Classification of Eclipsing Binaries in Large Surveys

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ABSTRACT : A procedure for automatic classification of eclipsing binaries based on the data on a thousand classified systems was applied to large surveys of variable stars. Several thousands catalogued eclipsing binaries as well as stars from lists of eclipsing variables obtained as by-products of microlensing surveys (OGLE, MACHO, ASAS-3) were classified, and they can be used for determination of astrophysical parameters of their components. The procedure can be also applied to coming data from future ground-based and space (GAIA, COROT) observatories.

I. Classification scheme for eclipsing binaries

We have investigated the distribution of some 1000 classified systems, catalogued in (Malkov et al. 2005) in various observational planes and extracted from them a number of rules that allows the classification of a given system basing on a set of observational parameters (see the poster of Oblak et al. "Procedure for the classification of eclipsing binaries", S240).

List of rules used for classification

- Light curve morphological type allowable values
- A_1-A_2 (depths of primary and secondary minima) relation for detached systems
- A_1-A_2 relation for detached MS systems
- A_1, A_2 and dA (=A_1-A_2) upper limits
- P (period) upper and lower limits
- P variation allowable values
- Duration of eclipses difference (DI-DII) ranges
- Phase of secondary minimum MinII-MinI ranges
- Primary and secondary spectral type (Sp_1, Sp_2) ranges
- Primary and secondary luminosity class (LC_1, LC_2) ranges

Specification of a classification scheme

- **D**: Detached system of unknown sub-class
- **DM**: Detached main sequence system
- **DR**: Detached subgiant system
- **DG**: Detached giant or supergiant system
- **S**: Semi-detached system
- **C**: Contact system of unknown sub-class
- **CB**: Near-contact system of unknown sub-class
- **CBF**: Near-contact F system
- **CBV**: Near-contact V system
- **CE**: Early-type contact system
- **CW**: Late-type contact system of unknown sub-class
- **CWA**: Late-type contact A system
- **CWW**: Late-type contact W system

II. Application of the procedure

The procedure assigns an evolutionary class to a system, basing on its available observational parameters. If, according to the result of the classification, a system can belong to more than one of the listed classes, a class of the system is considered to remain unknown. However, if a system could belong to both DM and DR, it was classified as D, etc.

In order to estimate the effectiveness of the procedure, we tested the procedure on the set of 1029 systems with known classifiers. Altogether 475 systems (46%) were classified, class of others remained unknown. In 189 cases a less accurate classifier was assigned to a system (e.g., some CWW systems were classified as CW). However, for 19 systems a classifier was made more accurate (e.g., a CB system was classified as CBV). In general, 113 of 194 (58%) D systems, 79 of 437 (18%) S systems and 283 of 398 (71%) C systems were classified correctly.

It should be noted that no one from 22 DR systems and 72 CWA systems were classified correctly; all of them were classified as D and C/CW systems, correspondingly (or class remained unknown).

For the further applications, large (more than thousand EB systems) surveys with at least two parameters were chosen.

III. Results of classification

Table 1: Results of EB classification from large surveys

Survey	Number of stars	Number of parameters	**D**	**DM**	**DR**	**DG**	**S**	**C**	**CB**	**CBF**	**CE**	**CW**	**CWA**	**CWW**
CEV	5301	13	48	58	1	81	199	521	33	3	7	15		24
Wood-5	3564	10	49	58	2	84	166	43	9	2		25	1	23
OGLE-LMC	2681	6	299	141		119	69	40	8		25	2		3
OGLE-SMC	1404	6	202	53		133	16	104	6		23	1		1
MACHO	6143	3	656	197		272	24					11		14
ASAS3-ED	3878	2	1			113	29					12		11
ASAS3-ESD	6219	2	3			280	30					208		127
ASAS3-EC	5384	2	2			137	14					301		152

- Catalogue of eclipsing variables, CEV (Malkov et al. 2005): light curve morphological type, A_1, A_2, Sp_1, Sp_2, LC_1, LC_2, P, P variation information, DI, DII, MinII-MinI for 5301 stars
- A finding list for observers of interacting binary stars, fifth edition, (Wood et al. 1980): A_1, A_2, Sp_1, Sp_2, LC_1, LC_2, P, DI, DII for 3564 stars
- OGLE Catalog of eclipsing binary stars from the LMC (Wyrzykowski et al. 2003) and OGLE Catalog of eclipsing binary stars in the SMC (Wyrzykowski et al. 2004): light curve morphological type, A_1, A_2, P, MinII-MinI for 4085 stars
- MACHO list of eclipsing variables (Faccioli, 2006, private communication): A_1, P, MinII-MinI for 6143 stars
- ASAS-3 Catalogue of variable stars, including ED (detached), ESD (semi-detached) and EC (contact) eclipsing variables (Pojmanski et al. 2005): A_1, P for 15481 stars

The lack of systems of some classes in the ASAS-3 survey is caused by the following reason. **DG**-type stars have largest P, **S**-type stars have largest A_1, **CW**-type stars have smallest P. To distinguish systems of other classes one usually needs to know values of other parameters, that is why classes of these systems mostly remained unknown.

IV. Conclusions

The previously compiled catalogue of 6330 eclipsing binaries (Malkov et al. 2005), representing the largest list of eclipsing binaries classified from observations has been used to develop the most comprehensive set of rules for the classification of eclipsing binaries to date.

We have investigated the distribution of the catalogued systems in various observational planes and extracted from them a number of rules that allows the classification of a given system basing on a set of observational parameters even if the set is incomplete.

The developed procedure was applied to large catalogues of eclipsing variables and lists of eclipsing variables obtained as by-products of microlensing surveys. The results are summarized in the Table 1, and lists of classified stars are available upon request. Altogether 5291 systems are classified for the first time. The classified systems can be used for determination of astrophysical parameters of its components.

The procedure can be also applied to coming data from future ground-based and space (GAIA, COROT) observatories.

References

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