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A word about the Teacher

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Abstract This is a memorial report on the biography and scientific heritage of M.A. Svechnikov — an outstanding scientist and teacher, the founder of the Ural school of close binary stars and the author of the classification scheme for eclipsing variable stars.

Key words: catalogs: photometric — spectroscopic — stars: eclipsing variables: classification scheme — close binary stars

1 SEMINAR ON "MODERN RESEARCH OF VARIABLE STARS"

2018 January 28 marked the eighty-fifth anniversary of Mariy Anatolevich Svechnikov's birth and was celebrated at the workshop on Variable Stars that took place in Kourovka Astronomical Observatory named after C. A. Barkhatova in the traditional framework of the 47th International Student Conference "Physics of Cosmos" held on Ural Federal University (UrFU). The Ministry of Education and Science of the Russian Federation, the Astronomy and Geodesy Department of UrFU, and Kourovka Astronomical Observatory named after C. A. Barkhatova as well as the Russian Foundation for Basic Research were the organizers of this event.

The Organizing and Scientific Committees of the seminar were presented by A. M. Sobolev (chairman, Kourovka Astronomical Observatory named after C. A. Barkhatova, UrFU, Yekaterinburg), E. D. Kuznetsov (UrFU, Yekaterinburg), N. N. Samus (Institute of Astronomy of the Russian Academy of Sciences (RAS), Moscow), T. S. Polushina (Kourovka Astronomical Observatory named after C. A. Barkhatova, UrFU, Yekaterinburg), S. Yu. Gorda (Kourovka Astronomical Observatory named after C. A. Barkhatova, UrFU, Yekaterinburg), G. N. Dryomova (Russian Federal Nuclear Centre named after academician E. I. Zababakhin, Snezhinsk).

The title of the seminar was "Modern research of variable stars." This seminar covered a wide range of issues related to comprehensive study of the evolution of binary stars, but went far beyond the stellar variability associated with eclipses. The concept of stellar variability today is equivalent to the evolutionary state of the star. By the type of variability, one can make conclusions about the internal physical processes taking place in a star. For example, variability of light may be associated with pulsation processes occurring in the interiors of stars, or caused by the flare activity of a star in its chromosphere and corona.

The variability of brightness can arise due to the loss of mass in the form of stellar wind and its interaction with the interstellar medium, and also because of magnetic fields that lead to chemical and temperature inhomogeneity, and to spot-cycle activity. Another factor in variability of the brightness is associated with rapid rotation of the stars. In addition, the variability of stars may be caused by explosions of the stars themselves or on their surface layers.

There are also more delicate expressions of brightness variability, associated, for example, with mutual tidal gravity arising in binary stellar systems, or with mass exchange between components.

All these examples cannot be analyzed without involving techniques and numerical modeling approaches. An important aspect is the comparison of the results of theoretical modeling and observational data, which, first and foremost, must be obtained and then processed. The accumulation of statistics on variable stars can serve as a guarantee and a kind of test for unification of theoretical models, that is, the ability to describe as many examples of variable stars as possible.

Thus, the goal of the seminar is to unite the efforts of researchers and their graduate students from various scientific institutions (universities, academic institutes and observatories) in order to coordinate the research results in three directions:

- Theoretical modeling;
- Accumulation of original observational data;
- Statistical processing: cataloging of observational data and their processing.

Fourteen reports (14 out of 16 planned) were presented at the seminar, prepared by astronomers from the State Astronomical Institute named after P. K. Sternberg, the Institute of Astronomy of the RAS, Chelyabinsk State University (CSU), UrFU named after the First President of Russia B. N. Yeltsin, the Space Research Institute of the RAS, Kourovka Astronomical Observatory named after C. A. Barkhatova, the Russian Federal Nuclear Centre named after academician E. I. Zababakhin and Crimean Astrophysical Observatory of the RAS.

It should be specially emphasized that more than half of the reports were devoted to the topic of studying close binary stars (CBSs). Historically, the first variable objects were binary stars whose variability in brightness is associated with periodic eclipses of both component stars.

This category of stars requires careful analysis of observational data covering an impressive variety of shapes of light curves and radial velocity curves, on the basis of which the principal classification criteria were developed that allows sorting out binary stars by evolutionary status. This became the scientific goal of Mariy Anatolevich Svechnikov.

2 BRIEF BIOGRAPHY OF MARIY ANATOLEVICH SVECHNIKOV

2.1 The Beginning. Years of Education

Mariy Svechnikov was born on 1933 January 28 into a family of medics in Odessa. His father, a hereditary Cossack named Anatoly Savvich Svechnikov, was a military doctor and candidate of medical sciences who returned from the battlefields of the Second World War with the rank of lieutenant colonel. His mother, Esther Lvovna Svechnikova, the daughter of a doctor, was a microbiologist and a candidate of medical sciences. The family left Odessa on the last boat in 1941.

