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Book of abstracts

Andronov, I. L.

Department of “Mathematics, Physics and Astronomy”, Odessa National Maritime University, Odessa, Ukraine

Improved Phenomenological Modelling of Multi-Component Signals: Applications to Variable Stars

Improvements of methods of time series analysis for signals with generally irregular distribution in an argument are reviewed. Astronomical photometrical surveys are typically irregular in time, obtained in space (Hipparcos/Tycho. Kepler, GAIA, WISE etc.) or using ground-based telescopes with CCD (NSVS, ASAS, CRTS, SuperWASP etc.) or photographic (Harvard, Sonneberg, Odessa etc.) equipment. This leads to the orthogonality of the basic functions, and thus the simplified methods give biased parameters of the approximations. In the commonly used methods, there is often a "matrix-phoebia".

We have elaborated a series of algorithms and programs for statistically correct analysis, and have applied them to 2000+ variable stars of different types. The data were obtained from an international collaboration in a frame of the "Inter-Longitude Astronomy" (ILA) campaign, as well as from the international databases. Some highlights of our studies are presented.

The main improvements were done:

1) for the periodogram analysis - the parameters are determined from a complete set of equations containing the (algebraic polynomial) trend superimposed on the (multi-) harmonic wave, so no "detrending", no "prewhitening" are used;

2) for the approximations - we use additional (multi-) harmonic waves, and also "special shapes" (patterns) for parts of the light curve, which correspond to relatively fast changes (minima of the eclipsing binaries, minima and maxima for the pulsating variables);

3) "Autocorrelation analysis" (ACF) - taking into account the bias due to a trend removal (previously - only a subtraction of the sample mean was taken into account); ACF for the irregularly spaced data;

4) for the signals with bad coherence, the "scalegram" analysis is proposed, which allows to estimate a characteristic cycle length and the amplitude, as well as to provide a realistic approximation;

5) the extension of the Morlet-type wavelet for more periodic signals;

6) "running" (parabola, sine) approximations for aperiodic and “nearly periodic” variations, respectively.

Although the methods were initially elaborated for the analysis of variable stars, some of them were applied by others in geo- sciences and even in a cardiology.

Andronov, I. L. (1), Andrych, K. D. (1) (2), Baklanov, A. V. (3), Bobrov, O (2), Breus, V. V. (1), Chinarova, L. L. (1) (2), Cook, L. M. (4), Dubovský, P. A. (5), Young-Beom Jeon (6), Yonggi Kim (7), Kolesnikov, S. V. (2), Kudashkina, L. S. (1), Kusakin, A. V. (8), Marsakova, V. I. (2), Medulka, T. (5), Mishevskiy, N. N. (9), Oksanen, A. (10), Petrík, K. (11) (12), Tkachenko, M. G. (1), Tsekhmeistrenko, V. S. (13), Tvardovskyi, D. E. (2), Joh-Na Yoon (7), Zoła, S. (14)

(1) Odessa National Maritime University

(2) Odessa National University

(3) Crimean Astrophysical Observatory

(4) priv. AO CBA Concord

(5) Vihorlat Observatory Humenné

(6) KASI, BOAO

(7) CBNU

(8) APhI

(9) priv. AO Ananjev (L33)

(10) priv. AO Hankasalmi

(11) AO & Planetarium, Hlohovec

(12) SU Opava

(13) priv. AO “Heavenly Owl”

(14) Jagelonnian University

"Inter-Longitude Astronomy" (ILA) Campaign: Some Highlights and Future Plans

We present some highlights of the campaign of studies of variable stars of different types, which is called “Inter-Longitude Astronomy” project. Recent review with a more extended list of co-authors of recent and on-going projects was published in 2017ASPC..511...43A. The project continues. The campaign has no additional financial funding, and is based on working groups supported by the host institutions from Ukraine, Slovakia, Czechia, USA, Korea, Poland, Kazakhstan, rarely Germany, Greece, Italy, Portugal, Spain and other countries. In our group, 2000+ stars have been studied, 376 papers listed in the ADS.

The main directions of the campaign are:

- Polar – photopolarimetric and spectroscopic study of gravimagnetic rotators in cataclysmic variables;
- Superhump – study of the precession of accretion disks in nova-like and dwarf nova stars;
- Symbiosis – symbiotic stars;
- Stellar Bell – analysis of multi-component pulsations of short- and long- period variable stars based on own photometric observations and the data from the international databases of AAVSO (USA), AFOEV (France) and VSOLJ (Japan) and CCD (ground-based or orbital observatories) photometrical surveys.
- Novice - Star classification and justification of suspected variables from surveys (space and ground-based observatories).

