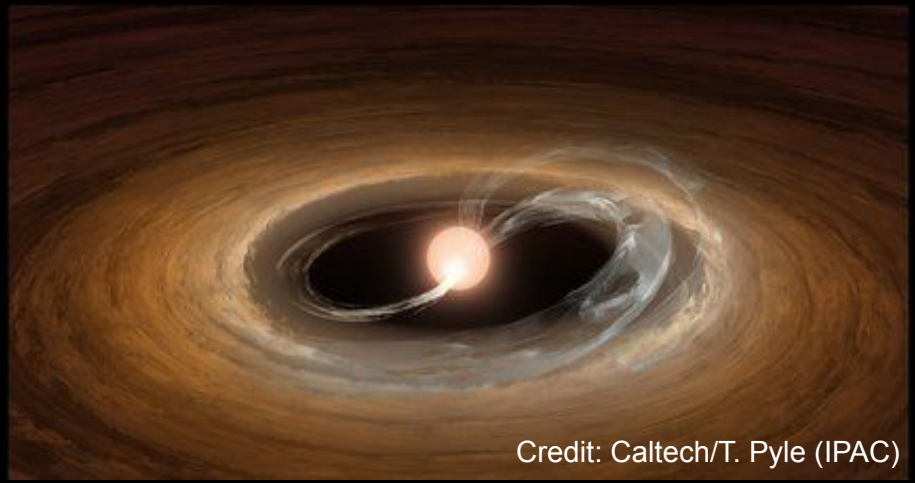
Analysis of the Gaia Alerted eruptive young star candidate Gaia24bux

Dániel Estók

BSc candidate, ELTE, HUN-REN CSFK, Konkoly Observatory

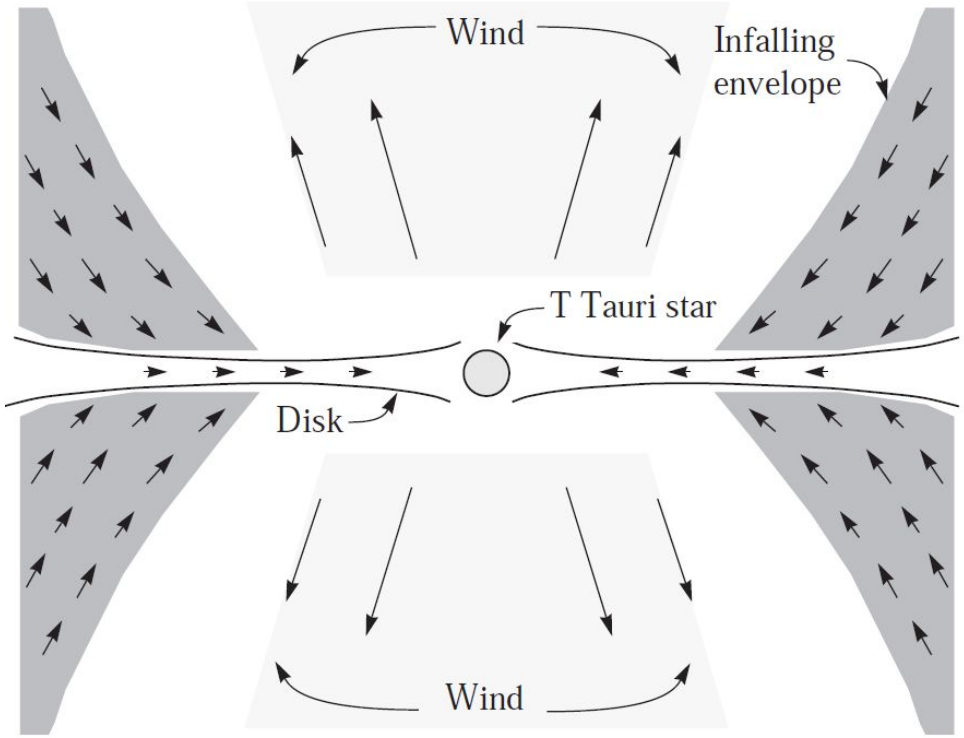
Supervisor:

Zsófia Nagy (HUN-REN CSFK, Konkoly Observatory)



Credit: Caltech/T. Pyle (IPAC)