In 1949, Svechnikov graduated from the secondary school in Makhachkala and entered Leningrad State University, named after A. A. Zhdanov. Being a freshman, Svechnikov was immediately drawn into research work and his first scientific results were published in 1950, when he was a second-year student. The research concerned observations of the Moon's surface during eclipses, study of the shadow contour of the Earth and light distribution over the disk, as well as observations of Perseids.

In 1954, student Mariy Svechnikov successfully graduated from university and began his teaching career at the Pedagogical University named after A. I. Herzen (formerly called the Institute of Education). Later these practices helped Svechnikov to acquire unsurpassed craftsmanship of a lecturer to become a talented teacher for of many generations of students.

In parallel, Svechnikov was matriculated immediately as a post-graduate student to Professor V. A. Dombrovskiy, who was among the first to explore interstellar polarization of the radiation of stars and nebulas.

In 1957, as a result of a search, the post-graduate student was commissioned to create a South Observational Station for Leningrad University on the territory of Byurakan Observatory. It was a project to build an educational observatory for students that included dome mounting and optics testing. So, M. A. Svechnikov and V. G. Hagen-Thorn (themselves "yesterday's students") were preparing a $20''$ telescope-reflector with an astrophotometer for photographic, colorimetric and polarimetric observations.

Romance at the southern observatory helped Mariy to find his other half and meet his future wife, Elvira Fedorovna Kuznetsova, who later gave him two sons (Leonid and Anatoly), and became his scientific companion and active co-author.

Gradually, interests of the young post-graduate student changed, and he by became engrossed in the study of eclipsing variable stars. A few years later, after completion of post-graduate courses, in 1959 M. Svechnikov defended his PhD thesis "Spectrophotometric research and studies of orbital period changes of ε *Aur*, *U Sge* and λ *Tau*."

2.2 Scientific Research and Findings. Ural period

The Ural period of his life began in 1964 when Mariy Anatolevich came to Ural State University (USU) named after A. M. Gorky at the Astronomy and Geodesy Department by invitation of the director of Kourovka Astronomical Observatory, Claudia Alexandrovna Barkhatova. His optimistic and cheerful character, and his openness for everyone, were immedi-

Fig. 1 At the stadium in Makhachkala watching a football match in 1949.

Fig. 2 During construction of the southern observatory, Byurakan, in the late 1950s.

ately acknowledged by his colleagues. As a true native of Odessa, Mariy Svechnikov possessed an excellent sense of humor and an inexhaustible store of original stories which made an unforgettable impression on an audience. Not only students but also colleagues were surprised by his great erudition and mental outlook.

M. A. Svechnikov very quickly won the rating of one of the best lecturers at the Physics Department of USU. For many years of his work in USU (1964–2009) Mariy Anatolevich prepared and then for a long time delivered courses of lectures entitled “Theoretical Astrophysics,” “Complementary Chapters of Theoretical Astrophysics,” “Variable Stars,” “General Astrophysics,” “General Astronomy” (for physicists), “Theory of dimension and similarity,” “Physics and evolution of stars” (for students of the Mathematics Department), “Cosmic Physics” (for physicists), “Problems of Modern Astrophysics,” and “Physiography and geophysics in natural history” for students of the teacher’s training institute. They were rather non-trivial lectures skillfully interweaving the newest data not entered into textbooks and catalogs yet with basic knowledge and mathematical traditions.

In parallel with his teaching work, Svechnikov continued to deal with eclipsing-variable stars. After defending his dissertation, he literally began "hunting" for any observational data on an increasing number of eclipsing-variable stars, which Svechnikov carefully systematized in his card catalog. The first data on eclipsing variables were very scanty and the first catalogs of CBSs could be counted on one's fingers. For example, the catalog by Lavrov (1955) included data on about 67 binaries. A year later, the catalog by (**?**) was published containing information about 83 binaries. The first papers in which the data of these catalogs were used for comparative analysis only appeared in 1963 (Wood 1963; Hack 1963). This opened up opportunities for statistical and theoretical studies, although on a small number of statistics on stars.

Since 1962, M. A. Svechnikov began to compile information on the relative and absolute elements of the CBS to increase the database of his card catalog. Based on data in the card catalog, Svechnikov published his first catalog named "Catalogue of orbital elements, masses and luminosities of close binary systems" including 197 binaries with known orbital elements and astrophysical parameters (Svechnikov 1969a). Namely these systems served as a basis for the systematization of CBSs in accordance with the generality of their geometric and physical properties.

To make the classification scheme capable of distinguishing close binaries based on evolutionary status, it is necessary that the classification criteria were fitted to evolutionary signs. During the evolution, the sizes of components and their mutual orbits change. At some moment, the components of close binary systems begin to interact actively via exchange of mass. Changes in geometrical characteristics of components are reflected by Roche lobe fill-out degree. This criterion has already been used by Kopal (1955) but it proved to be insufficient for complete classification. Since mass exchange is an important process in binary evolution, Svechnikov decided to implement the criterion by Kopal in a new classification scheme.

