Long-term optical photometry of the PMS stars V2764 Ori and LkHα 301 in the field of the McNeil's Nebula

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Abstract. In this paper, we present results from long-term $V(RI)_c$ photometric observations of the pre-main-sequence stars V2764 Ori and LkHα 301, located in the field of the McNeil's Nebula within the Orion star-forming complex. Our observations were performed in the period from August 2004 to November 2021 with three telescopes and seven different types of CCD cameras. Photometric observations, especially concerning the long-term behavior of the stars, are missing in the literature. We present the first photometric monitoring covering 17 years. Our data indicate that the variability of both stars is typical for classical T Tauri stars.

Key words: stars: pre-main sequence, stars: variables: T Tauri, star: individual: (V2764 Ori, LkHα 301)

1. Introduction

The McNeil's Nebula is a reflection nebula discovered by McNeil (2004). It is located in the LDN 1630 molecular cloud, within the Orion star-forming complex, and is associated with the point-like source IRAS 05436-0007 (V1647 Ori). V1647 Ori is an eruptive young object like FUor or EXor that illuminates the McNeil's Nebula. The Orion complex is one of the best-known sites of recent star formation containing many molecular clouds, dark and cometary nebulae, Herbig-Haro objects, and pre-main-sequence (PMS) stars.

Photometric variability in PMS stars is one of their main characteristics. Both classes of PMS stars − the low-mass ($M \leq 2M_\odot$) T Tauri stars (TTSs) and the more massive ($2M_\odot \leq M \leq 8M_\odot$) Herbig Ae/Be stars (HAEBESs) show various types of photometric variability (Herbst et al. 1994). The TTSs exhibit rapid irregular light variations and emission spectra (Joy 1945). They are divided into two subgroups: classical T Tauri stars (CTTSs) and weak-line T Tauri stars (WTTSs). Most of the features that characterize each subgroup suggest the pressence of accretion disks surround CTTSs, whereas they must have almost disappeared in WTTSs (see Bertout 1989 and Ménard & Bertout 1999). CTTSs are distinguished from WTTSs by their strong Hα emission line and significant infrared and ultraviolet excesses. The presence of hot and cool spots on the stellar surface, variable accretion activity, circumstellar dust or cloud obscuration events are possible reasons for the variability of TTSs (see Grinin et al. 1991, Herbst et al. 1994 and Ismailov 2005).

The stars included in the present study are located in the field of the McNeil's Nebula. V2764 Ori was found to be variable by Briceño et al. (2004). In their work, the star was labeled as "V". LkHα 301 was registered as Hα-emission star by Herbig & Kuhi (1963). Semkov (2004) confirmed that these stars are variables. Both V2764 Ori and LkHα 301 are X-ray sources (Simon et al. 2004). Flaherty & Muzerolle (2008) classified them as CTTSs and determined their stellar parameters – for V2764 Ori: spectral class K4, mass 1.56 $M_{\odot}$, effective temperature 4590 K, radius 3.04 $R_{\odot}$ and luminosity 3.576 $L_{\odot}$; for LkHα 30: spectral class K2.5, mass 1.85 $M_{\odot}$, effective temperature 4815 K, radius 2.74 $R_{\odot}$ and luminosity 3.525 $L_{\odot}$.

There are spectroscopic studies for V2764 Ori and LkHα 301 in the literature (see Flaherty & Muzerolle 2008, Fang et al. 2009 and Espaillat et al. 2012), but there is no long-term photometry. In this paper, we present the long-term optical light variations of the two stars.

2. Observations and Data reduction

The $V(RI)_c$ photometric observations of the field of the McNeil's Nebula were carried out in the period from August 2004 to November 2021 with the 2-m Ritchey-Chrétien-Coudé (RCC) and the 50/70-cm Schmidt telescopes administered by the Rozhen National Astronomical Observatory (Bulgaria) and the 1.3-m Ritchey-Chrétien (RC) telescope administered by the Skinakas Observatory[1] of the University of Crete (Greece). Seven different CCD cameras were used to obtain the observations as follows: VersArray 1300B and Andor iKon-L BEX2-DD on the 2-m RCC telescope, Photometrics CH360 and Andor DZ436-BV on the 1.3-m RC telescope, and SBIG ST-8, SBIG STL-11000M and FLI PL16803 on the 50/70-cm Schmidt telescope.

All frames were taken through a standard Johnson-Cousins ($V(RI)_c$) set of filters. Twilight flat-fields in each filter were obtained every clear evening or morning. The frames acquired with the cameras on the 2-m RCC and the 1.3-m RC telescopes are bias-frame subtracted and flat-field corrected. The frames obtained with the cameras on the 50/70-cm Schmidt telescope are dark-frame subtracted and flat-field corrected.

The photometric data were reduced using subroutine DAOPHOT in the IDL software package. As a reference sequence we used the $V(RI)_c$ comparisons reported in Semkov (2006). All data were analyzed using the same aperture, which was chosen to have a 5″ radius and background annulus from 10″ to 15″. The average value of the errors in the reported magnitudes is 0.01-0.02 mag for the I_c and R_c band data and 0.01-0.03 mag for the V band data.

