Optical Counterparts of the X-ray Sources Hercules X-1 and Cygnus X-2: Genuine and Fake

V. P. Goranskij

1Sternberg State Astronomical Institute,
Moscow State University, Moscow, 119992 Russia

This paper is a refutation of two researches by A. N. Sazonov on HZ Her and V1341 Cyg published in the Astronomy Reports (Vol. 55, p.p.142 and 230) in 2011. We analyzed his photometry along with other data collected in the literature and Internet. The observations of Sazonov are fake and are not related to real stars. Conclusions contained in his papers do not constitute any scientific value. We describe the properties of these two objects, derived from real observations. The following papers based on the same fake observations and published by him in astro-ph arXiv 0904.0168, 0907.3822, 0912.0706, 1011.3980, and 1102.0379 are also inauthentic.

I. INTRODUCTION

Her X-1 is an eclipsing X-ray system, consisting of a neutron star with the mass of about 1.4 $M_{\odot}$ and a star of A7 spectral type with a mass of 2.2 $M_{\odot}$, which fills its Roche lobe and is an accretion donor [1]. In the optical range the star is known as HZ Her. The orbital period of the system is 1.7 days. A wave with this period dominates in the optical light curve. This large-amplitude wave (1\textsuperscript{m}.7 in the $B$-band) is formed due to the reprocessing of X-rays coming from the neutron star on the surface of the donor, facing the neutron star (reflection effect). The neutron star is an X-ray pulsar with a period of 1.24 s.

Cyg X-2 is also an X-ray system, which includes a neutron star with a mass of 1.7 $\pm$ 0.2 $M_{\odot}$ and an optical component – an accretion donor of the spectral class A5 - F2 III, whose mass is estimated to be 0.6 $M_{\odot}$ [2]. The optical counterpart of this system is known as V1341 Cyg. The inclination of the orbit to the line of sight is 62.5 $\pm$4\textdegree, and the orbital period amounts to 9.84450 days. Since the radial velocity of the system $\gamma = -210$ km/s,
the star is the object of the spherical component of Galaxy population, and based on its photometric properties its optical component is likely to be a blue straggler [3].

In 2011, the Astronomy Report (Russian Astronomicheskii Zhurnal) published two papers by A. N. Sazonov describing the multi-color $W\,B\,V\,R$ photoelectric observations of the optical counterparts Her X-1 [4] and Cyg X-2 [5]. The first glance at Figs. 1 and 2 in [4] gives doubts about the authenticity of the observations of HZ Her, since the light curves in different filters are lacking the primary eclipse with a ”flat bottom.” It is known that in the primary eclipse of HZ Her the occultation of the accretion disk occurs. Usually in certain phases of the eclipses, we observe characteristic brightness variations, that occur at the ingress of the precessing disk behind the companion star, and egress from behind it. These brightness variations occur at different rates and depend on the ”on” and ”off” state of the X-ray source there [6]. The study of Sazonov [4] did not reveal such brightness variations. Similar doubts arise on a closer examination of the V1341 Cyg light curves in Fig. 1 of [5], where all the filters clearly show the eclipse-like minima: a deep and narrow minimum around the orbital period phase 0.0, and a shallow minimum around the phase 0.5. So far, this system with a small orbit inclination has only revealed the ellipsoidal brightness variations of the secondary component, which were superimposed by the chaotic variability. The amplitude of the chaotic variability increased from the visible to the ultraviolet range [3].

The eclipse in the system of HZ Her, the presence of a neutron star and an accretion disk surrounding the neutron star and precessing with a period of 35 days are firmly established facts, with the participation of independent observers working in different ranges of the electromagnetic spectrum. The star has also revealed abnormal states. It is known that the system was inactive for seven years between 1934 and 1940, when it lacked the reflection effect and the ellipsoidal effect of its optical component [7]. In this event, the star remained eclipsing, and its light curve revealed two brightness minima with the depth of about 0\,m.5. HZ Her was reported to have cases of abnormally low states in X-rays (ALS), when the flux was very weak and did not reach its normal high level in the ”on” state. Abnormally low states lasted for several 35-day cycles [1]. However, the optical light curves in the ALS were not different from those observed in the normal ”on” state. Abnormal states with brightness levels lower than in the quiescent state, which is characterized by an ellipsoidal light curve were also observed in visible light in V1341 Cyg [3]. The possibility of occurrence of abnormal states has to be taken into account when considering the observations of A.N. Sazonov.
To test Sazonov’s observations, we compared his tabular data, put out in the Internet and accessed from the references in [4] and [5] with the observations of other authors and with the observations of the SuperWASP-N robotic telescope [8], mounted on the La Palma island (Roque de los Muchachos Observatory, Canary Islands, Spain). The data on HZ Her used for comparison, is a collection of photoelectric multicolor observations in the $U(W)BVR$ bands in the time interval JD 2441511 – 2451046 (1972 – 1998). This database was analyzed earlier by N. I. Shakura et al. [9]. It is supplemented by the unpublished observations of V. M. Lyutyi and I. B. Voloshina, it contains 5936 observations in the $B$ band and a smaller number of observations in the $U(W)$, $V$ and $R$ bands. The database [9] was amended: the magnitudes were corrected to bring the discordant observations in the same photometric system, and some clearly erroneous observational nights were eliminated. The database does not contain Sazonov’s earlier published observations [10]. Sazonov’s tables [4] contain 1808 observations covering the period of JD 2446588 – 2448173 (1986 – 1990) and overlapping in time with the database in [9]. This time interval [9] contains 977 observations, which were made by independent groups of observers: Lyutyi and Voloshina [11] and Kilyachkov et al. [12]. On November 2, 2011 the table of observations of HZ Her was changed by Sazonov, when 133 observations were deleted from it and 42 observations were added. The new table is also analyzed in the present paper. The SuperWASP-N observations were obtained in the period from May 2004 to August 2007 (JD 2453129 – 2454681), and their number amounts to 41942. These observations have previously been analyzed in [1]. The system of these observations is reduced to $V$, the time is measured in seconds from JD = 2453005.5, and radiation fluxes are given in the Micro-Vega units, related to magnitudes via the formula \( \text{mag} = 15 - 2.5 \log(\text{Flux}) \). The accuracy of these observations differs a lot, and therefore from the whole data set we have selected 32143 observations, the accuracy estimate of which does not exceed 0.08$^{\text{m}}$. The nights with conflicting data were removed. It was easy to determine the cause of the controversy: observations were made with two cameras installed at the same mount, the object is located in different parts of the cameras’ field of view, simultaneous observations are not tied to the comparison stars, and are hence systematically different. The time points of the SuperWASP tables are converted into Julian dates, and fluxes – in magnitudes.