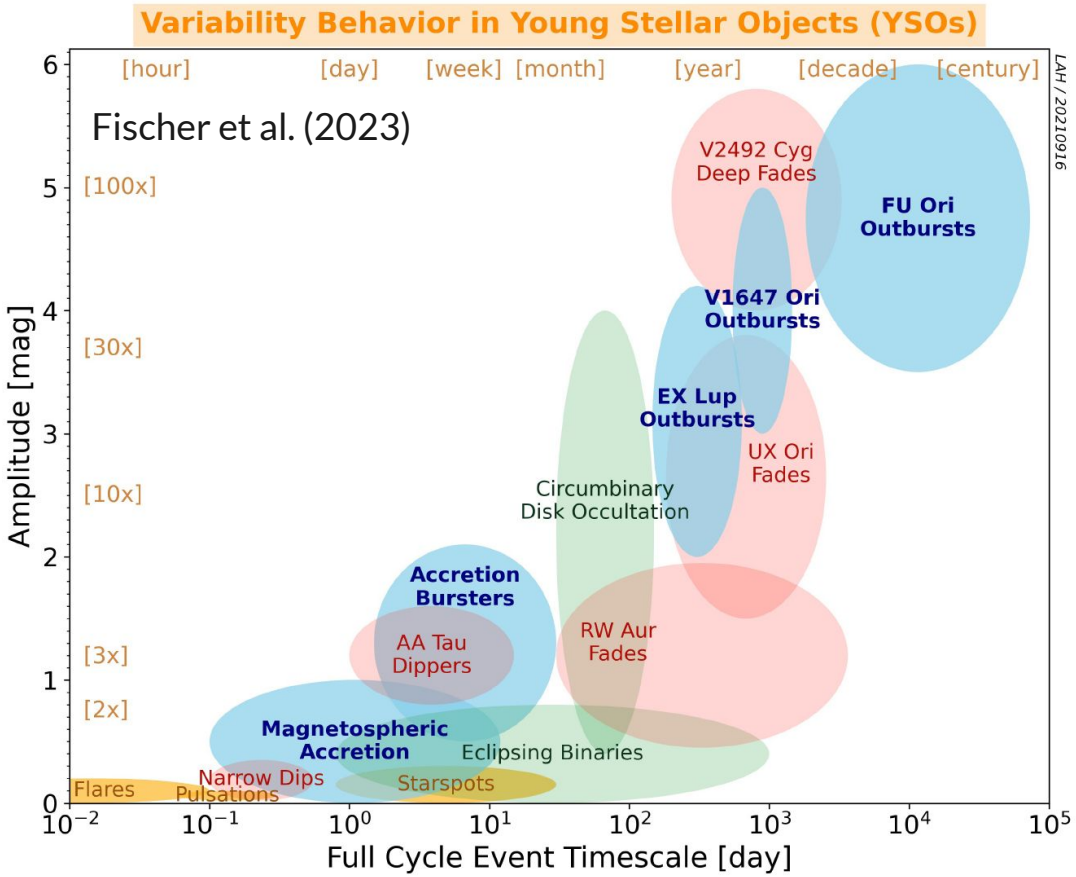
Introduction: pre-main-sequence stars



Kenyon & Hartmann (1996)

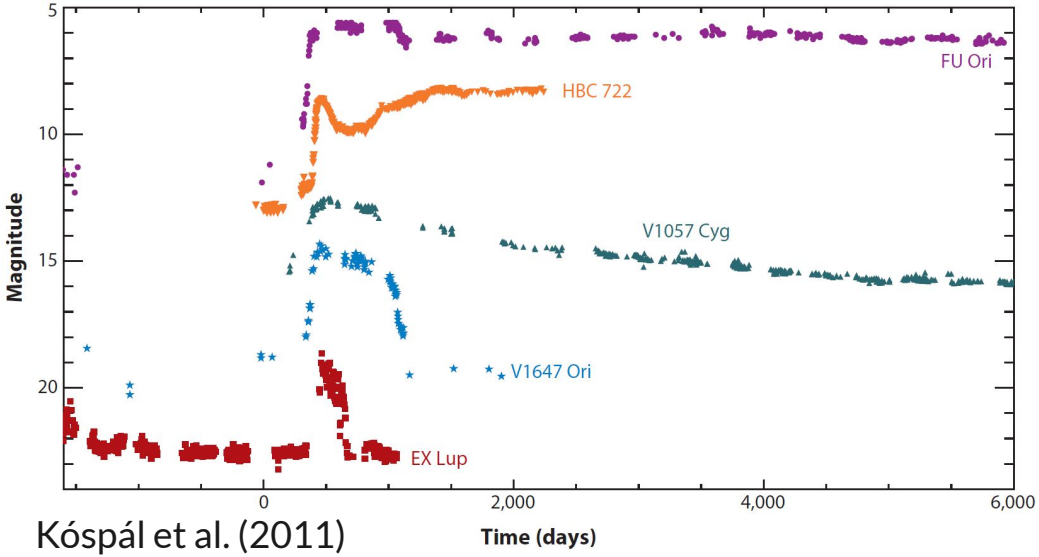
- Gas and dust fall from the envelope onto the outer disk
- The material accretes onto the stellar surface
- A fraction of the infalling matter is removed by outflows
- **Accretion** → heating of the disk, increases the luminosity of the star
- Inhomogeneous in space and time
- Can vary by orders of magnitude