3. Results and Discussion

Figure 1 shows an I_c band image of the field of the McNeil's Nebula in the LDN 1630, where the positions of the stars from our study and V1647 Ori are marked.

Results from our long-term CCD observations of V2764 Ori are summarized in Table 1. The columns in the table contain date (*dd.mm.yyyy* format) and Julian date (J.D.) of the observations, I_cR_cV magnitudes of the star, and telescope and CCD camera used. The light curves of the star constructed on

[1] Skinakas Observatory is a collaborative project of the University of Crete, the Foundation for Research and Technology, Greece, and the Max-Planck-Institut für Extraterrestrische Physik, Germany.

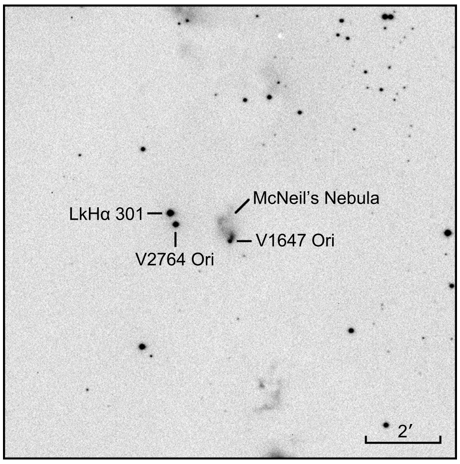

Fig. 1. An I_c band image of the field of the McNeil's Nebula obtained on 05 February 2013 with the 50/70-cm Schmidt telescope. The positions of the stars from our study and the young object V1647 Ori are marked. North is up, and east is left

the basis of our monitoring are displayed in Fig. 2. The available data suggest that during our observations the brightness of V2764 Ori generally varies around some intermediate level. The star exhibits irregular variability with different amplitudes in different periods. In August 2004 and December 2013, short-term decreases in the star's light were registered.

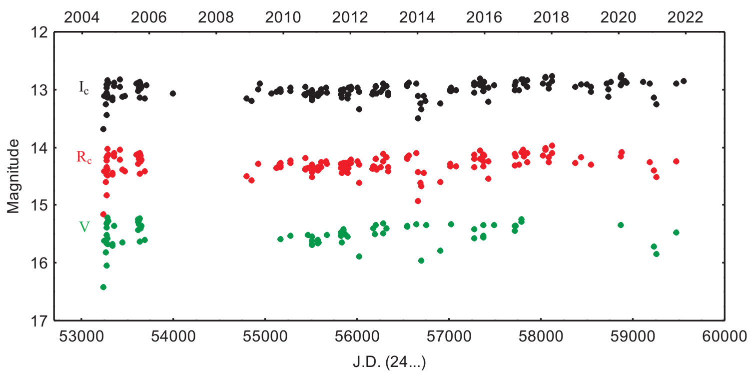

Fig. 2. $V(RI)_c$ light curves of V2764 Ori for the period August 2004−November 2021.

Table 1: Photometric CCD observations of V2764 Ori.

