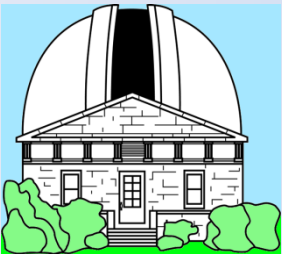# The Double Star Catalogs

of the

U.S. Naval Observatory

Brian D. Mason

WDS : Washington Double Star Catalog

- Currently* 1,276,937 measures of 132,600 pairs.
  - 15.5% (n=20558) deemed physical due to orbit, common proper motion, common parallax or other
  - 3.5% (n=4694) deemed optical due to linear solution, mutually exclusive proper motion, parallax or other
  - 0.6% (n=677) believed to be not real.
 - Rest (80.4%) status unknown.
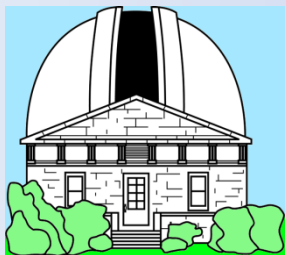
* Stats compiled 15 June 2015
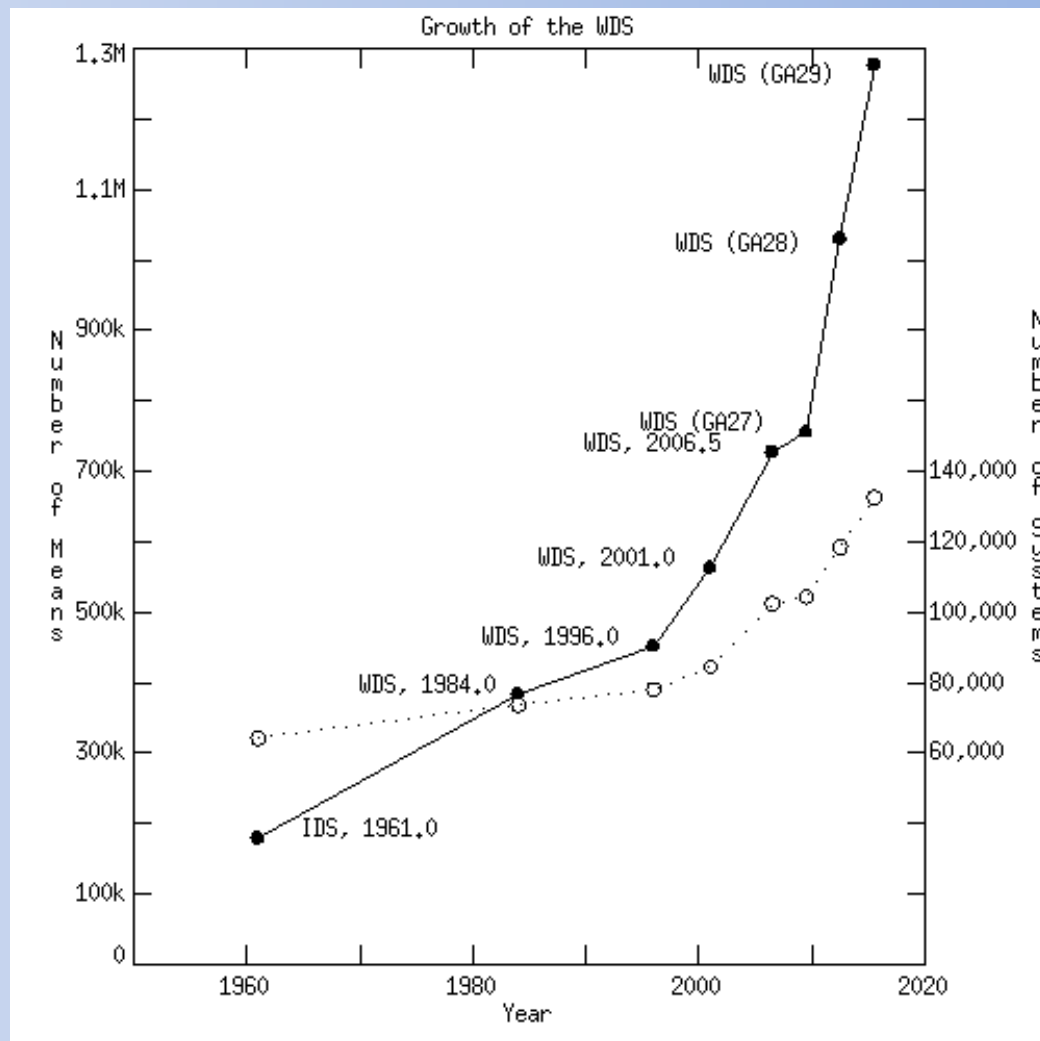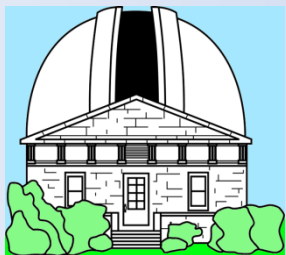
WDS: *Improving Statistics*

