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GENERAL CATALOGUE OF VARIABLE STARS: MODERN TRENDS

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Abstract. We discuss important changes in our work on the catalogues of variable stars because of the greatly increased flow of new discoveries and drastic changes in the astrophysical theory.

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1. INTRODUCTION

The General Catalogue of Variable Stars (GCVS) is probably the oldest European large-scale project. Before World War II, catalogues of variable stars were compiled at the Berlin-Babelsberg Observatory on behalf of the "Astronomische Gesellschaft". The catalogues were regularly published till 1942, first by R. Prager and then by H. Schneller. After the war, the IAU took charge of the catalogues and assigned this job to two groups in Moscow, now known as the GCVS group at the Institute of Astronomy and the variable star group at the Sternberg Astronomical Institute. The leaders of the project in Russia were P. P. Parenago (1906–1960), B. V. Kukarkin (1909–1977) and P. N. Kholopov (1922–1988).

Comparatively recently, our team has completed the fourth edition of the GCVS, consisting of five volumes and containing more than 28 000 reliable variable stars of the Galaxy, almost 11 000 variable stars in external galaxies, and about 1000 reliable or suspected extragalactic supernovae. The 4th GCVS edition is complimented

by the New Catalogue of Suspected Variable Stars (the NSV Catalogue), with more than 14 800 objects.

2. CURRENT STATUS

The Moscow GCVS team was, on behalf of the IAU, the official center of information on variable stars till 1994, when the IAU discontinued funding for the GCVS project. Nevertheless, we continue our GCVS activity and, though we do see serious problems in our work (to be discussed below), we are ready to keep being the world center of the variable star catalogues.

The long history of the GCVS has created a number of traditions. The GCVS is intended to include only reliable variable stars that should be sufficiently well investigated, so that they could be attributed to one of numerous variability types of the existing elaborated classification system or declared "unique" variables, not attributable to any type (and maybe future prototypes of new types).

If a star meets these criteria, it will be included in one of the Namelists of Variable Stars where it will get its "variable star name". Since 1999, we have given GCVS designations to Novae announced in IAU Circulars within days, upon request from the IAUC editors, and then include them into the next Namelist. We have recently published the 75th Namelist of Variable Stars (Kazarovets et al. 2000), and now the GCVS system includes 35 985 "named" variables (this number does not include spurious objects, now proven to be nonexistent, but includes named variables for which further studies led to doubts in variability). Normally, the GCVS team critically evaluates published variability information; in many cases, we used to derive new light elements from published data, to change published classifications according to uniform criteria, etc. Stars with doubtful variability or insufficiently studied variables should be included into catalogues of suspected variables. Recently, we have published a catalogue of 11 206 stars suspected in variability since the publication of the NSV catalogue (Kazarovets et al. 1998).

3. NEW TRENDS

The situation with variable stars has changed rather drastically during the recent decade. Several large-scale space-borne or ground-based projects aimed at automatic discovery of variable stars have

been successfully carried out and resulted in discoveries of many thousands of new variables. Our individual approach to each GCVS star becomes very difficult to continue. But we cannot just drop this tradition and include new stars into the GCVS with the published information accepted "as it is". Here our experience with the 74th Namelist of Variable Stars (Kazarovets et al. 1999), devoted to new variables discovered by the *Hipparcos* mission (ESA 1997), teaches us important lessons.

The *Hipparcos* team initially suggested the GCVS group to give GCVS names to 5665 stars, of which, 3157 were then named by us. The majority of the not named stars were included into the Supplement to the NSV Catalog (Kazarovets et al. 1998); a small number of stars were found identical with stars already having GCVS or NSV identifications. *Hipparcos* variables included into the NSV Supplement (1956 objects) are mostly stars with information insufficient for any reliable determination of their variability types. Out of the 3157 newly named *Hipparcos* variables, nearly 50% (1464 stars) have uncertain classification. We have encountered a number of cases of spurious variability in the *Hipparcos* data: due to wrong identifications in the input catalogue, some stars were attributed absolutely wrong spectral types, resulting in erroneous photometric reductions.

This experience shows the following drawbacks of even a very good large-scale automatic survey from the GCVS point if view:

– Observations are scheduled according to reasons far from those of variable-star research. Thus it is difficult to derive types for stars with certain characteristics. Interesting enough, pulsating variables dominate in the sample (2027 of 3157 stars). There are practically no Cepheids among new *Hipparcos* variables (11 stars in all subtypes of CEP, DCEP, or CW variables, and for 10 of them classification is uncertain). The *Hipparcos* team admits that it was especially difficult for them to derive periods in the typical Cepheid range. The number of RR Lyraes is only 28 (22 of them uncertain). On the contrary, δ Scuti and SX Phe stars are well represented (97 stars, of them 68 certain). Semiregular and irregular stars give a total of 1692, 54% of the sample. Thus, the distribution of the stars of the 74th Namelist over types is rather peculiar.

– Insufficient attention to identifications makes it more difficult to analyse photometric data. In the *Hipparcos* project, extensive use was made of the SIMBAD data base. This important source of information contains, however, mistakes and incompleteness in

identifications (in particular, because, up to recently, many catalogs had very bad positional accuracy). In our work on the 74th Namelist, we revealed more than 500 mistakes or imperfections in SIMBAD identifications.