Date	J.D. (24...)	I_c	R_c	V	Tel	CCD	Date	J.D. (24...)	I_c	R_c	V	Tel	CCD
18.08.2004	53235.723	13.67	15.15	16.41	1.3-m	Phot	03.09.2012	56173.572	13.03	14.31	15.40	1.3-m	AND
21.08.2004	53238.719	13.10	14.41	15.61	1.3-m	Phot	13.09.2012	56183.564	13.05	14.33	15.49	1.3-m	AND
09.09.2004	53257.704	13.24	14.59	15.81	1.3-m	Phot	23.09.2012	56193.576	12.95	14.19	15.34	1.3-m	AND
18.09.2004	53266.733	12.96	14.22	15.37	1.3-m	Phot	23.09.2012	56193.597	12.93	14.19	-	Sch	FLI
19.09.2004	53267.734	12.90	14.16	15.30	1.3-m	Phot	09.10.2012	56209.563	13.06	14.38	-	Sch	FLI
20.09.2004	53268.724	13.04	14.33	15.51	1.3-m	Phot	18.11.2012	56249.501	13.03	14.34	-	Sch	FLI
21.09.2004	53269.672	13.12	14.46	15.65	1.3-m	Phot	13.12.2012	56275.457	12.88	14.11	15.31	2-m	VA
23.09.2004	53271.716	13.44	14.81	16.04	1.3-m	Phot	14.12.2012	56276.450	12.98	14.24	15.48	2-m	VA
29.09.2004	53277.624	13.14	14.47	15.66	1.3-m	Phot	19.01.2013	56312.331	12.93	14.16	15.39	2-m	VA
30.09.2004	53278.619	13.09	14.38	15.57	1.3-m	Phot	04.02.2013	56328.303	13.09	14.40	-	Sch	FLI
01.10.2004	53279.627	12.90	14.13	15.28	1.3-m	Phot	05.02.2013	56329.311	13.05	14.33	-	Sch	FLI
02.10.2004	53280.736	12.82	14.02	15.21	1.3-m	Phot	05.09.2013	56540.584	12.91	14.18	15.35	Sch	FLI
03.10.2004	53281.729	12.88	14.12	15.27	1.3-m	Phot	07.09.2013	56542.564	12.91	14.19	-	Sch	FLI
19.11.2004	53328.498	13.17	14.46	15.69	Sch	ST-8	08.09.2013	56543.593	12.93	14.16	15.37	2-m	VA
21.11.2004	53330.546	13.13	14.43	15.67	Sch	ST-8	18.09.2013	56553.544	12.88	14.13	-	1.3-m	AND
08.12.2004	53348.359	12.93	14.14	15.35	Sch	ST-8	09.12.2013	56636.381	12.89	14.09	15.33	2-m	VA
10.12.2004	53350.390	12.87	14.10	-	Sch	ST-8	28.12.2013	56655.413	13.48	14.92	-	Sch	FLI
10.02.2005	53412.366	12.81	14.03	-	Sch	ST-8	29.12.2013	56656.404	13.10	14.41	-	Sch	FLI
11.02.2005	53413.350	12.95	14.21	-	Sch	ST-8	23.01.2014	56681.349	13.23	14.61	-	Sch	FLI
12.03.2005	53442.273	13.11	14.38	15.63	2-m	VA	05.02.2014	56694.316	13.33	14.67	15.96	2-m	VA
03.04.2005	53464.242	13.11	14.40	-	Sch	ST-8	26.02.2014	56715.250	13.10	14.43	-	Sch	FLI
14.08.2005	53596.730	12.89	14.11	-	1.3-m	Phot	22.03.2014	56739.222	13.18	-	-	Sch	FLI
27.08.2005	53609.713	13.02	14.28	15.43	1.3-m	Phot	30.03.2014	56747.311	-	-	15.34	2-m	VA
28.08.2005	53610.711	12.88	14.10	15.23	1.3-m	Phot	30.08.2014	56899.567	13.23	14.59	15.79	1.3-m	AND
29.08.2005	53611.708	12.88	14.13	15.28	1.3-m	Phot	13.12.2014	57005.488	13.02	14.32	-	Sch	FLI
03.09.2005	53616.724	12.96	14.20	15.32	1.3-m	Phot	15.12.2014	57006.601	12.99	14.28	-	Sch	FLI
10.09.2005	53623.724	12.91	-	15.26	1.3-m	Phot	24.12.2014	57016.438	12.95	-	15.33	2-m	VA
11.09.2005	53624.724	12.86	14.09	15.23	1.3-m	Phot	25.12.2014	57017.371	13.02	-	-	2-m	VA
15.09.2005	53628.702	13.12	14.45	15.62	1.3-m	Phot	20.02.2015	57074.281	13.00	14.32	-	Sch	FLI
19.09.2005	53632.688	12.94	14.20	-	1.3-m	Phot	02.09.2015	57267.570	13.04	14.34	15.57	1.3-m	AND
20.09.2005	53633.706	12.97	14.23	15.39	1.3-m	Phot	03.09.2015	57268.593	12.92	14.19	15.40	1.3-m	AND
25.09.2005	53638.699	12.91	14.13	-	1.3-m	Phot	04.09.2015	57269.581	12.87	14.12	-	1.3-m	AND
03.10.2005	53646.700	12.94	14.20	15.35	1.3-m	Phot	03.11.2015	57330.281	12.91	14.20	-	Sch	FLI
03.11.2005	53678.396	13.15	14.41	15.60	2-m	VA	05.11.2015	57331.511	12.80	14.04	-	Sch	FLI
26.11.2005	53701.340	12.92	-	-	Sch	ST-8	06.11.2015	57333.444	12.88	-	-	Sch	FLI
10.09.2006	53988.592	13.06	-	-	1.3-m	Phot	07.11.2015	57333.502	12.88	-	-	Sch	FLI
20.11.2008	54791.385	13.14	14.49	-	Sch	STL-11	08.11.2015	57334.501	12.87	-	-	Sch	FLI
11.01.2009	54843.261	13.18	14.57	-	Sch	STL-11	12.12.2015	57369.458	12.94	14.12	15.34	2-m	VA
24.03.2009	54915.260	12.99	14.28	-	Sch	STL-11	13.12.2015	57370.436	13.02	14.32	15.55	2-m	VA
16.04.2009	54938.268	12.89	-	-	Sch	STL-11	14.12.2015	57371.436	13.02	14.23	15.52	2-m	VA
22.08.2009	55065.559	13.06	-	-	Sch	FLI	15.12.2015	57372.435	12.86	14.11	-	Sch	FLI
09.10.2009	55114.450	13.03	14.35	-	Sch	FLI	17.12.2015	57374.398	12.86	14.13	-	Sch	FLI
