

NEW CANDIDATE ERUPTIVE YOUNG STARS IN LYNDS 1340

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ABSTRACT

We report on the discovery of three candidate eruptive young stars, found during our comprehensive multi-wavelength study of the young stellar population of the dark cloud L1340. These stars are as follows. (1) IRAS 02224+7227 (2MASS 02270555+7241167, HH 487S) exhibited FUor-like spectrum in our low-resolution optical spectra. The available photometric data restrict its luminosity to $23 L_{\odot} < L_{\text{bol}} < 59 L_{\odot}$. (2) 2MASS 02263797+7304575, identified as a classical T Tauri star during our H α survey, exhibited an EXor-type brightening in 2005 November at the time of the Sloan Digital Sky Survey observations of the region. (3) 2MASS 02325605+7246055, a low-mass embedded young star, associated with a fan-shaped infrared nebula, underwent an outburst between the DSS 1 and DSS 2 surveys, leading to the appearance of a faint optical nebula. Our [S II] and H α images, as well as the *Spitzer* Infrared Array Camera 4.5 μm images, revealed Herbig–Haro objects associated with this star. Our results suggest that amplitudes and timescales of outbursts do not necessarily correlate with the evolutionary stage of the stars.

Key words: stars: individual (IRAS 02224+7227, 2MASS 02263797+7304575, 2MASS 02325605+7246055) – stars: pre-main sequence – stars: protostars – stars: variables: T Tauri, Herbig Ae/Be

Online-only material: color figures, machine-readable table

1. INTRODUCTION

Eruptive young stellar objects (YSOs) are characterized by dramatically increased accretion from the circumstellar disk onto the star (Hartmann & Kenyon 1996). In addition to the classical FU Orionis-type (FUor; Herbig 1977; Hartmann & Kenyon 1996; Reipurth & Aspin 2010) and EX Lupi-type (EXor; Herbig 2007, 2008; Lorenzetti et al. 2012) stars, observations from the past decades revealed several embedded eruptive young stars whose classifications are uncertain, and differ from classical types in both amplitude and timescale (Reipurth & Aspin 2010; Kun et al. 2011a; Kóspál et al. 2013). Although the outbursts in each class are powered by enhanced accretion from the disk onto the star, the spectroscopic properties of FUors and EXors are radically different. EXors keep the major spectroscopic signatures of magnetospheric accretion during the outburst, whereas FUor spectra indicate star–disk interaction zones substantially transformed by the outburst. The powerful winds, associated with the high accretion rate, produce Herbig–Haro (HH) objects, which may thus be important tracers of the accretion history (Reipurth & Aspin 2010).

Since a sizeable part of the stellar mass may build up during repeated outbursts (Vorobyov & Basu 2006), and the high accretion luminosity and associated outflows affect the structure and evolution of the protoplanetary disks, outbursting stars are key objects for understanding the formation of Sun-like stars and their planetary systems. Their extreme rarity and diversity, however, hinder the understanding of the origin and nature of the outbursts. The recent review by Audard et al. (2014) lists 26 FUors and FUor-like objects, and 18 EXors can be found in the list of Lorenzetti et al. (2012). New discoveries

and their subsequent monitoring are thus relevant to a better understanding of the phenomenon of episodic accretion.

The new candidate eruptive stars presented in this Letter are found in Lynds 1340, an isolated dark cloud at $(l, b) = (130^{\circ}.1, 11^{\circ}.5)$. The first large-scale studies of the region (Kun et al. 1994; Kumar et al. 2003; Magakian et al. 2003) suggested that L1340, located at 600 pc from the Sun, has formed a few mid-B-, A-, and early-F-type, and some two dozen low-mass stars. We conducted a comprehensive multi-wavelength study of L1340, involving *Spitzer*, *Wide-field Infrared Survey Explorer* (*WISE*), Two Micron All Sky Survey (2MASS), and Sloan Digital Sky Survey (SDSS) photometric data, a search for H α emission stars via slitless grism spectroscopy, long-slit optical spectroscopy, narrow-band optical, and high angular resolution near infrared imaging observations (M. Kun et al. 2014, in preparation). This work led to a revised distance of 730 ± 30 pc for L1340, and resulted in the discovery of some 250 candidate YSOs. Among them we found three new candidate eruptive young stars which deserve special attention. One of them is IRAS 02224+7227, identified by Kumar et al. (2003) as the probable exciting source of HH 487, situated at 6'2 southwest of the star. The two others are 2MASS 02263797+7304575 and 2MASS 02325605+7246055, neither of which was mentioned previously as a young star. We present observational results which prove the eruptive natures of these objects. We adopt the revised distance of 730 pc.

