RevMexAA (Serie de Conferencias), **21**, 83–90 (2004)

ADDRESSING CONFUSION IN DOUBLE STAR NOMENCLATURE: THE WASHINGTON MULTIPLICITY CATALOG

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RESUMEN

Los avances en la instrumentación y la reducción de datos están borrando las diferencias históricas entre los diversos tipos de estrellas dobles. Un resultado de ello es la creciente confusión en la nomenclatura, puesto que las convenciones de los distintos observadores son a veces incompatibles. Se presenta el Washington Multiplicity Catalog como una contribución al desarrollo de un esquema único de nomenclatura para todos los tipos de estrellas dobles, y también como una base de datos amplia para toda la información relevante a la duplicidad estelar.

ABSTRACT

Advances in instrumentation and reduction methods are blurring the historical distinctions between various classes of double stars. One result of this is increasing confusion in double star nomenclature, as the conventions followed by different observers are sometimes incompatible. The Washington Multiplicity Catalog is presented as a means of developing a single nomenclature scheme for all types of doubles, as well as a comprehensive database for all duplicity information.

Key Words: **STARS: BINARIES**

1. INTRODUCTION: A WELCOME "PROBLEM"

The new observing and reduction techniques available to astronomers have led to remarkable changes in the field of double and multiple stars. New classes of companions, such as brown dwarfs and exoplanets, have been discovered. Binaries which previously constituted distinct classes are now observable by multiple techniques (witness, for example, the increasing overlap between the visual and spectroscopic regimes). With many long-baseline optical interferometers operational or planned, with improvements in other techniques (e.g., absorption-cell RV work), and with astrometric space-based missions in various states of planning and funding, the situation is likely to become more complicated. The result is greater understanding for the scientist, but greater challenges for the cataloger!

The "problem" is that purveyors of different techniques use different nomenclature. Visual binaries are given discoverer designations, based on observer's name (e.g., Σ or STF 13, β or BU 96), while spectroscopic binaries are usually identified by their HD number, eclipsing binaries by their variable star designation, occultation binaries by SAO or ZC number, and so on. Binaries analyzed by multiple methods may wind up with multiple designations.

While multiple designations are confusing, a large cross-reference list (such as SIMBAD) can usually handle these problems. Component confusion is even worse, however, as one person's **AB** pair may be another's **ab** or **BA** or **BC** or **primary/secondary**! It is this problem that we wish to address.

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2. ADDRESSING THE PROBLEM

An electronic discussion among an informal working group began in 1999. Over time, these discussions resulted in four suggested schemes:

- **KoMa**: a hierarchical scheme developed by D. Kovaleva and O. Malkov. Using a variety of upper/lower case alphabetic, numeric, and Roman numerals, this scheme indicated both hierarchy and type of companion (e.g., stellar, planetary, etc.).
- **UC**: developed by S. Urban and T. Corbin. This is a numeric-only, backside-expandable scheme similar to that used for library call numbers.
- **Sequential**: a non-hierarchical scheme developed by L. Dickel and P. Dubois. In this numeric scheme all components are assigned numbers in the order of their discovery, with no heed given to their relationship with other components.
- **WMC**: the Washington Multiplicity Catalog. This method, while based on the venerable series of upper and lower case letters used in the WDS, extends to multiple levels through use of additional numbers and letters.

At IAU Symposium 200 the attendees seemed to favor the WMC, with UC a close second. The sequential scheme, while not favored, was sufficiently different from others so that it continued to be discussed.

At IAU-GA XXIV interested parties met to discuss various methods for clearing up the nomenclature ambiguities. As a result of those discussions the WMC was endorsed and the following resolution was ratified by Commissions 5 (Documentation & Astronomical Data), 8+24 (Astrometry), 26 (Double & Multiple Stars), 42 (Close Binary Stars), and later 45 (Stellar Classification). The resolution read as follows:

On Designating Components of Binary/Multiple Star Systems

Recognizing

- the increasing synergy of techniques for the investigation of stellar companions blurring the traditional distinction between astrometric, spectroscopic, and photometric binary and multiple stars;
- the detection of substellar (including planets) as well as stellar components by these techniques and,
- the need for a simple, unambiguous, flexible, and computer friendly designation scheme for components of binary and multiple star systems,
- Noting that future ground and space-based telescope projects have the potential to detect both substellar as well as stellar components in increasingly large numbers,

Recommends that

- a uniform designation scheme, based on expansion of the new WDS system, be developed during the next 3 years to include all types of components and that this be reviewed in time for its adoption to be considered at General Assembly XXV.