28.10.2009	55133.417	13.02	14.34	-	Sch	FLI	06.02.2016	57425.312	12.95	14.23	-	Sch	FLI
19.11.2009	55155.408	12.99	14.28	-	Sch	FLI	07.02.2016	57426.302	13.20	14.54	-	Sch	FLI
20.11.2009	55156.470	12.99	14.27	-	Sch	FLI	05.04.2016	57484.260	12.91	-	15.34	2-m	VA
21.11.2009	55157.471	13.01	14.31	-	Sch	FLI	22.11.2016	57714.500	12.92	14.10	15.35	2-m	VA
25.11.2009	55161.496	13.03	14.34	15.57	2-m	VA	22.11.2016	57715.490	13.00	14.31	15.44	2-m	VA
11.03.2010	55267.275	13.01	14.26	15.52	2-m	VA	23.11.2016	57716.479	12.87	14.15	15.35	2-m	VA
12.03.2010	55268.321	12.96	14.22	-	2-m	VA	02.01.2017	57756.370	13.00	14.29	-	Sch	FLI
12.08.2010	55420.614	13.07	-	-	1.3-m	AND	27.01.2017	57781.304	12.81	14.08	-	Sch	FLI
20.08.2010	55428.606	12.94	14.18	-	1.3-m	AND	28.01.2017	57782.376	-	-	15.28	2-m	VA
24.08.2010	55432.586	13.09	14.38	-	1.3-m	AND	01.02.2017	57786.333	-	-	15.24	2-m	VA
25.08.2010	55433.594	13.09	14.37	-	1.3-m	AND	15.02.2017	57800.275	12.81	14.04	-	Sch	FLI
20.09.2010	55459.636	13.05	14.35	15.50	1.3-m	AND	16.02.2017	57801.305	12.83	14.07	-	Sch	FLI
30.10.2010	55499.524	13.07	14.36	15.61	2-m	VA	28.02.2017	57813.257	12.88	14.15	-	Sch	FLI
31.10.2010	55500.503	13.10	14.41	15.68	2-m	VA	04.03.2017	57817.268	12.85	14.11	-	Sch	FLI
01.11.2010	55501.501	13.15	14.42	15.66	2-m	VA	01.04.2017	57845.249	12.83	14.09	-	Sch	FLI
01.11.2010	55501.546	13.10	14.40	-	Sch	FLI	02.04.2017	57846.255	12.95	14.25	-	Sch	FLI
02.11.2010	55502.569	13.04	14.32	15.54	2-m	VA	17.09.2017	58013.548	12.88	14.14	-	Sch	FLI
04.11.2010	55505.472	13.00	14.28	-	Sch	FLI	17.10.2017	58043.523	12.79	14.03	-	Sch	FLI
06.11.2010	55506.501	13.11	14.42	-	Sch	FLI	18.10.2017	58044.595	12.77	14.00	-	Sch	FLI
07.11.2010	55507.511	13.17	14.51	-	Sch	FLI	22.11.2017	58080.483	12.90	14.17	-	Sch	FLI
01.01.2011	55563.420	13.06	14.36	-	Sch	FLI	23.11.2017	58081.486	12.98	14.25	-	Sch	FLI
06.01.2011	55568.388	13.10	14.39	15.66	2-m	VA	25.12.2017	58113.402	12.76	13.96	-	Sch	FLI
08.01.2011	55570.273	13.08	14.34	15.60	2-m	VA	26.12.2017	58114.397	12.85	14.10	-	Sch	FLI
09.01.2011	55571.378	13.09	14.37	15.63	2-m	VA	03.09.2018	58364.578	12.95	14.26	-	Sch	FLI
06.02.2011	55599.321	13.05	14.33	-	Sch	FLI	05.11.2018	58428.435	12.90	14.16	-	Sch	FLI
07.02.2011	55600.299	12.99	14.25	-	Sch	FLI	12.01.2019	58496.316	12.90	-	-	Sch	FLI
04.04.2011	55656.253	12.96	14.24	-	Sch	FLI	28.02.2019	58543.232	12.95	-	-	Sch	FLI
09.04.2011	55661.260	13.04	14.28	15.51	2-m	VA	01.03.2019	58544.250	13.03	14.29	-	2-m	AND
11.09.2011	55815.564	13.01	14.27	15.46	1.3-m	AND	12.08.2019	58707.587	12.89	-	-	Sch	FLI
12.09.2011	55816.591	13.07	14.34	15.52	1.3-m	AND	01.09.2019	58727.587	12.99	-	-	2-m	AND
20.09.2011	55824.537	13.13	14.43	15.64	1.3-m	AND	03.09.2019	58729.589	13.12	-	-	2-m	AND
08.10.2011	55842.510	12.99	14.26	15.41	1.3-m	AND	02.10.2019	58758.539	12.86	-	-	Sch	FLI
14.10.2011	55848.501	13.02	14.28	15.42	1.3-m	AND	15.01.2020	58864.358	12.78	-	-	Sch	FLI
30.10.2011	55865.483	-	14.37	-	2-m	VA	16.01.2020	58865.361	12.77	-	-	Sch	FLI
01.11.2011	55866.521	-	14.26	15.50	2-m	VA	18.01.2020	58867.372	12.91	14.15	15.33	2-m	AND
26.11.2011	55892.474	13.09	14.33	15.53	2-m	VA	20.01.2020	58869.361	12.89	14.07	-	2-m	AND
27.11.2011	55893.417	13.14	14.43	-	Sch	FLI	21.01.2020	58870.366	12.75	14.07	-	Sch	FLI
29.11.2011	55895.486	13.08	14.35	-	Sch	FLI	29.02.2020	58909.278	12.85	-	-	Sch	FLI
30.11.2011	55896.443	12.96	14.24	-	Sch	FLI	21.03.2020	58930.318	12.87	-	-	Sch	FLI
29.12.2011	55925.450	12.94	14.20	-	Sch	FLI	13.09.2020	59105.602	12.86	-	-	Sch	FLI
01.01.2012	55928.381	12.99	14.26	-	Sch	FLI	22.11.2020	59176.451	12.88	14.24	-	Sch	FLI
16.03.2012	56003.258	12.96	14.24	-	Sch	FLI	05.01.2021	59220.339	13.12	14.39	15.71	2-m	AND
26.03.2012	56013.259	13.33	14.61	15.88	2-m	VA	04.02.2021	59250.350	13.24	14.51	15.85	2-m	AND
28.03.2012	56015.310	13.03	14.29	-	2-m	VA	11.09.2021	59468.598	12.88	14.23	15.46	Sch	FLI
21.08.2012	56160.582	13.07	14.36	-	1.3-m	AND	30.11.2021	59549.451	12.85	-	-	Sch	FLI