On-going projects on own monitoring and in queue for the publication:

- classical polars: AM Her, QQ Vul, V808 Aur;
- Asynchronous polars: V1432 Aql;
- Intermediate polars: FO Aqr, MU Cam, V1343 Her,V2306 Cyg, V405 Aur, AO Psc, DQ Her, V709 Cas;
- Superhumpers and weakly magnetic CVs: TT Ari, MV Lyr, dwarf novae;
- Extreme Direct Impactors: V361 Lyr, V549 Cam;
- Magnetic Dwarf Nova = Outbursting Intermediate Polar: DO Dra;
- Eclipsing and interacting binaries.

Analysis using own software of published data:

- Eclipsing binary stars: (catalogue of phenomenological characteristics, modelling migrating spots);
- Symbiotic: AR Pav;

- Pulsating: Mira, SR (catalogue of phenomenological characteristics), RR (Blazhko Effect).

Improvement of own software:

- MCV, NAV, MAVKA et al.

Andrych, K. D. (1) (2), Andronov I. L. (1)

(1) Department of Mathematics, Physics and Astronomy, Odessa National Maritime University, Ukraine

(2) Department of Theoretical Physics and Astronomy, Odessa National University, Ukraine

The zoo of the shapes of extrema and the net of methods to capture the best

The variety of types of variable stars and their light curve shapes leads to a necessity of diversity of functions used for the approximation. A special attention is paid to studies of possible period changes in eclipsing (and other interacting) binaries and pulsating variables. Here we introduce the computer program MAVKA, which uses almost a dozen of methods. Contrary to usual methods of algebraic polynomial approximation, where the user sets the degree, in our program, we compare polynomials of the degree ranging from 2 to 9 and choose the one corresponding to the smallest error estimate of the timing. For higher orders, the approximation becomes better, but the apparent waves at the approximation arise, making not only multiple extrema, but also an underestimated error (so an overestimated weight). Similar problem is with the symmetrical algebraic polynomials, if the gaps are located symmetrically. Other approximations are based on splitting the data interval into two intervals, and the time of symmetry is an additional unknown parameter. Another parameter describes the shape, using two terms in the power series of the functions proposed by Andronov (2012Ap.....55..536A) and Mikulášek (2015A%26A...584A...8M). This is effective for symmetric eclipses with only the bottom parts of the ascending and descending branches. Next series of functions is based on splitting the interval into 3 parts. The middle part is suggested to correspond to a total eclipse, and other parts – to the ascending and descending branches, respectively. Taking into account the abrupt incline/decline, we call these functions as the "wall supported" (“WS”; Andrych, Andronov & Chinarova, 2017OAP....30...57A). These are the line (WSL) and parabola (WSP). The first one is better for a total eclipse, and the second may be better for a transit of a smaller star or an exoplanet. For asymmetric extrema, e.g. of pulsating stars or eclipsing binaries with the O'Connell effect, we use the "asymptotic parabolae" (Andronov & Marsakova, 2006Ap.....49..370A) and its improvement – a parabolic spline of defect k=1, which allows to use wider intervals for an adequate approximation.

The methods are applied to the light curves of pulsating and eclipsing variable stars and to transits of exoplanets in a frame of the international campaigns "Inter-Longitude Astronomy" (“ILA”, Andronov et al., 2017ASPC..511...43A) , "Virtual observatory” and “AstroInformatics” (Vavilova et al., 2017IAUS..325..361V) .

Bahýl, V. (1)(2), Tinh Pham Van (3)

(1) Observatory “Júlia”, Zvol. Slatina, Slovakia

(2) Slovak Union of Astronomers

(3) Faculty of Information Technology, Nong Lam University Thu Duc Distric, Ho Chi Minh City, Vietnam

Doppler tomography and BM3 modeling of the close binaries and their surroundings

In our paper we are presenting our access to the Doppler tomography of the close binaries surroundings. We have studied and modeled the systems TT Hydrae and U Sagittae. Our results we have compared with the results of the prof. Mercedes Richards as the proof that there are correct and acceptable. More, from the photometric data we have realized the BM3 models of these both systems and we have compared them with the Doppler tomography ones.

Bazyey, O.