2. DATA

Lynds 1340 was observed by the *Spitzer Space Telescope* using the Infrared Array Camera (IRAC; Fazio et al. 2004) on 2009 March 16 and the Multiband Imaging Photometer (MIPS) for *Spitzer* (Rieke et al. 2004) on 2008 November 26 (Prog. ID:

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Table 1
Photometric Data of the Target Stars

Date (yyyymmdd)	Band (mag)	2MASS 02263797	IRAS 02224+7227	2MASS 02325605	Source ^a
19991028	<i>J</i>	14.211 (0.031)	9.901 (0.023)	...	2MASS
19991028	<i>H</i>	13.403 (0.037)	9.084 (0.051)	...	2MASS
19991028	<i>K_s</i>	13.034 (0.028)	8.579 (0.020)	15.104 (0.163)	2MASS
20011014	<i>B</i>	...	14.656 (0.060)	...	Konkoly RCC
20011014	<i>V</i>	...	13.231 (0.050)	...	Konkoly RCC
20011014	<i>R_C</i>	...	12.317 (0.050)	...	Konkoly RCC
20011014	<i>I_C</i>	...	11.455 (0.050)	...	Konkoly RCC
20021024	<i>J</i>	...	9.990 (0.054)	...	CA 3.5 m/Omega-Cass
20021024	<i>H</i>	...	9.171 (0.051)	...	CA 3.5 m/Omega-Cass
20021024	<i>K_s</i>	...	8.694 (0.020)	...	CA 3.5 m/Omega-Cass

Note. ^a Telescope/instrument or data base.

(This table is available in its entirety in a machine-readable form in the online journal. A portion is shown here for guidance regarding its form and content.)

50691, PI: G. Fazio). The observations covered $\sim 1 \text{ deg}^2$ in each band. The centers of the 3.6 and 5.8 μm images are slightly displaced from those of the 4.5 and 8 μm images; therefore, the southeastern part of the molecular cloud was not covered by the 4.5 and 8 μm maps. Moreover, the southwestern part of L1340 is outside the field of view of the 24 and 70 μm images. We performed aperture photometry on individual saturation-corrected basic calibrated data (CBCD) IRAC images, produced by the S18.18.0 pipeline at the Spitzer Science Center (SSC), using a 2 pixel aperture radius, and a sky annulus between 2 and 6 pixels. An additional array-dependent photometric correction and a pixel-phase correction (see Hora et al. 2008), as well as an aperture correction, were applied. The final photometry and its uncertainty were estimated as the average and the rms of the individual flux densities measured in different CBCD frames. For MIPS data, we used MOPEX (Makovoz et al. 2006) to create mosaic maps from the 24 μm enhanced BCD and 70 μm BCD products (version S18.13.0) of SSC. Following Gordon et al. (2007) at 70 μm before mosaicking, we made a column mean subtraction and a time filtering on the BCD frames. Point-spread function photometry was used to determine the targets' fluxes in the mosaic maps. The resulted fluxes of the three targets are shown in Table 1. The quoted uncertainties were computed as a quadratic sum of the measurement errors and absolute calibration errors of 2% for IRAC (Hora et al. 2008) and 4% and 7% for 24 and 70 μm MIPS observations (Engelbracht et al. 2007; Gordon et al. 2007), respectively.

