Procedure for the classification of eclipsing binaries

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ABSTRACT : In this work we present a procedure for the automatic classification of eclipsing binaries. The procedure is based on the data from a new catalogue of 6330 eclipsing variable stars, compiled by the authors. The procedure allows the classification of a given system basing on a set of observational parameters even if the set is incomplete. Results of an application of the procedure to a test sample of 1029 classified systems and to a sample of 5301 unclassified systems are discussed.

I. Catalogues and eclipsing binary basis data

From the General Catalogue of Variable Stars (GCVS) a new catalogue of 6330 eclipsing binaries was compiled (Malkov et al. 2005). We added also data from the Pribulla et al. (2003) catalogue for contact systems, Budding et al. (2004) for semi-detached systems, Shaw (1994) for near-contact systems, Popper & Ulrich (1977) for subgiant detached systems and Popper (1980), Malkov (1993) and Svechnikov et al's catalogues for others various types. Twelve classes of systems are defined (see the chapter III).

We considered the characteristics of eclipsing binaries given in the Figure 1, to take into account for a new procedure of classification of these systems:

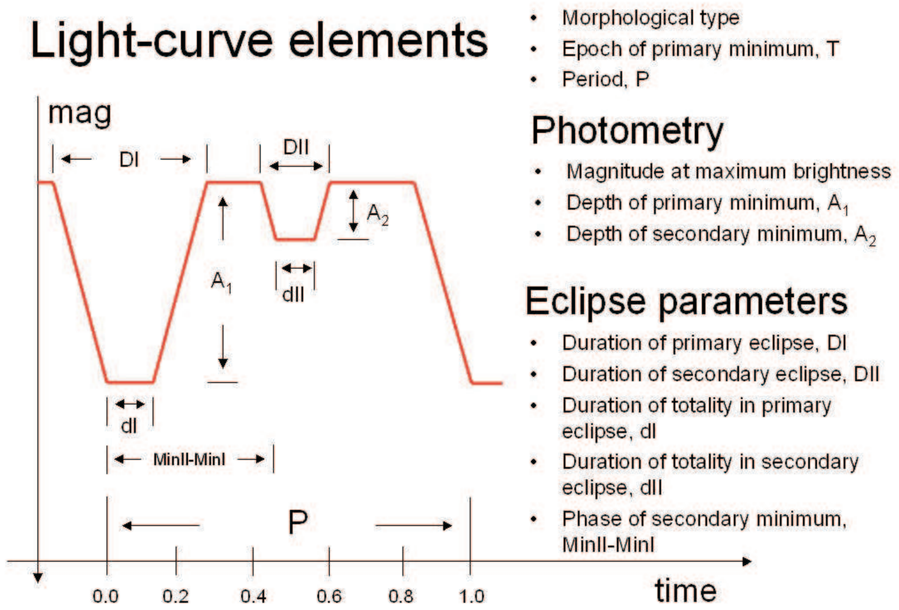

Figure 1. Characteristics of eclipsing binary light curves used in the procedure of the classification.