The brightness variation of V2764 Ori during the whole period of our monitoring is in the range 12.75-13.67 mag for the I_c band, 13.96-15.15 mag for the R_c band and 15.21-16.41 mag for the V band. The registered amplitudes of the light variations of the star during the same period are 0.92 mag for the I_c band, 1.19 mag for the R_c band and 1.20 mag for the V band. Variability with such amplitudes is observed in CTTSs and it can be explained by variations in the mass accretion rate and rotational modulation from a spot or group of spots on the stellar surface.

The measured color indices ($V - I_c$ and $V - R_c$) versus the V magnitude of V2764 Ori are shown in Fig. 3. As can be seen, the star becomes redder as it fades. Such color variation is typical for T Tauri variables, whose variability is produced by the presence of a spot or group of spots on the star's surface, as well as by the small irregular obscuration by the circumstellar material.

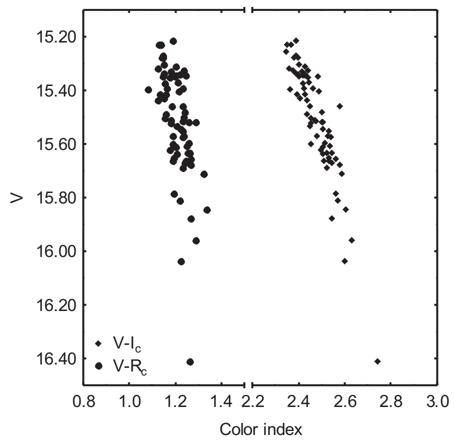

Fig. 3. Color indices ($V - I_c$) and ($V - R_c$) versus the V magnitude of V2764 Ori.

LkHα 301 is located at a distance of 20$''$ from V2764 Ori. Results from our long-term photometric monitoring of the star are summarized in Table 2. The columns have the same content as in Table 1. Figure 4 shows $V(RI)_c$ light curves of LkHα 301 from our observations. As can be seen, similar to V2764 Ori, LkHα 301 exhibits irregular light variations and its brightness varies around some intermediate level. In September 2004 and September 2019, two short-term decreases in the star's brightness were registered. During our monitoring the light variation of LkHα 301 is in the range 12.31-13.01 mag for the I_c band, 13.38-14.27 mag for the R_c band and 14.46-15.43 mag for the V band. The observed amplitudes are ΔI_c=0.70 mag, ΔR_c=0.89 mag and ΔV=0.97 mag, which are typical for CTTSs.

Table 2: Photometric CCD observations of LkHα 301.