As is known, the components of close binaries fill their Roche lobes multiple times during the evolution, therefore an additional criterion specifying the current state of each component is required. Such identification was performed using the Hertzsprung-Russell (HR) diagram for systems with known astrophysical parameters, i.e. for 197 systems from Svechnikov (1969a).

So, *Roche lobe fill-out degree* and *the location of the components on the HR diagram* were chosen by Svechnikov as *principal criteria* for new classification (Svechnikov 1969b). As a result of performed classification for 197 close binary systems, eight homogenous property classes were revealed: 43 detached main sequence systems (*DMS*), 64 semi-detached systems (*SD*), 16 detached systems with sub-giant (*DS*), 10 systems of the *AR Lac* type (*AR*), 18 contact systems of *W UMa* type (*CW*) and 8 contact systems of early spectral classes (*CE*), 15 giant and supergiant systems (*S-G*) as well as 10 systems having a hot sub-dwarf or white dwarf as one of the components (*SW*). A bit later a new ninth class of detached binaries similar to *W UMa* (*DW*) was extracted from the *DMS*-class. The components of *DW*-class are far from the sizes of their Roche lobes but their orbital periods are much shorter than those of *DMS* systems with the same masses but close to *W UMa*. *DW*-class is also known as short-period *RS CVn* cases.

Already established terminological concepts were used for introduced classes of close binaries, for example, "systems with detached components," "semi-detached," and "contact binaries of early-spectral types."

For these small groups, it was necessary to carry out statistical studies in order to reveal regularities in their properties. The comparison with theory allowed the interpretation of these types of CBSs and many of their features as different evolutionary phases of the systems depending on initial masses of the components and their initial separation. The analysis of properties within the group helped to understand the previous evolutionary steps of the binary and to incorporate them into a unified evolutionary history.

In 1970–1972, M. A. Svechnikov and L. P. Surkova published a series of works devoted to studying period changes and mass loss during evolution of binaries. It was shown that CBSs play a significant role in replenishing the interstellar medium with gaseous matter, which is necessary for further star formation in our Galaxy. The rate of matter loss accompanying the evolution of binaries in our Galaxy proved to be roughly estimated as 14 $M_\odot$ per year (Svechnikov 1973).

For statistical investigations, much larger data volumes are needed. But in catalogs as a rule, only the most general observational data are collected. For instance, in the third edition of the General Catalogue of Variable Stars (GCVS III) and in three supplements to it (Kukarkin et al. 1969–1976) for eclipsing variable stars, one can find information about the type of light curve (*EA, EB, EW*), orbital period, *P*, and primary minimum depth, A_1. But information about depth difference of minima, ΔA, is rare as well as spectral type of the primary component. Naturally the question arose: whether relying only on raw observational data, can one construct exactly the same classification of eclipsing variable stars as was performed based on analysis of astrophysical parameters of component stars?

The search for new simple criteria following from direct observations for the classification of eclipsing variables fell in the so-called Algerian period in the biography of Svechnikov.

2.3 Algerian Period

An academic mission in Algeria was an important stage in the development of Svechnikov as a scholar. During a mission in Algeria (from December 1972 to March 1976), Svechnikov together with other Soviet scientists restored the Algerian Observatory and trained scientific staff for it. He performed photographic observations on a normal astrograph. There he delivered two lecture courses in French for the natural science faculty of Algerian University entitled "Practical Astronomy" and "Theoretical Astrophysics" as well as published two methodological manuals for Algerian University: "Distribution de la densit estellaire dans un amas satellaire ouvert" and "Astrophysique theorique. Theorie des photospheres stellaires."

Being in scientific isolation far from progressive science, he spent all free time in cogitation on CBS classification. In Algeria, he devised new criteria for classification of eclipsing variables stars that proved to be so simple and obvious that the classification system won general acceptance very soon.

The card catalog by Mariy Svechnikov proved to be very useful in Algeria. For 367 of 474 close eclipsing binaries, the information about photometric elements including their mass ratio and in most cases primary spectral type, Sp_1 was available. Using approximation methods, one could derive absolute elements of the orbit and astrophysical parameters of stars (masses and radii). Analysis in the framework of theoretical stellar evolutionary models allowed sorting these systems into classes. The distribution of stars in classes was as follows: *DMS* — 77; *SD* — 143; *DS* — 21; *CW* — 47; *CE* — 48; *S-G* — 20; *AR* — 6; *SW* — 5.

It is important to emphasize that this distribution was obtained relying on known astrophysical data. But what if one did not have these data except for the raw observational data A_1, ΔA, P, Sp_1. Would the systems form exactly the same "islets"of clustering in the space of these four parameters?

To answer this question it was necessary to study projections of star distributions onto 2D planes defined by any two of these four variables. The treatment of the projections was carried out by means of cluster analysis and resulted in the formulation of reliable segregation criteria.

Needless to say, the young scientist was fascinated by the nature of Algeria and traveled over the Sahara, and the Tassili. He was fond of deep-sea diving and underwater hunting. He brought a lot of books, stones, different exotic things from Algeria and, of course, principles of new classification.

