L" code.
N Notes found in wdsnnot.memo of the WDS.
D Has measure in Delta-M catalog
I Identification uncertain. Match of object at precise position with WDS pair may or may not be correct. Currently under examination.
K Summary line gives K-band or other infrared (>1 micron) magnitudes
L Linear solution. Linear elements for this pair have been determined. Linear Elements Catalog is currently under development.
M Magnitude modified. Magnitudes have been corrected to the Tycho-V scale based on other systems measured by the discoverer and Tycho.
O Orbit, briefly described in WDSNOT MEMO and has entry in Orbit Catalog
P 100 year proper motion in right ascension
R 100 year proper motion in right ascension and declination
X A "Dubious Double" (or "Bogus Binary"). This pair may represent a positional typo in the original publication (so we're looking in the wrong location), an optical double disappearing due to radically different proper motions, a plate flaw, or simply a pair not at a magnitude, separation, etc., sufficiently similar to those noted when the first measure was added (making it too faint, too close, etc.). We would certainly like to know about any circumstances where you have found or have ascertained the mystery behind these pairs.

WDS OBSERVATION AND DELTA-M CATALOG, Method

(when blank, consult the notes)

A Refractor, micrometer

(Continued on page 30)
Requested Double Star Data from the U.S. Naval Observatory

(Continued from page 29)
B Reflector, micrometer
C Comparison image micrometer
D Heliometer
E Visual interferometer, aperture is of largest baseline on the monolithic mirror (e.g., Finsen's 26" or 240" on the 20 foot beam used on the 100"").
F CCD astrometry
G Photographic, with astrograph
H Photographic, with medium or long-focus technique
I Transit method
J Occultation binary
K Long baseline interferometer, aperture is of largest telescope/siderostat not the baseline.
L Electronographic camera
M Meridian circle
N Visual measures with a double-image micrometer
O Photographic, with ocular enlargement
P Photoelectric phase-grating interferometer
Q HST (FGS, WFPC, NICMOS, etc.).
R RGO use of micrometer plus comparison image micrometer on same star
S Speckle interferometry
T Hipparcos or Tycho type observation - aperture reflects Rayleigh limit at V
U Adaptive Optics
V Photocell with diaphragm in focal plane
W Area scanner
X Visual estimate made with an objective grating
Y Wedge photometer
Z Visual photometry with a double-image or polarizing photometer

WDS OBSERVATION CATALOG, Codes

1
2
3
4
5
6 Mean of multiple measures of same photographic plate or CCD.
7 No. of nights varies 50% or more between angle and separation measures
8
9

A Separation in milliarcseconds (mas)
B Blue (Johnson U or B, blue photographic, etc.) magnitudes
C Separation given in minutes of arc ('') instead of seconds of arc ("")
D Distance less than value quoted
E Elongated, but too close to measure
F Too faint, not seen, or not located
G
H
I Identification, or question about such
J
K K-band or other infrared (>1 micron) magnitudes
L Original PA given as n, nf, f, sf, s, sp, p, or np (n = north, f = following, s = south, p = preceding), and converted to 0, 45, 90, 135,
Requested Double Star Data from the U.S. Naval Observatory

(Continued from page 30)

180, 225, 270, or 315, respectively. Also, PA given as e or w (e = east,
w = west) is converted to 90 or 270 respectively. Due to the small number
of single letter codes (n, f, s, and p), the PA is assumed accurate only
to the nearest quadrant (i.e., +/- 45 deg).

M More than one telescope used

N Identification error, position error, or misprint in publication,
corrected.

O Optical

P Corrected by author

Q Quadrant reversed by the cataloger

R Red (Johnson R or I, red photographic, etc.) magnitudes

S Single

T Identification error, position error, or misprint in publication, NOT
corrected. Code "T" data are not included in the summary line. The T code
is also used to indicate measures superseded by later reductions of the
same data (for example, reprocessing of Astrographic Catalog data for the
WFC).

U Uncertain or Estimated

V Variable

W A magnitude, not a magnitude difference in columns 55-59

X General note, may be worth consulting

Y Author also published measures corrected for purported systematic effects.
However, only the uncorrected measures have been tabulated in the catalog.