Date	J.D. (24...)	I_c	R_c	V	Tel	CCD
18.08.2004	53235.723	12.61	13.78	14.89	1.3-m	Phot
21.08.2004	53238.719	12.67	13.86	15.00	1.3-m	Phot
09.09.2004	53257.704	13.01	14.27	15.43	1.3-m	Phot
18.09.2004	53266.733	12.59	13.72	14.81	1.3-m	Phot
19.09.2004	53267.734	12.95	14.19	15.34	1.3-m	Phot
20.09.2004	53268.724	12.62	13.78	14.87	1.3-m	Phot
21.09.2004	53269.672	12.55	13.69	14.76	1.3-m	Phot
23.09.2004	53271.716	12.57	13.71	14.79	1.3-m	Phot
29.09.2004	53277.624	12.47	13.61	14.73	1.3-m	Phot
30.09.2004	53278.619	12.45	13.55	14.64	1.3-m	Phot
01.10.2004	53279.627	12.50	13.61	14.69	1.3-m	Phot
02.10.2004	53280.736	12.48	13.58	14.69	1.3-m	Phot
03.10.2004	53281.729	12.49	13.62	14.69	1.3-m	Phot
19.11.2004	53328.498	12.56	13.69	14.86	Sch	ST-8
21.11.2004	53330.546	12.54	13.64	14.79	Sch	ST-8
08.12.2004	53348.359	12.45	13.57	14.73	Sch	ST-8
10.12.2004	53350.390	12.54	13.66	-	Sch	ST-8
10.02.2005	53412.366	12.41	13.51	-	Sch	ST-8
11.02.2005	53413.350	12.43	13.55	-	Sch	ST-8
12.03.2005	53442.273	12.47	13.60	14.72	2-m	VA
03.04.2005	53464.242	12.49	13.62	-	Sch	ST-8
14.08.2005	53596.730	12.45	13.61	-	1.3-m	Phot
27.08.2005	53609.713	12.45	13.59	14.67	1.3-m	Phot
28.08.2005	53610.711	12.44	13.59	14.67	1.3-m	Phot
29.08.2005	53611.708	12.37	13.51	14.58	1.3-m	Phot
03.09.2005	53616.724	-	13.56	14.62	1.3-m	Phot
10.09.2005	53623.724	12.46	-	14.67	1.3-m	Phot
11.09.2005	53624.724	-	13.63	14.71	1.3-m	Phot
15.09.2005	53628.702	12.41	13.53	14.57	1.3-m	Phot
19.09.2005	53632.688	12.38	13.51	-	1.3-m	Phot
20.09.2005	53633.706	12.41	13.52	14.57	1.3-m	Phot
25.09.2005	53638.699	12.46	13.59	-	1.3-m	Phot
03.10.2005	53646.700	12.45	13.61	14.68	1.3-m	Phot
03.11.2005	53678.396	12.50	13.67	14.76	2-m	VA
26.11.2005	53701.340	12.41	-	-	Sch	ST-8
10.09.2006	53988.592	12.44	-	-	1.3-m	Phot
20.11.2008	54791.385	12.45	13.62	-	Sch	STL-11
11.01.2009	54843.261	12.41	13.57	-	Sch	STL-11
24.03.2009	54915.260	12.42	13.59	-	Sch	STL-11
16.04.2009	54938.268	12.57	-	-	Sch	STL-11
22.08.2009	55065.559	12.33	-	-	Sch	STL-11
09.10.2009	55114.450	12.34	13.45	-	Sch	FLI
28.10.2009	55133.417	12.42	13.53	-	Sch	FLI
19.11.2009	55155.408	12.36	13.45	-	Sch	FLI
20.11.2009	55156.470	12.40	13.52	-	Sch	FLI
21.11.2009	55157.471	12.31	13.38	-	Sch	FLI
25.11.2009	55161.496	12.42	13.58	14.68	2-m	VA
11.03.2010	55267.275	12.43	13.54	14.65	2-m	VA
12.03.2010	55268.321	12.40	13.54	-	2-m	VA
12.08.2010	55420.614	12.44	-	-	1.3-m	AND
20.08.2010	55428.606	12.37	13.43	-	1.3-m	AND
24.08.2010	55432.586	12.43	13.52	-	1.3-m	AND
25.08.2010	55433.594	12.40	13.49	-	1.3-m	AND
20.09.2010	55459.636	12.36	13.45	14.47	1.3-m	AND
30.10.2010	55499.524	12.32	13.44	14.51	2-m	VA
31.10.2010	55500.503	12.36	13.51	14.61	2-m	VA
01.11.2010	55501.501	12.40	13.53	14.62	2-m	VA
01.11.2010	55501.546	12.36	13.46	-	Sch	FLI
02.11.2010	55502.569	12.40	13.52	14.61	2-m	VA
04.11.2010	55505.472	12.32	13.41	-	Sch	FLI
06.11.2010	55506.501	12.35	13.43	-	Sch	FLI
07.11.2010	55507.511	12.32	13.41	-	Sch	FLI
01.01.2011	55563.420	12.55	13.74	-	Sch	FLI
06.01.2011	55568.388	12.44	13.57	14.68	2-m	VA
08.01.2011	55570.273	12.42	13.52	14.63	2-m	VA
09.01.2011	55571.378	-	13.53	14.65	2-m	VA
06.02.2011	55599.321	12.37	13.46	-	Sch	FLI
07.02.2011	55600.299	12.34	13.40	-	Sch	FLI
04.04.2011	55656.253	12.36	13.46	-	Sch	FLI
09.04.2011	55661.260	12.39	13.50	14.61	2-m	VA
11.09.2011	55815.564	12.44	13.53	14.59	1.3-m	AND
12.09.2011	55816.591	12.43	-	14.57	1.3-m	AND
20.09.2011	55824.537	12.40	13.50	14.60	1.3-m	AND
08.10.2011	55842.510	12.40	13.49	14.54	1.3-m	AND
14.10.2011	55848.501	12.42	13.51	14.53	1.3-m	AND
01.11.2011	55866.521	-	-	14.64	2-m	VA
26.11.2011	55892.474	12.47	13.56	14.63	2-m	VA
27.11.2011	55893.417	12.40	13.49	-	Sch	FLI
29.11.2011	55895.486	12.35	13.43	-	Sch	FLI
30.11.2011	55896.443	12.38	13.50	-	Sch	FLI
29.12.2011	55925.450	12.35	13.43	-	Sch	FLI
01.01.2012	55928.381	12.39	13.48	-	Sch	FLI
