Binary star Data Base, BDB

http://bdb.inasan.ru

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Properties of binary stars

The components:

- **have the same age**

  (tests of theoretical models of evolution)

- **was born at the same place and time**

  (tests of chemical abundance)

- **are at the same distance**

  (tests of distance calibrations)

- **suffer the same interstellar extinction**

  (tests of interstellar reddening)

The binary stars give an access to the absolute stellar masses and radii.

The binary star data are those of single stars extended to pair and system characteristics.

The binary stars have a great variety of observational appearances.

At least half of the stars in galactic neighbourhood belong to double or multiple systems.

Binary star astronomy: scientific tasks

1. Study of stellar evolution
2. Determination of mass and other stellar parameters
3. Construction of fundamental relations between stellar parameters (mass-luminosity relation, etc.)
4. Construction of correlation diagrams
5. Statistical studies
6. Study of high-energy accretion processes
7. Planning of observations

Types of databases of binary stars

Usually data on various observational types of binaries are included in different databases/catalogues:

- WDS, CCDM - *visual binaries*,

- OARMAC, ORB6 - *orbital binaries*,

- INT4 - *interferometric binaries*,

- CEV, GCVS - *eclipsing binaries*,

- SB9 - *spectroscopic binaries*, …etc

There is no database synthesizing the various categories.

BDB aims to fill this gap.

History

- Initially, the first attempt to construct Binary star database (BDB) was made in Besançon Observatory.
- In 2008 it was decided to move BDB to the Institute of Astronomy (Moscow), where the database is significantly reconstructed and renovated.

Purposes. Main intentions

- BDB should provide all “binary” data (or metadata) on binaries. However, BDB should not repeat other databases’ job.
- BDB should be simple in use (less mouse clicks – more usability).
- BDB should be simple in maintenance (everyday’s discoveries should not lead to changes of main pages format).

BDB objectives

Allow the interrogation of data for all categories of binary stars:

Integrate and access data from large catalogues of binaries (CCDM, WDS, ORB6, CEV, …)

Establish links with databases of binary stars (SB9, ...) and general purpose databases (SIMBAD, IBVS, ...)

Integrate data from catalogues of astrophysical parameters – masses, radii, etc (Svechnikov, Pribulla, Budding, ...)

Main problems to solve

1. Compile **list of data sources** (catalogues, databases) for binaries/multiples of different types to be included in or linked with BDB
2. Link **right data to right objects**. It includes:

- A unique and consistent system for component designations (A, Ab, B, AB, C, ...)
- Problems of identifications in different catalogues (cross-matching)

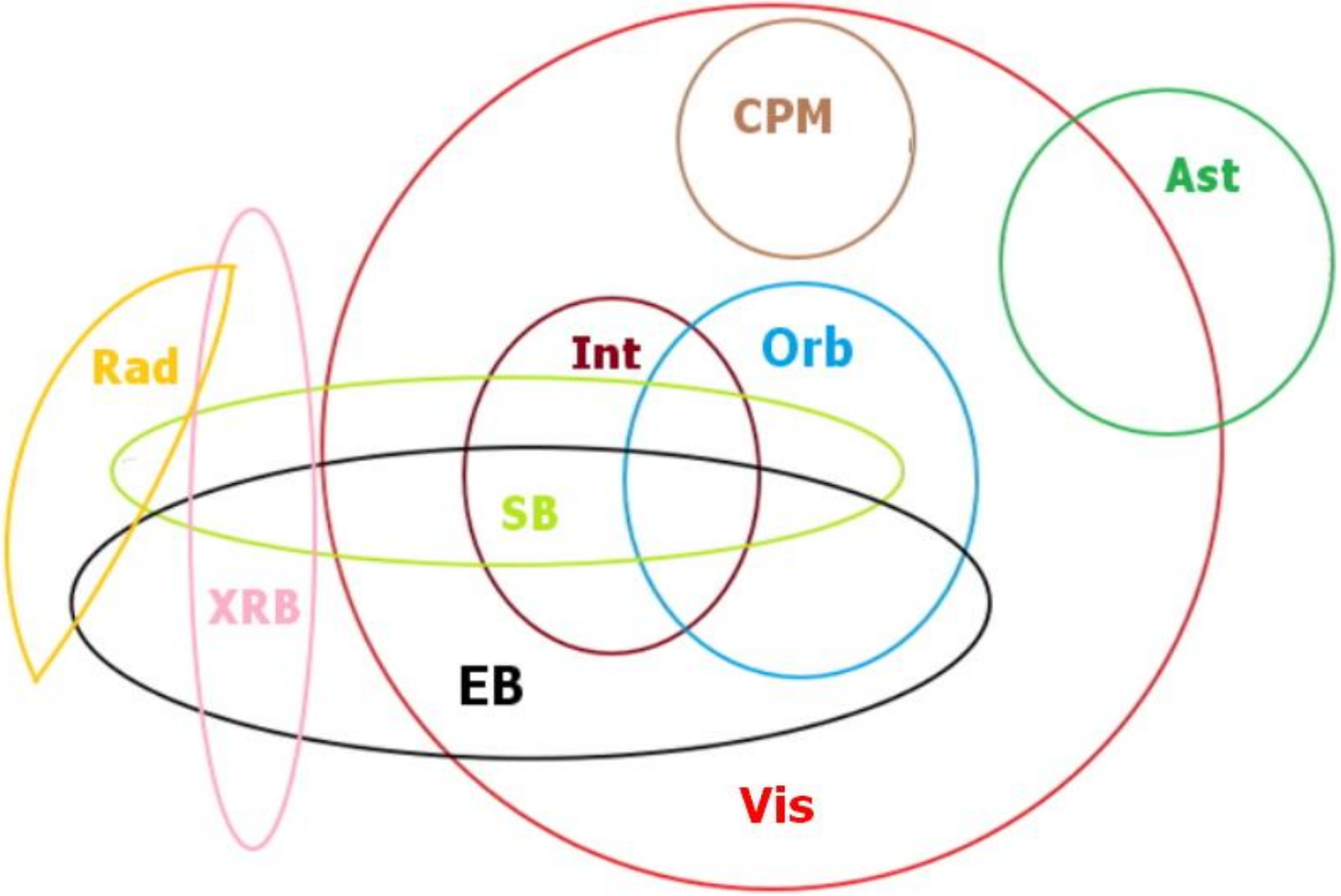
All other problems can be solved with Virtual Observatory tools

Classification of binaries / catalogues

- Astrometrically detected
  - Visual
  - Interferometric
  - Orbital
  - Astrometric
- Spectroscopically detected
  - Spectroscopic
  - Resolved spectroscopic
  - Chromospherically active
  - Spectrum (composite spectra)
  - Symbiotic (interactive spectrum)
- Photometrically detected
  - Eclipsing
  - Cataclysmic
  - Spotted, ellipsoidal, reflecting
- Detected in other wavelengths
  - X-ray
  - Radiopulsars
- Astrophysical parameters
  - Dynamical parameters
  - Estimated parameters
- Other
  - Multiple
  - Common proper motion
  - Optical

More than 5000 objects; 1000-5000 objects; less than 500 objects

Observational types of binaries



Catalogues

Visual binaries

- **WDS, 236885 components, 127766 pairs, 110074 systems (2016)**
- **CCDM 2002, 105838 entries, 49325 systems (of *visual* multiplicity from 1 to 18), 56684 pairs.**
- **Tycho Double Star Catalogue 2002, 70996 components of 32631 systems.**
- BV photometry for components of HIP doubles (Fabricius et al.) 2000, 9473 components of 5173 systems
- The Hipparcos Catalogues: Double and multiples (6 tables, about 42000 systems) + Hipparcos notes: Double and multiple systems

Interferometric binaries

- **INT4, 80916 systems (2016)**
- **DM3, 14329 systems (Jan 2013)** [DM2 2006, ~65000 systems, is included in WDS]**.**
- CHARM (Richichi) 2002, 3248 entries, 306 of them are for binaries.

