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A New FU Orionis Accretion Outburst in the W5 HII Region

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ABSTRACT

We announce a recently detected outburst that is currently only a few months old, and probably of FU Orionis type. The progenitor to the outburst was an emission-line, flat-spectrum SED young stellar object located in the W5 region, though somewhat outside the main star formation action. We present optical, near-infrared, and mid-infrared lightcurves that illustrate the quiescent state of [KAG2008] 13656 and its subsequent $\Delta r \approx -4$ mag and $\Delta J \approx -3$ mag outburst over $\sim$75 days in late-2025. Follow-up optical and near-infrared spectroscopy confirms the expected features from an FU Ori disk and outflow.

Keywords: FU Orionis stars (553), Young stellar objects (1834)

1. INTRODUCTION

Episodic accretion events in young stellar objects (YSOs) take many forms, with the longest duration and largest amplitude outbursts known as FU Ori stars - named after the prototype FU Ori (Herbig 1966). These outbursts are characterized by extreme brightening that can be $\sim 4-6$ mag in the optical and $\sim 1-3$ mag in the infrared, and have rise times of a few months to a few years. The outbursts are the result of disk instabilities and accretion rate increases (Hartmann & Kenyon 1996) that drive the accretion luminosity upward by factors of typically hundreds. In an FU Ori outburst state, optical and near-infrared observations are dominated by the accretion disk atmosphere.

Understanding the processes of stellar mass assembly, through disk accretion, requires understanding the rapid mass accumulation that occurs during FU Ori events (Fischer et al. 2023). Understanding the evolution of circumstellar disks into planets must also account for the effects of significantly variable heating, especially from ultraviolet photons, on disk dust and gas chemistry (Molyarova et al. 2018).

W5 is a large and multi-bubble HII region in the outer Galaxy, with distance $2.2-2.4$ kpc (Damian et al. 2021), also known as IC 1848. There are several massive star clusters with age ~ 2 Myr (Damian et al. 2024) each harboring multiple O-type stars.

Our source of interest at RA=02:58:07.83, Decl. = +61:12:57.09 (J2000.) is just north of W5/IC 1848 East. It has a well-characterized pre-outburst spectral energy distribution from the optical to the mid-infrared (Figure 1b). The source was cataloged as a Class II disk in the Spitzer study of the W5 region by Koenig et al. (2008), and similarly tagged by Marton et al. (2016) and Winston et al. (2020). It also appears in IPHAS as an Hα emission-line object. The location, SED, and evidence for emission lines all indicate [KAG2008] 13656 as a secure YSO.

2. PHOTOMETRIC OUTBURST DETECTION AND SPECTROSCOPIC FOLLOW-UP

Initial detection of the source brightening was due to a specially designed filter running on the Zwicky Transient Facility (ZTF; Bellm et al. 2019) alerts stream (Patterson et al. 2019). The filter selects only certain ZTF fields containing large star forming regions, and identifies sources with sustained brightness increases that are within the mag/month range exhibited by previous FU Ori outbursts. Although previously detected as a variable object and earning the name ZTF20abjgfwm, around MJD=60905 (2025-08-18 UT), the source began a seemingly colorless brightening event and passed our alert filter ~ 40 days later. The source is also detected in the Gattini time domain survey (De et al. 2020). Figure 1c shows the lightcurve assembled to date, including from NEOWISE (Mainzer et al. 2014) which unfortunately stops prior to the outburst. Lightcurve peak appears to be around MJD=60980.

The source was subsequently observed with the Palomar 60" telescope's SED Machine (SEDM; Blagorodnova et al. 2018) on 2025-11-01 UT. Figure 1d shows the steeply rising continuum to the red, and clear indication of shallow absorption in several key features: Hα, Hβ, Na ID, and the K I/doublet + O I/triplet that are blended at the $R \approx 100$ resolution. These lines are typical of the strong outflows seen in FU Ori stars. No emission is present, though prior to outburst Hα was in emission.