We obtained low-resolution optical spectra for the star coinciding with IRAS 02224+7227 on 2003 February 5 using CAFOS⁸ with the G-100 grism on the 2.2 m Telescope of the Calar Alto Observatory, and on 2004 December 11 using FAST on the 1.5 m FLWO Telescope (Fabricant et al. 1998). We reduced and analyzed the spectra in IRAF.

High angular resolution *JHK* images, centered on the same star, were obtained on 2002 October 24 using the near-infrared camera Omega-Cass,⁹ mounted on the 3.5 m Telescope of the Calar Alto Observatory. The plate scale was $0''.1 \text{ pixel}^{-1}$. The target was observed at four dithering positions, and the observations consisted of two dither cycles. The total integration time was 480 s in each filter. We reduced and analyzed the data in IRAF. Following the flat-field correction and bad pixel

removal, the sky frame for each cycle was obtained by taking the minimum of the images at different dithering positions. This sky frame was subtracted from each individual image of a given cycle, and the frames from a single cycle were combined into a mosaic image. Aperture photometry was performed on the reduced images. The instrumental magnitudes were transformed into the *JHK_s* system by using the 2MASS magnitudes of field stars within the field of view. The resulting magnitudes are listed in Table 1.

We performed a new search for H α emission stars in L1340 using the Wide Field Grism Spectrograph 2 installed on the University of Hawaii 2.2 m Telescope. The instrument setup and data reduction procedure were same as described in detail in Szegedi-Elek et al. (2013). We observed 2MASS 02263797+7304575 on 2011 October 16 and detected a H α emission with $\text{EW}(\text{H}\alpha) = -80 \text{ \AA}$ in its spectrum.

The *K_s* magnitude of 2MASS 02325605+7246055 was measured on the images obtained on 2010 October 18, during the monitoring program of V1180 Cas (Kun et al. 2011a), using the MAGIC camera on the 2.2 m Telescope of the Calar Alto Observatory.

Narrow-band images through [S II] and H α filters, as well as broad *R*-band images containing the environment of 2MASS 02325605+7246055, were obtained with the Schmidt Telescope of the Thüringer Landessternwarte (TLS), Tautenburg in 2011 May, June, and September. The frames obtained through the same filter were coadded, leading to integration times of 0.2, 3.0, and 4.0 hr in the *R*, H α , and [S II], respectively. Spectra of the nebula and the two brightest HH knots were obtained using the TLS medium-resolution Nasmyth spectrograph ($R \sim 700$) in 2011 November. The total integration time was 2 hr per object.

BVR_CI_C photometric observations of IRAS 02224+7227 were performed with the 1 m Ritchey–Chretien–Coude (RCC) Telescope of the Konkoly Observatory at three epochs between 2001 and 2011. We measured the *R_C* and *I_C* magnitudes of IRAS 02224+7227 and 2MASS 02263797+7304575 at several epochs between 2011 January and 2014 June on the images collected with the wide-field camera on the Schmidt Telescope of the Konkoly Observatory to monitor the light variations of V1180 Cas (Kun et al. 2011a). The results of the photometry are listed in the machine-readable version of Table 1.

L1340 is situated within Stripe 1260 of the *SEGUE* survey (Yanny et al. 2009), thus its entire area was observed in the *ugriz* bands in 2005 November–December. Each target star has high-quality 3.4, 4.6, 12, and 22 μm fluxes in the *AllWISE* data