To establish the reliability of Sazonov’s data on the object V1341 Cyg [5], we used the photoelectric $UBV$ observations from his earlier work [13], photographic observations of
M. M. Basco et al. [14] in the $B$ band, photoelectric $UBV$ observations of V. M. Lyutyi from [3, 15], and CCD observations of the author in the $UBV$ filters, performed with the 1-m Zeiss-1000 reflector of the SAO RAS, the Maksutov 50-cm meniscus telescope and the 60-cm reflector of the Sternberg Astronomical Institute Crimean Station. The photographic observations [14] were obtained with the Maksutov 50-cm telescope and feature the microphotometric measurements with an iris photometer. The full-time span of these observations is limited by the Julian dates JD 2442247 – 2455826 (1974 – 2011). The observations from [3, 14, 15] and CCD photometry have been reduced to a single photometric system of the SAO RAS. A collection of observations of the author is available for viewing with a Java-compatible browser on the Internet at

http://jet.sao.ru/~goray/v1341cyg.htm,

the table of observations is contained in the file

http://jet.sao.ru/~goray/v1341cyg.ne2.

The first column of the given table sets time points in the JD hel.– 2400000.0 format, the four subsequent columns contain observations in the $V, B, U,$ and $R$ order, and the last column contains the mark of two letters or numbers indicating the observational data source. At the time of analysis the file contained 1749 observations in the $B$ band, 743 sets in the $V$ band and 589 - in the $U$ band. Sazonov’s table from [5] contains 296 night-averaged $W BV R$ values in the time interval of JD 2446616 – 2448521. The number of observations of V1341 Cyg by the robotic telescope SuperWASP-N is 6444. The date of the countdown and intensity scale is the same as that for HZ Her. All the observations of SuperWASP-N were converted to Julian dates and magnitudes. The sample of observations was compiled based on the same features, as for HZ Her. The selected observations fall in the time interval from June 2004 to November 2007 (JD 2454279 – 2454419, 88 nights), and their number is 4053.

We have also analyzed the observations of these two X-ray sources made by the RXTE orbiting observatory with the ASM camera in the X-ray range of about 2 – 15 keV, available at the website

http://xte.mit.edu/ASM_lc.html.
II. METHODS OF ANSLYSIS

To identify and study the periodic components in the light curves, we used the methods of Lafler-Kinman [16] (phase dispersion minimization, PDM) and Deeming [17] (Fourier transform of discrete time series). We applied the EFFECT code, implementing these methods in the OS Windows environment and written by the author of this article. The software and user guide are available at

http://vgoray.front.ru/software.

The first method [16] is the most convenient to refine the orbital period of the system HZ Her, in which the light curve is dominated by the reflection effect. The second method [17] is applicable for the identification of the ellipsoidal effect wave from the chaotic light variability of V1341 Cyg, which has a relatively small amplitude. The software allows to calculate the average light curves of the periodic components, smooth them by hand and subtract by the phase from the light curves (prewhitening procedure).