- Over the past several years focus has been on measuring neglected pairs, that is pairs which are unconfirmed or not observed in many years.

- Matching WDS systems with astrometric catalogs and changes in observing strategies by many institutions has made a significant difference.

- Future large contributions will include matching URAT and other large astrometric catalogs will continue to make a big contribution.

Number of Means per System in the WDS (2015.5); N = 132,600
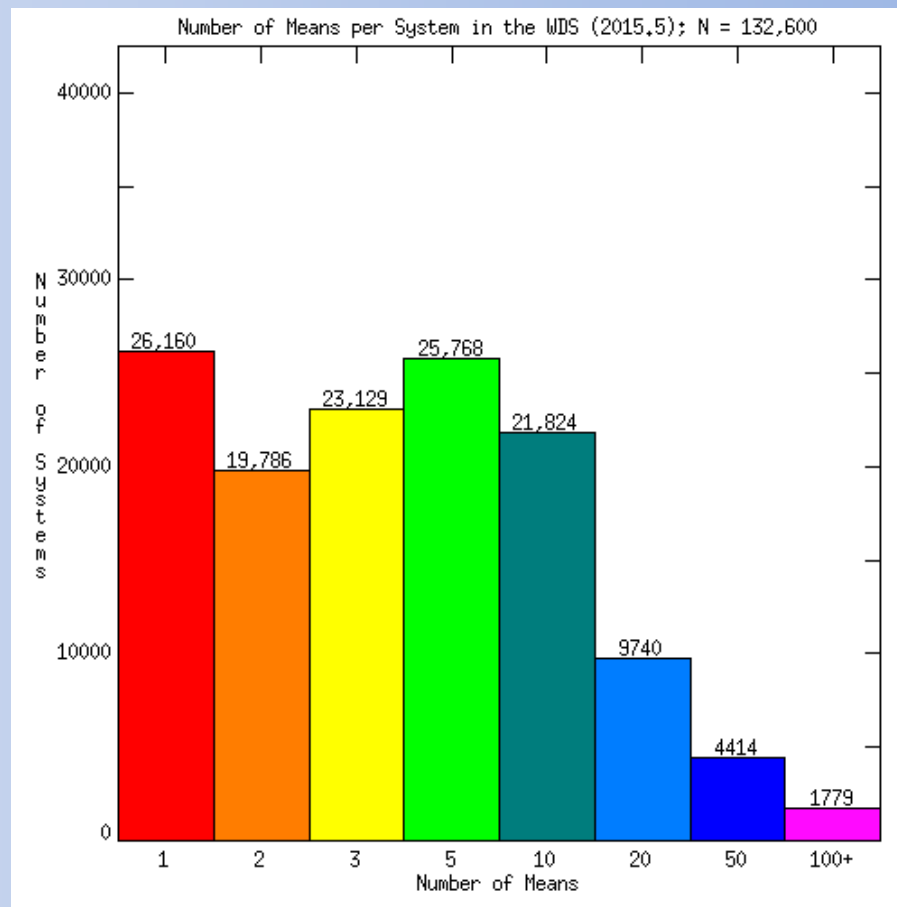
Orbit Catalog

- The 6th Catalog of Orbits of Visual Binary Stars contains 2634 graded best orbits of 2529 resolved pairs.