Orbital binaries

- OARMAC, Catalogue of Orbits and Ephemerides of Visual Double Stars (Docobo et al.), 2151 orbits for 1701 pairs (Jun 2012).
- **ORB6, 2327 orbits for 2007 pairs (2016).**

Catalogues

Astrometric binaries

- Makarov and Kaplan (2005) 1. Different HIP and Tycho-2 p.m. 1929 stars
- Makarov and Kaplan (2005) 2. Accelerating HIP p.m. 2622 stars
- **171 astrometric binaries are included in CCDM**

Eclipsing binaries

- **CEV2 (Avvakumova et al.) 2016, 7179 stars**
- **GCVS (Samus et al. 2013) 2016, ~75000 stars (MW + other galaxies + suspected)**
- EBs in microlensing surveys (OGLE, MACHO, ASAS-3, EROS, MOA) 2009, ~13000 stars
- Gettel et al. (2007) 1022 bright contact binaries
- W UMa (Maceroni et al.) 1996, 78 stars
- Near contact binaries (Shaw) 1994, 130 stars
- Wood5 1980, 3564 stars

Photometrically detected binaries

- Cataclysmic (Downes) 2006, 1830 stars,
- Ritter and Kolb 2006 (647 + 169 cataclysmic binaries and related objects).
- **GCVS contains 241 spotted, 139 ellipsoidal and 7 reflecting binaries**

Catalogues

Spectroscopic binaries

- **SB9, 3197 stars (2016)**

Resolved spectroscopic binaries

- Jancart et al. 2005, 282 stars

Chromospherically active binaries

- Karatas et al. 2004, 237 stars
- Strassmeier et al. 1993, 206 stars.

Spectroscopically detected binaries

- Spectrum binaries [composite spectra] (Ginestet et al.) 2002, 135 stars
- Symbiotic stars (Belczynski et al.) 2000, 218 stars.

Non-optic binaries (X-ray binaries, binary in radiopulsars)

- CBS database: evolved close binary stars, (Cherepashchuk et al.), in preparation, about 2000 objects (part of them are X-ray)
- **LMXB (Liu et al.) 2007, 187 stars.**
- **HMXB (Liu et al.) 2006, 114 stars.**
- Ritter and Kolb 2014.
- ATNF Pulsar Catalogue (Manchester et al..) 2005-2015, 239 binary pulsars.

Catalogues

Calculated astrophysical parameters

- **Svechnikov et al. (DMS, SD, C) catalogues 1997-2005, 113+96+31+68 stars**
- SMAC (Belikov) 1995, 271 systems.
- Malkov 1993, 144 systems
- Svechnikov 1986, 246 stars

Estimated astrophysical parameters

- Svechnikov et al. (DMS, SD, C, short-period RS CVn, massive) catalogues 1997-2005, 44+136+31+69+115 stars
- Kinematics of W UMa-type binaries (Bilir et al.) 2005, 129 stars
- Algol type (Budding et al.) 2004, 411 stars
- Contact binaries (Pribulla et al.) 2003, 361 stars
- Catalog of contact binary stars (Csizmadia et al.) 2004, 159 stars
- Visual binary orbits and masses post Hipparcos (Soederhjelm) 1999, 210 stars
- Svechnikov and Kuznetsova 1990, 3799 stars
- Brancewicz and Dworak 1980, 1048 systems

Other catalogues

- MSC (Tokovinin), 1359 stellar systems of multiplicity 3 to 7 (20.04.2010)
- LDS Common proper motion 1987, 6121 pairs.
- Catalog of Rectilinear Elements (Hartkopf et al.), 1310 systems (Jan 2013) (suspected optical pairs)

Our own catalogues were constructed

- The most comprehensive list of **visual** double and multiple stars (Isaeva et al. 2015).
- Catalogue of **orbital** binaries with dynamical masses (Malkov et al. 2012).
- Catalogue of **eclipsing** variables (Avvakumova et al. 2013).
- List of cross-identifications for **X-ray** binaries (Malkov et al. 2016).

Main problems to solve

1. Compile **list of data sources** (catalogues, databases) for binaries/multiples of different types to be included in or linked with BDB
2. Link **right data to right objects**. It includes:

- A unique and consistent system for component designations (A, Ab, B, AB, C, ...)
- Problems of identifications in different catalogues (cross-matching)

All other problems can be solved with Virtual Observatory tools

Requirements for an ideal designation scheme

- Designation stable with respect to new distant components.
- Designation stable with respect to new components of resolved binaries.
- Designation stable with respect to new planets.
- A particular name always represents one object only.
- A particular object is always represented by one name only.
- Independent of the nature of observations.
- Independent of the nature of components.
- Unique and consistent.
- Compatibility with existent nomenclatures, if possible.

Three categories of objects in multiple systems and their data

- **Component** data: mass, radius, temperature, flare activity, etc.
- **Pair** data: period, eccentricity, component separation (for resolved binaries), etc.
- **System** data: proper motion, parallax, etc.

- Coordinates, photometry, spectral types can be assigned to different categories (depending on observational type of system).
- The vast majority of binary (multiple) star catalogues contain information on **pairs**.

BSDB designation scheme

- BSDB identifier contains:
  - equatorial coordinates for the standard equinox of J2000.0 in the form of HHMMSS.ss+DDMMSS.s or HHMMSS.ss-DDMMSS.s;
  - specifier to distinguish systems, pairs, and components (s, p, and c, respectively);
  - indication which component or pair is referred to using numerals and capital letters.
- An example: an hierarchical triple system
  - J000144.48+590527.1:s
  - J000144.48+590527.1:p1A-1B
  - J000144.48+590527.1:c1A
  - J000144.48+590527.1:c1B
  - J000144.48+590527.1:p1-2
  - J000144.48+590527.1:c2

BSDB application

- BSDB scheme is intuitive and extendable to all observational types of binaries.
- It completely satisfies the IAU rules.
- BSDB identifiers are assigned to all objects in BDB.
- BSDB acronym is registered in the IAU Registry of New Acronyms.
- BSDB will hopefully be accepted by the astronomical community for designating components, pairs and systems within binary and multiple stars.

Table 1. ILB. An example: Castor. Some columns are empty and not shown here.

BSDB	Type	Bayer	Flamsteed	ADS	WDS	DD
J073436.00+315319.1:s						
J073436.00+315319.1:p1-2	vio	α Gem	66 Gem	6175	07346+3153 AB	STF1110
J073436.00+315319.1:p1A-1B	s	α^1 Gem			07346+3153 A	
J073436.00+315319.1:c1A						
J073436.00+315319.1:c1B						
J073436.00+315319.1:p2A-2B	s	α^2 Gem			07346+3153 B	
J073436.00+315319.1:c2A						
J073436.00+315319.1:c2B						
J073436.00+315319.1:p1-3	vi			6175	07346+3153 AC	STF1110
J073436.00+315319.1:p3A-3B	se				07346+3153 C	
J073436.00+315319.1:c3A						
J073436.00+315319.1:c3B						
J073436.00+315319.1:p1-4	vi			6175	07346+3153 AD	STF1110
J073436.00+315319.1:c4					07346+3153 D	
J073436.00+315319.1:p2-3	vi			6175	07346+3153 BC	STF1110
J073436.00+315319.1:p3-4	vi			6175	07346+3153 CD	STF1110

Table 1. (contd.)