⁸ <http://w3.caha.es/CAHA/Instruments/CAFOS/>

⁹ <http://www.caha.es/CAHA/Instruments/OCASS/ocass.html>

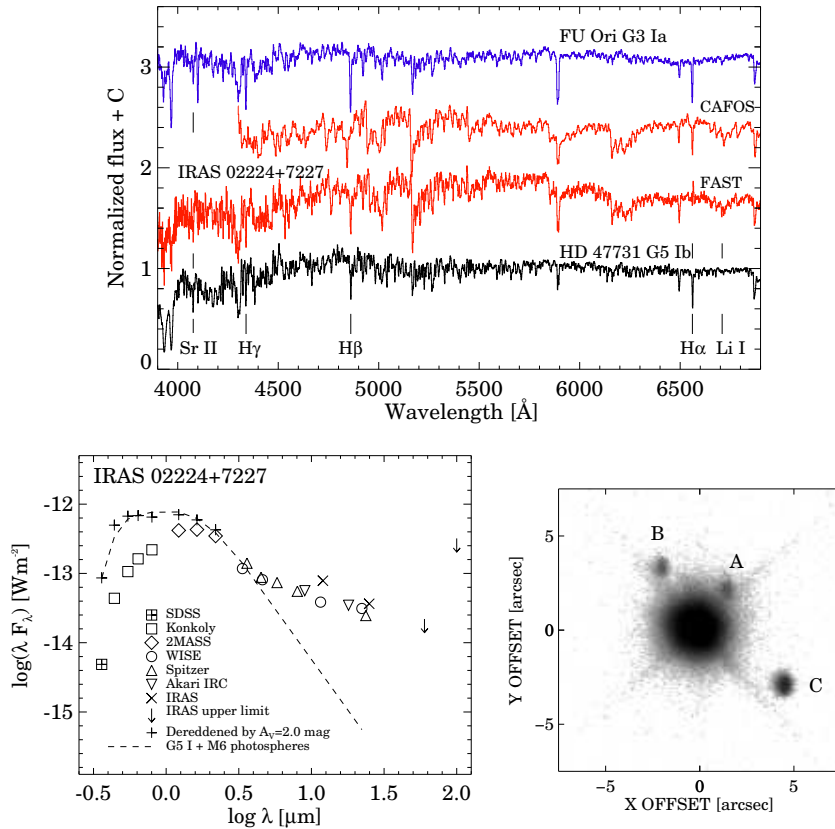


Figure 1. (1) Spectra of IRAS 02224+7227 (red), compared with that of FU Orionis (blue) and the spectrum of the G5 Ib type supergiant HD 47731 (black; Le Borgne et al. 2003). (2) SED of IRAS 02224+7227. (3) Visual companions of the same star in the Omega-Cass *K*-band image.

(A color version of this figure is available in the online journal.)

base. These data offer useful pieces of information on their spectral energy distribution (SED) and long-term photometric behavior.

3. RESULTS AND DISCUSSION

3.1. IRAS 02224+7227: a FUor-like Star

IRAS 02224+7227 (2MASS 02270555+7241167, HH 487S) is situated near the southwestern edge of L1340. The upper panel of Figure 1 shows its FAST and CAFOS spectra, together with that of FU Ori, found in the FAST Public Archive,¹⁰ and with the spectrum of the G5-type supergiant star HD 47731, found in Le Borgne et al.’s (2003) spectrum library. The hydrogen and metallic absorption spectra, characteristic of G-type stars, the Sr II line at 4077 Å, indicative of high-luminosity class, and the youth-indicator Li I line at 6707 Å can clearly be identified, suggesting the FU Ori nature of this star. Comparison of the strength of the Hγ, Hβ lines and the *G* band with those in spectroscopic standards (Jacoby et al. 1984; Le Borgne et al. 2003) suggests G4–G5 spectral type. Weak Hα emission can be seen in the FAST spectrum, while the Hα line is in absorption in the CAFOS spectrum. We estimated a foreground extinction of $A_V \approx 2.0$ mag from the G5 spectral type, and the $(R_C - I_C)$ color index, adopting an intrinsic color index of $(R_C - I_C)_0 = 0.37$ (Hartmann & Kenyon 1996).

The second panel of Figure 1 shows the SED of the star, constructed from SDSS *u*, (transformed into Johnson *U* following Jordi et al. 2006), *Spitzer*, 2MASS, *AllWISE*, and

