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Two New Cataclysmic Variables in Lyra

D. V. Denisenko

Space Research Institute, Moscow, Russia; e-mail: denis@hea.iki.rssi.ru

I report on the discovery of two cataclysmic variables in the same field in Lyra, originally identified on the base of their magnitudes in the USNO-B1.0 catalog and on Palomar images. The historical light curves were analyzed from 300+ photographic plates of the Moscow collection, covering 35 years of observations. One of the two stars, USNO-B1.0 1320–0390658, is showing rather frequent outbursts from $B \sim 20$ to $B = 15.2$ and is likely a dwarf nova of the UGSS subtype. The other variable, USNO-B1.0 1321-0397655, with only one observed outburst in 1993, from $R \sim 19$ to $I = 11.8$, is either an UGWZ dwarf nova or a recurrent nova. In both cases, its next outburst can occur in the nearest future.

In the course of my search for new cataclysmic variables, I found the star USNO-B1.0 1320–0390658 ($19^{\rm h}21^{\rm m}44\overset{\rm s}{.}232$, $+42°04'41\overset{''}{.}81$, J2000.0) showing strong variability between the two Palomar epochs: $B1 = 19.75$, $R1 = 19.14$, $B2 = 20.80$, $R2 = 15.87$, $I = 18.61$. Since the star's position is where three POSS-II fields overlap, three second-epoch plates are available for each band (blue, red and infrared), along with two first-epoch red plates and two Quick-V photovisual plates. The star was just outside the field of view of the first-epoch blue plate taken on 1951 September 2.

The variable was at outburst on the 1991 September 6 plate and in quiescence on all the remaining 13 plates. Fortunately, the R magnitude for the USNO-B1.0 catalog was measured from the 1991 plate. The comparison of fragments of the 1991 and 1995 red plates, centered at the new variable, is shown in Fig. 1.

While examining the Palomar plates of this field, I serendipitously found another variable in about $5'$ to the north of the first one, with a bright outburst on the 1993 June 11 infrared plate. This star also enters the USNO-B catalog as USNO-B1.0 1321–0397655, with the following coordinates and individual magnitudes: $19^{\rm h}21^{\rm m}48\overset{\rm s}{.}934$, $+42°09'46\overset{''}{.}60$ (J2000.0), $B1 = 20.48$, $R1 = 19.14$, $B2 = 20.61$, $R2 = 19.01$, $I = 11.75$. The comparison of 1993 June 11 and June 30 infrared plates centered at the second variable is shown in Fig. 2.

The image of the star in outburst was carefully examined to prove it was not an artifact. It has the same profile as those of other stars of similar brightness. The formal image characteristics (FWHM= 8.7, flatness= 0.03, maximum pixel value= 23000) are matching other stars in the 11–$13^{\rm m}$ range. Even the profile asymmetry is the same (the top of the Gaussian is tilted to the west for all overexposed stars, including the variable). Finally, the coordinates of the star in the June 11 plate are identical to those measured from all other images, within the astrometric uncertainties (0.1–$0.2''$ for different plates). This perfect match makes it extremely unlikely for the brightening to result from a chance alignment of the star with a satellite glint or from any other phenomenon, be it natural or artificial.

The $10' \times 10'$ finder chart, with the positions of both variables indicated, is presented in Fig. 3. The first variable is marked with two horizontal dashes and the second one, with a

horizontal dash and a vertical dash. Neither of the stars is present in the AAVSO Variable Star Index (VSX; Watson et al., 2006); the nearest variable listed there is NSVS 5539153 ($19^h21^m34\overset{s}{.}67$, $+42°03'03\overset{''}{.}1$, J2000.0), which is an EW eclipsing variable with $P = 0\overset{d}{.}42079$. The position of NSVS 5539153 is marked in the chart by an arrow. Also shown are blue (USNO-A2.0) magnitudes of the comparison stars used to estimate the new variables using Moscow archival plates.

Following the numbering scheme introduced back in 2007, the new variables were designated DDE 20 and DDE 21, using the AAVSO observer code of the author. The list of variables discovered by DDE with their coordinates, finder charts and references is available online at http://hea.iki.rssi.ru/~denis/VarDDE.html.

The magnitudes of the variables measured from Palomar plates are collected in Table 1. The brightest magnitudes detected for each of the stars are printed in boldface. It is notable that DDE 21 was fading after the outburst in June 1993. Its brightness in the June 24 red plate was $\sim 1.5^m$ above the quiescent level. Such fading is consistent with outbursts of the WZ Sge dwarf novae, with typical outburst amplitudes about 7.5^m. However, a recurrent nova outburst also cannot be ruled out.