Z Measurer other than author(s)

WDS OBSERVATION CATALOG, COLUMN 78

0 Post-IDS measure added by Lick Observatory
1 Post-IDS measure added by USNO
2 Measure prior to Lick punch-card collection, added by USNO
3 Post WDS (1984.0) measure added by USNO
4 Post WDS (1984.0) old measure added by USNO
5 Post WDS (1996.0) measure added by USNO
6 Post WDS (1996.0) old measure added by USNO
7 Post WDS (2001.0) measure added by USNO
8 Post WDS (2001.0) old measure added by USNO

6th Orbit Catalog Orbits

P = Period of revolution in years
a = Semimajor axis of orbit in seconds of arc
i = inclination, angle between plane of the sky and plane of the orbit,
   0 - 180 degrees. The motion is direct (i.e., in direction of
   increasing position angles) if i < 90 and retrograde if i > 90.
Node = Position angle of the line of intersection between the plane of the
   orbit and plane of the sky.
T = epoch of periastron passage
e = orbital eccentricity
omega = longitude of periastron,
G = orbit grade (1 = definitive, 2 = good, 3 = reliable, 4 = preliminary,
   5 = indeterminate, 9 = unknown). The grading procedure has been

(Continued on page 32)
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(Continued from page 31)

described (see http://ad.usno.navy.mil/ad/wds/int5.html).

Notes: In some cases more than one orbit will be provided. Cases like this
fall into one of two categories:

1. More than one binary in a multiple system has an orbit
   calculated.

2. While the orbit grading algorithm grades orbits objectively on
   many categories, they sometimes can achieve approximately the
   same grade and which orbit is better is ambiguous. As a rule
   of thumb, following the time-honored precepts of van den Bos
   and Worley, and asking the question "Is this Orbit Really
   Necessary?" (see, for example, PASP, 74, 297; 1962), we
   answer in the negative, and retain the earlier orbit. However,
   there still remain cases where the orbits can be sufficiently
   different but ambiguous (for example, solutions with different
   quadrants selected for small magnitude difference systems). In
   this case, more than one orbit may be retained.

: A grade 8 or 9 orbit (which was not provided in Worley & Heintz) is
  given when it is not possible to evaluate the orbit as no "classical
  double star" data are available.

  Interferometric orbits based solely on visibility data (i.e., no
  rho and theta provided) are given a grade of 8. Were complete data
  available these orbits (usually combined solutions with
  spectroscopic data) would undoubtedly have a very good grade.

  Astrometric orbits (derived from photocenter vs. barycenter
  shifts) are given a grade of 9. When resolved, systems of this type
  typically show rather large differences between the elements computed
  astrometrically and those based on differential measures.

: Further, the grades are only based on available visual double star
  data. If the solution to an orbit is based on a combined solution
  (e.g., with spectroscopic information), certain elements are
  certainly known better. Utilizers of the data are encouraged to
  thoroughly scan the "notes" section.

6th Orbit Catalog Ephemerides

Each orbit above is provided with an ephemeris for the next five years.
While many orbits may be of poor quality, short-term ephemerides are often
quite good.

6th Orbit Catalog Figures

In all orbit figures in this catalog, green plus signs indicate visual
(micrometric) observations, violet asterisks photographic measures, and blue
symbols various interferometric techniques (open circles, filled circles,
and filled squares for eyepiece interferometry, speckle or other
single-aperture techniques, and multi-aperture techniques, respectively).
Finally, a red "n" or "T" indicates a measure from Hipparcos or Tycho. The
dot-dash line indicates the line of nodes. Scales are in arcseconds, and the
curved arrow at lower right indicates the direction of orbital motion.
2. Observing List Request

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

Another feature which is not used as often is making a specialty observing list. The requestor places parameters appropriate to their observing. These are appropriate to their observing location (i.e., RA and Dec) as well as their instrumental capabilities (magnitude of both components, delta-m limit, separation limits), and various parameters which may or may not make the list more specialized. These latter include:

1. Most recent observation earlier than --- In other words, you don’t want to observe binaries which have been observed by someone else recently.