- It also contains 24 orbits of interferometric pairs. These are assumed to be of high quality but as the solutions are Baseline-Visibility rather than Separation-Position Angle (ρ, θ) they cannot be properly evaluated.

- It contains 523 astrometric orbits of unresolved pairs based on periodic variations in proper motion. Most of these are from Hipparcos.

- Finally, it has 43 partial solutions where at least one of the seven Campbell elements is not determined. These are of dubious value save as a possible indicator of physicality.
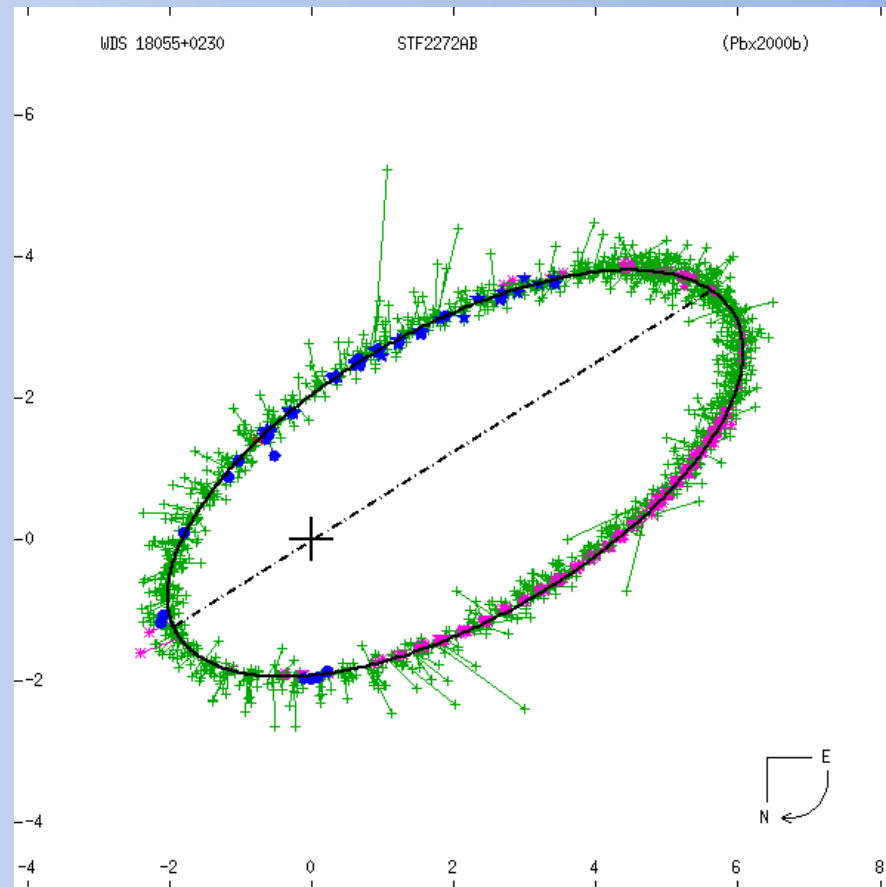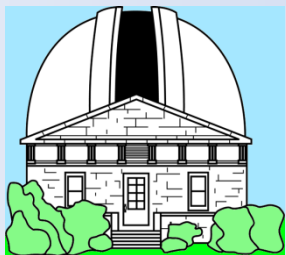
Linear Catalog

- The Catalog of Rectilinear Elements contains linear solutions to 1483 resolved pairs.
- While they could be long period, highly eccentric orbits, these are assumed to be optical until proven otherwise.