To search for possible past outbursts, I checked the existing photographic plates of the Sternberg Astronomical Institute (SAI), Moscow University (the Moscow plate collection, Samus et al. 2006). The new variables are inside the $10° \times 10°$ FOVs of three areas regularly photographed with the 40-cm astrograph of the SAI's Crimean Laboratory, the typical exposure times being 45–60 minutes (10–30 minutes in some exceptional cases). Depending on sky conditions, exposure times, and image quality, the limiting magnitudes of these plates vary in a wide range, being sometimes as good as 17.5, but typically between 16.5 and 17.0. In total, I examined 315 plates.

Eleven plates taken in August 1957 centered at 1906+38.5 were not usable for estimating DDE 20 since they had 10-minute exposures and the limiting magnitudes of 15^m. The variables were outside the FOV of 4 plates; 7 plates are of poor quality. All the remaining plates were usable, even though the variables were located just 1.5 cm north and 3.5 cm west of the corner of one of the fields (the plate size is 30×30 cm^2).

In total, eight outbursts of DDE 20 were found using these plates, with the maximum brightness of $B = 15.2$. Three of these outbursts have good coverage, with 5–10 available plates taken during several nights, while the other five outbursts were detected each on one plate only, due to gaps in observations. The entire light curve of DDE 20 is shown in Fig. 4; the gray triangles are upper limits (rounded to 0.5^m). Since the magnitudes of the variable in outburst were estimated by visual inspection, typical errors are $0.1–0.2^m$. Figure 5 shows the well-covered outburst of April 1968 in more detail.

The outburst dates of DDE 20 are listed in Table 2. The intervals between the outbursts and their durations most likely correspond to a dwarf nova of the SS Cyg subtype (UGSS); however, the SU UMa (UGSU) classification is also possible.

Moscow plates reveal no additional outbursts of USNO-B1.0 1321-0397655 = DDE 21. Unfortunately, no plates are available between 1991 May 23 and 1995 July 27. The 2MASS infrared images were also checked. The JHK images were taken on 1998 June 8, nothing is visible at the position of the variable down to the limiting magnitude (~ 17.5). Together with the USNO-B1.0 B and R magnitudes (the $B - R$ color index is formally 1.3–1.6) and the star's being faint on two POSS IR plates, this excludes the possibility of DDE 21 being a red flaring star. As it was already mentioned above, this variable is a likely representative of WZ Sge dwarf novae or even of a still rarer class of recurrent novae. Objects of both types are typically undergoing outbursts once in 20–30 years. Thus, DDE 21 may be on the way to its next outburst that can happen at any time in

Table 1: Magnitudes of new variables on Sky Survey plates

Date	Band	DDE 20	DDE 21
1951 July 09	Red	19.14	19.14
1951 July 09	Blue	18.92	19.75
1951 Sep 02	Red	18.97	18.49
1982 May 23	V	< 19.00	18.87
1982 May 23	V	19.10	18.72
1988 July 09	Blue	20.25	18.94
1989 July 04	Blue	20.80	19.29
1990 July 18	Blue	20.11	19.49
1991 Sep. 06	Red	**15.87**	18.92
1992 May 28	IR	< 18.50	18.20
1993 June 11	IR	18.61	**11.75**
1993 June 24	Red	19.32	17.54
1993 June 30	IR	< 18.50	17.95
1995 June 20	Red	19.27	18.36

the nearest future. A monitoring campaign of these two objects, located within just $5'$ from each other, is encouraged.

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References:

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Table 2: Outbursts of USNO-B1.0 1320-0390658 = DDE 20

Plate No.	Date yyyy.mm.dd	Time, UT	Exp. (min)	Mag
A05404	1967.08.11	17:54.0	45	16.1:
A05405	1967.08.11	18:43.0	45	16.0:
A05406	1967.08.11	19:29.0	45	16.1:
A05407	1967.08.11	20:15.0	45	15.9:
A05408	1967.08.11	21:01.0	45	16.2:
A05409	1967.08.12	18:24.0	45	15.2
A05410	1967.08.12	19:10.0	45	15.3
A05411	1967.08.12	19:56.0	45	15.4
A05412	1967.08.12	20:42.0	45	15.6
A05413	1967.08.12	21:28.0	45	15.5:
A05751	1968.04.18	18:08.7	30	15.5:
A05755	1968.04.18	20:41.7	30	15.3
A05766	1968.04.19	19:56.0	40	15.4
A05767	1968.04.19	20:42.6	30	15.4
A05781	1968.04.21	20:01.5	30	15.9
A05782	1968.04.21	20:38.0	20	15.9
A05795	1968.04.22	20:58.1	35	16.3
A05796	1968.04.22	21:40.1	20	16.1
A05805	1968.04.23	21:23.0	30	16.5:
A05806	1968.04.23	21:55.0	30	16.5:
A06072	1968.09.17	17:05.0	47	15.8
A14464	1981.08.22	20:14.0	48	15.3
A15695	1983.08.04	21:16.1	60	15.5:
A16310	1984.05.03	20:42.3	45	15.2
A16311	1984.05.03	21:32.7	45	15.4
A16312	1984.05.03	22:23.6	45	15.3
A16313	1984.05.03	23:12.8	45	15.2
A18383	1988.05.13	22:09.4	60	15.2:

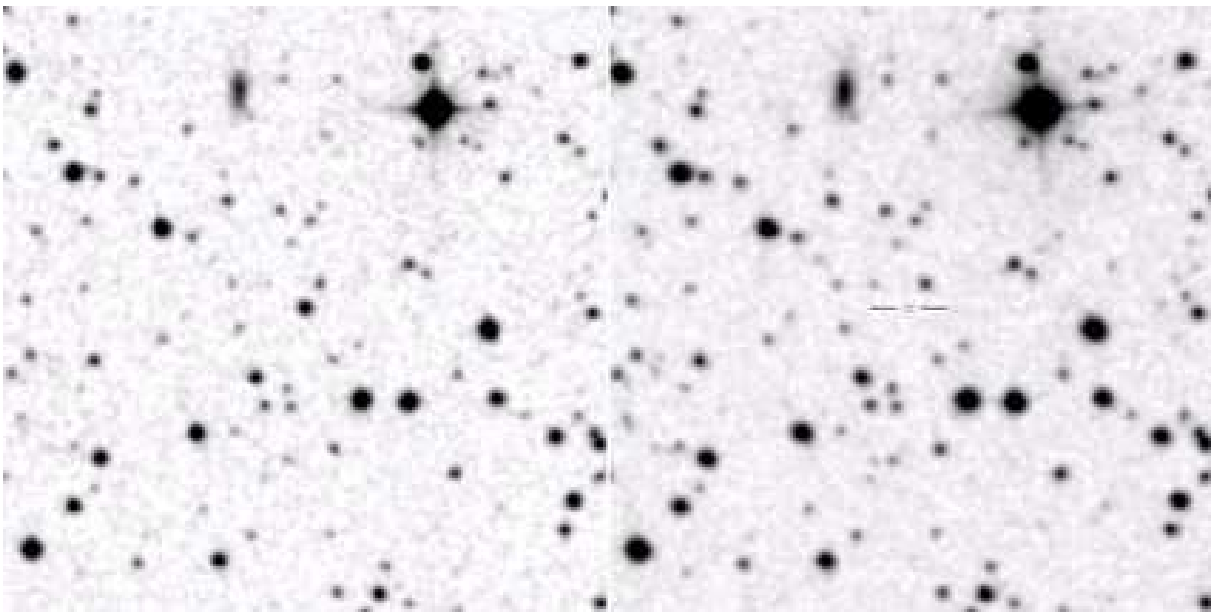

Figure 1. USNO-B1.0 1320-0390658 (DDE 20) on the red DSS plates taken on 1991 September 6 (left) and on 1995 June 20 (right). The FOV is $200'' \times 200''$; north is up and east is to the left.