BSDB	CCDM	HIP	HD	DM	TDSC	SBC9
J073436.00+315319.1:s						
J073436.00+315319.1:p1-2	07346+3153 AB	36850		+32 1581	20046 AB	
J073436.00+315319.1:p1A-1B	07346+3153 A		60179		20046 A	462
J073436.00+315319.1:c1A						462A
J073436.00+315319.1:c1B						462B
J073436.00+315319.1:p2A-2B	07346+3153 B		60178		20046 B	461
J073436.00+315319.1:c2A						461A
J073436.00+315319.1:c2B						461B
J073436.00+315319.1:p1-3	07346+3153 AC				20046 AC	
J073436.00+315319.1:p3A-3B	07346+3153 C			+32 1582	20046 C	463
J073436.00+315319.1:c3A						463A
J073436.00+315319.1:c3B						463B
J073436.00+315319.1:p1-4	07346+3153 AD				20046 AD	
J073436.00+315319.1:c4	07346+3153 D			+32 1580	20046 D	
J073436.00+315319.1:p2-3						
J073436.00+315319.1:p3-4						

Identification List of Binaries (ILB, Malkov et al. 2016) and BSDB designation scheme (Kovaleva et al. 2015)

X-ray astronomy identifiers

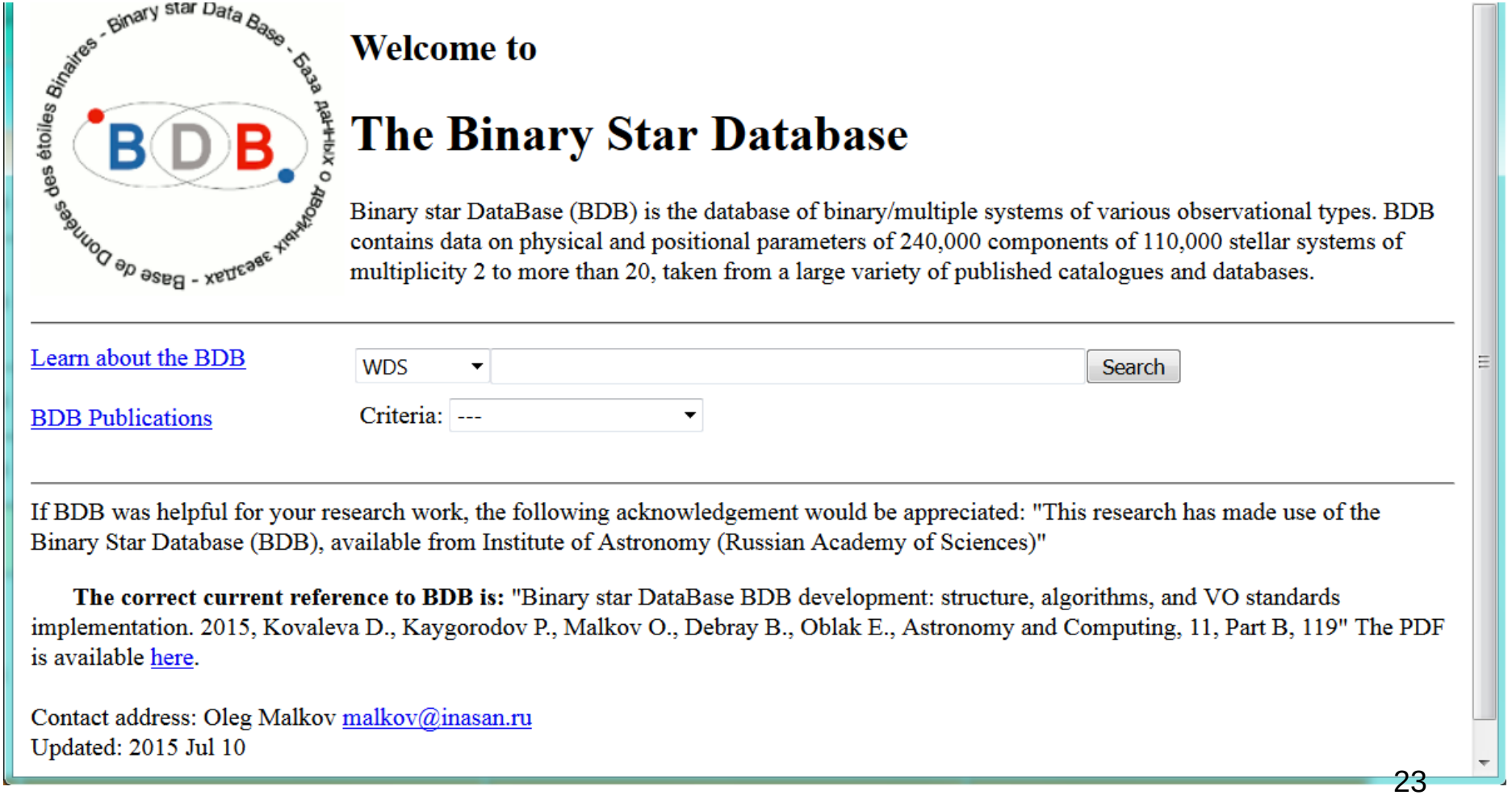
(first 15 objects from Liu et al. 2006 HMXB catalogue)

- IGR J00370+6122
- 2S 0053+604
- 2S 0114+650
- 4U 0115+634
- IGR J01363+6610
- RX J0146.9+6121
- IGR J01583+6713
- 1E 0236.6+6100
- V 0332+53
- 4U 0352+309
- XTE J0421+560
- RX J0440.9+4431
- EXO 051910+3737.7
- 1A 0535+262
- 1H 0556+286