Introduction: variability of pre-main sequence stars



- Sudden rises in brightness, measurable in visual and near infrared ranges
- High variability in amplitude and timescale
- Change in extinction or accretion → episodic accretion
- Outbursts

Introduction: eruptive young stars

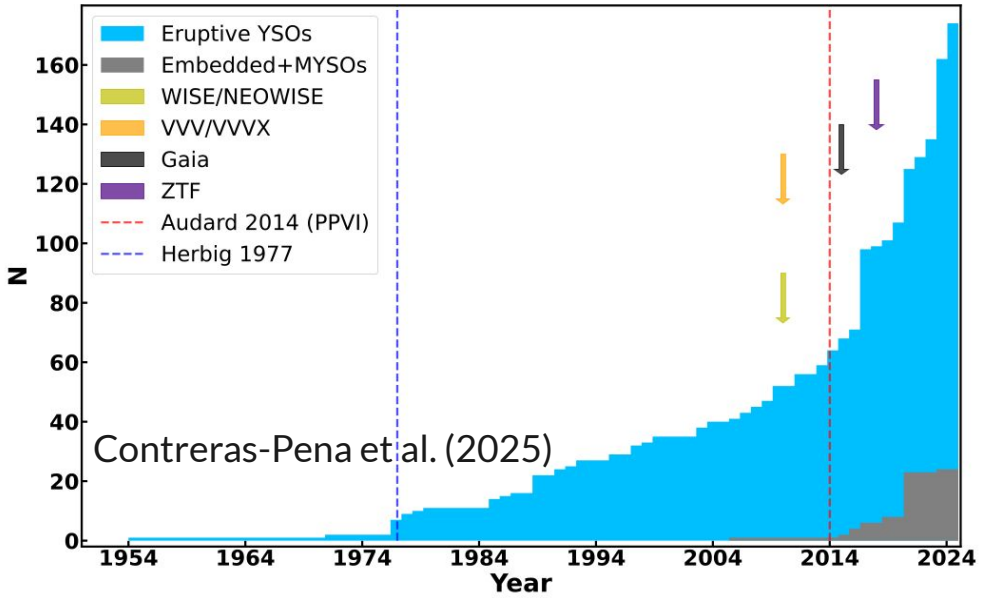


Kóspál et al. (2011)

- **FUor**: 4-5 mag amplitude outbursts, ranging from decades to centuries, spectra dominated by absorption lines
- **EXor/EX-Lupi type**: repetitive, 2-5 mag amplitude outbursts, ranging from months to a year, spectra dominated by emission lines

- **Peculiar/MNor/V1647 Ori-like**: outburst longer than EXors but shorter than FUors, spectra can show absorption, emission or can be featureless
- **Periodic**: quasiperiodic changes in luminosity, spectra can show absorption and emission

Discovery of new eruptive YSOs: transient surveys



Contreras-Pena et al. (2025)