One of the most important drawbacks of the existing catalogues of "old" variable stars, which makes automatic identification with "new" variable stars impossible, is their low positional accuracy. Formally, the equatorial coordinates presented in the printed 4th GCVS edition are given to 1^s in right ascension and to $0.1'$ in declination. Actually, the accuracy of the GCVS coordinates, usually just taken from discovery announcements, can be very different. Till early 20th century, many discoverers used to determine quite accurate coordinates for their variable stars. Then, discoverers at Harvard or Sonneberg Observatory, who were most active in the variable star research, began to present only very rough coordinates. Besides rare cases of absolutely wrong positions (errors up to 1° or even more), many *faint* variable stars have positions in error by several arcminutes. Drastic improvement of positional accuracy for all "old" GCVS stars is a very urgent task. Many groups in the world are working in this field. It is now much easier to solve the problem thanks to catalogues like the US Naval Observatory A1.0/A2.0 catalogue (Monet et al. 1998) containing more than 500 million stars with positional accuracy quite sufficient for automatic identifications. For variable stars not contained in that catalogue, it is often possible to use A1.0/A2.0 objects as reference stars and apply astrometric methods to Digitized Sky Survey images. Our group possesses the most complete information on "old" variable stars and is now approaching the problem systematically. We have recently prepared a version of the GCVS Volume 1 (constellations Andromeda – Crux) containing, whenever possible, improved positions and proper motions. For identifications, we used published positions, photometric information, finding charts. Similar work is being made by researchers in other countries, among them C. Lopez, T. Kato, B. Skiff, R. Webbink, G. Williams and others. Comparison of results makes it possible to reveal mistakes and solve especially complicated cases.

Note that finding charts are available practically for all variables discovered in Sonneberg. On the other hand, several thousand Harvard stars have no finding charts published, and in many cases their identification is not straightforward. Some red stars can be identified taking into account their associations with objects of the IRAS catalogue. In our work on the "astrometric" version of the

GCVS Volume I, we have been able to recover a number of variable stars on plates of Moscow collection of sky photographs and of the Maria Mitchell Observatory (MMO; Nantucket, USA) plate collection. Many variable stars were recovered in the Harvard plate collection by Drs. M. Hazen and G. Williams, whom we are most grateful for their cooperation. They are able to use ink marks left by discoverers on the plates. However, the rate of recoveries is not sufficiently high; this problem requires dedicated effort. Some cases remain very difficult despite serious attempts to solve them.

Also important is to improve the classification scheme for variable stars. It is tempting to introduce many new types of variables, and we are often urged by experts on particular kinds of variables to do so. But our catalogues are products to be used by a wide community, and the existing version of the classification system already contains too many types to be easily understood by the users. We would be grateful for suggestions aimed to a clear and *minimally* sufficient system of classification. Again, our experience with the *Hipparcos* Namelist teaches us some important lessons, mainly concerning the classification scheme for pulsating stars, for example:

– Among red stars, we meet probable pulsators not only among supergiants and giants but also among subgiants. For subgiants and especially for dwarfs, it is not easy to decide whether the observed variability is due to rotation or to pulsation. Already, it seems justified to introduce a type for semiregular pulsating red subgiants.

– Among red giants and supergiants, the *Hipparcos* team derived quite a number of short periods of variability (of the order of days). The light curves do not look very convincing. If real, such periods would cause problems for interpretation and make it necessary to revise the classification of numerous "old" SRB, SRC, LB, and LC stars for which such a behavior was even not looked for.

– Among O–F stars, we meet variables, and probably pulsating ones, not quite satisfying GCVS criteria for DSCT, SXPHE, BCEP, or ACYG stars. The γ Dor stars, a new type of pulsating variables (e.g. Balona et al. 1994), are obviously a related phenomenon (the type has just been accepted by us in the 75th Namelist), as are the Maia variables, suggested long ago and not understood until recent improvements of stellar opacities.

We are aware of many classification problems besides the above short list concerning only pulsating stars.

The *Hipparcos* Namelist was our first experience with large surveys. A number of stars of other, comparatively minor, surveys have been included in our regular Namelists, but new special Namelists, dedicated to larger surveys, will follow. We would like to emphasize that, if a large survey presents well-structured information on variables, the survey becomes self-sufficient to a considerable degree, and delays with GCVS naming are not so worrying. Almost perfect is, for example, the presentation of data in many OGLE publications (see, for instance, Udalski et al. 1994). However, the level of classification (eclipsers, short-period pulsators, miscellaneous periodic variables) is insufficient for traditions of variable star research. The same holds for the first impressive results of the ASAS project (Pojmanski et al. 2000), presented as a detailed catalogue of almost 4000 variables, with light curves and epoch photometry, but again with insufficiently detailed classification. On the other hand, the availability of data from some other surveys (for example, MACHO) becomes a serious problem, to be discussed at the IAU level. If, in a project, thousands of stars are being discovered, but only a small part of them are being announced in a manner sufficient for subsequent identification, the rest of the discoveries is effectively lost.

For new GCVS, NSV and NSV Supplement versions, regularly corrected and improved, with search options, see our web site at

http://www.sai.msu.su/groups/cluster/gcvs/gcvs/

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