¹⁰ <http://tdc-www.harvard.edu/cgi-bin/arc/fsearch>

Table 2
Visual Companions of IRAS 02224+7227

Star	<i>J</i> (mag)	<i>H</i> (mag)	<i>K_s</i> (mag)	Sep. ($''$)	P.A. ($^\circ$)
A	15.82	15.30	14.96	2.4	324.0
B	15.69	15.22	15.03	3.8	32.3
C	14.98	14.32	14.01	5.4	236.4

our own BVR_CI_C data. IRAS 02224+7227 lies outside the field of view of the 70 μm MIPS image, and only flux upper limits are available for the IRAS 60 and 100 μm bands. The shape of the dereddened SED in the 0.36–3.6 μm region can be satisfactorily approximated with the sum of a G5I and an M6-type photosphere, contributing nearly equally to the total flux at 2 μm, and supporting that FUors exhibit wavelength-dependent spectral types (Hartmann & Kenyon 1996). Integrating the dereddened SED over the 0.36–24 μm wavelength interval and assuming a distance of 730 pc, we obtain a luminosity of $L(0.36-24) \approx 23 L_\odot$. Including the IRAS 60 μm and 100 μm flux upper limits, we obtain $L(0.36-100) < 59 L_\odot$. Although most of the known FUors have $L_{\text{bol}} > 100 L_\odot$, both values are within the range of FUor luminosities ($7 \lesssim L_{\text{bol}}/L_\odot \lesssim 800$) compiled by Audard et al. (2014).

The third panel of Figure 1 shows the central part of the Omega-Cass *K*-band image. IRAS 02224+7227 has three wide companions. Table 2 lists the separations from the central star, position angles (from the north toward the east), and JHK_s magnitudes of the three stars. Each companion has normal

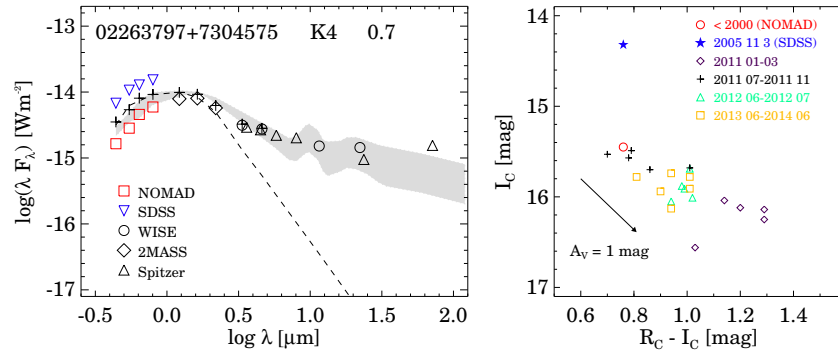


Figure 2. Left: spectral energy distribution of 2MASS 02263797+7304575. Crosses indicate the low-state fluxes, corrected for an extinction of $A_V = 0.7$ mag, and the dashed line is a K4-type photosphere fitted to the dereddened fluxes. The gray band indicates the median SED of the Taurus pre-main-sequence stars, fitted to the dereddened SED at $1.25 \mu\text{m}$. Right: R_C vs. $R_C - I_C$ color–magnitude diagram of the same star, containing all available data.

(A color version of this figure is available in the online journal.)

stellar colors in the near-infrared bands. The angular separations correspond to 1750–4000 AU at 730 pc, comparable with the typical size of protostellar envelopes. Spectroscopy and/or L/M -band photometry are required to decide whether or not these stars are physically related to each other.

Since the brightness of the star in the POSS 1 image, recorded on 1954 September 27, is similar to the more recent ones shown in Table 1, IRAS 02224+7227 has been in outburst for at least 60 yr. Similar to other FUor-like stars whose outburst dates are unknown, we observe in this star an evolved phase of outburst. If HH 487 was created by a previous outburst of the star and we assume a typical HH object space velocity 200 km s^{-1} , then its angular distance of $6''.2$, corresponding to 1.3 pc without accounting for the unknown inclination, suggests that a previous outburst might have occurred some 6500 yr ago. This interval corresponds to statistical estimates on the average time span between outbursts (Scholz et al. 2013). The present outburst thus might have occurred in a disk shaped by previous outburst(s). The Class II SED, with the absence of bright reflection nebulosity and the relatively low luminosity, may also suggest an “old” FUor. Our photometric measurements indicate no trend in the optical magnitudes between 2001 and 2014 (Table 1).

