The jet of the young star RW Aur A and related problems

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Abstract

Comparing the images of the jet of the young star RW Aur A, separated by a period of
21.3 years, we found that the outermost jet’s knots have emerged \(\approx 350 \text{ yr} \) ago. We
argue that at that moment the jet itself has appeared and intensive accretion onto the
star has began due to the rearrangement of its protoplanetary disk structure caused by
the tidal effect of the companion RW Aur B. More precisely, we assume that the increase
of accretion is a response to changing conditions in the outer disk regions, which followed
after the sound wave, generated by these changes, crossed the disk in a radial direction.
The difference in the parameters of the blue and red lobes of the RW Aur A jet, according
to our opinion, is a result of the asymmetric distribution of the circumstellar matter above
and below the disk, due to a fly-by of the companion. It was found from the analysis of
RW Aur historical light curve that deep and long (\(\Delta t > 150 \text{ days} \)) dimmings of RW Aur A
observed after 2010 yr, had no analogues in the previous 110 years. We also associate the
change in the character of the photometric variability of the star with the rearrangement
of the structure of inner (\(r < 1 \text{ a.u.} \)) regions of its protoplanetary disk and discuss why
these changes began only 350 years after the beginning of the active accretion phase.

Introduction

RW Aur A is a classical T Tauri star (CTTS). It means that it is a young low mass pre-
main-sequence star, activity of which (variable brightness, excess emission in lines and

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continuum in all spectral bands, powerful outflow from its vicinity etc.) in some way connected with accretion of protoplanetary disk matter [21]. It has a companion [25], which is now at angular distance $\approx 1.5''$ [7, 13], what corresponds to projected separation 210 a.u., if to adopt that the distance to RW Aur is 140 pc [17].

RW Aur A is one of the most active CTTSs what seems quite strange on closer examination. Indeed, estimations of the accretion rate from the protoplanetary disk onto the star $\dot{M}_{ac}$ yield a value greater than $2 \times 10^{-8} M_\odot/yr$ [6,7], while the mass and radius of the stellar protoplanetary disk are relatively small: $M_d = 4 \times 10^{-3} M_\odot$ [3] and $R_d < 80$ AU [9]. Therefore, the characteristic time of being in the active state for RW Aur A, which is $t_d \sim M_d/\dot{M}_{ac} \lesssim 2 \times 10^4$ yr, appears much less than its age, which knowingly exceeds 1 Myr [46].

To explain this fact the authors of [9] supposed that the observed high accretion rate was due to tidal disturbance of the RW Aur A disk caused by fly-by of another star – RW Aur B. Simulations carried out by [14] showed that the observed structure of outer regions of the RW Aur A disk could be reproduced if a companion fly-by the primary at a minimum distance of about 70 AU 400-450 yr ago.

The fact that passage of the companion resulted in the change of dynamics of inner parts of the RW Aur A disk was also discussed after unexpected long-term ($\Delta t \sim 150^d$) and quite deep ($\Delta V \sim 2.5 m$) dimming occurred in 2010-2011 [39], which repeated three years later on a greater scale: $\Delta t \approx 2$ yr, $\Delta V > 5 m$ [28]. Possibility of intensification of a "dusty" wind from inner ($r < 1$ AU) regions of the disk is considered as a probable cause of these events [37, 42, 8, 18].

It is well-known that there is an intensive outflow of matter from the RW Aur A (see, e.g., [35, 2] and references therein). [23] have found a bipolar jet in the star, which is a collimated part of the outflow. According to common terminology, the part of the jet moving toward the Earth will be called the blue lobe of the jet and the part moving away from the Earth – the red lobe. The radial velocity and physical parameters of gas in the blue and red lobes prove to be considerably different as well as their spatial extension (see e.g. [31] and references therein). Each jet consists of a chain of knots, the number of which are different in the lobes. The authors [30] have found that knots closest to the star ($d < 5''$) move away from it gradually changing their shapes.