Both Catalogs

- have shown considerable growth (orbit: 34%, linear: 27%) since their last major release (2006.5).

- *But …* many solutions may be premature, so *an* answer is not necessarily *the* answer. Here are two examples.
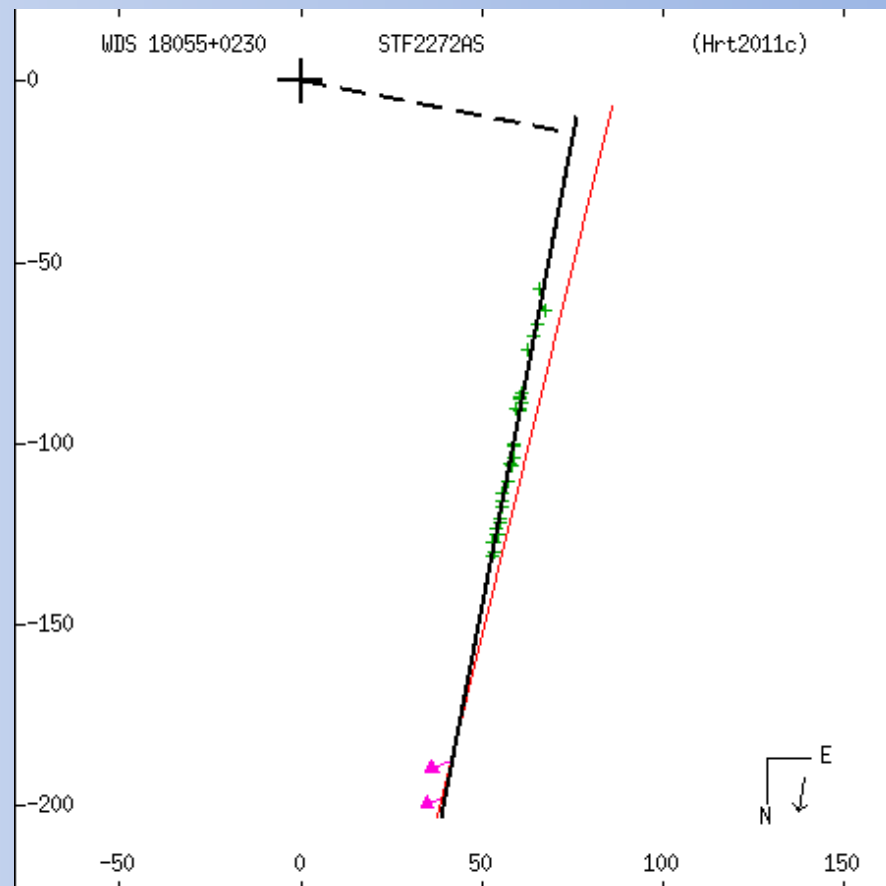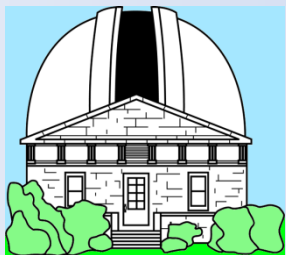
Premature solution: CHR 153 = HIP 21543

- Orbit determined in 2003 with three data points (72.3-y).

- Subsequent observations in 2005, 2008 and 2010 exhibited a trend in orbit residuals.