3.2. 2MASS 02263797+7304575: a Possible EXor

We identified this star as a candidate classical T Tauri star (CTTS) based on the strong $H\alpha$ emission ($\text{EW}(H\alpha) = -80 \text{ \AA}$) in its spectrum. The shape of its SED, constructed from the *NOMAD* *BVRI*, *SDSS*, *2MASS*, *AllWISE*, and *Spitzer* data, and plotted in Figure 2 (left), together with the band of typical SEDs of the Taurus pre-main-sequence stars (D’Alessio et al. 1999), confirms the CTTS nature. The *SDSS* *griz* magnitudes, measured on 2005 November 3, were transformed into the *BVR_CI_C* system (Ivezić et al. 2007) to compare them with other available photometric data. It is apparent that while the optical magnitudes of the *NOMAD* catalog, the *2MASS*, *Spitzer*, and *AllWISE* data, measured at various epochs, smoothly delineate a Class II SED, the *SDSS* magnitudes stand apart, suggesting that the star was unusually bright over the optical spectrum on 2005 November 3. We estimated the spectral type, extinction, and luminosity of the star by comparing the short-wavelength (*BVR_II_J*) side of the low-state SED with a grid of reddened photospheres, using the pre-main-sequence colors and bolometric corrections tabulated by Pecaut & Mamajek (2013) and the extinction law of Cardelli et al. (1989), as well as the $A_V \geq 0.5$ mag (foreground extinction

toward L1340; Kun et al. 2003) restriction. The dashed line shows the best estimate, the SED of a K4-type photosphere, fitted to the *NOMAD* and *2MASS* *J* magnitudes, dereddened by $A_V = 0.7$ mag. Its photospheric luminosity is $0.28 L_\odot$ at a distance of 730 pc. The total luminosity of the system, derived by integrating the dereddened SED and extrapolating the contribution of the spectral regions beyond $70 \mu\text{m}$ using the method by Chavarría-K. (1981), is $L_{\text{bol}} \approx 0.39 L_\odot$, suggesting $L_{\text{disk}}/L_{\text{star}} \approx 0.39$, higher than the upper limit (~ 0.2) for passive irradiated disks (Kenyon & Hartmann 1987).

The R_C versus $R_C - I_C$ color–magnitude diagram is plotted in Figure 2 (right). It can be seen that with the exception of the *SDSS* point, the star’s R_C magnitudes stay in the $15.4 < R_C < 16.3$ mag interval. The amplitude of the light variations within an observing season is about 0.5 mag, and the average brightness changes from season to season. The distribution of the points suggests variable circumstellar extinction. The single bright point indicates a burst-like event with an amplitude of 1.5–2.0 mag. Similar outbursts are supposed to frequently occur in CTTSs, but, due to their short duration, are hard to catch. Detection of such events may be helpful in looking for the specialities of EXor disks, distinguishing them from those of less violent pre-main-sequence stars. Such specialities may be the high $L_{\text{disk}}/L_{\text{star}}$, and the flattening of the SED between 24 and $70 \mu\text{m}$, unlike typical T Tauri SEDs, and indicative of a remnant infalling envelope (Calvet et al. 1994). A similar flattening can be seen in the SED of prototype EXor, EX Lupi (Sipos et al. 2009), and the candidate EXors identified by Giannini et al. (2009) also exhibit flat SEDs near the Class I/Class II boundary, indicating that eruptive events occur at the earliest evolutionary phases of the protoplanetary disks.

3.3. 2MASS 02325605+7246055: an Outbursting Protostellar Object?