2.4 Chelyabinsk Period

Mariy Anatolevich came to work in CSU in 1979, shortly after the university was founded (in 1976). He took a position of associate professor at the department of theoretical physics. In CSU, Mariy Anatolevich delivered lecture courses on "Astrophysics," "Thermodynamics," "Methods of dimensions and similarity," as well as "Fundamentals of Natural Science" for students in the Department of Mathematics. Mariy Anatolevich was one of the best lecturers in the Physics Department.

Good knowledge of the subject, clarity of the presentation along with enthusiasm and inspiration attracted students to him for work on qualification papers. In 1985, Mariy Anatolevich was one of the first among the staff of the Faculty of Physics to defend his doctoral dissertation on the topic "Classification and physical characteristics of eclipsing variable stars" at the State Astronomical Institute named after P. K. Shternberg, Moscow State University.

In 1987, Svechnikov received the title of professor, which made it possible in 1988 to open a postgraduate course in the specialty "Astrophysics" at the department. In 1993, Mariy Anatolevich returned to USU named after A. M. Gorky to take the position of chief researcher at Kourovka Astronomical Observatory, but continued to work at CSU concurrently until 1999.

While at the university, M. A. Svechnikov published an extended version of the "Catalogue of Orbital Elements, Masses and Luminosities of Close Binary Stars" (1986), containing data on 246 stars. The "Catalogue of approximate photometric and absolute elements of eclipsing variable stars" was published by Svechnikov and Kuznetsova in 1990. Work began on the statistical processing of catalogs, which required knowledge of the probability of the discovery of a CBS that is an eclipsing variable. It is this function that would allow us to transform the observed distributions into "true" ones. Two young graduates of CSU, Tatyana Taidakova and Olga Eretnova, were engaged in the construction and numerical calculations of this function. Under the leadership of Professor Svechnikov, they successfully investigated this problem, and for the first time determined the total probability of the discovery of close

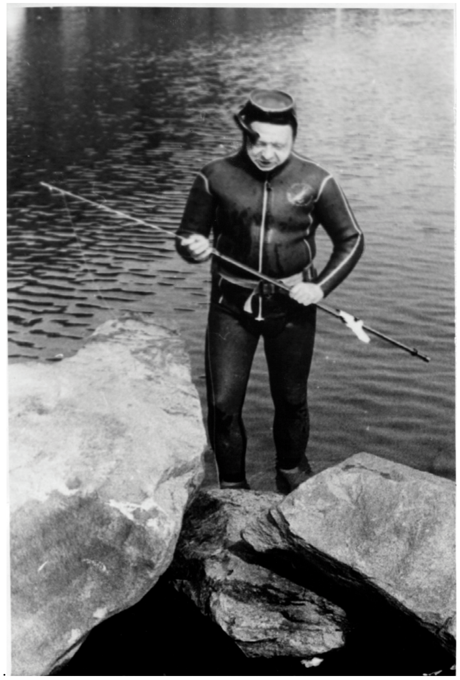

Fig. 3 His hobby of underwater hunting in the Black Sea, during the 1980s.

Fig. 4 Chair of Theoretical Physics of CSU, Chelyabinsk, 1987. Professor Svechnikov is sitting first on the right.

binary systems of various evolutionary types as eclipsing variable stars (Svechnikov et al. 1989; Eretnova et al. 1995). Taking into account the probability of star discovery, the spatial density of close binaries of various types in the vicinity of the Sun was estimated, which is of interest for theoretical studies on binary stars and, first of all, for determining such a fundamental function as the initial mass function (IMF). Comparison with the Salpeter law allowed us to investigate features of the formation of close binary systems for which the slope $\frac{dN}{dM} \propto M^{-(1+\alpha)}$ turned out to be smaller, $\alpha \approx 0.3$ (Svechnikov 1990), in contrast to the slope for single stars ($\alpha \approx 1.35$) (Salpeter 1955).

Mariy Anatolevich was an unusually versatile person. He was fond of diving, introducing to this his students, especially girls who were afraid to dive. He had a large collection of stones and stamps. At home, Mariy Anatolevich had a wonderful library. The bookshelves occupied most of the walls of his apartment from floor to ceiling. Books were not only scientific, but also artistic, and there were a lot of antiquarian folios. He himself read voraciously and generously shared books with students. M. A. Svechnikov had a unique memory, profound erudition and was an unbeatable interlocutor.

3 SIMPLE CRITERIA FOR THE CLASSIFICATION OF ECLIPSING VARIABLES

After Algeria, Mariy Svechnikov continued to accumulate data on stars and attracted young scientists L. F. Istomin and O. A. Grekhova (Svechnikov & Istomin 1979; Svechnikov et al. 1980a,b) to search for criteria for the evolutionary segregation of eclipsing variable stars, based on the initial observational data. They obtained distributions of these systems depending on the depth of the main minimum (A_1), the depth difference of minima (ΔA), the orbital period (P) and the spectral class of the main component (Sp_1), as well as two remarkable diagrams in which the mixed distributions of various classes of CBSs were finally separated. These diagrams were "A_1 – ΔA" and "P – Sp_1."