As known, the optical photometry of HZ Her shows a wave with an orbital period of 1.70017 day [18, 19]. Residuals after subtracting the wave reveal the period of 1.62 days. This is the beat period between the precession period and the orbital period [20]. The period of precession of the accretion disk is not detected in the residuals neither by the methods of dispersion minimization, nor by the Fourier transform, although the shape of the orbital light curve varies with this period. The lack of precession frequency in the residuals is due to the fact that in different orbital phases, precession brightness variations are either not visible (in the eclipse) or visible, but are caused by different reasons (precession of the disc itself, or the drift of the shadow from the plane of the disc over the stellar surface facing it). For these reasons, brightness variations with the precession period are in the phase opposition in different orbital phases. The author (V. P. Goranskij) proposed a computer-based method for finding periodicity in the light curve shape variations [21, 22] which makes it possible to identify and refine the periods of precession, or the light curve amplitude modulations (e.g., for the RR Lyrae type variable stars with the Blazhko effect). In the computer search of the periodicity, we usually test the trial periods in a fairly wide range in rather small steps in frequency, not to miss the real period value. Searching for periodicity via the Goranskij’s method, the computer memory builds the light curves with the known primary period (of the orbit or pulsations), separated by the phase intervals of the secondary trial period (precession
or amplitude modulation). As the dispersion parameter, similar to the method [16], we used the sum of squared deviations of each light curve point, subsequent in phase of the main period from the previous one. The parameter, on which we based our search, is the ratio of dispersion of the total light curve to the dispersion of light curves, divided by the phase of the secondary trial period. When the value of the trial period approached to the actual value, dispersion in the divided light curves sharply reduced, resulting in the parameter increase, and a peak appearing in the periodogram. The method allows to refine two periods of the system with the precessing disk, both orbital and precession [22]. This method was used to determine whether there exists a precession period in different sets of observations of HZ Her.

III. RESULTS OF ANALYSIS

A. HZ Her

An analysis of four series of observations of HZ Her has revealed the periods of the orbit $P_{orb}$, of the beats $P_{beat}$, and precession $P_{prec}$ (Table I). The parentheses give the errors of period determination in units of the last digit, the abbreviation LK, D, G imply the following methods of analysis: Lafler-Kinman, Deeming and Goranskij. To study the period variations we used the O–C method. The line ”JD 24...” shows the time range of the observational set, and the ”N” line gives the number of observations. An asterisk indicates the periods determined from a part of observations, the sample was compiled based on the phase of the orbital period in the ranges of $\varphi = \pm (0.08 – 0.14)$.

The orbital period is most precisely determined from the Doppler shift of the HZ Her pulsar pulses in the X-ray range [23]. The variation of the orbital period occurred between the values of $1^d.700167790 (10)$ in the time range of JD 2441300 – 2445120 and $1^d.700167504 (7)$ in the range of JD 2445120 – 2451000. The period variation may have been smooth in this time range. Such tiny variations in the orbital period can not be registered by the photometric method. Orbital periods, determined from all the four rows, do not contradict with the data of [23] within the error. The light curves with the orbital period are shown in Fig. 1 from the data collection by N. I. Shakura and colleagues [9], b – according to SuperWASP [1], c – according to A. Sazonov [4], d – according to the data of the collection
of observations in [9], only related to the time period, which includes Sazonov’s data [4]. At the bottom (e) you can see the orbital light curve according to the RXTE orbital observatory in the 2-15 keV X-ray range.

The optical light curves of HZ Her (Fig. 1 a, b, d) reveal a decrease in the dispersion of observations near the orbital phase \( \varphi = 0.0 \) – eclipses of the accretion disc. Minimum variability is observed in the largest phase of the eclipse, when the light of the back side of the companion (A7-type star) dominates. The variability is reduced because in this phase the highly variable brightness of the precessing disk and the hot spot on the side of the companion facing it is not visible. The data by Sazonov [4] (Fig. 1 c) show the equal dispersion during all phases. With the negligible dispersion of individual rows of monitoring in [4], reflecting the high accuracy of his data, the scatter of points in the zero phase remains maximum. This means that the data in [4] lacks any traces of the eclipse of the precessing accretion disc. Such a behavior of the star in the same period of time is not supported by the observations from the collection by Shakura et al. [9] acquired at the same time (Fig. 1 g).

The X-ray range (Fig. 1 e) near the zero phase reveals a total eclipse of the source lasting 0\(^d.24\). Phases of the beginning and end of the eclipse are \( \varphi = \pm 0.0706 \) relative to the middle of the eclipse. In this diagram, we do not observe the zero flux in the phase of the eclipse only because of the insufficient measurement accuracy of the ASM instrument on the RXTE orbiting observatory, where the measurement accuracy near the zero level amounts to 2.5 cps. At a low or zero flux, which is observed during the eclipse and in other orbital phases in the low ”off” state, the counts prove to be positive or negative (below zero) with equal probability. When the eclipse is viewed in the X-ray range, the occultation of the pulsar appears and pulsating radiation disappears. Before the eclipse, the phases \( \varphi = 0.80 - 0.90 \) of the X-ray orbital curve reveal a large depression because of the numerous short-term X-ray fall-offs (e.g., described in [24]), which are explained by the overlap of the X-ray emission by the thickening at the edge of the accretion disk (a blob), emerging in the region of the collision with the accretion stream [25]. Fast recessions and even flickering of the X-ray source in some phases of formation of this blob may be associated with the separation of the blob into sprays, which move on Keplerian orbits above the disc plane [26]. Ignan and Leahi [24] presented a survey of alternative explanations and patterns of this phenomenon, which is, however, not observed in the optics.