Odessa National University Research Institute “Astronomical Observatory”

About some computer developments for the children's astronomical society

In the Odessa Astronomical Observatory, the children's astronomical society has been conducting classes for 2 years already. Children age from 6 to 12 years.

We have created several children's educational computer applications. Among them are simulators "Constellations" and "Constellations at twilight". For novice observers of variable stars, we offer the Variable Stars simulator. The model

emulates the change in the brightness of stars and their flickering. Built-in calculator to determine the magnitude of the visual assessment of brightness by the method of Neyland-Blazhko.

A 3D model of the celestial sphere, showing the main circles and points, visibility conditions of the Sun and some constellations at different latitudes of the Earth is proposed. The model clearly illustrates changes in the horizontal, equatorial and ecliptic coordinates of the stars.

We hope that our development will be useful to other astronomical circles.

Bókon, A.

Observatory of Baja of University of Szeged

An MCMC fitting method for the analysis of eclipsed pulsations

It is a well known fact that we can determine the absolute physical parameters of eclipsing binaries (such as stellar radii and masses) via combined photometric and spectroscopic analysis. Nonradial pulsators in such systems offer an additional benefit, as the eclipses by the other component can „map” its surface, and the l and m nonradial mode numbers can be revealed for each pulsational frequency, which is an extraordinary opportunity for asteroseismic studies. Observations made by space observatories like Kepler could reveal 100 frequencies, which poses a challange for inversion methods due to the large number of variables, so application Markov Chain Monte Carlo analysis should be considered. In my talk I present an MCMC fitting method for this analysis, and its test results and implications. The challenge of a discrete parameter space can be solved, which is important for the appropriate sampling.

Briukhovetskyi, O. (1), Savanevych, V. (2), Dubovský, P. A. (3), Kudzej, I. (3), Khlamov, S. (4), Vlasenko, V. (1), Dikov, E. (5)

(1) National Space Facilities Control And Test Center, Kyiv, Ukraine,

(2) Main astronomical observatory of National academy of sciences of Ukraine, Kyiv, Ukraine,

(3) Vihorlat Observatory, Humenné, Slovakia,

(4) V. N. Karazin Kharkiv National University, Kharkiv, Ukraine,

(5) ScientificResearch, Designand Technology Institute of Micrographs, Kharkiv,Ukraine.

Automated light curves creation of variable stars: experience and prospects

Photometry of variable stars is a rapidly growing area of the observational astronomy. The software for automated light curves creation is needed to solve the modern problems in the photometry of variable stars. Otherwise, the observer has a large number of raw observations that are made on the quite expensive equipment. With automated photometry of variable stars, there should be easy to use the processing software and to receive the high accuracy of obtained results. The paper deals with a sequence of observer’s actions in preparing the light curves using CoLiTecVS software. It allows astronomer creating the light curves of investigated variable stars without manual-data handling between processing steps. Astronomer with a telescope and specified software takes images of the interesting sky areas where the investigated variable stars are located. These raw images will be moderated before its processing and the faulty/unsupported frames will be rejected by OLDAS system as soon as they are formed for speeding up the processing.

CoLiTecVS has the following workflow: forming the series of frames with the investigated variable star; brightness equalization of frames using master-frames and inverse median filter; preliminary segmentation of objects images; estimation of objects brightness and equatorial coordinates; frames identification; automatic selection of the reference stars in frame; brightness assessment of the investigated star using the developed computational method; preparing the task-file with selected comparison stars; processing of the photometric observations; light curve creation of the investigated variable star.

Particular attention is paid to the easy daily using of CoLiTecVS software during simultaneously frames receiving from the different telescopes and support by developers.

Dubovský, P. A.

Vihorlat Observatory, Humenné, Slovakia

Annual Report on Observational results of AO at Kolonica Saddle

Introductory presentation about observing program at Astronomical Observatory at Kolonica Saddle. Short overview of main observing campaigns

during last year, most important results, interesting light curves, new publications based on observations at AO Kolonica Saddle.

Gajdoš, P.

Institute of Physics, Faculty of Science, Pavol Jozef Šafárik University, Košice

New tool with GUI for fitting O-C diagrams

There are many different methods for fitting and analysing O-C diagrams. We present a new fitting tool for analysing O-C diagrams. Our method is based on Genetic Algorithms and Markov chain Monte Carlo. Monte Carlo method is used also to a very good estimation of errors of the parameters. Unlike many others fitting routine, our method does not need any initial values of fitted parameters. Fitting using presented software is quite simple thanks to a very intuitive graphic user interface. Currently, nine most common models of periodic O-C changes are included in this software.