It is generally thought that emerging of knots in jets is caused by non-stationary processes in the wind-formation region – stellar magnetosphere and/or the innermost regions of its accretion disk – during which short-term increasing of gas velocity takes place (see [27, 19] and references therein).

The aim of the present work is to associate the changes in the morphology of the RW Aur A jet, which happened in two past decades, and in the photometric behavior of the star after 2010 with tidal influence of the companion on the inner disk regions of the primary.

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1 In fact each knot is a Herbig-Haro object, but in the catalog of these objects [38], the reference number HH 229 has been assigned to the whole complex of the knots.
Observations

Observations of RW Aur were carried out with the 2.5-m telescope of the Caucasian Mountain Observatory of SAI MSU in 2017. In the optical range images of star’s neighborhood of a size of $10' \times 10'$ were obtained with the [S II] filter ($\lambda_c = 672.17$ nm, $FWHM = 5.68$ nm) on February 20 and 24 and with the $H_\alpha$ filter ($\lambda_c = 656$ nm, $FWHM = 7.67$ nm) on February 28 with the total exposure time 2500 and 2100 s respectively. The seeing varied from 0.8 to 1.3''

We used E2V CCD44-82 CCD with a pixel size of 15 \(\mu\)m as the light detector. The images obtained were corrected for BIAS and flat field in the standard way.

Using coordinates of more than 50 field stars taken from the USNO-B1.0 catalog [32], we found that the image scale is 0.1543''/pixel.

On February 24 and 28, 2017, we also obtained images of the region around RW Aur in the [Fe II] band ($\lambda_c = 1644.2$ nm, bandwidth – 26.2 nm) in the photometric mode of the ASTRONIRCAM infrared camera-spectrograph [34]. The image scale was 0.2695''/pixel, the field of view – 4.6'. The resulting image is a sum of 80 images obtained on February 24 with the accumulation time equal to 25 s and image quality $\approx 1.3''$; and a sum of 180 images with the accumulation time equal to 16 s and image quality $\approx 1.0''$, obtained on February 28. Thus, the total exposure time exceeded 80 minutes.

The resulting images in the [S II], $H_\alpha$, and [Fe II] bands are presented in three bottom panels of Fig. 1.

Proper motion of the jet’s knots

Observations [23], from which the jet of RW Aur A was found, covered the $30''$ region on both sides of the star. In October 1995, the authors of [33] obtained a much larger image of the neighborhood of the star in the [S II] band close in parameters to that we used. They have found that spots are seen up to $\approx 120''$ (the $I$ knot) in the blue lobe and up to $\approx 55''$ in the red lobe (the $M$ knot) (see the top panel of Fig. 1, which is a copy of Fig. 2 from [33]).

Images of inner ($d < 5''$) jet regions in the [S II] lines with high angular resolution were obtained in [16] [49] on December 30, 1997 and December 10, 2000 respectively. Having compared these images and those obtained by themselves on December 19, 1998, the authors of [30] determined the proper motion velocity of the knots in the inner region of the jet and inferred that the knots are moving away from the star 1.6 times faster in the blue lobe than in the red one.

In order to derive the tangential velocity of the knot motion $\mu$ at a greater distance from the star and in a longer time interval, we compared the image we obtained in the [S II] band and the data on the distance from the spots to the star $d$ in the similar band in different epochs: the values for $d_{1997}$ and $d_{2000}$ were taken from Table 1 of [30], and the values for $d_{1995}$ were obtained from Fig. 2 in [33], which we processed in the same way as images we observed. Our images in the $H_\alpha$ and [Fe II] $\lambda = 1.64 \mu$m bands were not used to determine $\mu$, as far as positions of the knots in the images slightly differ in various bands. For each knot, Table 1 gives distances from the point of its maximum intensity to RW Aur A (except for the $G$ knot), the $\mu$ value calculated from the difference
of coordinates, and also the ”age” of the knot $t_d = d/\mu$. The knot $G$ is crescent-shaped and we considered its position to be best characterized by the coordinate of the point most distant from the star at the arching edge of a crescent. Note that the knot marked in the table as $R_7$ has no designation in the paper [30].