Implementation of the scheme was to be as follows:

1. Present a sample of the resulting scheme to Commission 26 at Colloquium 191. This sample was to be in the form of a catalog of all types of binaries found within a particular patch of the sky, complete with component designations based on the new scheme (see Section 6 below).
2. Make any needed modifications based on suggestions from participants, then present this modified scheme to the SOC of IAU-GA XXV SPS 3 (Special Session 3: *A New Classification Scheme for Double Stars*).
3. Make additional modifications if necessary, then present the further modified scheme at SPS3, July 18, 2003.
4. If approved, present the all-sky WMC at IAU-GA XXVI in 2006, and continue to update and maintain.

3. ROOTS OF THE WMC

The root of the WMC is the Washington Double Star Catalog (WDS). The WDS, maintained at the United States Naval Observatory (USNO), is the principal database of astrometric double and multiple star data for the astronomical community. It contains (as of February 2003) nearly 600,000 mean positions for $\sim$100,000 pairs, and is updated nightly. The USNO double-star program also maintains catalogs of differential magnitudes, visual orbital elements, and interferometric and other high-resolution observations.

While the WDS is a complete listing of all resolved systems (i.e., visual and interferometric doubles), many components are detected but not resolved. These include:

- spectroscopic doubles (single- or double-lined),
- photometric or eclipsing binaries,
- astrometric doubles,
- lunar occultation doubles,
- other doubles, and
- planets and other substellar objects.

However, the WDS nomenclature rules (with slight modification) can accommodate all types of double stars.

4. THE WDS AND HIERARCHY

The WDS is system-based rather than object-based, as it contains relative measures between components of a given system. In an object-based scheme, a group of N objects yields N entries, but in a system-based scheme, N objects can yield up to $\frac{N(N-1)}{2}$ entries. The WDS may also contain measures between photocenters, and multiple systems may become quite complex as N increases. However, the WDS lists only pairings actually measured, and the observer's common sense usually implies the system hierarchy.

Generally, orbital period and/or separation are used to assign the hierarchical structure. The 3:1 ratio of semi-major axes determined by R.S. Harrington in his work on hierarchical multiples is generally followed, although separations $> 1''$ are usually given upper-case letters. This 3:1 ratio assumes physicality. However, most visual doubles do not have enough measures to determine whether motion is Keplerian or rectilinear. In general, then, all hierarchies in the WMC are *apparent* rather than *absolute*. It is assumed that all double stars within some small separation are of interest (if only as a warning of possible image blending), so are retained in the WDS and WMC even if shown to be optical.

5. RULES OF COMPONENT DESIGNATION

The WDS at present extends nomenclature to second level hierarchies. The WMC will extend this nomenclature to cover more complex systems, however, as follows:

Level 1: capital letters
(e.g., STF1523 AB)
Level 2: lower case letters
(e.g., FIN 347 Aa,Ab)
Level 3: numbers
(e.g., BNK 1 Ab1,Ab2)

Higher levels will alternate lower case letters and numbers (no examples of higher levels have yet been found, however).

A comma will be used as the delimiter between components in a system, with the full component identifier before and after the comma (e.g., Aa,Ab). The only exceptions: if only two characters are provided the delimiter is assumed (e.g., WAK 8CD = WAK 8C,D).

While the WMC will strive to maintain hierarchies in the assignment of letter and/or number, this is not always possible, given our often very limited knowledge. Also, if a subsystem is found that cannot be assigned unequivocally to a higher order component, a tentative best guess assignment will be given and a note added to the catalog.

Figure 1 illustrates a (fictitious) system, growing increasingly complex as new components are discovered.