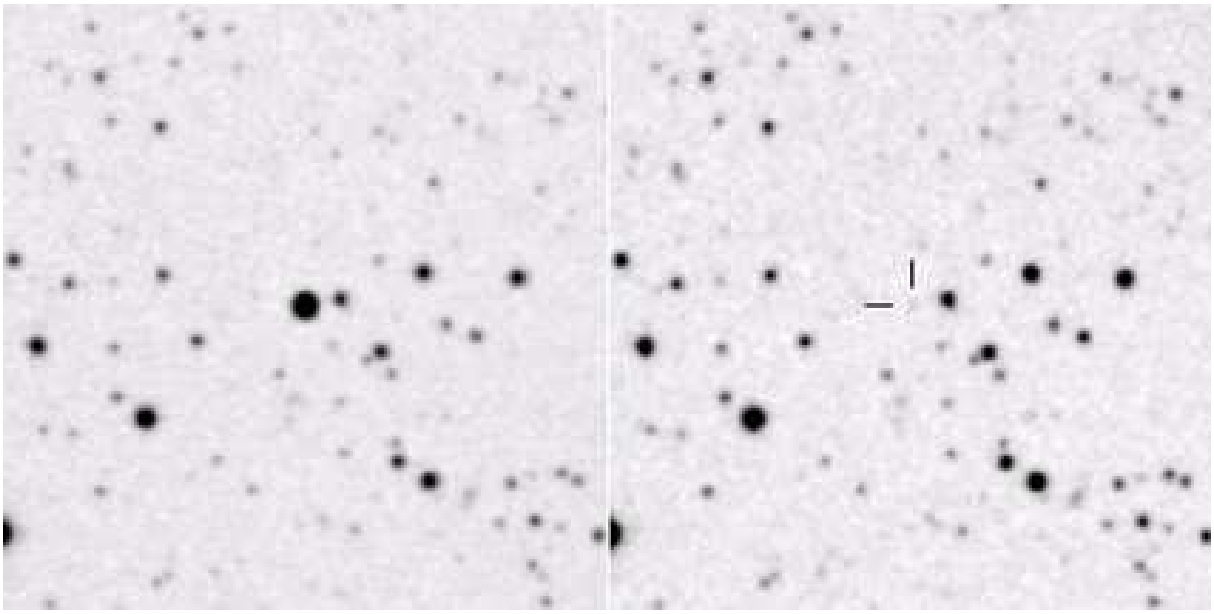

Figure 2. USNO-B1.0 1321-0397655 (DDE 21) on the infrared DSS plates taken on 1993 June 11 (left) and on 1993 June 30 (right). The FOV is $200'' \times 200''$; north is up and east is to the left.

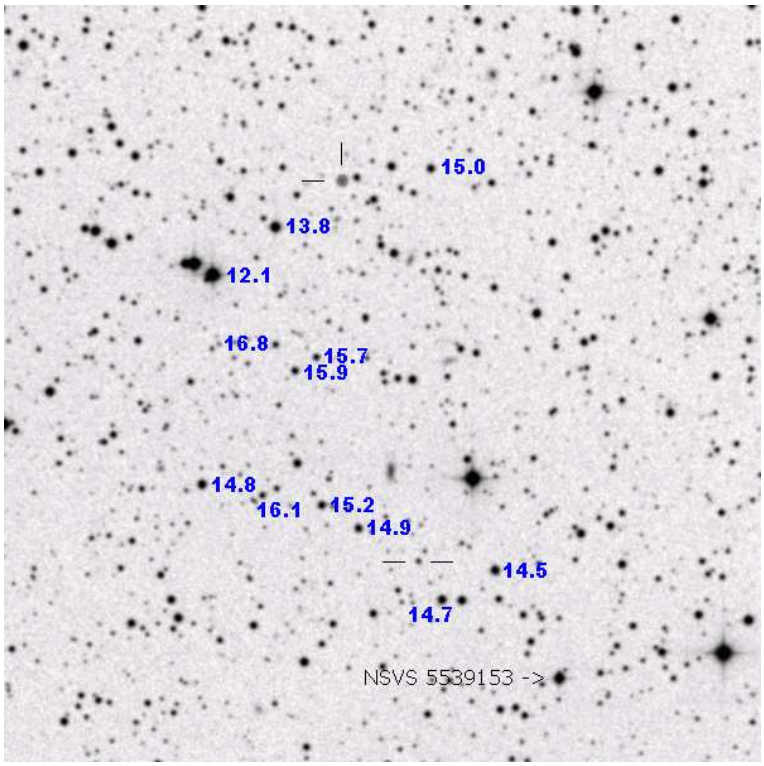

Figure 3. A $10' \times 10'$ finder chart of the two new variables. North is up and east is to the left.