II. Some relations of parameters of eclipsing binaries

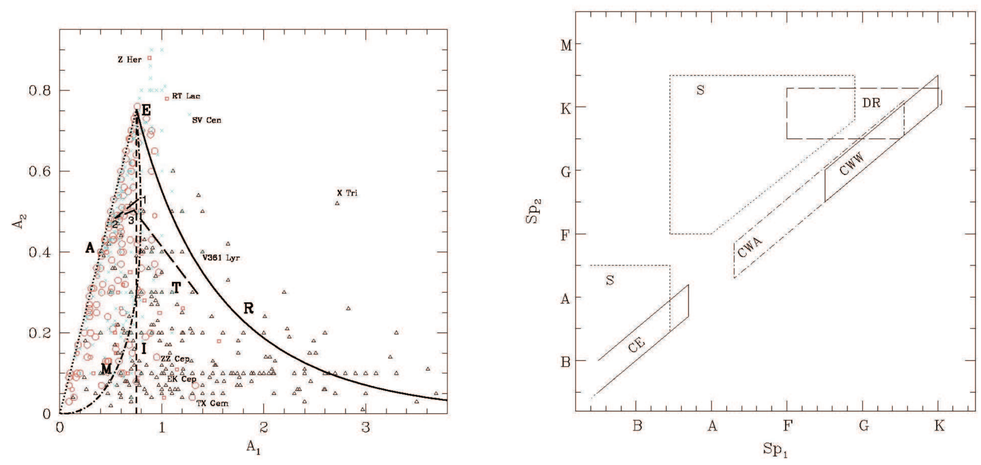

Figure 2. Left panel: Theoretical location of detached systems with total eclipses and catalogued systems in the A_1 (depth of primary minimum) — A_2 (depth of secondary minimum) plane. Line A — systems with components of equal temperatures, i.e., $A_1 = A_2$. Line R — systems with components of equal radii, upper limit for detached systems. Line I — systems with components of equal luminosities, i.e., $A_1 = 2.5 \log 2$, left limit for so called "inverse" systems (where brighter component is smaller). Line M — systems with $L_2/L_1 \propto (R_2/R_1)^{5.5}$ (approximate relation for O9.5 - M0 MS stars). Line T — evolutionary track of a 2.8$m_\odot$ + 2.5$m_\odot$ system (see text for details). Point E — systems with identical components. Catalogued systems: circles — DM systems (larger), DR systems (smaller), squares — DR systems, triangles — S systems, crosses — C systems.
Right panel: Selected classes of systems in the Sp_1 — Sp_2 plane. Spectra of DM and DG systems are spread from O to M. Spectra of CB systems are spread from B to K. Cool semi-detached systems are not shown.

III. New procedure of classification of eclipsing binaries and its testing

Rules used in the construction of a new procedure of classifi cation :

- Light curve morphological type allowable values
- A1-A2 (depths of primary and secondary minima) relation for detached systems
- A1-A2 relation for detached MS systems
- A1, A2 and dA(=A1-A2) 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 (SP1, SP2) ranges
- Primary and secondary luminosity class (LC1, LC2) ranges

The procedure assigns an evolutionary class to a system, basing on its available observational parameters. One of the following classes can be assigned:

- **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

We verifi ed the procedure, using 1029 systems with known classifi cation
Altogether 475 systems (46%) were classified: 113 of 194 (58%) D systems, 79 of 437 (18%) S systems and 283 of 398 (71%) C systems. Class of others remains unknown.
In 189 cases a less accurate classifier was assigned to a system (e.g. CWW → CW).
For 19 systems a classifier was made more accurate (e.g. CB → CBV).

IV. Application of the procedure to unclassified systems

We classifi ed 5301 eclipsing varaibles with unknown classifi er:
- For 86 stars all classes are forbidden (remain unclassified)
- More than one class can be applied to 4225 stars (class remains unknown)
- 990 stars are successfully classified

We present statistics of these 990 successfully classified stars:
- 188 are detached binaries, among them:
– 58 detached MS systems
– 1 detached subgiant system
– 81 detached giant or supergiant systems.
- 199 semi-detached binaries
- 603 contact and near-contact binaries, among them:
– 36 near-contact systems (3 of them are CBF)
– 7 early-type contact systems
– 39 late-type contact systems (24 of them are CWW)

Conclusions

The Figures 3 and 4 present respectively the accomplished and planing ongoing work on the classification of the eclipsing binaries. The above procedure was also applied to large stellar surveys (see the poster of Malkov & Oblak "Classification of Eclipsing Binaries in Large Surveys", JD13) and will be applied to a sample of about two thousand of eclipsing binaries with the goal to determine its fundamental physical parameters, which will be interpreted in the Besancon Double Stars Database (BDB).

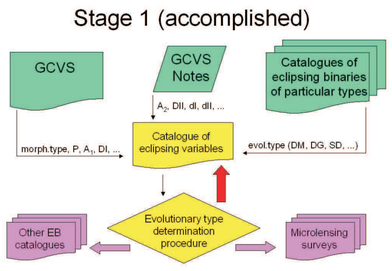

Figure 3. Accomplished goals.

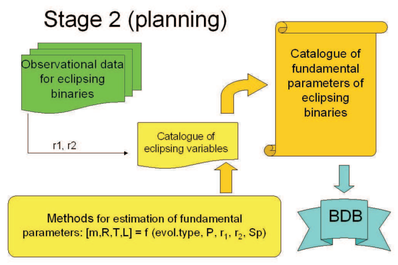

Figure 4. Planning activity.

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