6. THE SAMPLE WMC

The $11^h - 11^h30^m$ band of RA was selected for the sample WMC. As well as being historically compelling (containing ξ UMa), it includes a variety of component types:

- astrometric binaries,
- X-ray binaries, cataclysmic variables, and related objects,
- eclipsing binaries,
- occultation binaries,
- spectroscopic binaries (SB1 + SB2),
- spectrum binaries,
- interferometric binaries,
- visual binaries, and
- planetary companions (by extending to $10^h59^m.5$).

In addition to the WDS and other USNO double star catalogs mentioned earlier, sources of multiplicity tapped thus far for the sample WMC include:

- Downes et al., 2001, *A Catalog and Atlas of Cataclysmic Variables: On-line Version*, PASP **113**, 764 (`http://icarus.stsci.edu/ downes/cvcat/`),
- Ritter & Kolb 1998, *Catalogue of cataclysmic binaries, low-mass X-ray binaries, and related objects (Sixth edition)*, A&AS **129**, 83,
- Batten et al., 1989, *Eighth Catalogue of the Orbital Elements of Spectroscopic Binary Systems*, Pub. DAO, **17**,
- Pourbaix et al., 2003, *Ninth Catalogue of Spectroscopic Binary Orbits* (`http://sb9.astro.ulb.ac.be/`),
- Svechnikov & Bessonova 1984, *Catalog of Orbital elements, Masses and Luminosities of close double stars*, Bull. Inf. CDS 26, 99,
- van Paradijs 1995, *A Catalogue of X-Ray Binaries*, in *X-ray Binaries*, Lewin et al, eds., Cambridge Univ. Press, ch. 14, pp 536-577,
- California & Carnegie Planet Search web site (`http://exoplanets.org/`) and links therein.

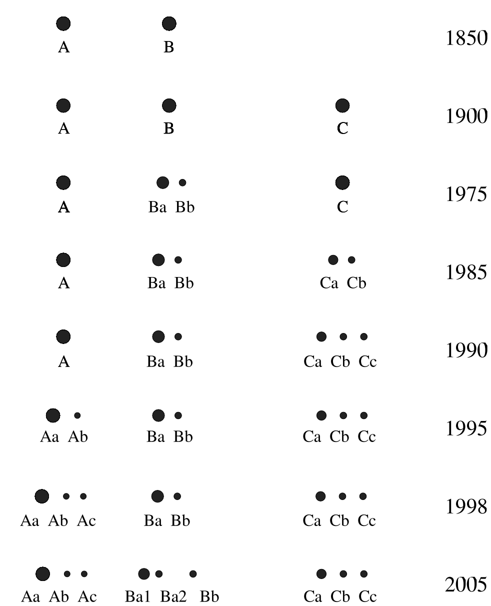

Fig. 1. Illustration of nomenclature assignment as a (fictitious) system system grows more complex:

1850: visual pair is discovered
1900: wide common proper motion companion is found
1975: B component is found to be spectroscopic binary
1985: C component is split by speckle interferometry
1990: additional speckle C component is resolved at a similar separation
1995: planet is found orbiting the A component
1998: second planet is found
2005: primary of B is resolved by long-baseline interferometry

Information on other prospective sources is needed and welcome.

These techniques contribute to the sample WMC in the following percentages:

95.8%	visual binaries and optical pairs
50.6%	interferometric binaries and optical pairs
1.7%	spectroscopic binaries
1.4%	cataclysmic variables or related objects
1.0%	occultation binaries
0.3%	astrometric binaries
0.2%	eclipsing binaries
0.2%	X-ray binaries
0.1%	spectrum binaries
0.1%	planets

Since the techniques are complementary, the sum is >100%. It should be noted that this breakdown is biased significantly by selection effects. For example, while visual binaries may be discovered (and cataloged) after a single observation, data on spectroscopic pairs are often not published until the full orbit has been characterized.

7. COORDINATE MATCHING

System matches are based on the arcsecond-precise coordinates of the primary stars in each individual pair. The most time-consuming aspect of the WMC construction (by far!) was the improvement of the arcminute-precise coordinates found in the WDS. Some 80% of the 1,645 different primaries in the sample region were matched to Hipparcos or Tycho-2 objects. An additional 19% matched to GSC2, USNO A2, 2MASS, etc. via individual inspection using ALADIN. There remain 1.3% (21 pairs) which still have coordinates of only arcminute accuracy. Nearly all of these are older, unconfirmed, visual doubles (including some very wide common proper motion pairs and some with suspect coordinates).