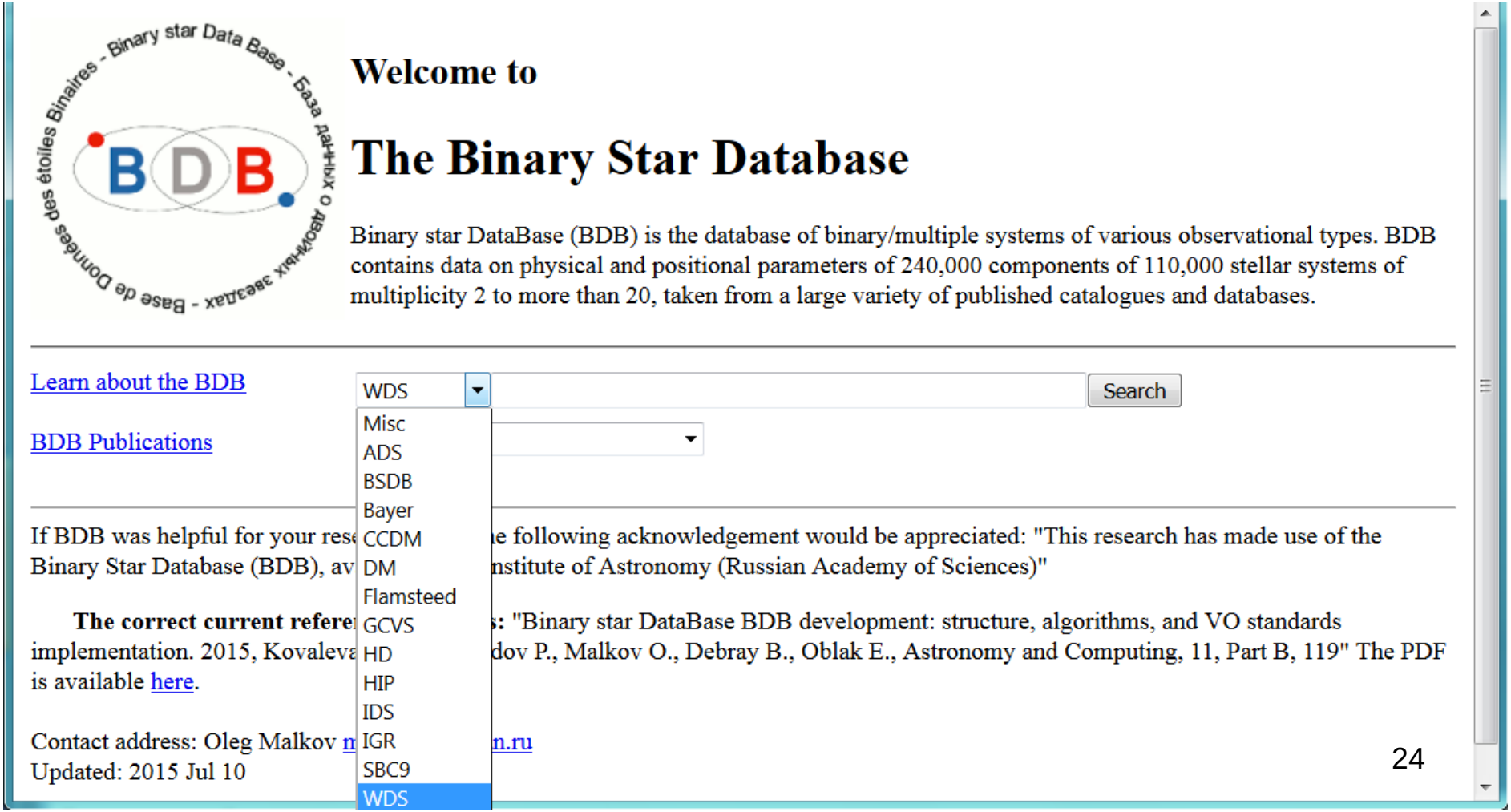
About 20 identifiers are used in the list of 100 objects.

For comparison: about 10 identifiers are used for all other types of binaries (10^5 objects)

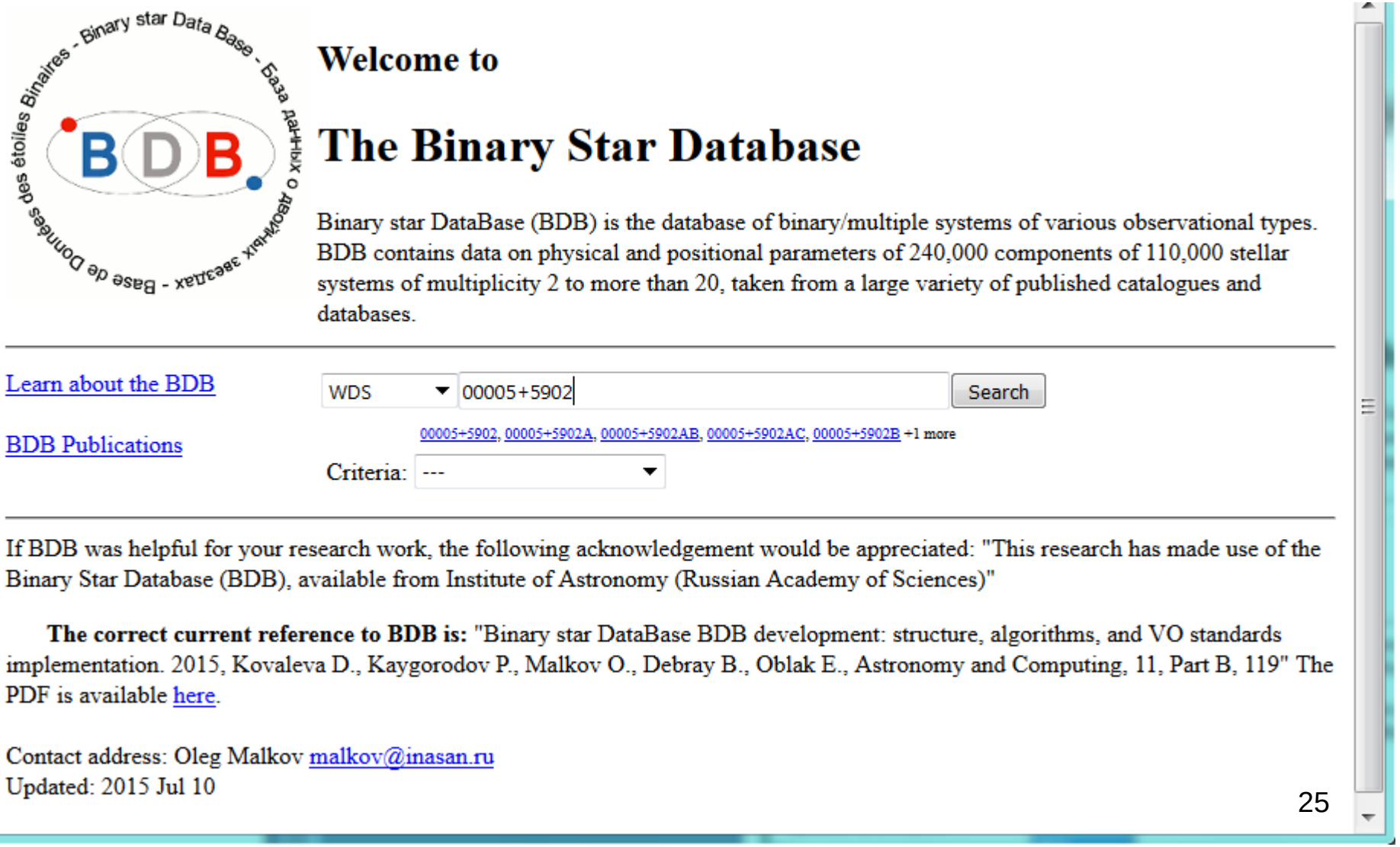
BDB: title page



BDB: search by identifier



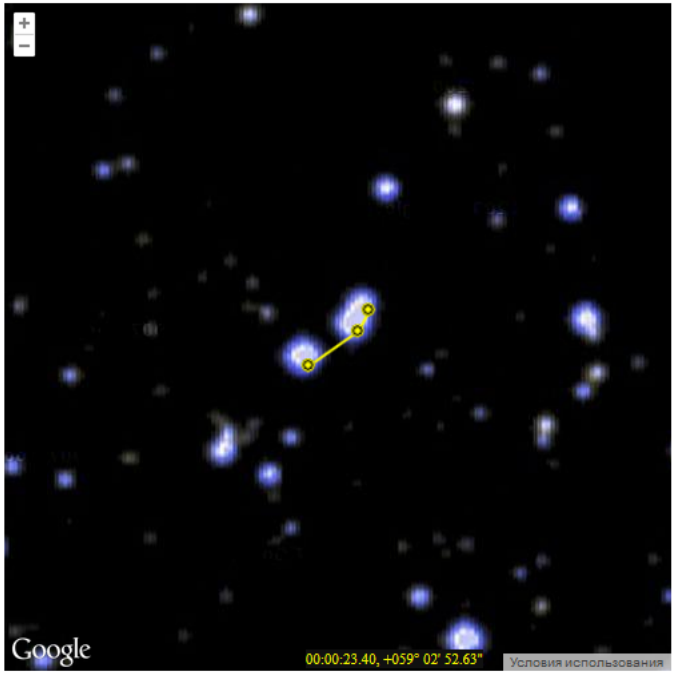
BDB: search by identifier



BDB: result

Zoom out of the screen if you do not see background picture

[report error]