The secondary eclipse also looks unusual in Sazonov’s data [4], during which there occurs
a transit of the precessing accretion disk in front of the companion against the hot spot on the companion’s surface (reflection effect). Observations [1] and [9] indicate that the secondary eclipse is not always visible or its amplitude is small, although it can be deep. The largest depth of the eclipse is observed in the high ”on” state of the 35-day cycle. At the same time when the secondary eclipse has the greatest depth, the amplitude of the reflection effect wave decreases. These features of the light curves of HZ Her have been well demonstrated in Fig. 5 by Gerend and Boynton [20]. In Sazonov’s data [4], deep secondary eclipses occur in all the phases of the precession cycle if these phases are counted from the elements determined from the observations [1] and [9]. It is easy to explain the appearance of deep secondary eclipses in the ”on” state. In these phases the accretion disk is open to the observer on Earth, and when passing in front of the secondary component, the surface of which has a bright hot spot, it covers the largest area of this spot. Moreover, the shadow of the plane of the disk is visible separately therefore the area of shadow additionally reduces the spot brightness. In the ”off” state, the disk is visible ”edge-on”, and in the orbital motion, as viewed by an external observer, it moves along its shadow, so the loss of brightness of the hot spot for this observer is minimum, the eclipses are almost invisible, and the amplitude of the reflection effect gets maximum. If the secondary eclipse was in fact always deep, as stated in Sazonov [4], the accretion disk would be always open and only towards the observer, which is a nonsense and contradicts the X-ray data, clearly demonstrating the high and low states.

Fig. 2 shows the fragments of the orbital light curve of HZ Her, built in the orbital phases near the primary eclipse. During the main eclipse, the precessing accretion disk, which is a highly variable object, gets covered. The observations [1] and [9] (Fig. 2 a, b, d) near the zero phase show an area of the ”flat bottom” with minimum variability, when the disk is completely covered. A careful study of these observations in the ”flat bottom” area in different eclipses sometimes reveals small-amplitude variations, such as jumps or trends of the light curves, but these variations are small and are in fact the radiation of the circumstellar gas, not obscured in the eclipse.

When the precessing accretion disk comes into eclipse, the brightness decay rate varies depending on the opening angle of the disk towards the observer, resulting in a gradual reduction of the dispersion of observations. When the eclipse is ending, the dispersion of observations increases for the same reason. In Sazonov’s data [4], the brightness variation rates are about the same, the scattering of certain light curves does not change even near the
zero phase, hence, the eclipse is missing in these phases (at that, however, a deep secondary eclipse is present). This is nonsense, from which it follows that the data [4] is spurious. The main eclipses were always observed in this system, both in the X-rays and optics, and even when the reflection effect was off. The presence of the primary eclipses is confirmed both in the sample of data [9] in the same time range, which includes the data of [4].

When the neutron star, which is the X-ray source, gets covered, the hot spot of the reflection effect becomes invisible for the terrestrial observer. In the narrow range of orbital phases 0.03 after the neutron star is covered by the limb of the secondary component, and in the same phase interval prior to the opening of the neutron star, the accretion disk is partly visible, and we can observe its precession from the opposite sides. Prior to the first contact of the neutron star and after its last contact, a large part of the accretion disk or the entire disc is visible, but the contribution of the hot spot proves to be significant (which looks like a narrow crescent moon in these phases). Near the contacts, while the contribution of the disk is relatively small, the effect of the hot spot can be compensated in order to extract the light curve which is due only to the precession of the disk. To do this, we subtracted the average orbital light curve by the orbital phases, and selected in the excess file the observations from the orbital phase ranges 0.86 – 0.92 and 0.08 – 0.14. From this sample, from different series of observations, we can determine and refine the precession period by the Lafler–Kinman method from the dispersion minimum. For the sample from the collection of Shakura et al. [9], it becomes equal to $34^d.89 \pm 0^d.01$ (Fig. 3 a), and from the sample of SuperWASP data [1] it amounts to $34^d.75 \pm 0^d.05$ (Fig. 3 b). In the sample of these orbital phases, we can observe the precession of the accretion disk "in its purest form". The light curve, constructed in accordance with the precession phase, shows two peaks: a high peak - opening the disc "from above", and a low peak - opening the disc "from below". In the corresponding sample of Sazonov's data [4] this period is completely lacking (Fig. 3 c).

The stability of the precession period (the accuracy of the "35-day clock") has been studied in [27] from the X-ray data. The O–C curves were determined from the time of switching the X-ray source "on", from the time of absorption recession occurring in the X-ray light curve and from the optical light curves via the method proposed by J. Deeter [27]. According to Deeter, the precession phase can be refined from the three-dimensional phase diagram orbital phase–precession phase–deviation from the mean orbital light curve. All
these methods have shown such variations of the precession cycle that the O–C deviations vary within 6–7 days, i.e. up to 19% by the precession phase ([27], Fig. 1). Fig. 3 a, b show the way the light curve is floating exactly within the same precession period phase interval. However, the graphs show the precession curve with two brightness peaks: with a maximum around $\varphi = 0.15$, corresponding to the high ”on” state, and with a maximum around $\varphi = 0.65$, corresponding to the low ”on” state in the X-rays. These states correspond to the opening of the accretion disk from the top and the bottom.