The details inside the region of the radius $5 - 10''$ around RW Aur are indistinguishable in Figure 1. However, $A$ and $B$ components of the binary system, the angular distance between which is $1.5''$, are confidently separate in all our images, so that we have quite reliably determined the centroids of the knots close to RW Aur A after subtracting the wings of images of both components.

It follows from the Table 1 that the mean proper motion $\mu$ of six knots in the red lobe for about past 20 yr is equal to $0.18 \pm 0.03''/yr$. This coincides, within error, with the value of $0.16''/yr$ found by [30] from two knots in the time interval of about two years. In the blue lobe, these authors measured $\mu$ for the $B_3$ knot only. They found $0.26 \pm 0.035''/yr$, which is also in agreement with the value we obtained $0.26 \pm 0.02''/yr$. However, we found a slightly greater mean value $\mu$ for the knots $B, C_1, C_2, D$, and $G$ of the blue lobe: $0.34 \pm 0.02''/yr$. It is difficult to say how significant this difference is, although, if one calculates the mean proper motion from all knots of the jet blue lobe, it will be equal to $0.33 \pm 0.04''/yr$, i.e. 1.8 times greater than that of the red lobe, which, within error, coincides with the ratio found in [30].

### Estimation of the jet’s age

If to divide the coordinates of the outermost knots $M$ and $I$ in the jet’s 1995 image by the mean $\mu$ values in the corresponding lobes and to add 21.3 yr, one can found that they have appeared $320 \pm 50$ and $380 \pm 40$ yr ago respectively.

A number of the knots seen in the 1995 image are absent in the 2017 image. This is the case, in particular, of the bright knot $H$ and also the knots most distant from the star – $I$ and $M$. On the other hand, there are spots in the 2017 image marked as $N_1 – N_3$ that have not been noticed earlier. Thus, one cannot exclude that there had been knots before 1995 which were farther from the star than the knots $I$ and $M$, but they have disappeared by 1995. Formally, this means that the age of the jet we determined, $t_{jet} \approx 350$ yr, is the lower limit. However, as can be seen from Fig. 4 in [14], formation of tidal arms in the disk of A-component has started not earlier than 200 years before the periastron passage of the companion, i.e., approximately less than 650 years ago, so our value $t_{jet}$ should be close to realistic. Moreover, increasing the age of the jet means reducing the time $t_{exc}$ that necessary for tidal disturbance to come from the outer regions to the innermost, while the value $t_{exc}$ we obtained is already quite short: $650 - t_{jet} \approx 300$ yr.

Let us clarify the foregoing. As can be seen from the same figure, during fly-by of the companion the outer regions of the RW Aur A disk undergo strong deformation and, in fact, are transformed into two spiral arms, one of which stretches toward the companion and the other – in the opposite direction. However, even at a minimal approach of the stars, the influence of the companion on the innermost regions of the A-component disk

\[ ^2 \text{Mean } \mu \text{ values correspond to motion of knots perpendicularly to the line of sight with a linear velocity of about } 160 \text{ km s}^{-1} \text{ in the blue lobe and about } 90 \text{ km s}^{-1} \text{ in the red lobe.} \]
is extremely small. Consequently, the burst in the accretion activity of RW Aur A is a response not to the gravitational field of the companion, but to a change in physical conditions at the outer boundary of the disk, which manifests itself after some time \( t_{\text{exc}} \).