The KeckI telescope and MOSFIRE (McLean et al. 2012) were used on 2025-11-12 UT to obtain the infrared spectrum in Figure 1b, which exhibits the mix of molecular (H_2O, CO) and atomic (Na I, Ca I, Al I, Mg I, Si I) features expected for a solid FU Ori classification.

3. DISCUSSION

Should the current photometric and spectroscopic source characteristics persist, following the convention introduced in Hillenbrand et al. (2025), the source would be named FUOr-Cas 0258+6112. Multi-wavelength follow-up is encouraged, especially over the next few months to year, as the spectrum and lightcurves likely evolve.

REFERENCES

Bellm, E. C., Kulkarni, S. R., Graham, M. J., et al. 2019, PASP, 131, 018002, doi: 10.1088/1538-3873/aaecbe

Blagorodnova, N., Neill, J. D., Walters, R., et al. 2018, PASP, 130, 035003, doi: 10.1088/1538-3873/aaa53f

Damian, B., Jose, J., Samal, M. R., et al. 2021, MNRAS, 504, 2557, doi: 10.1093/mnras/stab194

Damian, B., Jose, J., Das, S. R., et al. 2024, MNRAS, 535, 1321, doi: 10.1093/mnras/stae2452

De, K., Hankins, M. J., Kasliwal, M. M., et al. 2020, PASP, 132, 025001, doi: 10.1088/1538-3873/ab6069

Fischer, W. J., Hillenbrand, L. A., Herczeg, G. J., et al. 2023, in Astronomical Society of the Pacific Conference Series, Vol. 534, Protostars and Planets VII, ed. S. Inutsuka, Y. Aikawa, T. Muto, K. Tomida, & M. Tamura, 355, doi: 10.48550/arXiv.2203.11257

Hartmann, L., & Kenyon, S. J. 1996, ARA&A, 34, 207, doi: 10.1146/annurev.astro.34.1.207

Herbig, G. H. 1966, Vistas in Astronomy, 8, 109, doi: 10.1016/0083-6656(66)90025-0

Hillenbrand, L. A., Carvalho, A. S., Stern, D., et al. 2025, ApJ, 988, 77, doi: 10.3847/1538-4357/ade14d

Koenig, X. P., Allen, L. E., Gutermuth, R. A., et al. 2008, ApJ, 688, 1142, doi: 10.1086/592322

Mainzer, A., Bauer, J., Cutri, R. M., et al. 2014, ApJ, 792, 30, doi: 10.1088/0004-637X/792/1/30

Marton, G., Tóth, L. V., Paladini, R., et al. 2016, MNRAS, 458, 3479, doi: 10.1093/mnras/stw398

McLean, I. S., Steidel, C. C., Epps, H. W., et al. 2012, in Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series, Vol. 8446, Ground-based and Airborne Instrumentation for Astronomy IV, ed. I. S. McLean, S. K. Ramsay, & H. Takami, 84460J, doi: 10.1117/12.924794

Molyarova, T., Akimkin, V., Semenov, D., et al. 2018, ApJ, 866, 46, doi: 10.3847/1538-4357/aadfd9

Patterson, M. T., Bellm, E. C., Rusholme, B., et al. 2019, PASP, 131, 018001, doi: 10.1088/1538-3873/aae904

Winston, E., Hora, J. L., & Tolls, V. 2020, AJ, 160, 68, doi: 10.3847/1538-3881/ab99c8