- The system is better fit by a linear solution, indicating the pair is likely optical.
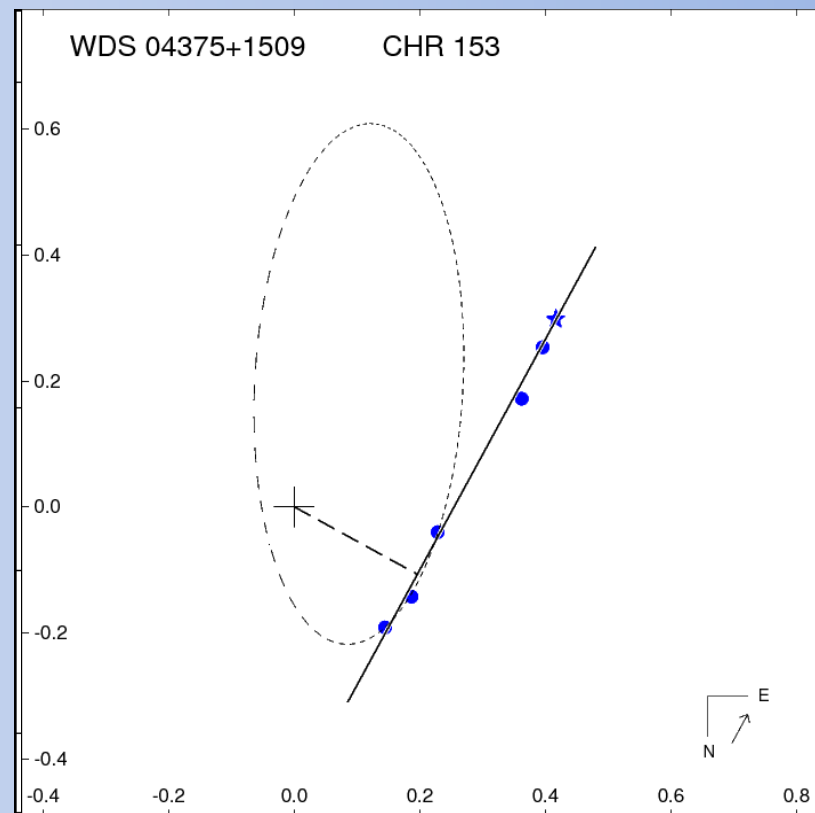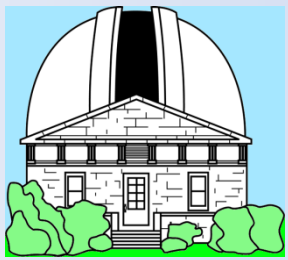
Premature solution: STF 147 = HIP 7916

- Solution first determined in Linear Catalog release (2006.5) seemed likely.

  - More recent observations have large residual offsets.
  - Data seems better fit with an orbit such as this unpublished solution.
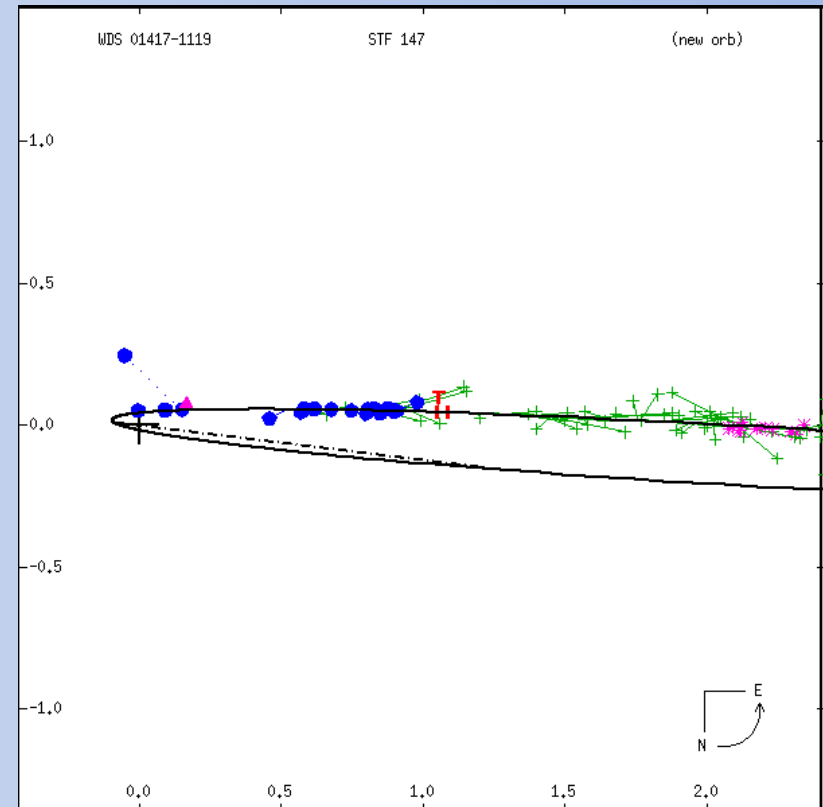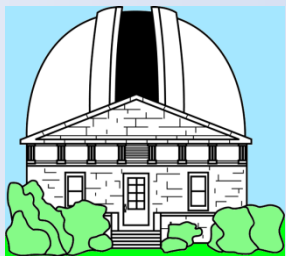
Other Catalogs and Services