The stability of the precession period of HZ Her from the RXTE/ASM X-ray data was studied in [28]. Precession variations of the X-ray flux are observed in all phases of the orbital period, except for the primary eclipses. In the X-ray range the light curve of the precession period is not disturbed by the influence of the reflection effect and the movement of the shadow on the companion’s surface, and thus resembles the curve in the visible range that we have identified in the narrow range of orbital phases (Fig. 3 a, b). The precession phase curve has the form of a double wave with high and low ”on” states, and in the ”off” states the flux is near the detection level ([28], Fig. 2). The RXTE/ASM satellite recorded two abnormally low states (ALS), at which the precession curve with a double wave was absent, and the radiation flux remained at a low level: JD 2451280–2451647 (April 1999–March 2000) and JD 2453003–53091 (January – March 2004). The X-ray orbiters RXTE/PCA and BeppoSAX have registered in the state of ALS in 1999–2000 the X-ray emission of the pulsar, reflected by the secondary component. The intensity of the pulsar varies with orbital period [29, 30]. In the optical range there are 445 NSVS database observations for this ALS episode

http://skydot.lanl.gov/nsvs/nsvs.php,

which confirm that at this time the reflection effect was present in the visible range, and its amplitude was $0^m.7$ (CCD without the filter). These observations suggest that direct X-ray emission in the ALS was blocked in the direction of the terrestrial observer as a result of changes in the structure of the disk, while the central X-ray source had a normal luminosity and irradiated the surface of the companion. However, no optical or X-ray observations provide information about whether the precession of the disk persisted during the ALS. Our O–C analysis of the 35-day periodicity according to the up-to-date RXTE/ASM data in the range of JD 2450087–2455817 shows the precession period variability between 34.5 – 35.2
days. This causes phase shifts of the precession curve with the amplitude of 13 days with respect to the linear elements, what is demonstrated in Fig. 3 d.

The analysis of periodicity in the residuals after subtracting the mean light curve of the orbital period (the reflection effect) was carried out using the Deeming method, and its results are summarized in the third row of Table I. In the data of [1] and [9] the beat period $P_{\text{beat}} = 1.621$ is present, coupled with the precession period $P_{\text{prec}} = 34.9$ and orbital period as follows:

$$P_{\text{prec}}^{-1} = P_{\text{beat}}^{-1} - P_{\text{orb}}^{-1}.$$ 

Sazonov’s data [4] lacks the beat period.

The precession period was found and refined from the optical observations of [1] and [9] by Goranskij’s method, including all phases of the orbital period. The results are given in Table I, and the periodograms are shown in Fig. 4. These calculations have shown that the period of precession in the data of Sazonov [4] is missing absolutely. However, the precession period is present in [1] and [9], it is also present in the sample from the collection of [9] in the same time range to which pertains the data in [4]. The precession period is detected despite its variability and small shifts of the precession light curves by phase. This fact indicates that Sazonov’s data are fake, and precession brightness variations were not included during their preparation.

Comparing the collection by Shakura et al. [9] with Sazonov’s data [4], we found two nights during which the long monitoring series coincide in time, and which belong to the phases when the accretion disk leaves the primary eclipse in the ‘on’ state. These are the nights JD 2447365 and 2448062. During these nights Sazonov’s data [4] coincide in time with the observations of Kilyachkov et al. [12]. The light curves in $B$ and $U$ ($W$) filters are compared in Fig. 5. The differences between the data of [9] and [4] in the $B$ filter reach $0.3$, and in the ultraviolet filters they are up to $1.0$. The differences in the ultraviolet light curves of the $U$ and $W$ filters can not be explained by the differences in the filter response curves only. The reason of such large differences is obvious: in the process of counterfeit, Sazonov’s data failed to take into account the precession variations of brightness. Due to the falsification it is not advisable to use the data [4] for the study of HZ Her.
B. V1341 Cyg

The orbital period of V1341 Cyg is known from the spectroscopic observations. Its latest and the most reliable determinations belong to Elebert et al. [31], $9^d.84456 \pm 0^d.00012$, and Casares et al. [2], $9^d.84450 \pm 0^d.00019$. We used the latter value for the construction of light curves. The initial point of phase count we used was the epoch of the inferior conjunction of the normal class F2 star $T_0 = JD 2451387.148 \pm 0.018$ from [2].

