Article

Binary Star Database BDB: New Developments and Applications

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Abstract: Binary star DataBase (BDB) is the database of binary/multiple systems of various observational types. BDB contains data on physical and positional parameters of 260,000 components of 120,000 stellar systems of multiplicity 2 to more than 20, taken from a large variety of published catalogues and databases. We describe the new features in organization of the database, integration of new catalogues and implementation of new possibilities available to users. The development of the BDB index-catalogue, Identification List of Binaries, is discussed. This star catalogue provides cross-referencing between most popular catalogues of binary stars. We describe ideas and methods for reliable cross-identification of different entities (systems, pairs, components) in binary and multiple stellar systems.

Keywords: astronomical data bases; catalogues; binaries: general; cataclysmic variables

1. Introduction

The Binary star DataBase (BDB, bdb.inasan.ru) is the development of the original database constructed at the Besancon Observatory [1]. Later BDB was moved from Observatoire de Besançon to the Institute of Astronomy of the Rus. Acad. Sci. [2], [3]. BDB contains information about binary/multiple stars of all known observational types taken from several dozens of original catalogs of binary stars. Collection, parsing and indexing of principal catalogues for all types of binaries are described in [4], [5], [6]. Within the framework of the BDB, cross-identification of the objects included in it was completed and a three-level identification system BSDB and a catalog of object identifiers in double and multiple ILB systems were created, which made it possible to uniquely identify the systems, pairs and components, included in BDB. The search for objects in the database is possible both with the identifier (all major identification systems are supported) and by parameters. BDB contains data on the physical and observational parameters of about 260,000 components included in about 120,000 systems with a multiplicity of 2 to more than 20. New functionality and advancement of BDB was recently discussed in [7].

BSDB identification system and Identification list of binaries ILB are briefly described in Sections 2 and 3, respectively. Observational types of binaries, included in BDB, are considered in Section 4. In particular, there we discuss cataclysmic binaries. Connection with external databases are described in Section 5.

2. Binary and multiple star objects identification scheme BSDB

Support of data on a large number of heterogeneous, but intersecting observational types of stars (see Section 4) required conducting of a thorough cross-identification and construction of a new identification system, BSDB. The BSDB scheme covers all types of observational data. Three classes of objects introduced within the BSDB nomenclature provide correct links between objects and data,

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what is especially important for complex multiple stellar systems. Within BDB, the entire system, the pair and the component have their unique BSDB identifier. In particular, BSDB is resistant to cases when a component is itself resolved into sub-components, and when a new (distant) component of a system is discovered. In these cases BSDB allows do not change the identification data and to link information from sources (catalogues) having different spatial resolution.

The principles underlying the BSDB identifier compilation do satisfy the "IAU Specifications concerning designations for astronomical radiation sources outside the solar system". The problems typical of binary/multiple-star designation schemes are basically avoided by the BSDB.

Details of the BSDB identification system construction and application can be found in [8].

3. Identification List of Binaries

The Identification List of Binaries (ILB) is a star catalogue constructed to facilitate cross-referencing between different catalogues of binary stars. ILB is based on the BSDB identification system (see Section 2), and ILB underlies the BDB search engines.

ILB represents a table of identifications (or running numbers) of double/multiple systems, pairs and components from the following catalogues (designation schemes): BSDB, Bayer/Flemsteed, DM (BD/CD/CPD), HD, HIP, ADS, WDS, CCDM, TDSC, GCVS, SBC9, IGR (and some other X-ray catalogues), PSR and Discoverer and number designation (DD). Coordinates (together with their source code) are also given for each component. For each pair, ILB provides information on its observational type(s).

The content of BDB is not limited to data included in ILB. Having found the necessary objects according to the data available in ILB, the user can obtain all the information related to the objects from the original catalogs (copies of which are integrated into BDB). However, BDB does not perform any filtering or data evaluation, providing the user with maximum of available information.

ILB currently contains about 520000 entries: 120000 systems, 140000 pairs and 260000 components. ILB is regularly updated, improved (bugs and errors are fixes) and expands as new catalogues are added to BDB. Identification List of Binaries is described in detail in [9].

4. Observational types

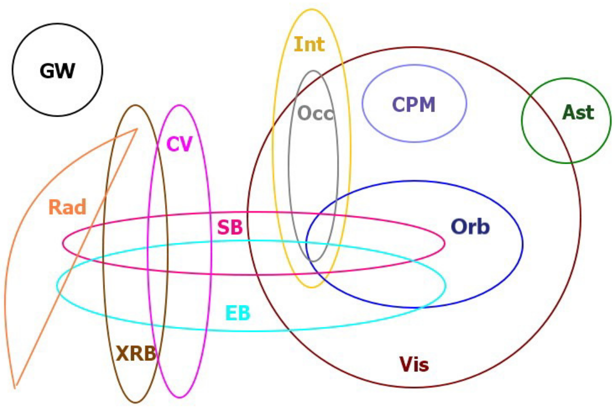

Figure 1. Observational types of binaries. See text for details.