- The 4th Catalog of Interferometric Measurements of Binary Stars provides online high resolution measurements of known double stars as well as single star detections.

- The 3rd Photometric Magnitude Difference Catalog contains reliable differential magnitude information.

- Much of the information from these two catalogs has recently been added into the WDS database.

- We also provide all available published data to specific systems on demand and can provide custom made observing lists specific to your telescope, instrument and location.

- We also maintain web pages for Commission 26 and G1.
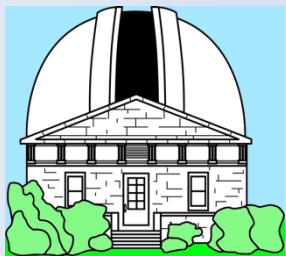
WDS: *data line changes*

- Changes in WDS data format includes more photometric information, formal errors, and higher precision.

```
00049+5832STF3057       1828 2009   61 302 298   3.5   3.8  6.70  9.30 B3V        +013-006 +009-003 +57 2855 N D  000454.98+583155.8
00049+5832              1828.      301.6   3.5    .   2.    2 HJ_1831  18B  B
00049+5832              1830.60    300.7   4.76   .   4.0   1 HJ_1833a 05A U8
00049+5832              1832.29    299.5   3.64  7.2  9.3   3 StF1837  10A  2
00049+5832              1889.57    300.1   3.66  9.1  6.8   3 Bu_1894  36AQ 2
00049+5832              1999.71    298.0   3.34   .    .    1 TMA2003  51EK 7
00049+5832              2006.028   297.8   3.850  .    .    1 Pru2008  40SR A
00049+5832              2009.755   297.9   3.754  .    .    1 Los2010  16SR A


00049+5832STF3057       1828 2009   61 302 298   3.5   3.8  6.70  9.30 B3V        +013-006 +009-003 +57 2855 N D  000454.98+583155.8
00049+5832     1828.       301.6    .      3.5    .     .     .     2.    .                 0.5   2 HJ_1831  Mb   7
00049+5832     1830.60     :300.7   .    : 4.76   .     .     .     4.0   .                 0.1   1 HJ_1833a Ma   6
00049+5832     1832.29     299.5    .      3.64   .    7.2    .     9.3   .                 0.3   3 StF1837  Ma   3
00049+5832     1889.57     q300.1   .      3.66   .    9.1    .     6.8   .                 0.9   3 Bu_1894  Ma   3
00049+5832     1999.71     298.0    .      3.34   .    6.528 0.039  6.805 0.023  1256 245   1.3   1 TMA2003  E2   7
00049+5832     1999.71      .       .      .      .    6.539 0.027  6.863 0.061  1633 160   1.3   1 TMA2003  E2   7
00049+5832     1999.71      .       .      .      .    6.558 0.018  6.863 9.998  2210 300   1.3   1 TMA2003  E2   7
00049+5832     2006.028    297.8    0.3    3.850  0.3   .     .      .    .       644  70   1.0   1 Pru2008  S    7
00049+5832     2009.755    297.9    .      3.754  .     .     .      .    .       720 420   0.4   1 Los2010  S    7
```
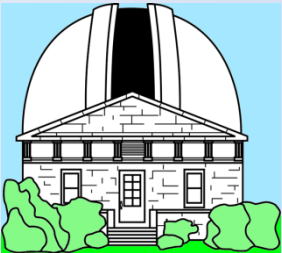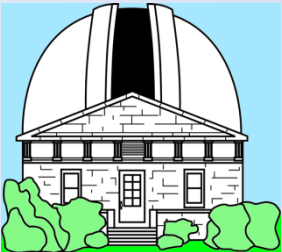
WDS: *possible summary line changes*