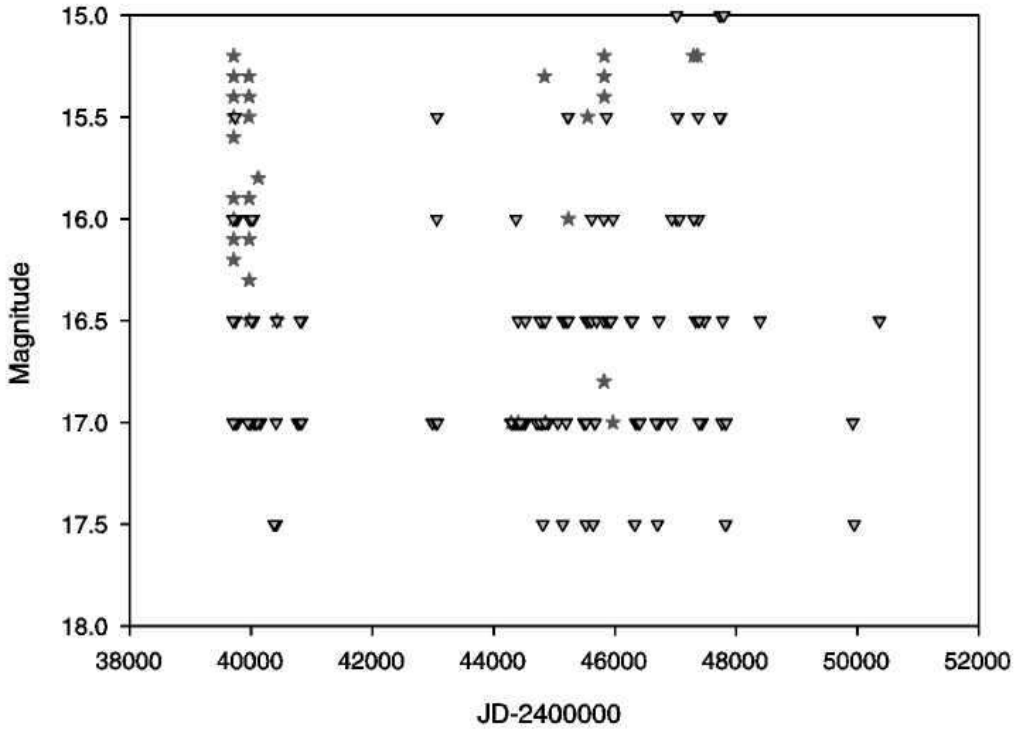

Figure 4. The light curve of DDE 20 from Moscow photographic plates. Asterisks are positive detections and triangles, plate limits.

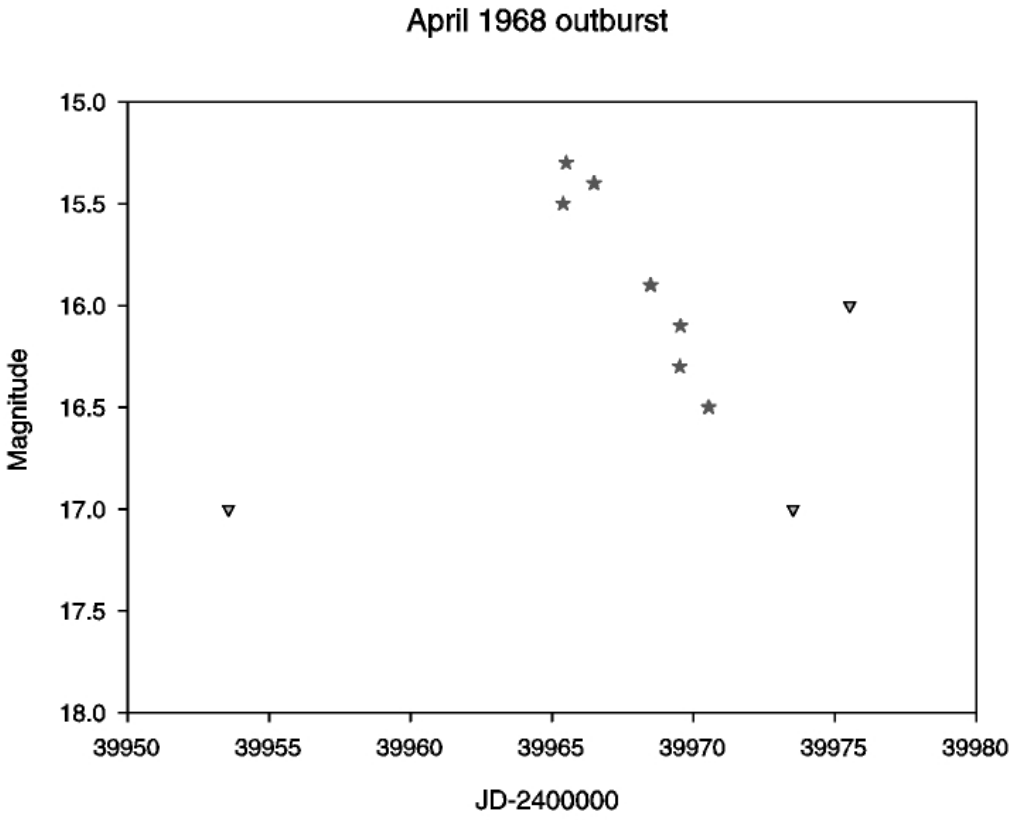

Figure 5. The light curve for the April 1968 outburst of DDE 20 from Moscow photographic plates. The symbols are the same as in Fig. 4.