Components:

IDs	mag	band	pmRA (mas/y)	pmDE (mas/y)	RA	DEC (DE)
BSDB J000032.59+590239.6:c1						
WDS 00005+5902A, MRI 51, STI3079	13.9, 12.3	vis	5.0, 4.0	-2.0	00 00 32.59	+59 02 39.6
CCDM 00005+5903A, IDS 23554N5829	13.9	V			00 00 32.6	+59 02 40.9
BSDB J000032.59+590239.6:c2						
WDS 00005+5902B, STI3079	13.9	vis	6.0	0.0	00 00 34.137	+59 02 31.548
BSDB J000032.59+590239.6:c3						
WDS 00005+5902C, MRI 51	14.3	vis			00 00 32.266	+59 02 44.501

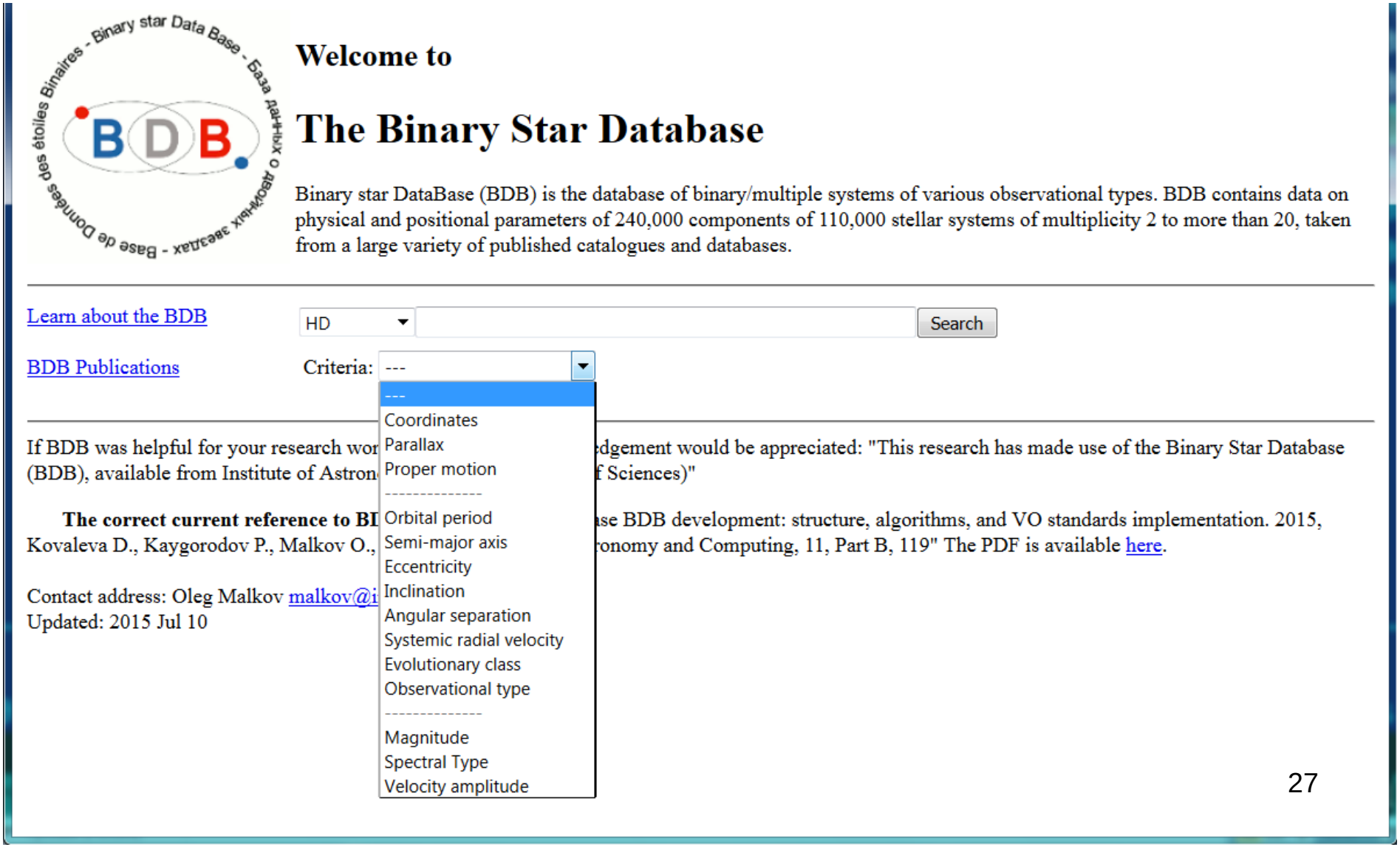
show selected data

System:
STI3079, BSDB J000032.59+590239.6:s, WDS 00005+5902

Pairs:

IDs	Theta (deg)	Rho (arcsec)	EType	OType	Epoch (year)
BSDB J000032.59+590239.6:p1-2					
CCDM 00005+5903AB, IDS 23554N5829, STI3079	123.0	14.5		Detached	Visual
WDS 00005+5902AB, STI3079	124.0	14.4		Detached	Visual
BSDB J000032.59+590239.6:p1-3					
WDS 00005+5902AC, MRI 51	333.0	5.5		Detached	Visual

BDB: search by criteria



BDB: search by criteria

Welcome to

The Binary Star Database

Binary star DataBase (BDB) is the database of binary/multiple systems of various observational types. BDB contains data on physical and positional parameters of 240,000 components of 110,000 stellar systems of multiplicity 2 to more than 20, taken from a large variety of published catalogues and databases.

Learn about the BDB

BDB Publications

Misc | Search

Search

Orbital period (days): 1 to 10 remove

Eccentricity 0.0 to 0.1 remove

Criteria: ---

Search

If BDB was helpful for your research work, the following acknowledgement would be appreciated: "This research has made use of the Binary Star Database (BDB), available from Institute of Astronomy (Russian Academy of Sciences)"

The correct current reference to BDB is: "Binary star DataBase BDB development: structure, algorithms, and VO standards implementation. 2015, Kovaleva D., Kaygorodov P., Malkov O., Debray B., Oblak E., Astronomy and Computing, 11, Part B, 119" The PDF is available here.