- Current arcminute identification not adequate in crowded fields.

WDS: *possible summary line changes*

```
1850048+332146CIA   3Aa1,2a20200200007  7 259557070 0.0.0 0.0.03.6.6 4.4. B8B8Bab   +000000404        +33332223NODD 18500047993322145566
1850048+332146 Aa1,2a20200505012 25355.4   . . m m0.01811   . .        . .  . .      0.01010.0212 163630    27878.8 1 CIA2A08D8KcKc 7 7
1850048+332146 Aa1,2a20200505012 25353.7   . . m m0.05853   . .        . .  . .       . .  . .     163630    27878.8 1 CIA2A08D8KcKc 7 7
1850048+332146 Aa1,2a20200505040 25353.3   . . m m0.09891   . .        . .  . .      0.07170.0616 163630    33030.7 1 CIA2A08D8KcKc 7 7
1850048+332146 Aa1,2a20200505040 25254.4   . . m m0.08686   . .        . .  . .       . .  . .     163630    33030.7 1 CIA2A08D8KcKc 7 7
1850048+332146 Aa1,2a20200515676  7379.9   . . m m0.67575   . .        . .  . .      0.96960.0313 163630    33030.7 1 CIA2A08D8KcKc 7 7
1850048+332146 Aa1,2a20200525959  7273.3   . . m m0.04842   . .        . .  . .      0.00400.3535 163630    33030.7 1 CIA2A08D8KcKc 7 7
1850048+332146 Aa1,2a20200525959  6966.6   . . m m0.08383   . .        . .  . .       . .  . .     163630    33030.7 1 CIA2A08D8KcKc 7 7
```

- Current arcminute identification not adequate in crowded fields.
- Current multiplicity field not adequate for nested hierarchies.

WDS: *possible summary line changes*

```
1850048+332146CIA   3Aa1,Aa2 2007 2007      7 255  70   0.00  000003.6.6 4.4.  B8B8Bab     +000000004      +33+32232MGDNOD85085004+392343165.6
1850048+332146 Aa1,Aa2 2007.5012    255.4     .    m 0.811    .      .    .     0.01  0.12  1630      278.8   1 CIA2008b Kc    7
1850048+332146 Aa1,Aa2 2007.5012    253.7     .    m 0.853    .      .    .      .     .    1630      278.8   1 CIA2008b Kc    7
1850048+332146 Aa1,Aa2 2007.5040    253.3     .    m 0.891    .      .    .     0.17  0.16  1630      330.7   1 CIA2008b Kc    7
1850048+332146 Aa1,Aa2 2007.5040    254.4     .    m 0.886    .      .    .      .     .    1630      330.7   1 CIA2008b Kc    7
1850048+332146 Aa1,Aa2 2007.5176     73.9     .    m 0.675    .      .    .     0.96  0.13  1630      330.7   1 CIA2008b Kc    7
1850048+332146 Aa1,Aa2 2007.5259     72.3     .    m 0.842    .      .    .     0.40  0.35  1630      330.7   1 CIA2008b Kc    7
1850048+332146 Aa1,Aa2 2007.5259     69.6     .    m 0.783    .      .    .      .     .    1630      330.7   1 CIA2008b Kc    7
```

- Current arcminute identification not adequate in crowded fields.
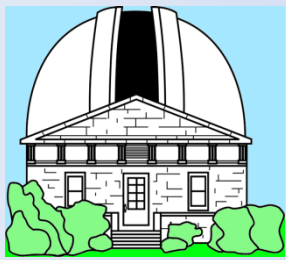- Current multiplicity field not adequate for nested hierarchies.
- Separation precision inadequate for current techniques.