Gális, R. (1), Merc, J. (1) (2), Leedjärv, L. (3)

(1) Institute of Physics, Faculty of Science, P. J. Šafárik University, Park Angelinum 9, 040 01 Košice, Slovak Republic

(2) Astronomical Institute, Faculty of Mathematics and Physics, Charles University, V Holešovičkách 2, 180 00 Prague, Czech Republic

(3) Tartu Observatory, Faculty of Science and Technology, University of Tartu, Observatooriumi 1, Tõravere, 61602 Tartumaa, Estonia

The peculiar outburst activity of the symbiotic binary AG Draconis

AG Draconis is a strongly interacting binary system which manifests characteristic symbiotic activity of alternating quiescent and active stages. The latter ones consist of the series of individual outbursts repeating at about a one-year interval. After seven years of flat quiescence following the 2006-08 major outbursts, in the late spring of 2015, the symbiotic system AG Dra started to become brighter again toward what appeared to be a new minor outburst. The current outburst activity of AG Dra was confirmed by the following three outbursts in April 2016, May 2017 and April 2018. The photometric and spectroscopic observations suggest that all these outbursts are of the hot type. Such behaviour is considerable peculiar in almost 130-year history of observing of this object, because the major outbursts at the beginning of active stages are typically cool. In the presented work, the current peculiar activity of the symbiotic binary AG Dra is presented in detail.

Horbachova, A. S., Bazyey, A. A.

Department of theoretical physics and astronomy, Odessa I.I.Mechnikov National University, Dvoryanskaya str., 2, Odessa, 65082, Ukraine

Optimization of the transfer trajectory to Near-Earth Asteroids

In terms of orbital elements, Near-Earth Asteroids with perihelion distance q less than 1.3 au [1] Taking into account the peculiarities of the orbit of the NEAs [2], the possibility arises of making a transfer to the NEAs of an interplanetary probe within the sphere of the Earth's influence.

To simulate of the transfer trajectory, we selected the NEAs according to the following criteria: small orbital inclination to the equatorial plane, time that corresponds to the minimum distance between the NEAs and the Earth not later than 2050 and heliocentric velocity of the asteroid in the Near-Earth space must be at least as different from the heliocentric velocity of the Earth [1, 3].

We stopped at a high circular geocentric waiting orbit for the interplanetary probe with a radius of 196260 km.

To construct a transfer trajectory from a geocentric waiting orbit to a meeting point with an asteroid in a heliocentric orbit, we applied the orbit search method behind two radius vectors. Thus, in the first approximation, the Keplerian transfer trajectory, that is, the approximation of the two-body problem, is used. We assumed that the control pulses of the engines of the interplanetary probe are instantaneous.

In the future, we calculated the Kepler elements of the orbit of the motion of the interplanetary probe along a hyperbolic transfer trajectory to approaching an asteroid. The main requirement for flight orbit: minimal change to speed spacecraft and the minimum angle between the velocity vector in the transfer trajectory with the velocity vectors in the waiting orbit and on the asteroid's trajectory.

Movement of the spacecraft on the transfer trajectory towards convergence with the asteroid 2013 GM3 possible with implement a gravity assist maneuver in the gravitational field of the Moon. To do this, we performed a numerical integration of the equations of motion of the asteroid and the spacecraft in Near-Earth space, taking into account the perturbations from the Moon and the Sun. We used the implicit method Everhart 15th order [4].

As a result, we selected start points respective to the smallest angle between the velocities of the spacecraft and asteroid 2013GM3 at the meeting on April 14 at 14:00 - 23.10. The change in the velocity of the spacecraft on the transfer trajectory with the speed in the waiting orbit is 2.9 km per s, the change in the velocity of the spacecraft on the transfer trajectory with the velocity in the trajectory of the asteroid is 3.2 km per s.

The obtained characteristics of the space maneuvers are extreme, but further optimization may make it possible to reduce the angles between the trajectories and the increase in speeds.

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Jäger, Z.

Baja Observatory, University of Szeged. Hungary

A numerical optimization code for supernova light curves

Supernovae are extremely energetic explosions, which highlight the violent deaths of various types of stars. Studying such cosmic explosions may be important because of several reasons. Supernovae play a key role in cosmic nucleosynthesis processes, and they are also the anchors of methods of measuring extragalactic distances. Several exotic physical processes take place in the exploding ejecta produced by the explosion.