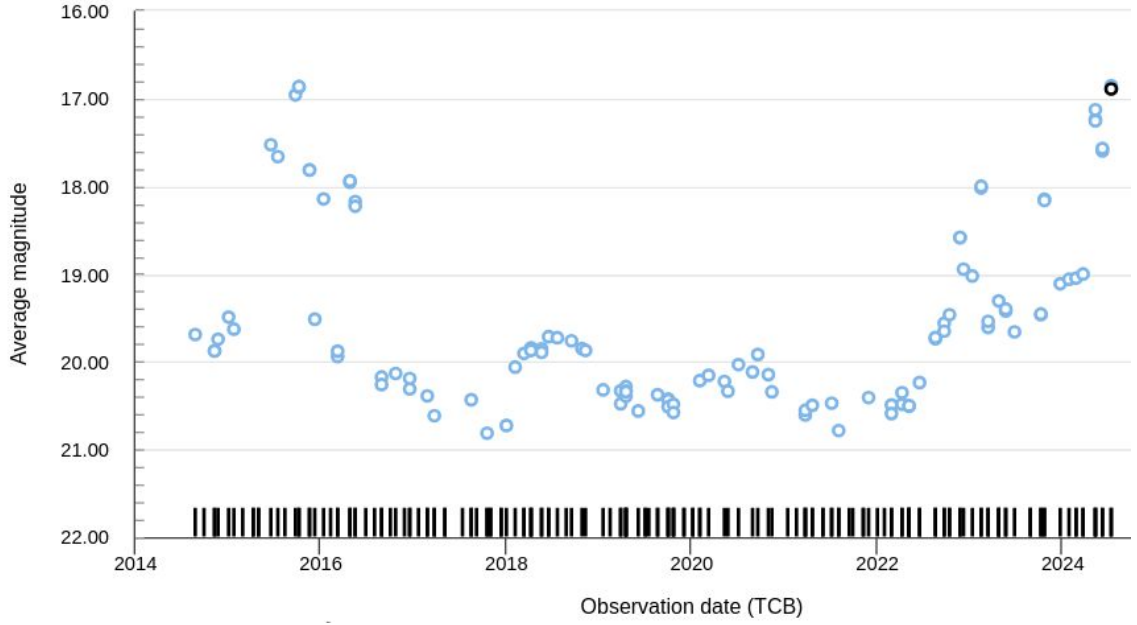
- All-sky surveys to detect and track changes in stellar objects
- Pan-STARRS, LSST, ZTF, Gaia
- Increase in the number of discovered eruptive YSOs


Wikipedia

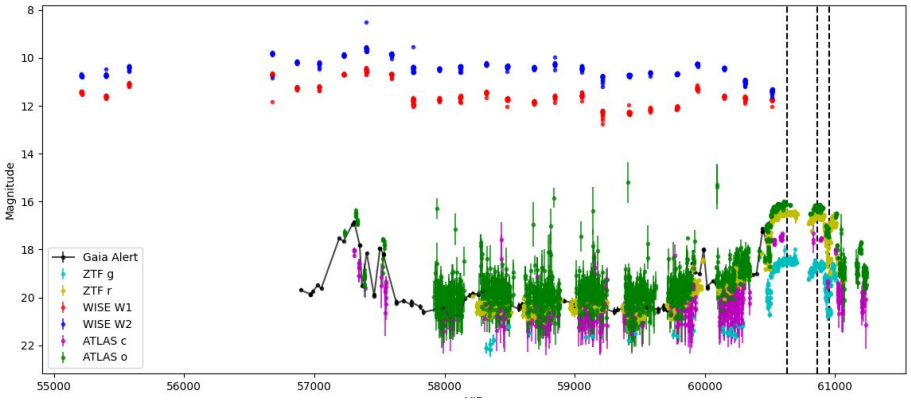
- Gaia: position and photometry for billions of stars
- Gaia Photometric Science Alerts (Hodgkin et al. 2021): alerts, when a large change in brightness is detected
- GLORIOUS Collaboration: aims to find new eruptive young stars, originally based on Gaia alerts

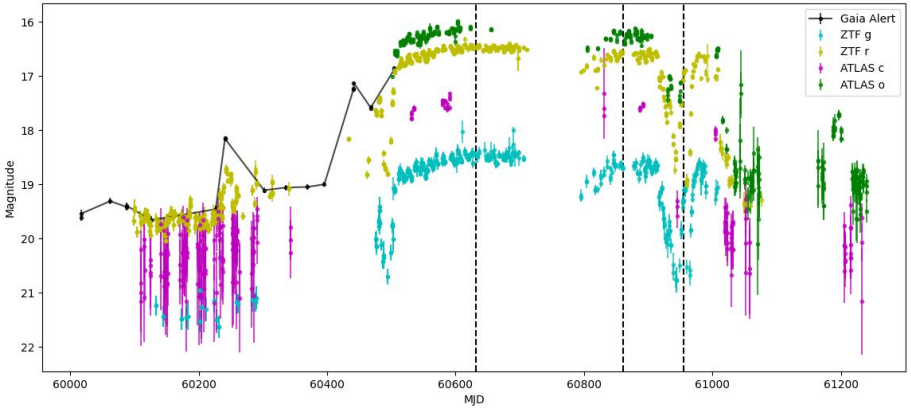
Target: Gaia24bux, an eruptive young star candidate