WDS: *possible summary line changes*

```
1850048+332146CIA   3Aa1,Aa2 2007 2007    7 255  70   0.00m  0.00  3.6   4.   B8Iab      +001-004             +33 3223 NOD  185004.79+332145.6
1850048+332146 Aa1,Aa2 2007.5012    255.4    .   m  0.811    .     .     .   0.01  0.12  1630     278.8   1 CIA2008b Kc   7
1850048+332146 Aa1,Aa2 2007.5012    253.7    .   m  0.853    .     .     .    .     .    1630     278.8   1 CIA2008b Kc   7
1850048+332146 Aa1,Aa2 2007.5040    253.3    .   m  0.891    .     .     .   0.17  0.16  1630     330.7   1 CIA2008b Kc   7
1850048+332146 Aa1,Aa2 2007.5040    254.4    .   m  0.886    .     .     .    .     .    1630     330.7   1 CIA2008b Kc   7
1850048+332146 Aa1,Aa2 2007.5176     73.9    .   m  0.675    .     .     .   0.96  0.13  1630     330.7   1 CIA2008b Kc   7
1850048+332146 Aa1,Aa2 2007.5259     72.3    .   m  0.842    .     .     .   0.40  0.35  1630     330.7   1 CIA2008b Kc   7
1850048+332146 Aa1,Aa2 2007.5259     69.6    .   m  0.783    .     .     .    .     .    1630     330.7   1 CIA2008b Kc   7
```

- Current arcminute identification not adequate in crowded fields.
- Current multiplicity field not adequate for nested hierarchies.
- Separation precision inadequate for current techniques.
- Adding separation code can allow much closer and wider separations to be specified.
    - Default is arcseconds. Code could be ', m, or u (arcminute, milliarcsecond, microarcsecond)
- Similar codes between like fields could specify:
    - When magnitude is not V (e.g., B, R, K)
    - When proper motion is not mas/yr
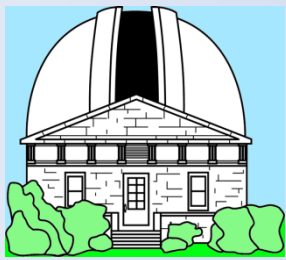
WDS: *Other Possible Changes*

```
00049+5832STF3057      1828 2009   61 302 298    3.5    3.8   6.70   9.30 B3V          +013-006 +009-003 +57 2855 N D  000454.98+583155.8
00049+5832       1828.        301.6     .         3.5     .       .     .     2.    .                         0.5   2 HJ_1831   Mb  7
00049+5832       1830.60     :300.7     .     :   4.76    .       .     .     4.0   .                         0.1   1 HJ_1833a  Ma  6
00049+5832       1832.29      299.5     .         3.64    .     7.2     .     9.3   .                         0.3   3 StF1837   Ma  3
00049+5832       1889.57     q300.1     .         3.66    .     9.1     .     6.8   .                         0.9   3 Bu_1894   Ma  3
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00049+5832       2006.028     297.8    0.3        3.850   0.3     .     .       .   .        644  70          1.0   1 Pru2008   S   7
00049+5832       2009.755     297.9     .         3.754   .       .     .       .   .        720 420          0.4   1 Los2010   S   7
```

- Other considerations …
  - What cross reference to use? (Currently: BD, CD or CpD)
  - Is more space needed for spectral type? (Now eight characters for both)
  - Is more space needed for very fast moving systems? (0.0001y = 8h46m)
  - Should we switch to more familiar reference code? (e.g., CIA2008b becomes 2008ApJ…682..577B)
  - Should we include proper motion errors?

- **What else???**