In my work I modeled the brightness as a function of time (i.e. the light curve) with numerical codes developed by myself and others. The code uses Marcow Chain Monte Carlo (MCMC) algorithm to search and determine the most important basic physical parameters of the supernova, i.e. the radius of the progenitor star, the mass of the ejected envelope, the mass of the radioactive nickel synthesized during the explosion, etc without supervision from the user.

Kudzej, I.

Vihorlat Observatory, Humenné, Slovakia

From Kolos to Kolos

Traditional talk about the gradual development of the Astronomical Observatory at Kolonica Saddle.

Mackovjak, Š., Bobık, P., Strharský, I., Baláž, J., Putiš, M.

Department of Space Physics, Institute of Experimental Physics, Slovak Academy of Science, Košice, Slovakia

Airglow Monitoring by One-pixel Detector

The night time UV radiation composed of airglow, starlight, and zodiacal light act as a background for detection of the Extensive Air Shower (EAS) fluorescence induced by Ultra-High Energy Cosmic Rays (UHECR). To monitor this background, we have developed the one-pixel instrument that provides the absolute intensities within the spectral range 300 – 480 nm in the one second temporal resolution. The Airglow MON-itor (AMON) instrument is designed to be simple, resistant, and to operate in full automatic mode. Therefore it could be placed in various locations and provide long-therm measurements. The first results demonstrate that the data might be useful not only for the high-energy astrophysics purposes but also for the studies of the airglowdynamics. Especially, location with very good observational conditions, like at Astro-nomical Observatory on Kolonica Saddle, is very convenient for extension of AMON program for the airglow science.

Marsakova, V., Andrych, K.

Odessa Mechnikov National University

Periods and eclipse shape analysis of eclipsing symbiotic star AR Pav

AR Pav is the S-type symbiotic variable with regular eclipses of hot component with period of 604,5 d. For our analysis we use the AAVSO observations that show the long-term transition from high to low state (in accretion activity), eclipses and the variability in non-eclipse state. We analyzed the non-eclipse variability (to confirm or refute the pulsating activity of red giant) and variability in the eclipses separately. To analyze the changes in the eclipses shapes we use the several methods of approximation realized in the Mavka program.

Mitnyan, T. (1), Szalai, T. (1), Vinkó, J. (1) (2)

(1) University of Szeged, Hungary

(2) Konkoly Observatory, Hungary

Correlations between chromospheric activity and physical parameters of contact binary stars

There are lots of contact binaries that show activity signals, and stellar activity can alter the formation and evolution of these systems. One of these signals is the emission excess observed in several ultraviolet and optical absorption spectral lines (Ca II H+K, Mg II, Hα), which indicates ongoing chromospheric activity. As different systems have different physical and orbital parameters, the strength of chromospheric activity can also be different, hence, it seems to be evident that there is a relation between these quantities. In previous studies on contact binaries, this topic has been investigated only in the ultraviolet domain involving the Mg II line; they show that there is a correlation between the strength of the chromospheric activity and of several quantities e.g. orbital period, B-V colour index, or the logarithm of the inverse Rossby-number. There are no comprehensive studies in the literature based on the analysis of the optical Hα-line, however, the equivalent width of this spectral line can be also used to measure the strength of the chromospheric activity. Therefore, our main objective is to find possible correlations between the strength of the chromospheric activity on contact binary stars and all of their physical and orbital parameters that can be derived from our observations. In order to make a decent statistical analysis, as many targets have to be observed as possible. For this purpose, we regularly obtain spectra with the 1m telescope located at Piszkés-tető Mountain Station, Hungary. For fainter targets, we occasionally observe with the 2m telescope of Rozhen Observatory in Bulgaria. To increase the number of the derived quantities and construct a detailed physical model of the observed targets, we also try to obtain simultaneous photometric measurements with the 0.5m telescope at the Baja Astronomical Observatory, Hungary. This also allow us to study the more interesting or peculiar systems in more details, for example getting a deeper insight in short-scale variations of the photospheric and chromospheric activity (within one night), as can be seen in our recent paper, Mitnyan et al. 2018 (A&A, 612, A91).