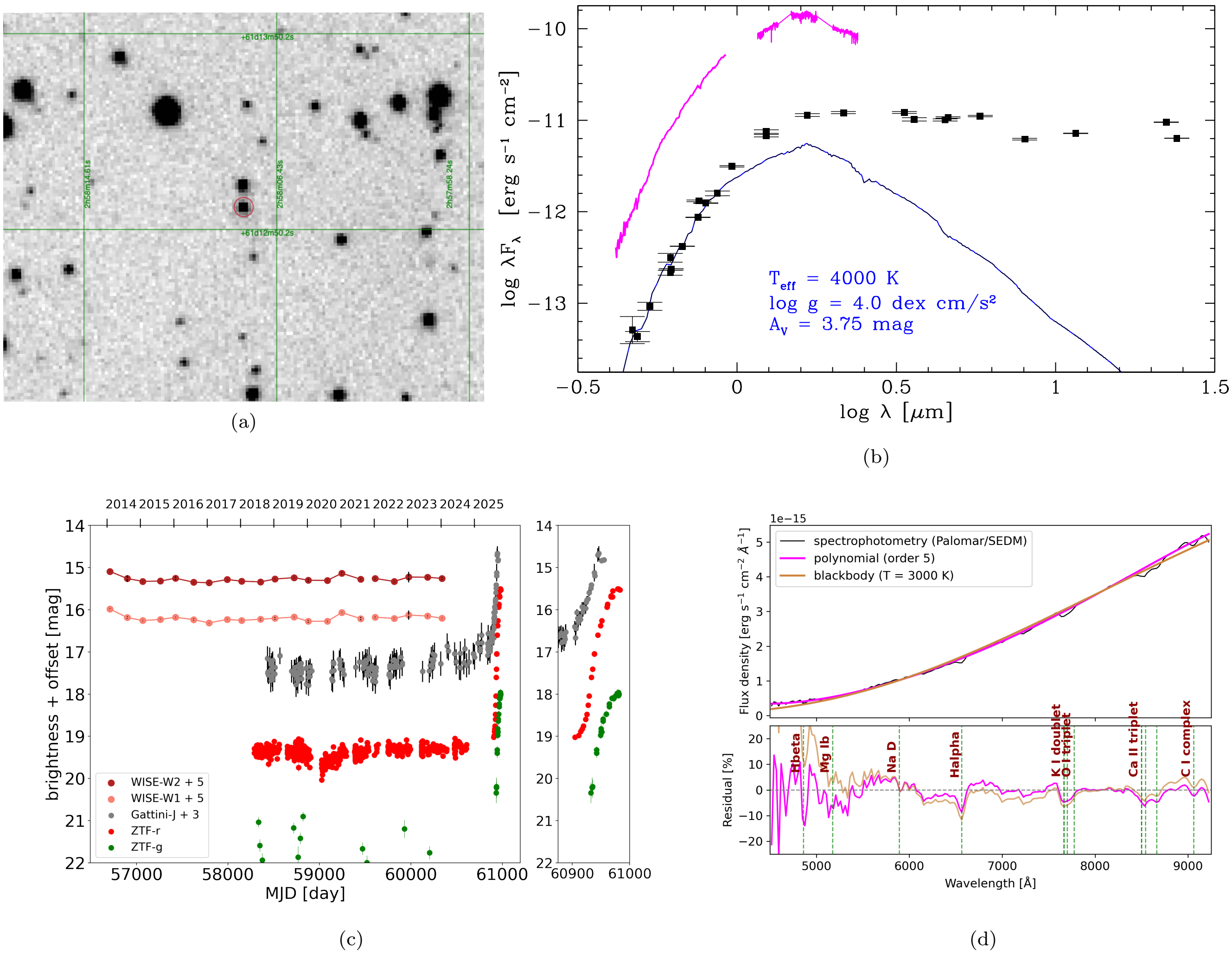

Figure 1. Top left: ZTF r-band image (N/E are top/left) of the pre-outburst source and environment. **Top right:** SEDs assembled for the progenitor source (black points) along with a plausible stellar model (blue line), and for the outbursting source (magenta). **Bottom left:** Lightcurves in optical ZTF g-band (0.48 μm), r-band (0.64 μm); near-infrared Gattini J-band (1.6 μm); and mid-infrared NEOWISE W1 (3.6 μm), W2 (4.5 μm) bands. **Bottom right:** Optical spectrophotometry highlighting absorption in plausible disk/wind lines.