Following coordinate matching we found a total of 1,465 systems in this slice of the sky. These may be broken down as follows:

1,336 (91%)	simple binaries
80 (5.5%)	non-hierarchical triples
16 (1.1%)	non-hierarchical systems, >3 components
25 (1.7%)	hierarchical triples
8 (0.5%)	hierarchical systems, >3 components

8. THE CATALOG

A sample page from the catalog is shown in Figure 2, and an explanation of the columns follows. (Note: In the explanation for columns 3 and 4, the names in parentheses indicate the usual order of preference for that column.).

1	WMC designation (WDS or J2000 arcsecond coordinates of system primary)[2]
2	component designation (AB; Aa,Ab; etc.)
3	catalog and name (Bayer/Flamsteed/variable star designation, HD, DM, discoverer designation, etc.)
4	catalog and name (HD, Tycho-2, GSC2, USNO A2, 2MASS, etc.)
5	angular separation (including separations predicted from spectroscopic orbit and parallax, vector separations, etc.)
6	orbital period
7,8	magnitudes (flags for variability, filter codes if not V,)
9,10	spectral types
11	parallax (from Hipparcos, orbit, etc)
12,13	masses (or mass function, mass ratio. etc.)
14	binary type (visual, spectroscopic, X-ray, etc.)
15	references (with web links to on-line catalogs)
16	J2000 arcsecond coordinates of principal star of pair

9. EXAMPLES FROM THE SAMPLE WMC

A few systems from the portion of the sample WMC shown in Figure 2 are noted below. These illustrate some of the features of the WMC, as well as some of the difficulties to be encountered in creating the full catalog.

1100004+413608, **1100006-285044**, etc.: These simple doubles, whether of visual, astrometric, spectroscopic, or other discovery origin, are by far the most common entries in the WMC.

1059280+402549 and **1113063-421643**: These two triples are treated in the same manner, even though one consists of three stars and the other a star and its two planets. In both cases, the apparent separations of the AB and AC pairs are comparable, so all components are considered to be at the same hierarchy.

1101493+295217: This is an example of a simple hierarchical triple.

[2]The WMC designation was given to arcminute accuracy in the version presented at the Merida talk. However, following discussions during this talk, the WMC was modified to J2000 arcsecond coordinates.