This star is invisible in the DSS 1 red image. A faint bow-shaped nebula appears near its position in the DSS 2 red image, indicating that the outburst of an embedded star opened a cavity in its circumstellar envelope between 1954 September 27 and 1994 January 3. The nebula is also visible in our R_C and I_C images, obtained since 2001 with various instruments of the Tautenburg and Konkoly Observatories. The shortest wavelength where the star appears is the *K* band. Our K_s image obtained in 2010, as well as the *Spitzer* 3.6 and $4.5 \mu\text{m}$ images (Figure 3, upper right panel), show a small fan-shaped nebula next to the star at the northwestern side,

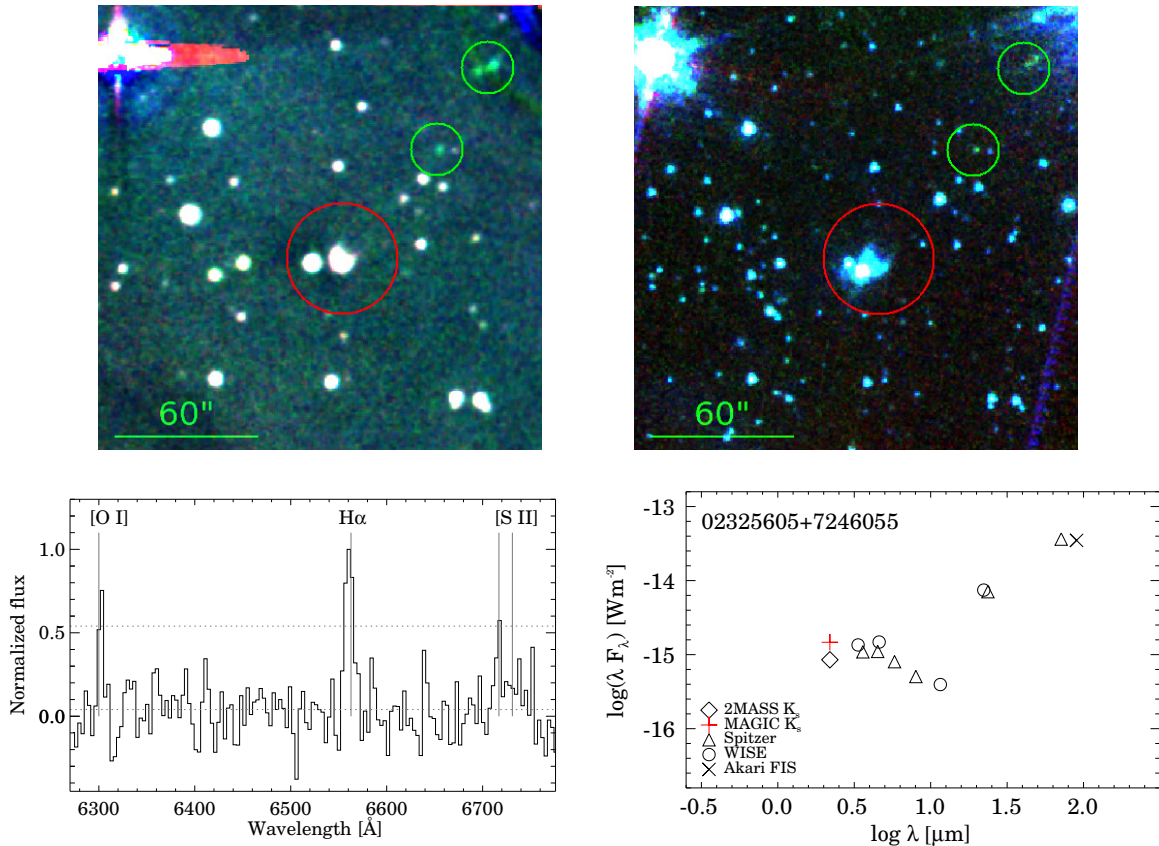


Figure 3. Top left: three-color image, composed of R_c (red), $H\alpha$ (green), and $[S\text{ II}]$ (blue) images of the environment of 2MASS 02325605+7246055 (located within the red circle), obtained with the Tautenburg Schmidt Telescope. Green circles encompass the HH objects. Top right: IRAC 3.6 (blue), 4.5 (green), and 5.8 (red) composite image of the same area. Bottom left: part of the spectrum of the NW HH knot. The dotted horizontal lines show the mean and 3σ levels. The vertical lines indicate rest wavelengths. Right: SED of 2MASS 02325605+7246055.