But how is the relevant information passed from the outer regions of the disk to the inner ones? In calculations of the dynamics of the RW Aur A disk under the influence of the companion’s fly-by, the authors of [14] considered only the regions distant from the primary star over 6 AU. Since we are interested in much closer neighborhood, we are forced to confine ourselves to corresponding estimates. According to [1] the characteristic time for the rearrangement of the radial structure of the disk of RW Aur A (the so-called ”viscous time”) is

\[
 t_{\text{vis}} = \frac{t_k}{2\pi \alpha} \left( \frac{H}{R_d} \right)^{-2}, \quad t_k = 2\pi \left( \frac{R_d^3}{GM} \right)^{1/2}.
\]  

(1)

Here \( M = 1.4 M_\odot \) [18] is the mass of the star; \( R_d \approx 60 \) AU [14] is the external radius of the disk before the companion’s fly-by; \( \alpha \) and \( H \) are the Shakura-Sunyaev parameter and the half-thickness of the disk at the outer boundary, respectively. The values \( \alpha \approx 0.01 \) and \( H/R_d \approx 0.1 \) are considered as typical of the CTTS’s disks [21], from where it follows that the orbital period at the outer disk boundary (”Keplerian time”) \( t_k \approx 400 \) yr, and \( t_{\text{vis}} \approx 6 \cdot 10^5 \) yr. Thus, disturbances that led to the birth of the jet transited from the periphery to inner regions of the disk in time that much less than \( t_{\text{vis}} \), but comparable with the Keplerian time.

Let us now estimate how much time \( t_{\text{hyd}} \) it will take the sound wave to cross the disk ”to inform” its inner regions about pressure variations at the outer boundary. According to [9], the temperature at the outer boundary of RW Aur A’s undisturbed disk is \( \approx 30 \) K, and at present epoch, the gas temperature (which is already heated by the tidal interaction) is \( 80 \pm 20 \) K. Considering that gas of outer disk regions mainly consists of molecular hydrogen, we obtain that the sound speed \( V_s \) in this region is \( 0.6 \) km s\(^{-1}\) with accuracy of \( \approx 30 \)%. Consequently, \( t_{\text{hyd}} \approx R_d/V_s \approx 500 \) yr. [3]

The observed difference of velocities of the companion and the primary star is about of several km s\(^{-1}\) [47, 7]. Therefore, the relative velocity of the stars, when they have approached each other, was about an order of magnitude higher than \( V_s \). If it follows from this fact that the disturbance propagated through the disk with supersonic velocity, at least in its outermost regions, then the time \( t_{\text{exc}} \) is in a full agreement with the restriction resulting from our observations: \( \lesssim 300 \) yr.

### Analysis of RW Aur’s historical lightcurve

However, the question on how the passage of the companion affected the inner regions of the disk of RW Aur A is not exhausted by this coincidence. We have already mentioned in the Introduction that in the current decade several long-lasting and deep dimmings of the A-component have occurred, which were apparently associated with the rearrangement of

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3 It is not by chance that we obtained almost similar values of times \( t_k \) and \( t_{\text{hyd}} \). If to write down the expressions for the scale height of an \( \alpha \)-disk at its outer boundary as \( H = V_st_k/2\pi \) [1], then one obtain \( t_k/t_{\text{hyd}} = 2\pi (H/R_d) \sim 1 \), because \( H/R_d \sim 0.1 \) in our case.
the structure of the outer disk regions in some way or other. To understand how unique these events are, let us consider the historical light curve of RW Aur.

Since L. P. Ceraski detected the brightness variability of this star [10], the character and possible causes of these variations at the time intervals from minutes to several years were repeatedly discussed (see, e.g., [44, 11, 12, 22, 37, 6, 20, 39, 10, 8] and references therein). Strictly speaking in these cases summary brightness of A and B components was used, as the distance between them is < 1.5″. However, resolved photometry presented in [46, 4] showed that until 2010 the companion was fainter than A-component by 2 − 2.5 mag in the B and V bands, so it can be accepted that the integrated brightness variations reflect the behavior of RW Aur A.

The historical light curve presented in Fig. 2 was constructed using photoelectric, photographic, and visual observations on the assumption that photographic and visual measurements are identical to the photoelectric in the B and V bands, respectively. Photoelectric data were taken from [22], the RR [20], and AAVSO [26] databases as well as from papers [5, 39].