The light curves, constructed with these elements are shown in Fig. 6. All the scales in these diagrams are the same. To the left you can see a collection of observations compiled by the author (referred to as the Goranskij’s collection). These observations show a double wave over the orbital period on the lower, quiet brightness level and a significant chaotic variability, which increases from short- to long-wave filters (from the $V$ filter to the $U$ filter). The amplitude of the wave is on the average $0^m.27$ in the $V$ filter. In [3], this wave was explained by the ellipsoidal effect. New observations made in the SAO and SAI do not contradict the old photoelectric observations by V. M. Lyutyi and old photographic observations, showing the characteristic behavior of the object. Active and quiet states are typical of it. In the active states brightness increases, and the points deviate up from the double wave. The right-hand side shows the light curves in the $WVR$ system, built according to Sazonov. They have the same shape in all spectral bands, reminiscent of the light curves of the eclipsing contact systems such as $W$ UMa. One can not distinguish quiet and active states in these data. The amplitude of the orbital variability is on the average $0^m.6V$, which is twice the amplitude of the ellipsoidal effect from the Goranskij’s collection data. This amplitude is too large to be explained by the ellipsoidal effect. Attention is drawn to the same ratio of the depth of minima in the light curves in different filters. Since the system has an accretion disk, which makes a significant contribution to the total brightness of the system and has an ultraviolet excess, the depth of the primary eclipse in the $W$ band has to be much larger than in the other filters, what is not visible Fig. 6. Sazonov [5] concluded that the optical star in the V1341 Cyg system belongs to red giants, rather than to the "blue stragglers" (despite the fact that the spectrum of the optical star is clearly visible in the total spectrum of the system and is defined as the A5-F2 III, and it is not a red giant). The light curves, based on Sazonov’s "multi-color observations", which show the same ratio of the depths of minima in different filters, are in an insuperable conflict with his
conclusion about the red giant. In addition, the orbital periods of the X-ray systems with red giants (SyXB) make up hundreds of days, while in V1341 Cyg the orbital period is only $9^d.84$.

The results of the periodicity analysis of V1341 Cyg are listed in Table II. According to the observations from the Goranskij’s collection in the ultraviolet, the orbital period cannot be detected by any frequency analysis method. However, the average light curve in the $U$ band with accepted elements reveals a wave with the amplitude of $0^m2$ and a brightness minimum, which coincides with the moment of inferior conjunction of the optical component. This is quite certainly a reflection effect similar to the reflection effect, observed in HZ Her, whose amplitude is much smaller due to the small inclination of the orbital plane to the line of sight. The reflection effect usually has maximum amplitude in the ultraviolet rays. The peaks with a period equal to half the orbital period are reliably detected in the $B$ and $V$ filters, applying the Deeming method. The Lafler–Kinman method detects both the double wave with the orbital period, and a solitary wave with a half-period. Sazonov’s data [5] contain a periodic component (a double wave for the period), which is present in all filters. The differences of the orbital period according to [5] and spectroscopic [2] are not significant.

In this paper we also analyzed the observational data of the SuperWASP and RXTE orbital observatories. In the SuperWASP optical data (column FLUX2) the object mostly varies in the range of values $14.0\text{–}14.9$ in the $V$ filter, although a number of (several tens of) observations fall below, up to the value of $15^m.6$. These flux decays are mainly concentrated in phases $-0.3 < \varphi < +0.1$. They are mostly random, though some are clearly related to the breaks or the end of monitoring. Such profound light decays are absent both in the old photoelectric observations by Lyutyi and in the modern CCD observations. These decays are perhaps associated with passing clouds. According to the SuperWASP, the double wave with the orbital period of $9^d.82$ and the average full amplitude of $0^m.13$ is confirmed.

The RXTE/ASM data reveal a lot of flares and active states, so that the level of the quiescent state can not be determined. A multitude of short-term flux dips can be observed, which occur in different phases of activity, and even near the flare maxima. They are not associated with the orbital phase. So Cyg X-2 is not an eclipsing X-ray source. The frequency analysis does not detect any periodic variations near the orbital period, even after the Fourier decomposition and the cleanup of this series from the long-period components.

The differences in the shapes of light curves of V1341 Cyg, built based on the observations
from the early study of Sazonov [13] (which are contained in the Goranskij’s collection) and based on the data from the work of Sazonov [5] are obvious. Some of these observations overlap in time. In Fig. 7 a the observations from [13] are circled on the background of Goranskij’s collection data (points). They are in a very good agreement with the photo-electric observations by Lyutyi and CCD photometry. Fig. 7 b compares the observations of Sazonov from [13] with the observations of Sazonov from [5] depending on time. The dates of observations from [13] and [5] coincide, which makes it evident that the data in [5] have been amended, which resulted in an artificial enlargement of the amplitude of orbital variability, and attaching the narrow ”eclipses” that have previously never been observed by anyone, including Sazonov himself. This concocted part of the observations from [5], as well as the other observations from the same source can not be considered reliable. The conclusions of paper [5], based on unreliable data can therefore not be considered objective and valuable for science.

The papers of Sazonov, published in arXiv.org [32–36] and based on the same data should also be considered unreliable. The use of these materials for the scientific research purposes is not recommended. However the reliability of the earlier observations [10, 13] as well as the observations of other objects published by him before 1996 can not be doubted.

At the same time, the SuperWASP data contain a large percentage of defective and unreliable observations, and they should be used with caution. Obviously, these are absolute measurements and an account of the variable atmospheric extinction over large areas of the sky on the CCD frames can lead to significant systematic errors. These data can be perhaps improved for individual stars using the measurements of the nearest neighbor stars as a standard.

IV. ADDITIONAL REMARKS

Sazonov’s observations in [4] and [5] have been presented in the PhD thesis, and were therefore considered by the Dissertation Council D501.001.86 of Sternberg Institute of the Moscow University and a specially appointed Commission of this council (Transactions No.103 on 15 December, 2011).