(A color version of this figure is available in the online journal.)

similar to those found near several embedded eruptive stars (e.g., RNO 125 associated with PV Cep (Kun et al. 2011b), and McNeil’s Nebula with V1647 (Ori Briceño et al. 2004)). The K_s magnitude of the star, measured in 2010, was some 0.5 mag brighter than the 2MASS K_s (Table 1), suggesting that the star has a brightening timescale of years. Our $H\alpha$ and $[S\text{ II}]$ images (Figure 3, upper left) show two faint HH knots, located at $71''$ (SE) and $112''$ (NW) to the northwest of the star, at (R.A., decl.)_(SE) = ($2^{\text{h}}32^{\text{m}}45^{\text{s}}.3$; $+72^{\circ}46'56''$), and (R.A., decl.)_(NW) = ($2^{\text{h}}32^{\text{m}}40^{\text{s}}.2$; $+72^{\circ}47'32''$), respectively. The HH knots are associated with shocked H_2 emission seen in IRAC $4.5\ \mu\text{m}$ image. While the spectrum of the SE HH knot has low signal-to-noise ratio, the NW knot exhibits $H\alpha$, $[\text{O I}]$, and $[\text{S II}]$ emission lines (Figure 3, lower left panel). The radial velocity of the $H\alpha$ is $v_{\text{LSR}} = -85 \pm 30\ \text{km s}^{-1}$, consistent with the cometary morphology of the object in the sense that we see the scattered light from the blueshifted outflow lobe. The monopolar morphology in the optical/IR implies a significant inclination. The spectrum of the object shows a faint continuum but lacks $H\alpha$ emission. This indicates that at present accretion is weak or even absent, which points to the lack/replenishment of the inner disk, most likely depleted during the outburst. The SED, plotted in the lower right panel of Figure 3, suggests an embedded object with deep silicate absorption at $10\ \mu\text{m}$. Its bolometric luminosity, estimated from the $70\ \mu\text{m}$ flux following the method of Dunham et al. (2008), is $L_{\text{bol}} \approx 1.2 L_{\odot}$ at 730 pc. The lack of $H\alpha$ emission from the spectrum and the low bolometric luminosity suggest the present low-accretion state of 2MASS 02325605+7246055.

The remnant of its recent outburst, the reflection nebula which appeared between 1954 and 1995, suggests an EXor-like event.

4. CONCLUSIONS

We identified three candidate eruptive young stars associated with the molecular cloud L1340, whose YSO population consists of some 250 members (M. Kun et al. 2014, in preparation). Together with the previously identified V1180 Cas (Kun et al. 2011a), some 1.6% of the total YSO population belong to eruptive classes. The observed properties of the FUor-like IRAS 02224+7227 suggest a late stage of its episodically accreting phase of evolution. The EXor candidate 2MASS 02263757+7304575 exhibits a Class II SED, but its high $70\ \mu\text{m}$ flux is indicative of a remnant infalling envelope. The nebulosity beside the Class I protostar 2MASS 02325605+7246055 is a signature of a recent EXor-like outburst. These results indicate that the amplitudes and timescales of YSO outbursts do not strictly correlate with the evolutionary stage of the star. The divergent observed properties of the eruptive young stars (e.g., Quanz et al. 2007; Lorenzetti et al. 2012) point to objects at various episodes of their consecutive outbursts.

We are grateful to Gábor Fűrész for obtaining the FAST spectrum of IRAS 02224+7227. This work makes use of observations made with the *Spitzer Space Telescope*, which is operated by the Jet Propulsion Laboratory, California Institute of Technology under a contract with NASA. Our results are partly based

on observations collected at the Centro Astronómico Hispano Alemán (CAHA) at Calar Alto, operated jointly by the Max-Planck Institut für Astronomie and the Instituto de Astrofísica de Andalucía (CSIC). This research utilized observations with the 2.2 m Telescope of the University of Hawaii and we thank Colin Aspin and Bo Reipurth for their interest and support. Our research has benefited from the Vizier catalogue access tool, CDS, Strasbourg, France. Financial support from the Hungarian OTKA grant K81966 is acknowledged.

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