Found from the distribution and diagram analysis, the classification criteria for eclipsing variable stars should be based on data from the GCVS III and in three supplements to it (Kukarkin et al. 1969–1976).

For this purpose, three "independent verifiers," Svechnikov, Istomin and Grekhova, reclassified the same 367 eclipsing binaries from the card catalog by Svechnikov, based only on the data about A_1, ΔA, P, Sp_1 which were taken from GCVS III and three supplements to it Kukarkin et al. 1969–1976). Results of the reclassification were then compared with the results of physical classification derived from the analysis of astrophysical parameters of star components and their localization on the HR diagram. It appeared that for 326 of 367 close binaries (almost 90%), the results of both classifications coincide (Svechnikov et al. 1980a).

The percentages of "admixtures" and "loss" were determined by the incompleteness of the information on A_1, ΔA, P, Sp_1. For example, the absence of information on Sp_1 may lead to erroneous classification of *DW* class systems, which are identified as *CE* class systems. The same concerns short-period *DMS* systems with $P < 1.58^{\rm d}$ which cannot be recognized by the classification scheme without knowledge of Sp_1 and, as a consequence, are "admixed" with the *CE* class.

Relying on obtained comparison results, the conclusion about practical applicability of simple criteria for the classification of eclipsing variable systems was made. Being approximate, the classification is of great interest to statistical study of close binaries and to the study of their evolution. This conclusion was immediately tested on GCVS III data containing 4704 eclipsing variable stars designated as E-"eclipse" (Kukarkin et al. 1969–1976).

For many of these systems, the data about minima depth difference, ΔA, could not be found. For 581 eclipsing variable stars, the information about orbital period was absent and such systems were immediately excluded from the sample. Primary spectral type, Sp_1, was known for a limited number of systems — 1285. They were considered a benchmark dataset for extensive testing of the four-parameter classification scheme. For the majority of systems from GCVS III (Kukarkin et al. 1969–1976), the data about Sp_1 were not given and therefore two- or three- parameter classification was performed.

Applying the symbols adopted in GCVS III to designate the degree of data reliability, the results were as follows:

- 58% is the share of surely classified systems
- 17% is the share of classified systems with a slight degree of confidence
- 13% is the share of classified systems with high degree of uncertainty
- 12% is the share of non-classified systems.

Application of the proposed classification scheme to eclipsing variables with known A_1, ΔA, P, Sp_1 from GCVS III (Kukarkin et al. 1969–1976) resulted in publication of classification data in the next edition, GCVS IV, released in 1985 under the editorship of Kholopov (Kholopov et al. 1985).

The results of this extensive work formed the basis for defending the doctoral dissertation in 1985 at the State Astronomical Institute named after P. K. Sternberg in Moscow. The theme of his scientific work was "Classification and physical characteristics of eclipsing variable close binary stars."

4 SVECHNIKOV'S CATALOGS OF CLOSE BINARY SYSTEMS

Working on the classification of CBSs, Professor Svechnikov founded a school that united around him many pupils, followers and continuers of his ideas.

Below is the list of CBS catalogs compiled by Svechnikov and his followers:

(1) Svechnikov M. A., Catalogue of orbital elements, masses and luminosities of Close Binary Stars, 1969, Sverdlovsk, Scientific Notes, N 88, Astronomy series, issue 5, 179 p.

(2) Svechnikov M. A., Bessonova L.A., Catalogue of orbital elements, masses and luminosities of close double stars, 1984, Bull. Inform Centre Donnees Stellaires, Strasbourg, N 26, p.99–101

(3) Svechnikov M. A., Catalogue of orbital elements, masses and luminosities of Close Binary Stars, 1986,

Irkutsk, Publishing House of Irkutsk State University, 226 p.
(4) Svechnikov M. A., Kuznetsova E. F., Approximate photometric and absolute elements of Eclipsing Variable Stars, 1990, Sverdlovsk, Publishing House of Ural State University, vol.1,2
(5) Bondarenko I. I., Perevozkina E. L., The catalogue of photometric, geometrical and absolute elements of contact binary stars of the early spectral type, Odessa Astronomical Publications, 1996, vol. 9, p. 20
(6) Svechnikov M. A., Perevozkina E. L., Catalogue of orbital elements, masses and luminosities of Eclipsing Variable Stars of DMS type with known photometric and spectroscopic elements, 1999, Yekaterinburg, Publishing House of Ural State University, pp. 5–30
(7) Perevozkina E. L., Svechnikov M. A., Catalogue of orbital elements, masses and luminosities of Eclipsing Variable Stars of DMS type with known elements of photometric orbit and unknown spectroscopic elements, 1999, Yekaterinburg, Publishing House of Ural State University, pp. 122–132
(8) Polushina T. S., Catalogue of massive close binaries with early-type components of the main sequence: observed characteristics, 2004, Astronomical and Astrophysical Transactions, vol. 23, Issue 3, p.213–227, 2011yCatp044002301P
(9) Surkova L. P., Svechnikov M. A., Semi-detached eclipsing binaries, 2004, VizieR On-line Data Catalog: V/115, 2004yCat.5115....0S
(10) Dryomova G. N., Perevozkina E. L., Svechnikov M. A., Catalogue of the orbital elements, masses, and luminosities for short-periodic RS CVn-type systems, Astron.Astrophys. 2005, v.437, issue 1, pp. 375–381