The Commission found that ”the observational data sets [series] that satisfy a linear function of time with the accuracy, ensuing from the author’s numerical data could not
have been obtained in the stated conditions and using the tools available to the thesis' author.” This applies to the data on HZ Her [4]. In other words, it is recognized that the accuracy of 0".001 in the color indices for a star having the brightness of 14".8, is not real. The presence in Sazonov’s data of small time intervals between the observations of different objects, eliminating the possibility of telescope repointing was confirmed. These facts are indicative of the falsification of the observational data.

At the same time, examining Sazonov’s data, the Commission judged from the following provisions: (1) “the discrepancy of the observational results of the defender of thesis with other observational results does not allow to consider them obviously incorrect”; (2) ”the discrepancy of the observational results of the defender of thesis with the currently existing models of the studied objects does not preclude from considering them [the observations] as obviously incorrect.” Based upon these provisions, the facts set out in this paper do not prove the counterfeit of the original observational data in Sazonov’s papers.

Such initial assumptions of the Scientific Council on the thesis defense are quite puzzling. On the cosmic scale human life and even the existence of mankind are inappreciable. Each event in the astrophysics may be prove to be unique or never recur again for centuries. The reliability of data in the astrophysics can be tested and determined only in the independent observations by different observers with different tools and instruments. No other possibility exists in the astrophysics, since it is impossible to carry out the experiment. The only exceptional opportunity to look into the past is the light echoes of large explosions. Special means are contrived in science for urgent telegrams and electronic messages of alert in order to attract the attention of independent observers to important astronomical events and phenomena, to confirm or deny the incoming information. The presence of eclipses and the precessing accretion disk in the system HZ Her, as well as the absence of eclipses in the system V1341 Cyg are not the ”model representations,” but objective facts, firmly established by the observations at different wavelengths at the ground-based and space-based observatories.

This paper describes the properties of HZ Her and V1341 Cyg, which are based on the genuine observations.
Acknowledgments

We used the database of the American Association of Variable Star Observers AAVSO, the Northern Sky Variability Survey NSVS, the SuperWASP wide-angle search for exoplanets, as well as the electronic version of the General Catalog of Variable Stars. The operation of the SAO RAS telescopes are funded by the Ministry of Education and Science of the Russian Federation.