Sample Washington Multiplicity Catalog

WMC...........	Comp.....	?? NAME.............	?? NAME..............	Sep....*	Period.y	Mag1.f	Mag2.f	Spec1......	Spec2...	Parallax	Mass1.....*	Mass2.*	Btype.	References......	RA,Dec (2000).
1059280+402549	AB	* 47 UMa	HD 95128	0.14	2.982y	5.05		G0V	planet	71.05h		2.54j	S1	CCP	1059280+402549
1059280+402549	AC	* 47 UMa	HD 95128	0.26	7.1 y	5.05		G0V	planet	71.05h		0.76j	S1	CCP	1059280+402549
1100004+413608	AB	BD +42 2173	T2 3012 01054 1	0.005a	0.899y	10.08	.	R...	.	5.29h	.	.	A	O6	1100004+413608
1100006-285044	AB	** TDS7598	T2 6647 01291 1	0.46	.	11.13	11.52	.	.	.	.	.	V	WDS,I4	1100006-285044
1100175-295159	AB	* EC 10578-2935	G2 S12221102974	.	.	15.9	.	?	.	.	.	.	CV	CCV	1100175-295159
1101493+295217	Aa,Ab	HD 95515	T2 1980 00145 1	0.262	.	7.8	.	K0	.	9.00h	.	.	V	WDS,I4	1101493+295217
1101493+295217	Aa,B	HD 95515	T2 1980 00145 1	1.13	.	7.00	9.36	K0	.	9.00h	.	.	V	WDS,I4	1101493+295217
1108028-774227	Aa,Ab	** GHE 35	G2 S1101231136	0.72	.	7.03k	8.38k	?e	.	7.1 r	.	.	V	WDS,I4	1108028-774227
1108028-774227	Ab1,Ab2	** BNK 1	G2 S1101231136	0.100	.	8.92k	9.32k	.	.	7.1 r	.	.	V	WDS,I4	1108028-774227
1108028-774227	AB	** GHE 35	G2 S1101231136	2.7	.	7.03k	9.5 k	?e	.	7.1 r	.	.	V	WDS,I4	1108028-774227
1108028-774227	AC	** SZR 1	G2 S1101231136	17.	.	7.03k	10.1 k	?e	.	7.1 r	.	.	V	WDS,I4	1108028-774227
1108059-615608	AB	V* RS Car	HD 96830	.	0.083d	7.0 b	18.0	nova	.	.	.	.	CV	CCV	1108059-615608
1113063-421643	AB	CD -41 6409	T2 7734 00204 1	2.503	.	10.55	11.69	.	.	.	.	.	V	WDS,I4	1113063-421643
1113063-421643	AC	CD -41 6409	T2 7734 00204 1	5.46	.	10.55	13.6	.	.	.	.	.	V	WDS	1113063-421643
1113125-262754	AB	V* TT Hya	HD 97528	0.65 m	6.953d	7.60	8.90	A2Ve	K1.5IV	6.50h	2.08	0.65	E,S1	SvB,SB8,SB9	1113125-262754
1115073-611539	Aa,Ab	HD 97950	T2 8959 01959 1	0.339	.	10.5	11.1	.	.	.	.	.	V	WDS,I4	1115073-611539
1115073-611539	Aa,Ac	HD 97950	T2 8959 01959 1	0.371	.	10.5	11.3	.	.	.	.	.	V	WDS,I4	1115073-611539
1115073-611539	Aa,Ad	HD 97950	T2 8959 01959 1	0.784	.	10.5	10.3	WN...	WN...	.	.	.	V	WDS,I4	1115073-611539
1115073-611539	AB	HD 97950	T2 8959 01959 1	1.81	.	9.03	10.8	WN...	WN...	.	.	.	V	WDS	1115073-611539
1115073-611539	AC	HD 97950	T2 8959 01959 1	2.69	.	9.03	11.3	WN...	.	.	.	.	V	WDS	1115073-611539
1115073-611539	AD	HD 97950	T2 8959 01959 1	3.54	.	9.03	12.3	WN...	.	.	.	.	V	WDS	1115073-611539
1115073-611539	AE	HD 97950	T2 8959 01959 1	4.59	.	9.03	11.8	WN...	.	.	.	.	V	WDS	1115073-611539
1118047+361614	AB	** KZA 16	2M 1118046+361614	8.08	.	11.0	11.5	.	.	.	.	.	V	WDS	1118047+361614
1118109+313145	Aa,Ab	* xi UMa	T2 2520 02634 1	0.053	669.18 d	4.41	.	G0V	M3V?	127.	0.022 f	0.37:	A,S1	O6,SB8	1118109+313145
1118109+313145	AB	HD 98231	T2 2520 02634 1	2.536	59.878y	4.41	4.87	G0V	F8.5V	127.	2.21 t	.	V	WDS,O6,I4	1118109+313145
1118109+313145	AC	HD 98231	T2 2520 02634 1	54.31	.	4.41	15.0	G0V	.	127.	.	.	V	WDS	1118109+313145
1118109+313145	Ba,Bb	* xi UMa	T2 2520 02634 2	0.33 m	3.981d	4.87	.	F8.5V	.	127.	0.000052f	.	S1	SB8	1118108+313145
1118109+313145	Ba,Bc	HD 98230	T2 2520 02634 2	0.026	.	4.87	.	F8.5V	K2-3V?	127.	.	.	V	WDS,I4	1118108+313145
1124349+021238	AB	** SLE 597	A2 0900-06920936	40.68	.	11.9	12.5	.	.	.	.	.	V	WDS	1124349+021238
1129041+392013	AB	HD 99787	T2 3013 02482 1	5.45	.	5.35	10.67	A2V	.	15.59h	.	.	V	WDS,I4	1129041+392013
1129041+392013	AC	HD 99787	T2 3013 02482 1	216.55	.	5.35	11.6	A2V	.	15.59h	.	.	V	WDS	1129041+392013
1129041+392013	AD	HD 99787	T2 3013 02482 1	344.36	.	5.35	7.73	A2V	K0	15.59h	.	.	V	WDS,I4	1129041+392013
1129041+392013	AE	HD 99787	T2 3013 02482 1	100.33	.	5.35	10.6	A2V	.	15.59h	.	.	V	WDS	1129041+392013
1129041+392013	AF	HD 99787	T2 3013 02482 1	131.03	.	5.35	10.3	A2V	.	15.59h	.	.	V	WDS	1129041+392013
1129041+392013	AG	HD 99787	T2 3013 02482 1	330.27	.	5.35	10.3	A2V	.	15.59h	.	.	V	WDS	1129041+392013
1129041+392013	DE	HD 99720	T2 3013 01407 1	99.06	.	7.73	10.6	K0	.	4.23h	.	.	V	WDS,I4	1128359+391829
1129041+392013	DF	HD 99720	T2 3013 01407 1	128.54	.	7.73	10.3	K0	.	4.23h	.	.	V	WDS	1128359+391829
1129041+392013	EF	** STF1543	T2 3013 01935 1	43.88	.	10.6	10.3	.	.	.	.	.	V	WDS,I4	1128353+391650