Visual estimates are taken from the AAVSO database and 3287 photographic estimates of brightness – from the book [44], such as 2748 of them are based on measurements of plates from the Harvard College Observatory (USA) Astronomical Plate Stacks observed in the period of JD 2 414 639–2 437 288. Additionally, we estimated the brightness of RW Aur from 166 photo plates from the same collection in the time interval of JD 2 439 801–2 447 862. We studied the DNB photo plates acquired using a 38 mm aperture camera; they have a resolution of 580 ″/mm and a limiting magnitude of about 15″. Let us note that the historical light curve given in Fig. 3 in [6] was constructed from the measurements of 150 photoplates from the same collection. In the digital form, these estimates are not presented in the paper, but most likely they are among our much more numerous data.

Let us consider initially the period before 2010. Figure 2 shows that at that time the brightness of the star during the seasons varied without any noticeable regularity, although, single episodes of about several tens of days took place in which the stellar brightness attenuated and then reverted to the initial level: examples of such episodes are presented in Fig. 3.

According to photoelectric measurements only, started from the beginning of the 60s, the average brightness of RW Aur in the B and V bands is equal to 11.2 and 10.5 mag, respectively. The amplitude of season variations in the V band was about 1.4 mag, such as the brightness of the star during the whole period of photoelectric observations never dropped below 11.8″. Among ≈ 10 000 visual estimates of brightness before 2010, the lower values (down to V = 12.6 mag) were observed in twenty cases only, however, some of these estimates were undervalued and in other cases duration of a state with V > 12″ usually did not exceed several days (see, e.g., the central panel of Fig. 3). The star demonstrated similar behavior but with a greater variability amplitude in the B band: as can be seen from the top panel of the same figure, the stellar brightness in this range could vary by more than 2.5″, for about a month, which was also mentioned in [6].

It also follows from Figure 2 that during the past century mean seasonal values of brightness have undergone wavy, aperiodic variations. Note that decreasing in the mean seasonal level of brightness at the end of the 30s to the minimum value apparently reflects
real changes happened to the star, because the minimum is observed both in the $B$ and $V$ bands. Thus, the photometric behavior of RW Aur in the period under study at all time scales was nonstationary and non-trivial, probably because the brightness variability was due to the combined effect of two mechanisms: non-stationary accretion and shielding of starlight by relatively small gas-dust clouds [36].

However, even on this background, the stellar brightness attenuation in 2010-2011 lasted for about 200 days, during which $V$ magnitude was weaker $13''$ [39], became an extraordinary event. Three years later, the dimming of even greater scale has occurred: it lasted for two years and the brightness of RW Aur A fell down to $V \approx 15.1''$ at the minimum [28]. The intensive study of the star in this period in the range from 5 $\mu$m to 10 keV showed that attenuation of the brightness of A-component happened due to its eclipse by a gas-dust cloud distant from the star by less than 1 AU [37, 42, 41, 8, 39, 40, 43, 18]. By August 2016, the brightness of RW Aur has returned to the average level before 2010, but two months later a new eclipse has began, which is lasting till now (April 2017).

It is assumed that the disk of RW Aur A is inclined to the line of sight at an angle of $30 - 45^\circ$ [9], so the issue about what made the dust to rise so high and stay so long above the disk plane is actively discussed in the above-mentioned papers. Intensification of ”dusty wind” from the inner ($r < 1$ AU) disk regions and/or deformation (bending) of these regions are considered as a probable reason for this. However, even if deformation of the disk is associated with an existence of close low-mass companion [18], the question arises: why have not such deep and long-term eclipses taken place before 2010?

The same question can be formulated in another way. Whatever the mechanism for the appearance of large-scale dust clouds in the line of sight after 2010 is, its starting as well as formation of the jet is associated with the rearrangement of the inner disk regions after the fly-by of the companion near RW Aur A. The question then is: why are these two events separated by a time span of about 350 yr?