Contact address: Oleg Malkov malkov@inasan.ru
Updated: 2015 Jul 10

BDB: result

[back]

[report error]

Welcome to

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#	ID	RA (HH MM SS.ss)	DEC (dd mm ss.ss)	P (day)	e	V0 (km/sec)
1	SBC9 2069	02 48 22.19	-11 17 12.5	1.0072701	0.0	7.44
2	SBC9 100	01 57 46.06	+38 04 28.4	1.0105	0.0	5.4
3	SBC9 1331, HIP 107556	21 47 2.44	-16 07 38.2	1.0228, 1.0227683	0.01, 0.0	-0.2, -3.4
4	SBC9 1121, HIP 93808	19 06 17.03	+41 24 49.6	1.0309	0.02	-21.2
97	SBC9 2674, HIP 73106	14 56 29.93	+17 06 11.6	1.68486	0.0	-26.2
98	SBC9 578, HIP 47178	09 36 51.81	+26 13 57.6	1.6861	0.0	10.0
99	HZ Her, SBC9 937	16 57 49.81	+35 20 32.4	1.7002	0.0	
100	SBC9 913, HIP 79069	16 08 27.27	+86 11 59.6	1.7012	0.09	-17.9

more

[download as text file]

If BDB was helpful for your research work, the following acknowledgement would be appreciated: "This research has made use of the Binary Star Database (BDB), available from Institute of Astronomy (Russian Academy of Sciences)"

BDB realization

DBMS: PostgreSQL (http://www.postgresql.org)

ORM: Elixir & SQLAlchemy (http://elixir.ematia.de, http://www.sqlalchemy.org)

Framework: Nagare (http://www.nagare.org)

Programming language: Stackless Python (http://stackless.com)

VO standards (to be implemented)

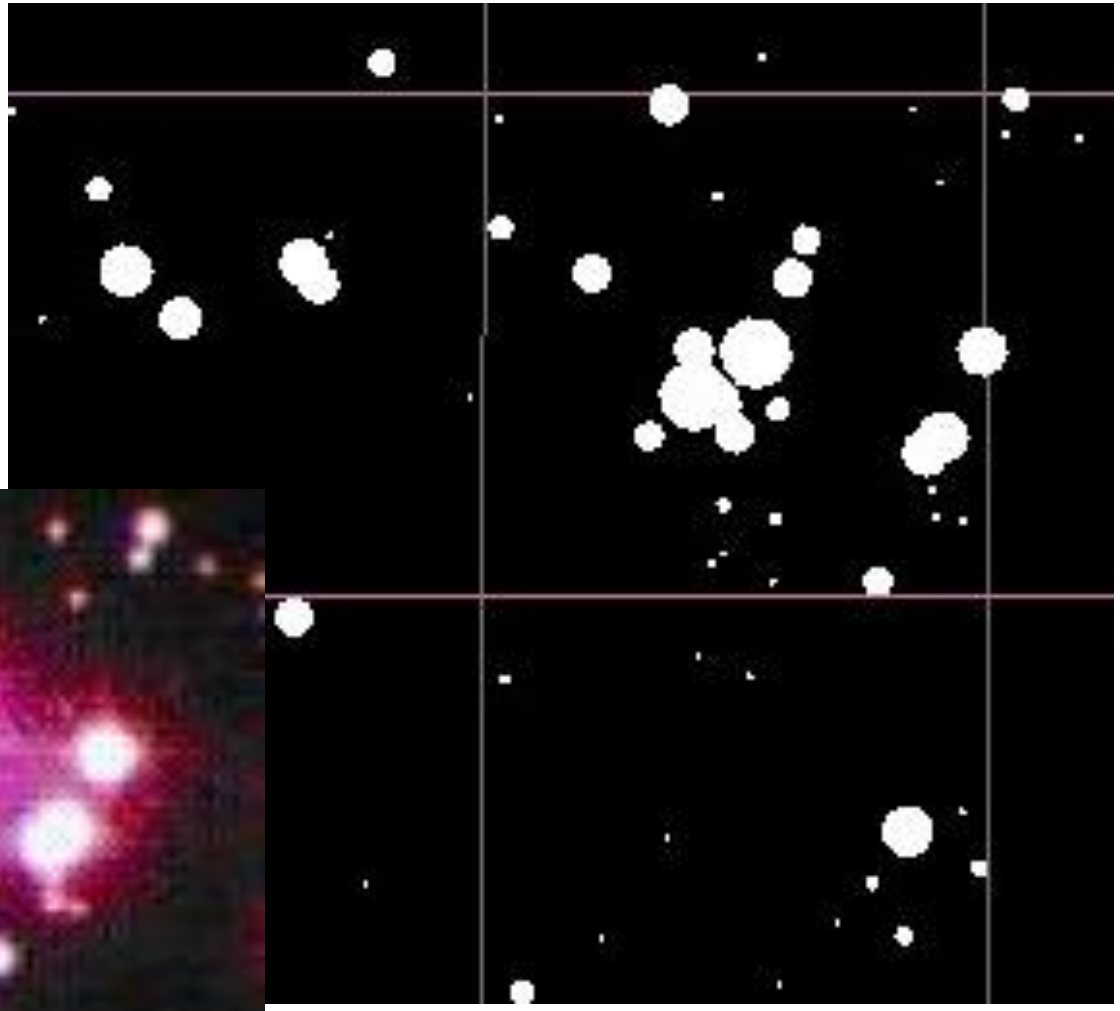
- VO ConeSearch protocol (Williams et al. 2011)
- VOTable (Ochsenbein et al. 2013) output format. VOTable implies the use of UCDs (Derriere et al. 2011); UCDs to characterize some data specific to binary star need to be added to the present UCD controlled vocabulary (Preite Martinez et al. 2011).
- BDB will be referenced in VO Registry (Benson et al. 2011).
- When batch mode is provided, a web service will be set up which will follow the Universal Worker Service (UWS) pattern (Harrison & Rixon, 2011)
- TAP (Table Access Protocol) service (Dowler et al. 2011)

BDB statistics

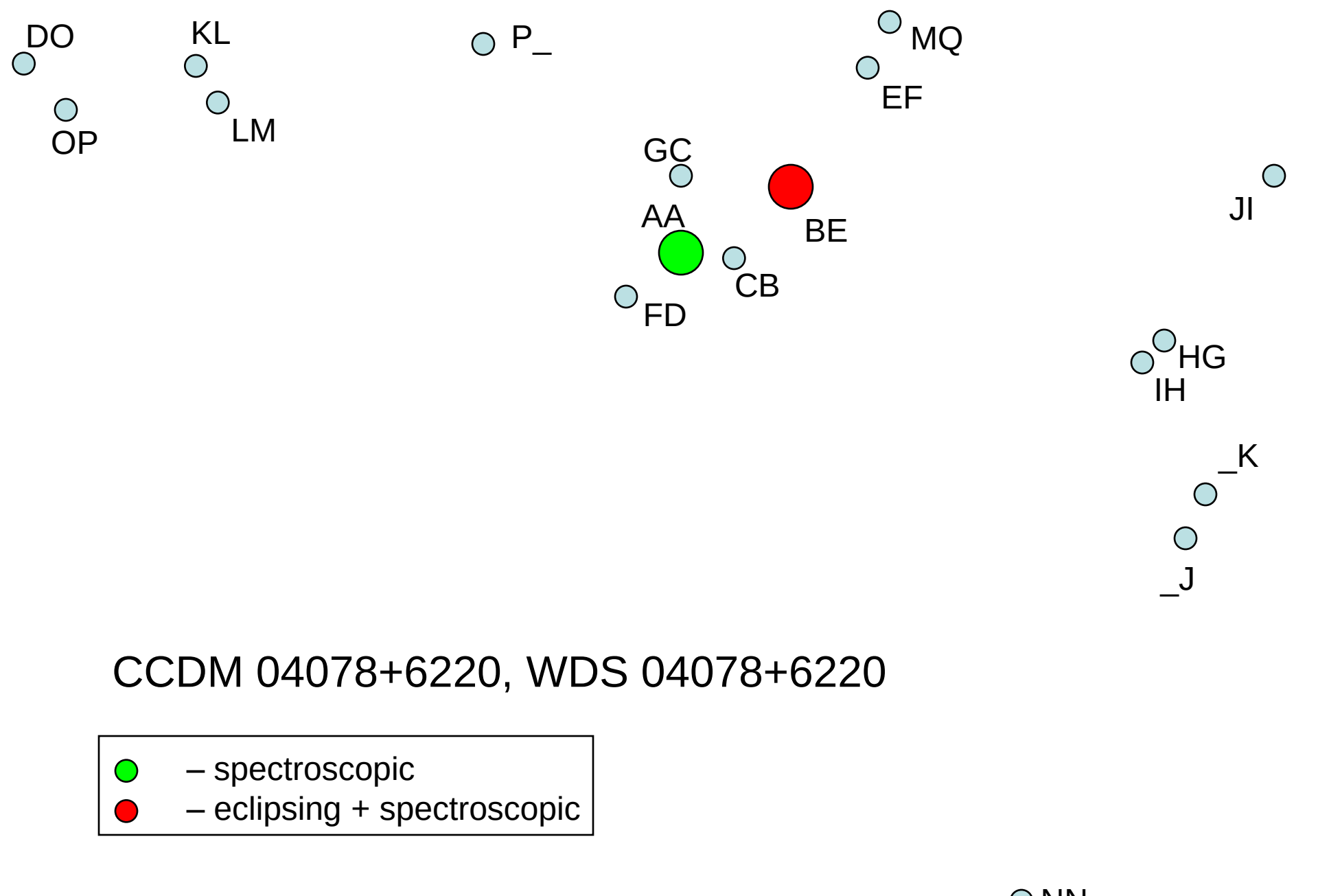
- BDB contains 120,000 systems.
- BDB contains 1,500,000 identifiers
- BDB size ≈ 10 Gb