2. Upper and lower limits to the number of observations --- If a binary has been observed 1000 times, maybe it doesn’t need another observation. On the other hand, if a binary has only been observed 1 time maybe it’s veracity is questionable and you don’t want to try it.

3. Unknown magnitudes: A total of 857 A components and 2749 B components have no listed magnitude. While these may be difficult to find, there is the potential to make a more significant contribution to the WDS if you can identify one of these systems.

4. Unknown separation: In addition, 374 systems have no measured separation. Again, these may be difficult to find but the return is significant.

The information returned from an observing list request is a file listing the parameters which were entered in the program for your checking as well as the listing of WDS systems matching your criteria. The observing list example I selected was for some midsummer observing (15 to 20 hours RA) at a declination
Requested Double Star Data from the U.S. Naval Observatory

easy to see (+10 to +50). I selected doubles not observed since 2000 with no restriction on the number of observations. The separations I wanted from 3.5 to 10.0 arcseconds and I wanted the A component brighter than 10th and a delta-M limit of 3.0. A total of 36 systems fit these criteria. The output files are listed below.

file: obslist.params

---------------------------------------------

OBSLISTMAKER.PRG: Program to make observing lists
Version 1.3 (02/25/05)

This program makes an observing list from the web version of the WDS. It reads in the whole dataline and based on several input parameters decides which objects to keep.

The parameters considered include:
RA,
Dec,
Date of last observation,
Number of observations,
Last separation,
Magnitude of primary,
Magnitude of secondary, and
Delta-mag.

Output in the file obslist.out and obslist.params.

Enter Right Ascension (i2) for start of list: 15
Enter Right Ascension (i2) for end of list: 20

Enter Declination (i3) for Northern Limit of list: 50
Enter Declination (i3) for Southern Limit of list: 10

If you only want binaries not observed since DATE enter that, else 9999: 2000

If you only want binaries observed NUM< times enter that here, else 9999: 9999

If you only want binaries observed >NUM times enter that here, else 0: 0

Enter lower limit on separation (or 0.0 for no lower limit): 3.50000
Enter upper limit on separation (or 999.9 for no upper limit): 10.0000

Do you want to keep binaries with unknown separation data? (y/n): n

Magnitude of primary: Faint limit? (or 99 for no limit): 9.00000
: Bright limit? (or -2 for no limit): -2.00000
Magnitude of secondary: Faint limit? (or 99 for no limit): 10.0000
: Bright limit? (or -2 for no limit): -2.00000
Delta-M limit: Upper limit? (or 99 for no limit): 3.00000

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Requested Double Star Data from the U.S. Naval Observatory

(Continued from page 34)

: Lower limit? (or 0 for no limit) : 0.00000

Do you want to keep binaries with unknown primary magnitude data? (y/n) : n
Do you want to keep binaries with unknown secondary magnitude data? (y/n) : n

file : obslist.out

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3. WDS Comments
http://ad.usno.navy.mil/wds/wds_comments.html

The WDS Comment form is a web based tool for you to tell us anything about the catalogs you'd like. From the more technical "The 6 hour bands of the WDS take to long down load, can you make them smaller 2 hour bands" to the curious "Why are some Tycho doubles designated TDS and other TDT?" to the effusive "You guys Rock!"

4. Footprint Observing List Request
(coming soon, no link yet)

When reading James Jones' article in JDSO #1 on doubles observed near the Blue Snowball a program idea presented itself. Modify the observing list request software so that it determines a circular patch around a specified coordinate and provides a WDS listing of those doubles. For example, you're observing the Ring Nebula this summer, and thought you might want to look at doubles within 1.5 degrees of it. This program would provide this sort of list. While some doubles would probably not be appropriate, imagine a Double Star Marathon to coincide with a Messier Marathon. You'd probably just look at doubles and then move on, certainly not make measurements.

5. CD Request
http://ad.usno.navy.mil/wds/cd_request.html

Our Double Star CD which came out in a pressing of 1000 units was much more successful than we anticipated and we quickly ran out. We are planning a Second Double Star CD for mid-2006 (to coincide with the IAU General Assembly in Prague) which will provide updates and enhancements to all of our catalogs. You can get on the mailing list for this product at this website.