The orbital and absolute elements in the fourth catalog from the above list were estimated from data in GCVS IV (Kholopov et al. 1985), using approximate statistical relationships such as "mass-radius," "mass-luminosity," and "mass-spectrum," dependence of the orbital inclination on the depth of the main minimum, and others that were found as a result of statistical processing of data from the first three catalogs listed above.

Some systems from the fourth catalog were provided with reliable astrophysical data, but they were announced as unknown cases except for A_1, ΔA, P, Sp_1 taken from GCVS IV (Kholopov et al. 1985). Let us demonstrate, using the example of the *DMS*-class, how the scheme for restoring astrophysical and geometric parameters worked.

Initially, from the known spectrum of main component Sp_1 using the "$M - Sp$" relationship and Popper's effective temperature scale (Popper 1980), the mass M_1 and effective temperature $T_{\rm eff}{}^1$ of the main component were restored. Then from the surface brightness ratio J_1/J_2, determined on one hand through the depths of the main and secondary minima of the eclipse, A_1 and A_2, and on the other hand with the assumption that the stars are ideal black bodies whose radiation obeys Planck's law, one can estimate the effective temperature of the satellite $T_{\rm eff}{}^2$, and hence its spectral class Sp_2 according to Popper (1980), which makes it possible to "reconstruct" the mass of the satellite M_2, again using the well-known dependence '$M - Sp$" for main sequence stars. Further, it is possible to calculate the parameter $q = M_2/M_1$ and the semi-major axis of the orbit A by Kepler's third law. The next step is to calculate the absolute radii of the components R_1 and R_2 using the "$M - R$" relationship for main sequence stars and to estimate the relative radii by the formulas $r_1 = R_1/A$ and $r_2 = R_2/A$. Knowing absolute radii and effective temperatures, one can determine bolometric absolute magnitudes of the primary and secondary components of the binary. Finally, applying the relations $L_1 + L_2 = 1$ and $\frac{J_1}{J_2} = \frac{L_1}{L_2} \cdot \frac{r_2^2}{r_1^2}$, we can estimate relative luminosities of the components L_1 and L_2.

If the depth of the secondary minimum A_2 was unknown, then the parameter q was imposed on the average value, characteristic for the *DMS*-class — $q = 0.8$, by which the mass of satellite M_2 was "restored." In other aspects, the scheme for determining the orbital elements remained the same.

It should be emphasized that partial control of the described scheme is provided by additional relationships linking such observational parameters as the duration of the eclipse D and the duration of the constant brightness phase at a minimum of d with relative radii, $\pi \cdot D \approx r_1 + r_2$ and $\pi \cdot d \approx r_1 - r_2$.

So, for each class of eclipsing variable, the reconstruction of absolute and relative elements of the orbit was carried out, relying on the statistical dependence found earlier from data in the first three catalogs including CBSs with well-known spectroscopic and photometric parameters.

As a result, the catalog of approximate absolute and relative elements was elaborated on by M. A. Svechnikov and his wife E. F. Kuznetsova for almost 5000 eclipsing-variable stars. Of course, in this extensive work, which was carried out in the 1980s (when there was no internet or powerful computers yet), students, post-graduate students and employees of two universities, in the Sverdlovsk and Chelyabinsk regions, were involved.

Mariy Svechnikov often repeated that a "good regular paper lives on average one or two decades but catalogs live through the ages." Catalogs of close binary systems

Fig. 5 With sons in 1984.

with known astrophysical parameters allowed the solution of a number of specific problems in astrophysics. For example, back in the late 1960s from analysis of the statistical distribution of eclipsing variable stars in the "$M_1 - A$" diagram, Svechnikov found a deficit of short-period *DMS* systems, which became known as the "forbidden triangle" problem and was confirmed by data with more rich statistics (Kraicheva et al. 1978). In the 1980s, an explanation of this problem was elucidated on in that it was associated with the accretion regime of the formation of close binary systems and, as a consequence, the limitation of the size of young just formed stars (Popova et al. 1982). The same triangle turned out to be filled with *CW* binaries.