16.03.2012	56003.258	12.34	13.42	-	Sch	FLI
26.03.2012	56013.259	12.41	13.52	14.58	2-m	VA
28.03.2012	56015.310	12.47	13.60	-	2-m	VA
21.08.2012	56160.582	12.43	13.49	-	1.3-m	AND
03.09.2012	56173.572	12.41	13.48	14.46	1.3-m	AND
13.09.2012	56183.564	12.41	13.45	14.49	1.3-m	AND
23.09.2012	56193.576	12.45	13.50	14.54	1.3-m	AND
23.09.2012	56193.597	12.44	13.51	-	Sch	FLI
09.10.2012	56209.563	12.34	13.44	-	Sch	FLI
18.11.2012	56249.501	12.38	13.48	-	Sch	FLI
13.12.2012	56275.457	12.46	13.58	14.68	2-m	VA
14.12.2012	56276.450	12.46	-	14.72	2-m	VA
19.01.2013	56312.331	12.45	13.55	-	2-m	VA
04.02.2013	56328.303	12.56	13.71	-	Sch	FLI
05.02.2013	56329.311	12.40	13.49	-	Sch	FLI
05.09.2013	56540.584	12.43	13.53	14.61	Sch	FLI
07.09.2013	56542.564	12.42	13.54	-	Sch	FLI
08.09.2013	56543.593	12.45	13.55	14.63	2-m	VA
18.09.2013	56553.544	12.57	13.73	-	1.3-m	AND
09.12.2013	56636.381	12.53	13.63	14.75	2-m	VA
28.12.2013	56655.413	12.42	13.52	-	Sch	FLI
29.12.2013	56656.404	12.43	13.51	-	Sch	FLI
23.01.2014	56681.349	12.46	13.58	-	Sch	FLI
26.02.2014	56715.250	12.45	13.57	-	Sch	FLI
22.03.2014	56739.222	12.40	-	-	Sch	FLI
30.03.2014	56747.311	-	-	14.69	2-m	VA
30.08.2014	56899.567	12.45	13.57	14.61	1.3-m	AND
13.12.2014	57005.488	12.43	13.53	-	Sch	FLI
15.12.2014	57006.601	12.42	13.49	-	Sch	FLI
24.12.2014	57016.438	12.50	13.57	14.69	2-m	VA
25.12.2014	57017.371	12.43	-	-	2-m	VA
20.02.2015	57074.281	12.40	13.49	-	Sch	FLI
02.09.2015	57267.570	12.46	13.53	14.63	1.3-m	AND
03.09.2015	57268.593	12.47	13.57	14.66	1.3-m	AND
04.09.2015	57269.581	12.46	13.56	-	1.3-m	AND
03.11.2015	57330.281	12.43	13.54	-	Sch	FLI
05.11.2015	57331.511	12.40	13.50	-	Sch	FLI
06.11.2015	57333.444	12.39	-	-	Sch	FLI
07.11.2015	57333.502	12.40	-	-	Sch	FLI
08.11.2015	57334.501	12.49	-	-	Sch	FLI
12.12.2015	57369.458	12.38	13.44	14.53	2-m	VA
13.12.2015	57370.436	-	-	14.63	2-m	VA
14.12.2015	57371.436	12.41	13.48	14.61	2-m	VA
15.12.2015	57372.435	12.43	13.55	-	Sch	FLI
17.12.2015	57374.398	12.39	13.49	-	Sch	FLI
06.02.2016	57425.312	12.48	13.60	-	Sch	FLI
07.02.2016	57426.302	12.44	13.53	-	Sch	FLI
05.04.2016	57484.260	12.48	-	14.65	2-m	VA
22.11.2016	57714.500	-	-	14.61	2-m	VA
22.11.2016	57715.490	12.44	-	14.61	2-m	VA
23.11.2016	57716.479	12.42	13.59	14.69	2-m	VA
02.01.2017	57756.370	12.44	13.54	-	Sch	FLI
27.01.2017	57781.304	12.40	13.51	-	Sch	FLI
01.02.2017	57786.333	-	-	14.62	2-m	VA
15.02.2017	57800.275	12.48	13.58	-	Sch	FLI
16.02.2017	57801.305	12.47	13.58	-	Sch	FLI
28.02.2017	57813.257	12.44	13.54	-	Sch	FLI
04.03.2017	57817.268	12.44	13.53	-	Sch	FLI
01.04.2017	57845.249	12.45	13.57	-	Sch	FLI
02.04.2017	57846.255	12.45	13.58	-	Sch	FLI
17.09.2017	58013.548	12.47	13.59	-	Sch	FLI
17.10.2017	58043.523	12.49	13.57	-	Sch	FLI
18.10.2017	58044.595	12.43	13.51	-	Sch	FLI
22.11.2017	58080.483	12.47	13.55	-	Sch	FLI
23.11.2017	58081.486	12.48	13.58	-	Sch	FLI
25.12.2017	58113.402	12.48	13.56	-	Sch	FLI
26.12.2017	58114.397	12.46	13.54	-	Sch	FLI
03.09.2018	58364.578	12.50	13.62	-	Sch	FLI
05.11.2018	58428.435	12.50	13.61	-	Sch	FLI
12.01.2019	58496.316	12.49	-	-	Sch	FLI
28.02.2019	58543.232	12.56	-	-	Sch	FLI
01.03.2019	58544.250	12.72	13.94	-	2-m	AND
12.08.2019	58707.587	12.58	-	-	Sch	FLI
01.09.2019	58727.587	12.77	-	-	2-m	AND
03.09.2019	58729.589	12.89	-	-	2-m	AND
02.10.2019	58758.539	12.53	-	-	Sch	FLI
15.01.2020	58864.358	12.49	-	-	Sch	FLI
16.01.2020	58865.361	12.49	-	-	Sch	FLI
18.01.2020	58867.372	12.60	13.80	-	2-m	AND
20.01.2020	58869.361	12.61	-	-	2-m	AND
21.01.2020	58870.366	12.42	13.61	-	Sch	FLI
29.02.2020	58909.278	12.45	-	-	Sch	FLI
21.03.2020	58930.318	12.47	-	-	Sch	FLI
13.09.2020	59105.602	12.44	-	-	Sch	FLI
22.11.2020	59176.451	12.40	13.62	-	Sch	FLI
05.01.2021	59220.339	12.58	13.71	14.78	2-m	AND
04.02.2021	59250.350	12.54	13.70	14.76	2-m	AND
11.09.2021	59468.598	12.41	13.61	14.71	Sch	FLI
30.11.2021	59549.451	12.41	-	-	Sch	FLI