Fig. 2. Sample page from the WMC Catalog.

IAU Colloquium 191 - The Environment and Evolution of Double and Multiple Stars (© Copyright 2004: IA, UNAM)
Editors: C. Allen & C. Scarfe

1108028-774227: This is the only system in the sample WMC showing all three levels of hierarchy.

1129041+392013: All components of this system (apparently a small cluster) are wide, so no hierarchical structure was assigned, despite the wide range in separation.

1118109+313145: The ξ UMa system is another complicated multiple. The A component is a spectroscopic binary; the B component has also been split spectroscopically (with separation estimated as 0.33 milliarcseconds). There is also a component of B resolved by speckle interferometry. Based on the separations, one would ordinarily assign the speckle pair the second level of hierarchy (e.g., Ba,Bb) and assume one of those components was split spectroscopically (e.g., Ba1,Ba2). However, we are familiar with the speckle pair and suspect the resolution may be spurious, as it has never been confirmed. We're thus reluctant to assign a different hierarchy to the very close pair.

1115073-611539: This is another apparent small cluster. Since the component we call A was later resolved into four stars, we assigned those stars to a second apparent hierarchical level.

10. HELP!

Your suggestions and opinions are needed, be they on format, information to add or delete, etc.). See the WMC web site (linked from the WDS web site: `ttp://ad.usno.navy.mil/wds/wds.`tml).

One question to ponder: Should old component designations be changed to the new scheme or should they remain as they are? On the one hand, some of these older designations may have been in the literature for many years, and changing them could lead to confusion. On the other hand, some designations (such as those for systems given different designations by different techniques) will have to change. Others have argued that consistency in new designations will lead to less confusion in the future. (One comment heard: "The future is longer than the past!")

Your data are needed (for the WDS, visual and spectroscopic orbit catalogs, etc., as well as the WMC). Send comments, etc. to wih@usno.navy.mil or bdm@usno.navy.mil. Comments and questions regarding the WMC will be posted as deemed appropriate.

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DISCUSSION

Zwitter – Any system in future should allow for dynamical changes. GAIA is bound to discover huge numbers of systems, and their physical status will be sometimes quite provisional, at least during the data collection phase. Can't we favor a system of one designation per star, with their membership in binary or multiple systems being marked by pointers that may change with time?

Hartkopf – I can't, off the top of my head, think of a good way to implement such a scheme. One aspect of a catalogue of this nature which must be taken into consideration is that it must aid the astronomer in visualizing the system under investigation, especially such systems as a complex hierarchical multiple. A set of several (10 or 12-digit) numbers would make that very difficult, in my opinion.

Griffin – Are intending to 'correct' presently entrenched nomenclature where it conflicts with the new system? For example, in ζ Cancri there is a close pair called A and B, and a distant component C, and they have been know as such for 150 years. Will you reverse the identities of B and C, confusing everyone who is already conversant with the object, or leave them the same, confusing posterity?

Hartkopf – I am of two minds about this problem. We want the catalog to be as correct as possible, yet want to minimize confusion with information already in the literature. Perhaps it is best to keep the old designations but describe the hierarchy we believe to be correct in detailed notes.