Papp, S. (1), Hegedüs, T. (2)

(1) University of Szeged, Hungary

(2) Baja Observatory, Hungary

Polarimetry of variable stars in open clusters (POSTER)

We observe open clusters with various distances (300-7000 pc) and ages (10^7 - 10^9 years) containing X-ray binaries with B,V,R,I and linear polarization filters. Our first goal is to determine the distribution of these binaries in their cluster. Besides our own observations we use data from Gaia DR2 to retrieve the accurate distance of stars, and other catalogues to classify the X-ray binaries. With imaging polarimetry we can estimate their relative distances in the cluter, decide whether they are members of the cluster or not, in addition get information about the amount of intracluster dust.

Parimucha, Š., Čokina, M

Institute of Physics, Šafárik University in Košice

Classification of eclipsing binaries by machine learning algorithms

Research of eclipsing binaries is based on investigation of their lightcurves. In the last decades, several thousands of new eclipsing binary stars was discovered and one can expect that a huge amount of them will be discovered by existing and planned ground-based and space surveys. Only few of them (~300) have been analysed in details.

Such a large number of eclipsing binaries does not allow their manual analysis anymore. Nowadays, there are a lot of attempts in many areas handled a big data with an artificial intelligence. In this contribution, we will present several ideas how to use machine learning algorithms in classification of binary star systems.

Skulskyy, M. Yu.

Lviv Polytechnic National University, Lviv-79013, Ukraine

Magnetic field and accretion in the Beta Lyrae system

We conducted long-year spectral observations of the interacting massive Beta Lyrae system on powerful telescopes. As to this topic, the magnetic field of the donor was discovered and investigated, as well as the dynamics of the circumstellar gas and the structure of the disk around the accretor formed as a result of the active mass transfer were studied. These studies were required to be correcting due to the results of new simulations of light curves. Confirming the significant contribution of the radiation of the accretion disk to the light curve of the Beta Lyrae system, hot areas on the rim of the disk facing to the

donor were fixed. It was suggested that these areas may be formed by collisions of gas streams with a disk but without appropriate arguments. Here, there is offered a physical mechanism for the formation of such hot areas on the disk rim which is due to the effect of the donor's magnetic field on the moving gas in space between the components of this system.

We have studied the curves of the change in the magnetic field and the curves of changes in the intensities and radial velocities of the spectral lines with the orbital phase, taking into account the results of absolute spectrophotometry, polarimetry and photometry. It is shown that the spatial structure of mass transfer between the components of the Beta Lyrae system is essentially due to the specific configuration of the donor magnetic field. The energy effect of collision with a disk of magnetized plasma, which is canalized by the donor's magnetic field towards a massive acretor with speeds of 100-700 km/s, is amplified by counter rotating the rim of the disk at speeds of 250 km/s to the gas falling on the disk. This leads to the heating of practically the entire rim of the accretion disk facing to the donor in the phases of both quadratures. Also the gas shell is generated which partially masks the components of the Beta Lyrae system beyond the Lyman limit and entirely in the soft X-ray range.

Tvardovskyi, D. E., Marsakova, V. I., Andronov, I. L., Shakun, L. S.

Odessa, Ukraine

Period variations and possible third components in several eclipsing binaries

In our research we investigated 14 eclipsing binary stars with different types of period changes. To analyze them, we used data from BRNO and AAVSO databases. We divided them into five groups according to these types of period changes. In the first group there are two stars which have sinusoid-like period changes – KR Cyg and BX And. We explain this type of period changes as the possible presence of the third component as the factor which causes light-time effect (LTE). For these two stars we supposed that the orbits of the third components are circular. For another four stars (V0382 Cyg, U Peg, WZ Cyg and V0523 Cyg) which form the second group, we detected that cyclic period changes were combined with steady ones. We explained steady period changes as the mass transfer between components. The third group consists of three stars (BF Aur, SX Aur, V0388 Cyg) which have mass transfer but no cyclic period variations (within the errors of observations), thus we did not supposed any additional components in there systems. The fourth group is the smallest one, it consists only of one star – ZZ Cas. Actually, this star is not usual because of the clear asymmetry in the period changes. So, we supposed that it also has the third component but with elliptical orbit which is inclined relatively to observer. Finally, the fifth group (AH Tau, EP And, AR Lac and BF Vir) are the stars which have both mass transfer and presence of the third component with elliptical orbit. For all stars with possible presence of the third components we calculated minimal possible masses of the third components. For stars with mass transfer we calculated its rate. Moreover, for stellar systems with elliptical orbits of the third components we computed orbital elements of these orbits using our own program in computer language Python.