- Ra: 23:09:40.36; Dec: 62:28:58.66 → Cepheus
- Class I/II candidate (Marton et al. 2016)
- Probability of being a YSO: 93.82% (Marton et al. 2019)
- d=945.73(+326.83/-126.24)pc
- Gaia Alert on 2024.07.13
- Brightening of ∼3.5 mag



Analysis: light curves

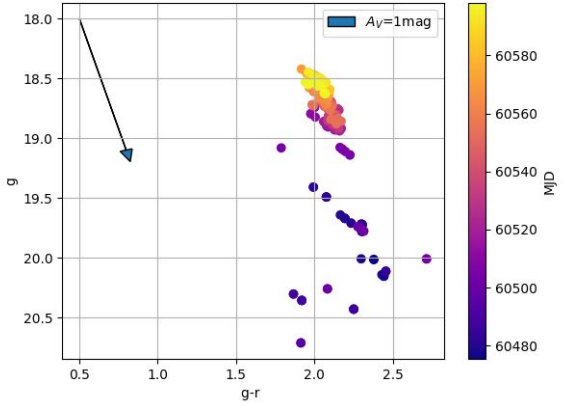


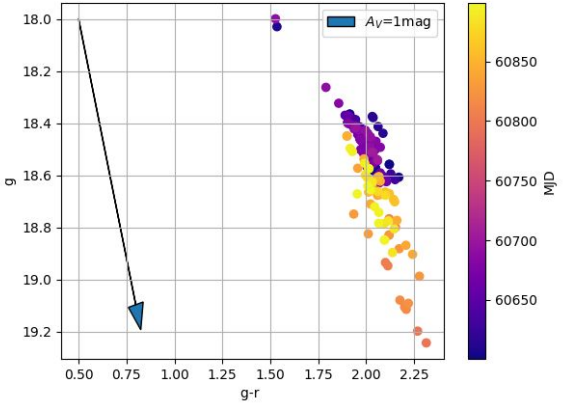


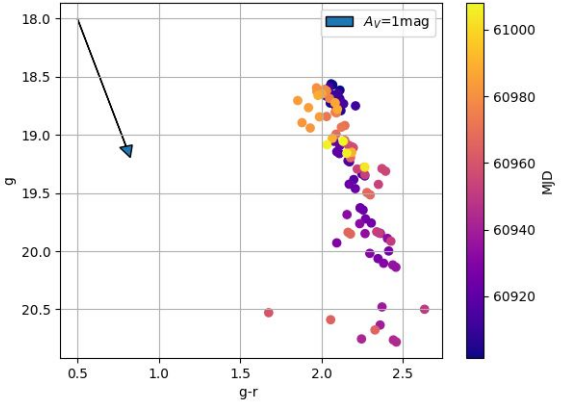
- Gaia G, ZTF g and r, ATLAS c and o, (NEO)WISE W1 and W2
- Brightening from 2024-05 to 2025-10
- Previous brightening in 2015-06 with similar timescale
- Dips in brightness