Further comparison of the observed properties of binary systems, as well as an analysis of their statistical distributions, made it possible to relate statistics and lifetimes of various classes of binaries to one evolutionary sequence, the driving force of which is the magnetic stellar wind. This leads to a loss of orbital angular momentum, and as a result, the approach of the component stars and eventually their complete merging. Extensive observation material of the fourth catalog helped to demonstrate several evolutionary chains, for example, *short-periodic DMS* → *DW* → *W UMa* → *blue stragglers* or *short-periodic DMS* → *short-periodic R CMa* → *W UMa* → *blue stragglers*. This is a typical problem in the theory of population synthesis, one of the solution methods of which is built on the use of a large volume of homogeneous observational data and with the use of evolutionary stellar models. In the framework of magnetic breaking formalism (Schatzman 1962), a Trapezium-Cluster-like domain populated by young *DMS* binaries with $A < 10\,R_\odot$, $M_1 \leq 2.5\,M_\odot$ and $M_2 \leq 1.5\,M_\odot$ was found in the "$M_1 - A$" diagram as a habitat for potential "parents" of *blue stragglers* (Tutukov et al. 2004).

Based on the catalogd data by Svechnikov, the possibilities of studying spatial distributions of different classes of binaries were opened. Modern and initial functions of star formation were constructed on the basis of current and initial distributions of various classes of binaries, corrected for the probability of star discovery as an eclipsing variable and per unit volume of space in the vicinity of the Sun (Dremova & Svechnikov 2001). This gave an independent way of evaluating the function of star formation, which is an alternative to the analysis of star luminosity function, and can be a comparison with known star formation functions, such as Salpeter or Miller & Scalo ones (Salpeter 1955; Miller & Scalo 1979). This topic was linked with the analysis of open clusters, for which permanent star formation was noted for the first time in a series of papers (Zakharova & Svechnikov 1973a,b).

In the framework of statistical studies of *W UMa* type binaries, carried out in cooperation with L. F. Istomin, it was shown that two-thirds of contact systems are triple (Istomin 1990). Also, a detailed consideration was given regarding the question of luminosity excesses of *CW*-satellites under the assumption that the increase in luminosity of the satellite is due to release of gravitational energy of the matter falling onto the surface of the more massive component (Istomin 1986).

The observations of eclipsing variable stars in Kourovka Astronomical Observatory were initiated by Mariy Anatolevich Svechnikov in the mid-1960s. As a rule, the investigations were based on electrophotometrical observations with the application of area scanning technique for the first time proposed by Franz (1966) and Rakos (1965). The active participants of this program have been S. Yu. Gorda and T. S. Polushina.

The first eclipsing binary of this program was visual double star *ADS 9537* ($\rho = 16.3''$), both components of which are *W UMa* type binaries, *BV Dra* and *BW Dra*. The analysis of these observations allowed conclusions to be drawn about orbital coplanarity of these two eclipsing binaries in *ADS 9537* (Gorda 1986; Gorda 1990). In the future, with the instruments at Kourovka Astronomical Observatory, the variability of *DN UMa* with the *ADS 8347A* component (Gorda & Popov 1994) was discovered by the direct photometric method for the first time. The program of observations also included such an eclipsing variable as *SZ Cam*, for which a complete set of parameters for the apparent relative orbit of the third body was determined for the first time and subsequently the duality of the third component was demonstrated relying on observational data performed on the six-meter telescope at the Special Astrophysical Observatory (SAO) of the RAS, and the AZT-3 telescope of Kourovka Astronomical Observatory (Gorda 2002; Gorda et al. 2007a; 2007a).

CC Cas, SZ Cam, UU Cas, V368 Cas, BH Cen, SV Cen, LY Aur and *V701 Sco* is another list of interesting eclipsing variables studied at Kourovka Astronomical Observatory. These are massive close binaries with hot components for which some estimates of the circumstellar matter parameters were obtained by T. S. Polushina and her post-graduate student at that time, E. A. Avvakumova. The results of this work were published in the catalog of massive CBSs compiling physical, geometrical and evolutionary characteristics of these objects as well as features of their separate photometric solutions (Polushina 2002; Polushina 2004).

The changes in mass and orbital period are two key evolutionary parameters, which serve as an object of scrupulous attention and constant interest in new observational data on binary systems. Therefore, Svechnikov set the task to observe eclipses in binary systems for young observers first at the Kourovka Astronomical Observatory and then for astronomers at the Crimean Astrophysical Observatory of the RAS. The Pulkovo Astronomical Observatory of the RAS, the Astronomical Observatory of the Odessa National University named after I. I. Mechnikov and others were gradually involved in the observation program of eclipsing stars.

For a long time, Svechnikov kept in touch with a colleague from the SAO, T. A. Kartasheva, who conducted observations of the Wolf-Rayet star *CQ Cep* (Kartasheva & Svechnikov 2006).

In 1987, M. A. Svechnikov and E. F. Kuznetsova published a series of articles devoted to spectrophotometric research of *SD*-class binary *RZ Cas*. Photoelectric scans of integrated spectra of this eclipsing variable were obtained in October of 1977. The excess of the continuum radiation in the “active” phases out of eclipses (when strong emission lines were present) as compared to the “quiet” phases indicated the short-term appearance of an additional source of radiation with a temperature of about 25 000–30 000 K during the outbursts (Kuznetsova & Svechnikov 1977; Kuznetsova & Svechnikov 1984; Kuznetsova & Svechnikov 1987).