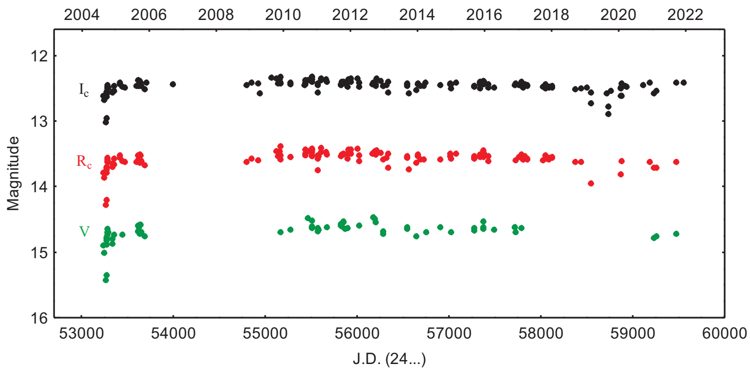

Fig. 4. $V(RI)_c$ light curves of LkHα 301 for the period August 2004–November 2021.

The measured color indices $V - I_c$ and $V - R_c$ versus the V magnitude of LkHα 301 are plotted in Fig. 5. A clear dependence can be seen from the figure: the star becomes redder as it fades. This is an expected color variation in the CTTSs.

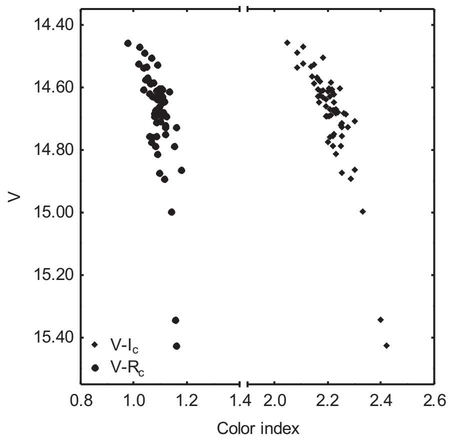

Fig. 5. Color indices $(V - I_c)$ and $(V - R_c)$ versus the V magnitude of LkHα 301.

We utilized the software package PERIOD04 (Lenz & Breger 2005) to search for periodicity in the light variations of V2764 Ori and LkHα 301. We did not identify any periodicity in their photometric behavior. The reason for this negative result is probably the short life of the hot spots on the stellar surface. Another reason may be the insufficient number of photometric points we have for the stars. Due to negative declination, the field of the McNeil's Nebula can be observed from Southern Europe only in the period August-April. In some months and years, we have only a few observations of this field.

4. Concluding remarks

We presented and discussed the optical CCD light curves and color−magnitude diagrams of V2764 Ori and LkHα 301. Our observations cover 17 years and represent the first long-term $V(RI)_c$ monitoring of the stars. The shape of the light curves, the brightness variations, and the observed amplitudes of both stars are typical for CTTSs. Our study adds two CTTSs with long-term photometry to the family of known PMS stars. We plan to continue our monitoring of the field of the McNeil's Nebula during the next years.

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