Analysis: color-magnitude diagrams

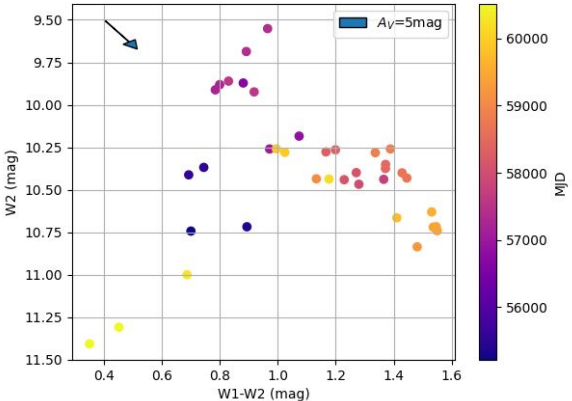
ZTF data







(NEO)WISE

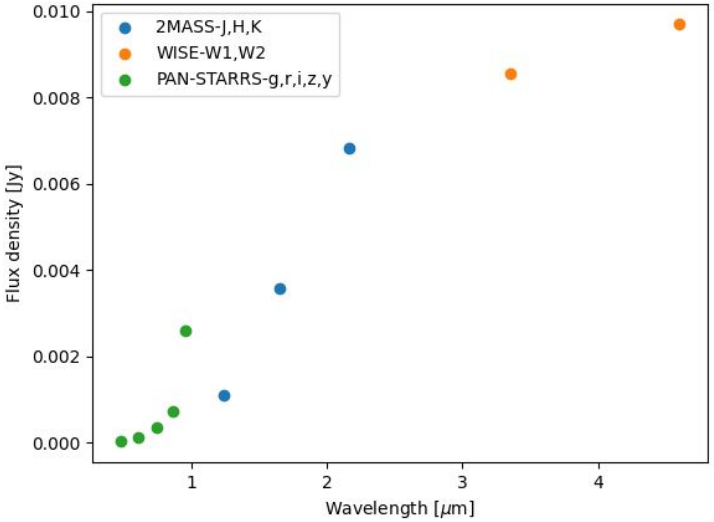


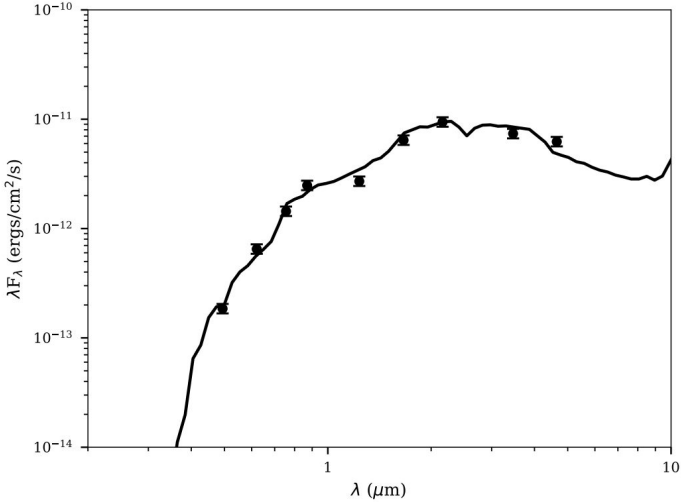
- ZTF: some of the data points are parallel to the direction of the A_v
- Lines fitted to ZTF data → **not just A_v change, most likely a combination of changing extinction and accretion rate**

(NEO)WISE: some of the data points are parallel to the direction of A_v

Analysis: stellar parameters

Quiescent Spectral Energy Distribution (SED) in order to derive stellar parameters