It can be assumed that the scale and/or nature of the processes causing the appearance of dust in the line of sight have changed after 2010 due to the fact that an outwardly propagating wave of adjustment of the outer disk regions to the changed conditions at the inner boundary has reached the corresponding region. If we put $t_{\text{vis}} = 350$ yr, then it follows from relation (1) that during this time the rearrangement of the radial structure of the disk can occur up to distances of about 0.4 AU. It is interesting that, apparently, the dust cloud eclipsing the star after 2010 was at approximately the same distance from RW Aur A [42]. We cannot say whether such a coincidence is accidental.

**On a cause of asymmetry of RW Aur A jet**

Consider now the problem of asymmetry of RW Aur A jet, which is manifested in the difference in the morphology, physical parameters of the gas (density, temperature, and ionization degree), as well as velocities of the knots in the blue and red lobes. Similar asymmetry is quite often observed in CTTS jets, and, in principle, can be due to an asymmetry of the parameters of the circumstellar environment or and/or the region in which the jet is formed (see, for example, [45] and referenced therein). The authors of [31] found that the mass loss rates in the red and blue lobes of the RW Aur A jet are approximately
equal \((2.6 \times 10^{-9} \text{ and } 2.0 \times 10^{-9} \, M_\odot/\text{yr}, \text{ respectively})\) and therefore the reason for jet’s asymmetry is associated with the difference in the properties of the environment.

According to the results of calculations [14], the companion moves around RW Aur A in an orbit close to parabolic, the plane of which is inclined to the plane of the disk \((z = 0)\) at an angle of 18°. Initially \((t = -\infty)\), the companion was in that region of space (relatively speaking at \(z > 0)\), where the blue lobe of the jet was located, moving from top to bottom. At some moment the companion crossed the plane \(z = 0\) and reached the periastron, which is below the disk. After that, the companion began to move away from RW Aur A, crossed the plane \(z = 0\) once more and now \((t = 0)\) is above it. Most likely, the circumstellar gas above and below the disk plane experienced disturbances to various extent during fly-by of the companion. However, without making appropriate simulations, it is difficult to say whether this circumstance has influenced the distribution of matter along the jet axis to such an extent to explain the observed asymmetry of jet’s lobes.

As we noted above, knots in CTTSs jets emerge due to the fact that significant increase of gas outflow velocity occasionally occurs in the wind formation region. Apparently, such an episode, lasting for several days only and accompanied by the stellar brightness increase by \(\Delta B \approx 6\) mag, was observed in the star DF Tau A [29]. In the last column of Table 1, we presented estimates of the age of the spots \(t_d\) (for 2017). For seven spots, the times of their birth fall within the range of the historical light curve of RW Aur we constructed, however, we have not found bursts comparable in scale with the burst of DF Tau A near these times. On the other hand in the period of appearance of a giant ”bubble” in the jet of XZ Tau A [27], no peculiarities in the light curve of this star were noticed [15]. Either flares of RW Aur A and XZ Tau A have been missed because of their short duration, or ejections of high velocity gas from CTTSs are not always accompanied by flares of noticeable amplitude, what imposes restrictions on the mechanism of ejections that is not known yet (see [21, 19] and references therein).

**Conclusion**

We found from the comparison of RW Aur A jet images separated by the time interval of 21.3 yr that the most remoted from the star knots have emerged \(\approx 350\) years ago. We suppose that at that moment the jet itself emerged and the epoch of intensive accretion onto RW Aur A has begun, caused by the rearrangement of the structure of its protoplanetary disk due to tidal influence of the companion RW Aur B.

The companion, moving along a highly elongated orbit, passed through the periastron 400 – 450 years ago, having greatly changed the structure of the outer disk regions of the primary. But its direct influence on the inner disk regions was apparently negligible. Therefore, we assume that the increase in accretion rate onto the primary is a reaction to a fundamental change in conditions in the outer regions of the disk, which followed after the sound wave, generated by these changes, passed along the disk in the radial direction.