[1] E. Jurua, P. A. Charles, M. Still, and P. Meintjes, Monthly Notices of the Roy. Astron. Soc. 418, 437 (2011).
[2] J. Casares, J.I. Gonzalez Hernandez, G. Israeliian, and R. Rebolo, Monthly Notices of the Roy. Astron. Soc. 401, 2517 (2010).
[3] V. P. Goranskii & V. M. Lyuyi, Sov. Astron. 32, 193 (1988).
[4] A. N. Sazonov, Astron. Rep. 55, 230 (2011).
[5] A. N. Sazonov, Astron. Rep. 55, 142 (2011).
[6] V. M. Liutyi, R. A. Siuniaev, A. M. Cherepashchuk, Sov. Astron. 18, 684 (1975).
[7] W. Wenzel, R. Hudec, Inform. Bull. Variable Stars No. 1082 (1976).
[8] A. Collier Cameron, D. Pollacco, R. A. Street, T. A. Lister, et al., Monthly Notices of the Roy. Astron. Soc. 373, 799 (2006).
[9] N. I. Shakura, A. V. Smirnov, N. A. Ketsaris, ASP Conf. Series 121, p. 379 (1997).
[10] A. N. Sazonov, Astron. Tsirkular No. 1518, 5 (1987).
[11] V. M. Lyutyi & I. B. Voloshina, Sov. Astron. Lett. 15, 347 (1989).
[12] N. N. Kilyachkov, V. S. Shevchenko, S. D. Yakubov, et al., Astron. Lett. 20, 569 (1994).
[13] A. N. Sazonov, Astron. Tsirkular No. 1531, 15 (1988).
[14] M. M. Basko, V. P. Goranskij, V. M. Lyutyj, et al., Variable Stars (Peremennye Zvezdy) 20, 219 (1976).
[15] M. M. Basko, V. P. Goranskij, V. M. Lyutyj, et al., Sov. Astron. Lett. 2, 214 (1976).
[16] J. Lafler, T. D. Kinman, Astrophys. J. Suppl. 11, 216 (1965).
[17] T. J. Deeming, Astrophys. and Space Sci. 36, 173 (1975).
[18] N. E. Kurochkin, Astron. Tsirkular No. 717, 1 (1972).
[19] H. Tananbaum, H. Gursky, E.M. Kellogg, et al., Astrophys. J. 174, L143 (1972).
[20] D. Gerend, P. E. Boynton, 1976, Astrophys. J. 209, 562 (1976).
[21] V. P. Goranskij, Variable Stars (Peremennye Zvezdy) 2, 323 (1976).
[22] V. P. Goranskij, Sov. Aston. Lett. 9, 20 (1983).
[23] M. Still, K. O’Brien, K. Horne, et al., Astrophys. J. 553, 776 (2001).
[24] C. D. Igna, D. A. Leahi, Monthly Notices of the Roy. Astron. Soc. 418, 2283 (2011).
[25] L. Crosa, P. E. Bointon, Astrophys. J. 235, 999 (1980).
[26] N. G. Bochkarev, Sov. Astron. 33, 638 (1989).
[27] P. E. Boynton, L. M. Crosa, J. E. Deeter, Astrophys. J. 237, 169 (1980).
[28] D. A. Leahi, C. D. Igna, Astrophys. J. 713, 318 (2010).
[29] M. Still, K. O’Brien, K. Horne, et al., Astrophys. J. 554, 352 (2001).
[30] A. N. Parmar, T. Osterbroek, D. Dal Fiume, et al., Astron. and Astrophys. 350, L5 (1999).
[31] P. Elebert, P. J. Callanan, M. A. P. Torres, and M. R. Garcia, Monthly Notices of the Roy. Astron. Soc. 395, 2029 (2009).
[32] A. N. Sazonov, astro-ph arXiv 0904.0168 (2009).
[33] A. N. Sazonov, astro-ph arXiv 0907.3822 (2009).
[34] A. N. Sazonov, astro-ph arXiv 0912.0706 (2009).
[35] A. N. Sazonov, astro-ph arXiv 1011.3980 (2010).
[36] A. N. Sazonov, astro-ph arXiv 1102.0379 (2011).
FIG. 1: Orbital light curves of HZ Her in the optical range (a—[9], b—[1]) and in the X-ray range (d). (c) is the light curve according to A. Sazonov [4]. (e) is the light curve according to the observations [9], built for the sample from the same time range, which includes the data from [4].
FIG. 2: The primary eclipse of HZ Her in the optical range (a–[9], b–[1]). (c) the light curve according to A. Sazonov [4]. (d) is the light curve from the observations of [9], built for the sample from the same time range, which includes the data from [4]. The vertical lines mark the times of contact of the X-ray pulsar – the compact X-ray source – with the limb of the secondary component.
FIG. 3: Precession brightness variations of HZ Her in the orbital period phases $\varphi=0.86 - 0.92$ and $0.08 - 0.14$ (a–[9], b–[1]); (c) is the light curve according to Sazonov [4]; (d) – is the $2 - 10$ keV X-ray flux curve according to the RXTE/ASM data.
FIG. 4: Periodograms of the search of the secondary period in the orbital light curve shape variations of HZ Her by Goranskij [21] (a—according to [9], b—from [1], c—according to the RXTE/ASM data). Sazonov’s data (c) lacks periodic changes in the orbital light curve shape.
FIG. 5: A comparison of the observations of Kilyachkov et al. [12] coinciding in time (dots in circles) and the data from the paper by Sazonov [4] (dots) in the B filter (top) and in the UV filters U and W (bottom) over two nights in which the object was in its "on" state. Sazonov's observations do not reflect the "on" state at the end of the eclipse, i.e. do not contain information on the uncovering of the accretion disc.
FIG. 6: Orbital brightness variations of V1341 Cyg in the $UBV$ system filters according to the data of Goranskij’s collection described above (left) and in the $WBVR$ system filters according to Sazonov [5] (right). The scale of all the diagrams is the same.
FIG. 7: (a) A comparison of observations of V1341 Cyg in the V-band from the collection by Goranskij (points) with the observations of the early work of Sazonov [13] (points in circles). A good agreement of these data is obvious. (b) A comparison of the early observations by Sazonov from [13] (points in circles) with his own observations from [5] (circles). Obviously, these are the same observations, coinciding in time, but later they were amended to increase the amplitude. (c) The corrected light curve from [5] already looks like an eclipsing one.
### TABLE I: Determination of the periods of the orbit, beats and precession of HZ Her

| Parameter | Shakura et al. | Sazonov | SuperWASP | RXTE |
|-----------|----------------|---------|-----------|------|
|           | (V)            | (B)     | (V)       |      |
| JD 24...  | 41511 – 51046 | 46588 – 48173 | 53129 – 54681 | 50087 – 55817 |
| $P_{\text{orb}}$ | 1.70017 (1) LK | 1.70014 (6) LK | 1.70016 (3) LK | 1.70017 (4) LK |
| $P_{\text{beat}}$ | 1.62116 (2) D | no | 1.6210 (2) D | 1.6213 (1) D |
| $P_{\text{prec}}$ | 34.89 (1) G | no | 34.74 (4) G | 34.95 (2) D, LK |
|           | 34.89 (1) LK* | no | 34.75 (5) LK* | 34.5 – 35.2 O–C |
| $N$       | 5936           | 1808    | 32143     | 95558 |

* For the phase-selected extraction near ingress and egress of the eclipse.

### TABLE II: Determination of the orbital period of V1341 Cyg

| Parameter | Filter | Goranskij et al. | Sazonov | SuperWASP |
|-----------|--------|------------------|---------|-----------|
| JD 24...  | –      | 42247 – 55826    | 46616 – 48521 | 54279 – 54419 |
| $P_{\text{orb}}$ | U      | no               | 9.843(2) |           |
| $P_{\text{orb}}$ | B      | 9.8445(4)       | 9.842(2) |           |
| $P_{\text{orb}}$ | V      | 9.8447(4)       | 9.842(2) | 9.82(7)  |