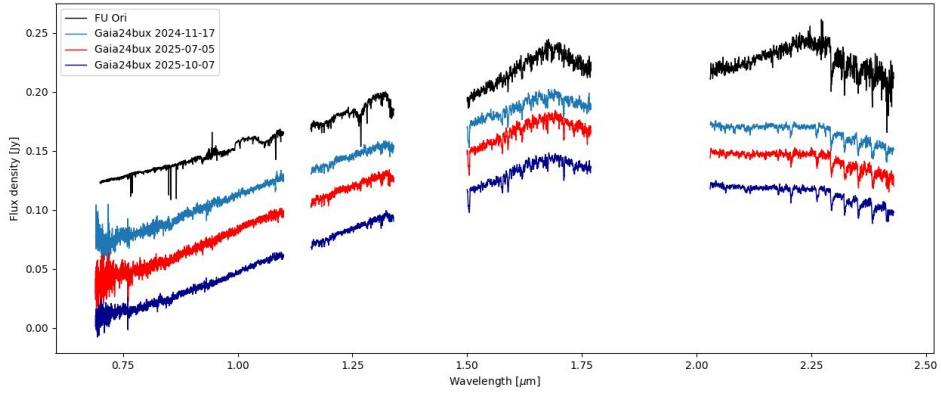


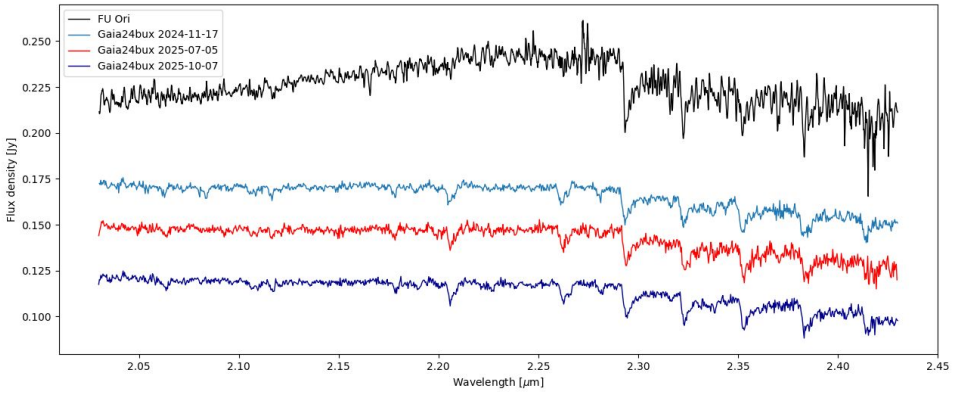


- A_v=0.80 mag
- M=0.47 $M_\odot$
- R=5.63 $R_\odot$
- T_{eff}=3672 K

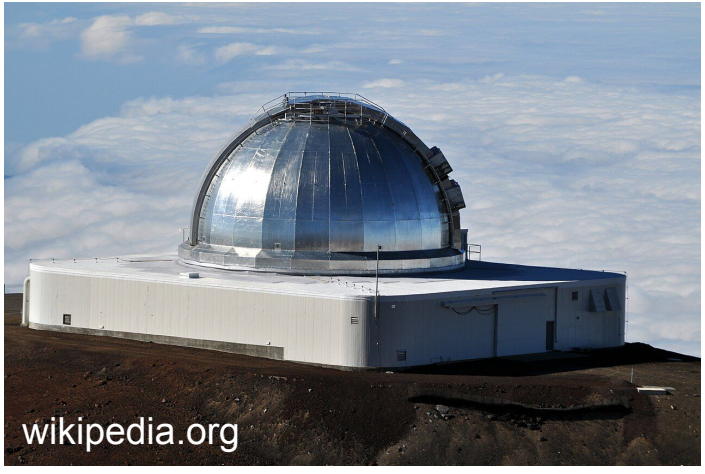
- SEDfitter python package (Robitaille et al. 2007), 200000 SEDs of young stellar objects with various masses and evolutionary states (Robitaille et al. 2006)
- χ^2 method fitting, with A_v as free parameter

Analysis: spectra

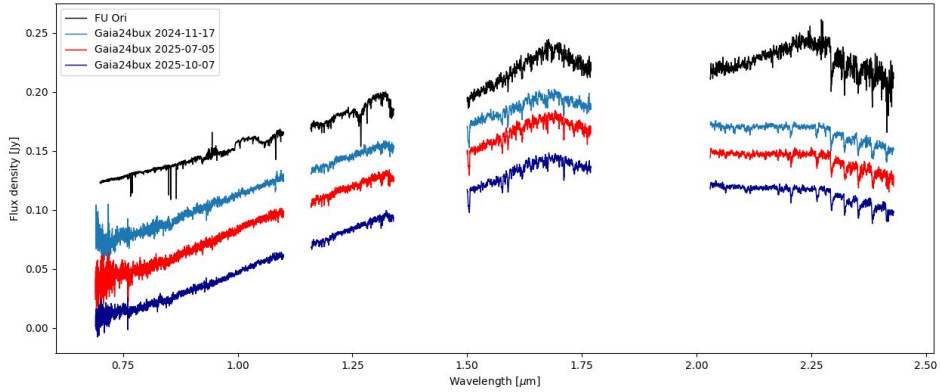


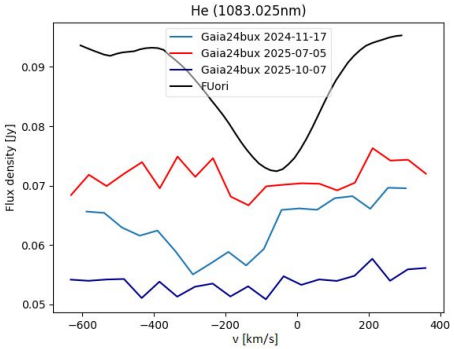


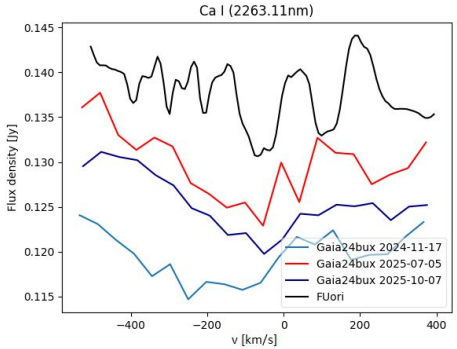
- **NASA Infrared Telescope Facility (IRTF)**, 3.2 m diameter
- Spectra for 3 epochs during the outburst
- Spectra dominated by absorption lines (eg. He I, Ca I, CO)
- Calculated EW and FWHM using specutils