It looks resonable to propose that the difference in the parameters of the blue and red lobes of the jet is associated with the asymmetric distribution of the circumstellar matter above and below the disk, which occurred due to the tidal impact of the companion on
the circumstellar gas.

Finally, we also assume that deep, long-lasting dimmings of RW Aur A after 2010 due to its eclipse by the "dust screen" are also associated with the rearrangement of the structure of the inner ($r < 1$ AU) disk regions, the original cause of which is the close fly-by of the companion. However, it is still unknown not only what the nature of this screen is but also why it has emerged only 350 yr after the beginning of the active accretion phase.

Answers to the posed questions can be obtained from numerical calculations considering the influence of the companion’s fly-by on the structure and dynamics of RW Aur A inner disk regions as well as the distribution of the circumstellar matter around the primary.

We did not compare intentionally in this paper the images of RW Aur A jet observed in different bands. Such a comparison, supplemented by the spectral data, is supposed to be done in the future with the goal of studying physical conditions in previously unstudied regions of the jet at distances $> 30''$. As we know up to now the images of these regions in the $H_{\alpha}$ and [Fe II] $\lambda = 1.64$ mkm bands have not even been published, so we find it appropriate to present them in Fig.1

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Table 1: Position and proper motion of knots in RW Aur A jet

| Knot | $d_{1995}$," | $d_{1997}$," | $d_{2000}$," | $d_{2017}$," | $\mu$,"/yr | $t_d$, yr |
|------|--------------|--------------|--------------|--------------|------------|----------|
| $M$  | 54.0         |              |              |              |            |          |
| $L_1$| 43.4         |              |              |              |            |          |
| $L_2$| 41.1         |              |              |              |            |          |
| $K_1$| 23.2         | 26.5         |              |              | 0.154      | 170      |
| $K_2$| 20.6         | 24.2         |              |              | 0.170      | 140      |
| $R_1$| 11.1         | 14.0         |              |              | 0.153      | 92       |
| $R_2$| 7.9          | 12.3         |              |              | 0.231      | 53       |
| $R_4$| 2.92         | 3.45         | 6.8          |              | 0.205      | 33       |
| $R_7$| 0.25         | 2.6          | 0.145        |              |            |          |
| $B_3$|              | −1.25        | −5.4         | −0.258       | 21         |          |
| $N_3$|              | −14.2        |              |              |            |          |
| $N_2$|              | −18.9        |              |              |            |          |
| $N_1$|              | −23.3        |              |              |            |          |
| $B$  | −22.2        | −28.7        | −0.305       | 94           |            |          |
| $C_2$| −27.3        | −34.7        | −0.347       | 100          |            |          |
| $C_1$| −29.7        | −37.2        | −0.359       | 104          |            |          |
| $D$  | −35.2        | −42.5        | −0.341       | 125          |            |          |
| $G$  | −95.2        | −103.2       | −0.372       | 280          |            |          |
| $H$  | −109.1       |              |              |              |            |          |
| $I$  | −119.0       |              |              |              |            |          |
Figure 1: Images of the RW Aur A neighborhood obtained in different bands and epochs. The top panel – 1995, in the [S II] band (adopted from [33]); the second from the top – 2017, in the [S II] band; the third from the top – 2017, in the $H\alpha$ band; the bottom – 2017, in the [Fe II] 1.64 mkm band. The jet axis (PA ≃ 130°) in all the images is directed along the horizontal axis, the coordinate center coincides with the position of RW Aur A.
Figure 2: Historical light curve of RW Aur in the B (top panel) and V (bottom panel) bands. Red squares denote average brightness for seasons before 2010 yr with more than 30 measurements.
Figure 3: Selected parts of RW Aur’s historical light curve showing episodes of dimmings happened before 2010 yr.