Griffin – Please could I make another remark? I'd like to say how troublesome it is to have double stars identified only by 'discoverer designations - spectroscopists who might well like to look at some of the objects have a hard time finding what the objects actually are. If people would use HD numbers it would be much easier. I do not see the point of constantly re-naming perfectly well-known stars anyway – that is one of the few points on which I find myself in agreement with Luyten. For example the SAO is only a derivative catalogue and there was no reason for it to re-name all the stars in it; and then Hipparcos not only assigned its own numbers to all the stars it observed notwithstanding the fact that they all already had catalogue identifications, but then the WDS gave ADDITONAL 'Hipparcos' numbers to all the new double stars it found! Spectroscopists like me feel ill used when we discover spectroscopic binaries, determine their orbits, see that they would be of interest to interferometric observers, point them out to you, and you observe them and then assign them YOUR discovery numbers!

Hartkopf – I have of course heard your opinion of discoverer designations before, Roger. However, Brian and I specifically wanted to avoid making the WMC look just like the WDS. The priority for names in the first name column is, I believe, variable star designations, HD, DM, and only when there aren't other possibilities are DDs listed. You'll see that the only DD's (indicated by a "**", like in SIMBAD) are for quite faint stars.

As for the whole idea of discoverer designations, I don't feel it necessary for me to defend a naming convention which dates back some two centuries. One might also turn your question back at you and ask why you use designations named after Henry Draper when there are perfectly good Durchmusterung designations which predate that catalog by many years?*

Mathieu – Open cluster spectroscopic binary populations will need arcsecond designations to distinguish different binaries.

Hartkopf – OK. I think arcsecond designations will also be necessary to accommodate the large numbers of new binaries expected in future surveys.

Tokovinin – Do you foresee to put combinations of observing techniques, e.g., V+S+A?

Hartkopf – Yes, I do have those in the sample catalog. None happened to be on the page captured for the example, however.

Tokovinin – How do you deal with optical doubles? Shall you put a flag when it is known that a component is physical or optical?

Hartkopf – Optical doubles will be included in the catalog. I think it would be a good idea to flag systems we know definitely are physical (for example, those showing definite orbital motion), common proper motion pairs, or optical doubles (for example, showing clear rectilinear motion). Perhaps the "V" for visual double could be replaced by "Vp", "Vc", "Vo", for example, for those cases when we can make a reasonably definitive determination.

Scarfe – Nomenclature of eclipsing systems is even more beset by discovery catalogue designations despite the best efforts of the groups in Moscow who produce name lists of variable stars.

Hartkopf – True. Visual binary people are by no means the only astronomer who add their names to their "discoveries"!

Scarfe – How many of the stars in WDS have ever been measured for radial velocity? Hugo Levato maintains bibliography of RVs, and it might be worth consulting him.

Hartkopf – I have no idea at present. I have not at this point added variable RV systems; Levato sounds like an excellent contact for these objects.

Aarseth – I would like to comment that the phrase "hierarchical" implies stability. However, using the ratio of 3:1 is arbitrary because stability of a triple depends on the outer eccentricity, which may be large.

Hartkopf – Unfortunately many systems have only one or two observations, so there is no way to determine eccentricities or even whether all components are physical. The best we can do is use some "rule of thumb" for these cases. Perhaps I should use the term "apparent hierarchy" to stress our lack of sufficient knowledge.

Pourbaix – How do you designate systems where only one component is seen (e.g., SB1)?

Hartkopf – We would treat an SB1 the same as any other binary. The secondary in this case would have unknown spectral type and perhaps only a limit on magnitude. It would, I suppose, be similar to an astrometric pair.

Pourbaix – How does the designation change if the hierarchy goes up?

Hartkopf – It is uncertain. I would be tempted to correct the designation to reflect the correct hierarchy. However, in order to avoid confusion with already published measurements, it might be better to keep the old designations (say, AB), make the new wider component C, and add a note describing the correct hierarchy and the reason for the incorrect designations.

[Note: In later "off-line" discussions, Dimitri gave one strong argument in favor of changing designations as we learn of new components, etc. - namely to enable astronomers to use the catalog for statistical studies of multiples.]