Analysis: comparison to FUor spectra







- Even though the outburst ended (i.e., not FUor time scale), the spectra look very similar to FUor spectra

- "Triangular" H band continuum
- Strong CO absorption bands
- Absence of emission lines
- Metallic lines of Na I and Ca I
- He I line at high velocity

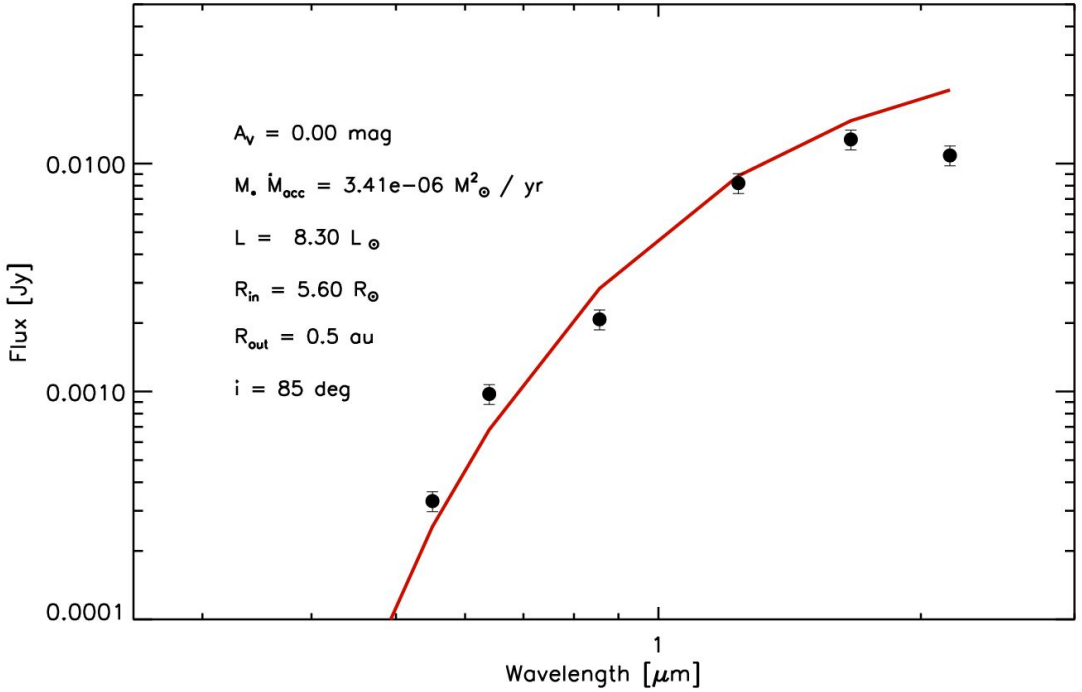
Such spectral features are also seen in the PVM-type of eruptive YSOs.

Is it an eruptive YSO?
→ Estimate of the accretion rate.

Analysis: estimate of the accretion rate

- Steady, optically thick **accretion disk model** (Kóspál et al. 2016)
- Constant accretion rate in the radial direction

- Estimate of **the accretion rate x the stellar mass** during the outburst
- Optical photometry from Mount Suhora (Poland) and NIR photometry from the IRTF
- **Best fitting parameters:**
- $M_* \dot{M}_{acc} \sim 3.4 \times 10^{-6}\ M^2_{Sun}\ yr^{-1}$
- Also: high inclination and low A_V during the outburst



Summary and future plans

Summary

- High probability of being an eruptive YSO
- Shows similar spectral features to FUors
- Most likely MNor/V1647 Ori-type YSO

Future plans

- Calculating accretion rate for the epochs of the later IRTF spectra
- Comparison of the spectra at the different epochs
- Comparison to other FUors and MNors
- Publish the results.

GLORIOUS (Gaia science aLerts tO find eRuptIve yOUng stellar objectS) **collaboration**

Péter Ábrahám, Ágnes Kóspál, Zsófia Nagy, Mária Kun, Gábor Marton (Konkoly Observatory)
Dániel Estók, Botond Marosi, Patrik Németh (Eötvös University, Konkoly Observatory)
Máté Szilágyi (University of Vienna)
Michal Siwak (Mt. Suhora Observatory)
Fernando Cruz-Sáenz de Miera (Université de Toulouse)
Eleonora Fiorellino (Università di Bologna)
Simone Antoniucci, Roberta Carini, Teresa Giannini, Brunella Nisini (INAF Rome)