It is important to note the sixth catalog from the list, which includes the spectroscopic and photometric orbit data of *DMS*-systems, evaluated with high reliability (Perevozkina & Svechnikov 1999). Taking into account that all these systems were discovered in a photographic way, more valuable is that these data withstood a competition with the modern catalog by (Torres et al. 2010). Furthermore, these systems allowed solution of some problems with the tidal evolution in close binary systems on the basis of tidal torque constants, the calculation of which enabled estimation of the synchronization timescale for the stellar components, the time of their orbital circularization and also the apsidal period for eccentric binaries (Dremova & Svechnikov 2011).

Another interesting problem proposed by Svechnikov at the beginning of the 21st century concerned a class of spotted low-mass binaries of *RS CVn* type. This program was actively picked up by A. V. Kozhevnikova, who conducted observations for *CG Cyg, BH Vir, WY Cnc, IL Com, IN Com, V711 Tau* and *CM Dra* based on multicolor B, V, R, I-band photometry obtained with the 70-cm telescope and multichannel photometer at Kourovka Astronomical Observatory of the UrFU from 2003 to the present day (Kozhevnikova & Alekseev 2014; Kozhevnikova et al. 2018). This program led to close cooperation with the Crimean Astrophysical Observatory of the RAS, including joint observations and data processing using the multiparameter zonal model of Alekseev & Gershberg (1997).

Today, the search for a new classification covering a wide range of modern observational data of eclipsing variable stars is continued by E. A. Avvakumova and O. Yu. Malkov. One should emphasize that Svechnikov’s classification scheme is organically integrated into the new one, and now the modern electronic edition of GCVS already allocated 16 types of classified eclipsing binaries. Questioning the accuracy of this classification scheme is still ongoing, since only 74 percent of the tested systems from the Catalogue of eclipsing variables (Malkov et al. 2007) can be reliably classified (Avvakumova et al. 2013). It should also be noted that GCVS is constantly being updated (Samus' et al. 2017).

Mariy A. Svechnikov was the creator and leader of the scientific direction at USU named after A. M. Gorky on statistical research of close binary systems. He published five teaching aids, and 170 scientific papers in Russian and international journals, and among these publications there are 7 monographs. Catalogs by M. A. Svechnikov and his students have been handed over to the Strasbourg Astronomical Data Center. Under the leadership of Professor Svechnikov, ten Ph.D. theses were prepared and defended.

5 INTERUNIVERSITY COLLABORATION

Svechnikov paid special attention to interuniversity collaboration and he was in close scientific cooperation with Saint Petersburg State University, Odessa National University named after I. I. Mechnikov, CSU, Karaganda Pedagogical University, Chita Pedagogical University and also with a series of observatories such as Pulkovo Observatory of the RAS, Crimean Astrophysical Observatory of the RAS as well as with the Estonian Academy of Sciences and Uzbek Academy of Sciences.

6 STELLAR PORTRAIT

In the history of astronomy, many names of compilers of star catalogs have survived: the legendary Hipparchus, the famous Ulugbek, the unsurpassed Tycho Brahe, etc. The name of our teacher, Mariy Anatolevich Svechnikov, should be placed in this row, because he managed to create a new “format” for the star catalog, not limited to position coordinates and stellar magnitude, a standard that was established for almost two millennia. Of course, by the middle of the nineteenth century, catalogs began to “grow” with data on proper stellar motions and parallaxes, and spectroscopic data by the end of the 19th century.

Having chosen eclipsing variable stars for one's research, Mariy Anatolevich literally “plunged” into investigating the variety of shapes of light curves and radial velocity curves that were still waiting for their final “decoding” — at that time the methods for solving these curves were still being created. For almost half a century, the process of collecting observational information and its generalization was continued to create an objective classification system for CBSs. This allows one to go straight to the evolutionary status of the star, starting from direct observations (the orbital period, depths of the eclipses and so on), and in fact “restore” the portrait of the star.

This is not just an artistic metaphor. Many, especially those who studied with Mariy Anatolevich, remember that he, speaking in modern language, could “google” any eclipsing variable when there was no internet for research. It is a mystery in what detail he memorized them. In the catalogs published by him, the number of eclipsing variables varied from 197 to almost 4 000 stars, but his card catalog contained many more stars because he never stopped the process of data accumulating. In fact, he created a portrait gallery of stars, with a description of their physical, geometric, spectroscopic, photometric and other important characteristics.

Creating portraits of eclipsing variable stars, Mariy Anatolevich painted his portrait, as artists often do. It is a portrait of a man who generously shared his knowledge, observations, ideas and conjectures. It is believed that the most harmonious era in the history of humankind was the era of antiquity in ancient Greece, the philosophy of which professed principles of education and the need to share knowledge. Of course, in one lesson, it is impossible to make of a person educated, but it is quite possible to enlighten him or her, and in years and decades it is possible to teach and hand over experience and knowledge, as Mariy Anatolevich did. Actually it seems now that it was like the whole process was one lesson, after which a big deal began...

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