CCDM 04078+6220

Aladin previewer

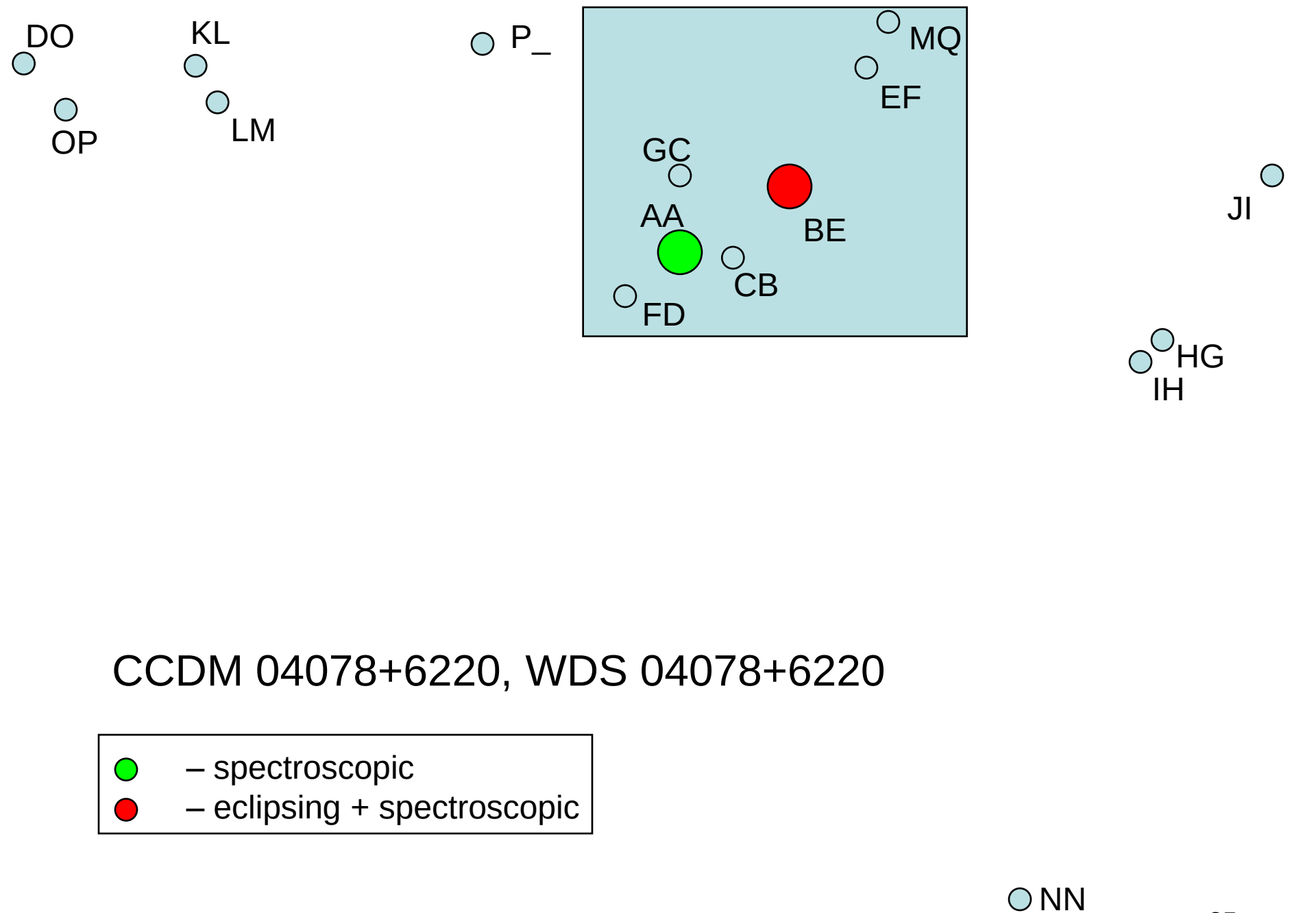


2MASS visualization software, magnitudes are recalculated to R (Piskunov et al. 2008)