Observational types of binaries, included in BDB, are illustrated in Figure 1. Below we give short description of all observational types (for details see [10] and [11]).

- Visual binary (**Vis**) — a binary star system in which both components are visible and resolvable in a telescope.
- Orbital binaries (**Orb**) are visual binaries, demonstrating sufficiently remarkable orbital motion to calculate orbital parameters.
- Common proper motion (**CPM**) binaries are pairs of stars separated by a few arcseconds or arcminutes and having the same proper motions. The members of each pair presumably formed in close association, and are expected to be coeval and to have the same chemical composition.
- Astrometric binaries (**Ast**), or stars with invisible companions, can be deduced from periodic variations in the star's position, if the position is determined relative to other stars. The alterations in position, which are superimposed on the proper motion of the star, are caused by its revolution with the invisible companion about their common centre of gravity.
- Interferometric binaries (**Int**) present cases where the components are so close that it can not be observed directly as a visual binary, but can be resolved using various interferometric techniques.
- Occultation binaries (**Occ**) are discovered by photoelectric analysis of lunar (or asteroid) occultation of very close pairs.
- In spectroscopic binaries (**SB**) the variation of the radial velocities during a revolution of a binary star can be observed spectroscopically: the lines in the overlapping spectra of the two components show periodic doubling or displacement (so called SB2 and SB1, respectively).
- Eclipsing binaries (**EB**) are binary stars of which one at times eclipses the other, thus leading to alterations in the apparent total brightness of the combined stars.
- X-ray binaries (**XRB**) are pairs of stars producing X-rays, as the stars are close enough together that material is pulled off the normal star by the gravity of the dense, collapsed star.
- Radiopulsars in binary systems (**Rad**) show periodic variations in the pulsation period caused by orbital motion.
- Recently detected gravitational-wave signals produced by the coalescence of two stellar-mass black holes led to appearance of a new observational type of binaries, gravitational-wave binaries (**GW**).
- Cataclysmic variables (**CV**) — see below.

Size of areas in Figure 1 does not comply with number of known binaries of the particular observational type. Overlaps in Figure 1 demonstrate that some binaries can be detected by two or more observational techniques. Thus, an overlap of **Vis** and **SB** areas contains well known resolved spectroscopic binaries (RSB) observational type. Note also that currently **GW** is an isolated area in our diagram, but later, when signals from coalescence of two *neutron stars* are detected, it will probably overlap with the **XRB** area.

4.1. Cataclysmic variables

Cataclysmic variables (CV) are close binaries, undergoing mass transfer and exhibiting sudden outbursts, generally arising either from the release of gravitational energy through accretion or from thermonuclear processes.

Currently we include cataclysmic variables in BDB. Main sources of that observational type of binaries are Catalogue of Cataclysmic Binaries, Low-Mass X-Ray Binaries and Related Objects (Edition 7.24, 31 Dec 2015 — The Final Edition) [12], Catalog of Cataclysmic Variables (Ver. 2011-2006) [13], and General Catalogue of Variable Stars (Ver. GCVS 5) [14]. The three catalogues contain 1429, 1830 and 938 CV, respectively, and some of CV are included in more than one catalogue. Some tens of CV are included in only one of three catalogues.

We have carried out a cross-identification of CV in the three catalogues and have made a search of these objects in Simbad. It should be noted that by no means all catalogued CV are included in Simbad. Altogether 617 CV are included both in three catalogues and in Simbad.

Sometimes CV are observed also as binaries of other types. Among the studied catalogues, only [12] contains indication of eclipsing or/and spectroscopic binarity for the catalogued CV. Some of objects, catalogued in [13], are in fact non-CV.

Besides the cataclysmic binaries, [12] contains low-mass X-ray binaries and related objects. Low-mass X-ray binaries from [12] were included in BDB earlier (see [15]), while related objects are being included in BDB at this stage. There are 619 such objects in [12], and we designate them as pre-CV objects.

We should note that there is a number of other lists of CV published in literature, however we currently discard them for one or more of the following reasons: (i) they contain too few objects, (ii) they contain just *candidates* to CV, (iii) they provide too scarce information on the catalogued objects.

4.2. Other observational types of binaries

Some observational types of binaries are not yet included in BDB and, consequently, are not discussed in the current paper. Among them are

- chromospherically active binaries,
- composite spectrum (including symbiotic) binaries,
- spotted variables (binaries),
- ellipsoidal variables (binaries),
- reflecting variables (binaries).

All of these types are relatively small and contain no more than a couple of hundred (two former types) or just a dozed (the others) of objects.

5. Connection with external databases

Additional information on binary/multiple stars can be obtained from other databases/catalogues. We have established links to general purpose databases: Simbad, VizieR, ADS. Corresponding buttons appear in the BDB resulting page, and one can get information on the queried objects from the databases.

Besides, we plan to establish links to databases/catalogues of binaries of particular observational type: WDS [16] for visual binaries, SB9 [17] for spectroscopic binaries, CEV [18] for eclipsing binaries, etc.

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