CCDM 04078+6220, WDS 04078+6220

– spectroscopic
– eclipsing + spectroscopic



CCDM 04078+6220, WDS 04078+6220

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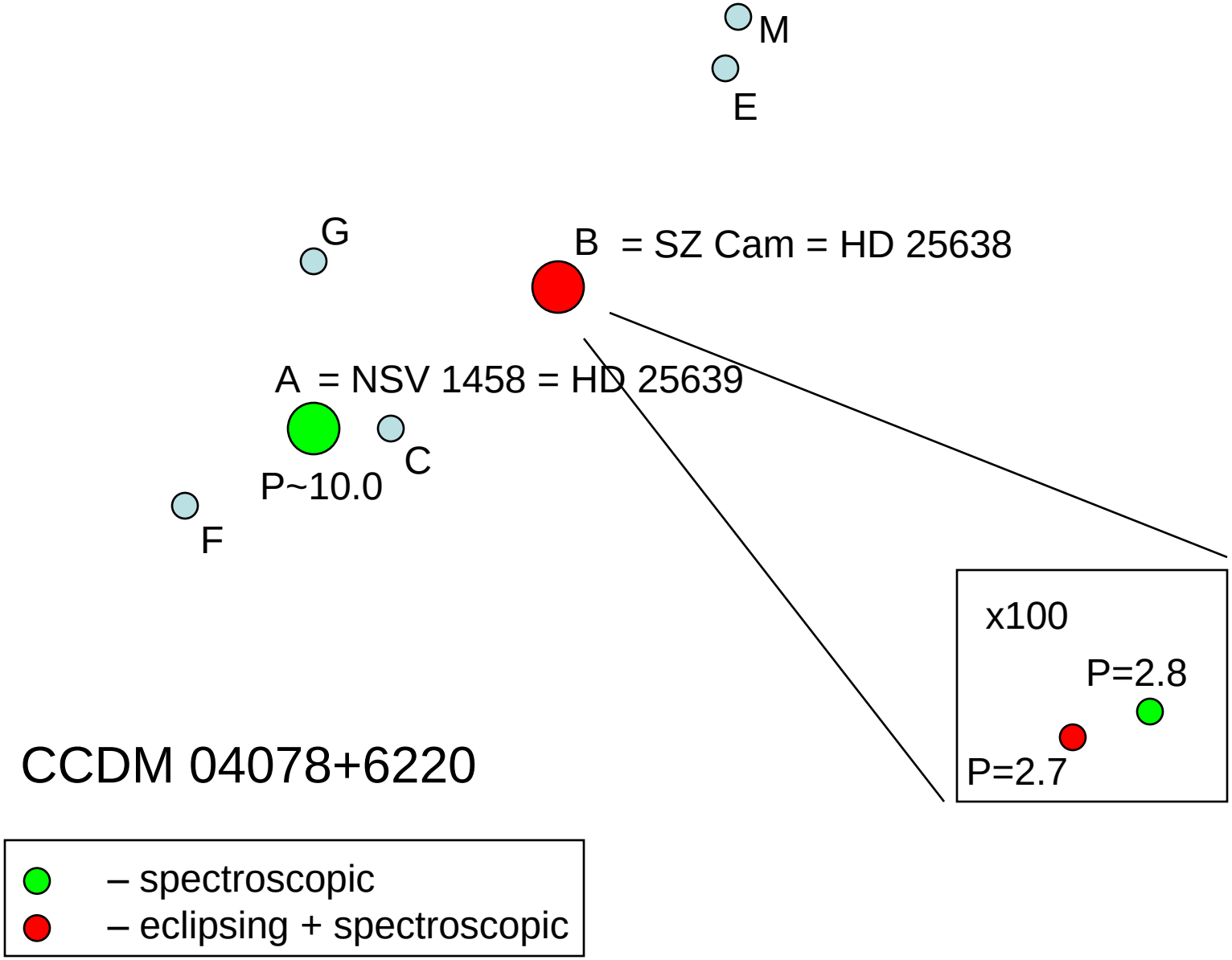

Spectroscopic periods in day are given from MSC

CCDM 04078+6220 “error budget”

- ADS: 1 misprint
- IDS: 3 misprints
- HD: 1 confusion
- WDS: 2 corrections
- CCDM: no error is found
- DM2: 6 corrections (2 pairs x 3 bands)
- SB9: 1 correction
- Simbad: 4 corrections
- One question is still open

System or cluster?

- Almost all stars in CCDM 04078+6220 system are members of open cluster NGC 1502 (cross-identification of variable stars in NGC 1502 was studied by Kazarovets and Lipaeva 1998, Variable Stars 24, 27).
- Tokovinin catalog of multiple systems (MSC) do not contain systems of 8- and higher multiplicity. CCDM contains 24 such systems (WDS contains more).
- *"**System** should have a Keplerian orbit, stable during at least several revolutions. All others (including **trapeziums**) are **clusters**. Moreover, CCDM and WDS contain a lot of optical pairs"* – A. Tokovinin.

We nevertheless include such systems in BDB

Highest multiplicity systems

- WDS 19062-0453 = λ Aql: **105 components**. Result of the high-contrast imaging search for components. Most of them are field stars.
- WDS 05387-6906 = 30 Dor = Tarantula Nebula: **66 components**. H II region in LMC.
- WDS 17505-0603: **63 components**. Result of a near-infrared adaptive optics search for giant planets and brown dwarfs around nearby young stars.

Highest multiplicity **physical** systems

- v Sco: 7 components.
- AR Cas: 7 components. Young cluster?
- Trapezium cluster contains 9+ stars.

- Ref: Tokovinin A.A. *MSC - a catalogue of physical multiple stars.* 1997, Astron. Astrophys. Suppl. Ser. 124, 75

BDB publicity in IAU

- Links from IAU Commissions pages
  - Commission 42: Close Binary Stars
  - http://www.konkoly.hu/IAUC42/C42_networks.html
  - Commission 26: Double and Multiple Stars
  - http://ad.usno.navy.mil/wds/dsl.html#iau
  - Post-GA Commission C.G1: Binary and Multiple Star Systems (under construction)
- Included in Commission 26 Triennial Report
- Publication in Commission 26 Circular
- Registration in the IVOA registry

Catalogues of Binary and Multiple Stars

- BDB - Binary star DataBase
- CALEB - Catalog and Atlas of Eclipsing Binaries
- CEV - Catalogue of Eclipsing Variables
- CVcat - Catalogue of Cataclysmic Variables
- DEBCat - Detached Eclipsing Binary Catalogue
- Downes - Catalog and Atlas of Cataclysmic Variables (Downes et al.)
- IPHome - Koji Mukai's intermediate polar catalogue
- Ritter-Kolb - Catalogue of CVs, LMXBs and related objects
- SB9 - Ninth Catalogue of Spectroscopic Binary Orbits

Comparison with analogical databases/catalogues

- SIMBAD: there are no parameters of binaries among query parameters, not all catalogued binary stars are included, there is a confusion in designations of systems and components.
- VizieR: not all binary star catalogues are included in VizieR, list of query parameters is limited, confusion in designations.
- Catalogues and databases on binary stars: provide information only on particular type of binaries.
- Multiple Star Catalog: contains only objects with Keplerian orbits stable during several revolutions (1359 stellar systems of multiplicity 3 to 7), list of query IDs is too short.
- All: do not provide adequate image.

Scientific applications

- Parameterization of stars and compilation of catalogues of astrophysical parameters.
- Construction of fundamental stellar relations.
- Study of binary star formation and evolution.
- Study of accretion processes in interacting binaries.

BDB close future

- Inclusion of **new catalogues**
- Continued effort to **resolve any inconsistencies** in data entries
- Access (links) to general purposes databases (**SIMBAD, ADS**)
- Realization of **batch mode**
- **Improvements** in the presentation of the query results
- **Mirror** in Besançon

Reference

- If BDB was helpful for your research work, the following acknowledgement would be appreciated: "This research has made use of the Binary Star Database BDB (Kovaleva et al. 2015), available from Institute of Astronomy (Russian Academy of Sciences)”
- **The correct current reference to BDB is:** "Binary star DataBase BDB development: structure, algorithms, and VO standards implementation" 2015, Kovaleva D., Kaygorodov P., Malkov O., Debray B., Oblak E. Astronomy and Computing, 11, 119.

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Conclusions

- Binary star database is constructed, it contains data on physical and positional parameters of 260,000 components of 120,000 stellar systems of all observational types of multiplicity 2 to more than 20;
- Designation scheme for binary/multiple systems is developed;
- Identification list of binaries is compiled;
- A number of original catalogues of binary stars is constructed.

Announcement: DAMDID'16

- Data Analytics and Management in Data Intensive Domains (DAMDID) conference: Oct 11-14, 2016, Ershovo, Moscow
- http://damdid2016.frccsc.ru/en/conference_short.html
- DAMDID'15 publication: "New Data Access Challenges for Data Intensive Research in Russia" (Kalinichenko et al. 2015): http://ceur-ws.org/Vol-1536/paper31.pdf

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- Audience – for your attention and for future comments and criticism