The New EXor Outburst of ESO-Hα 99 observed by Gaia ATLAS and TESS

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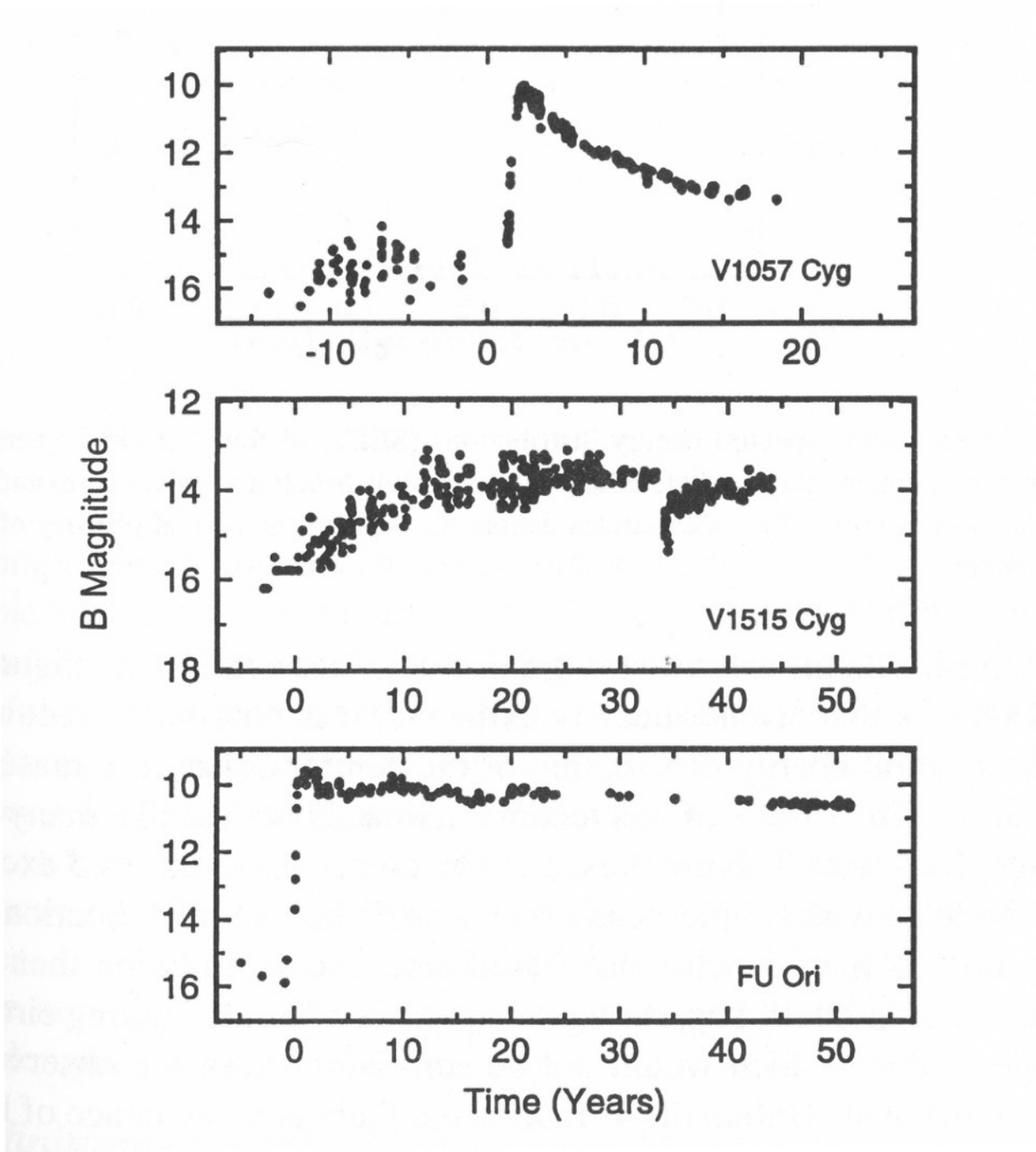
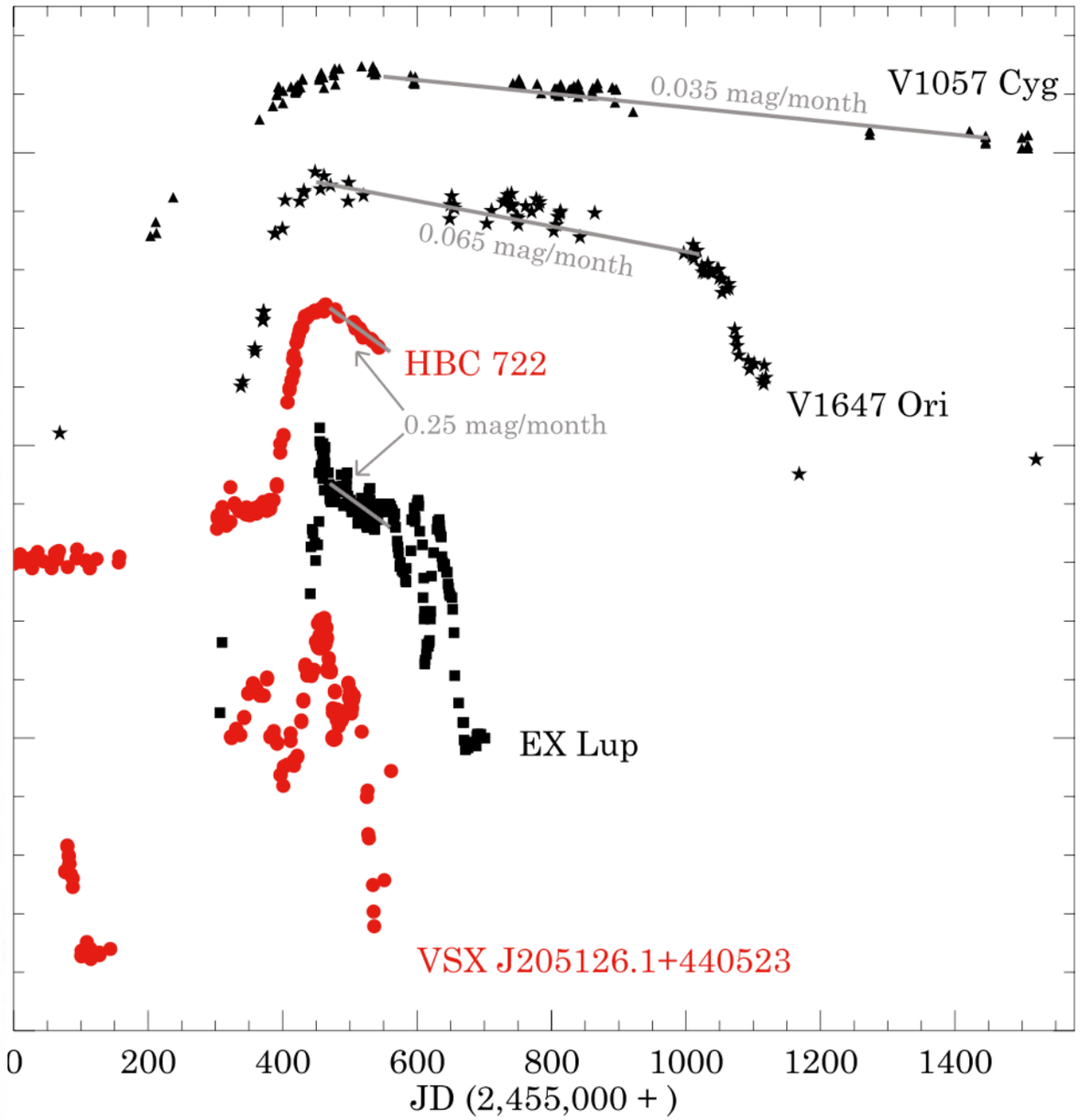
- Under what conditions do stars accumulate most of their mass ?
- Luminosity problem, HR diagram scatter ?
- What is the thermal history of proto-planetary disks ?

Credit: NASA/JPL-Caltech/R. Hurt

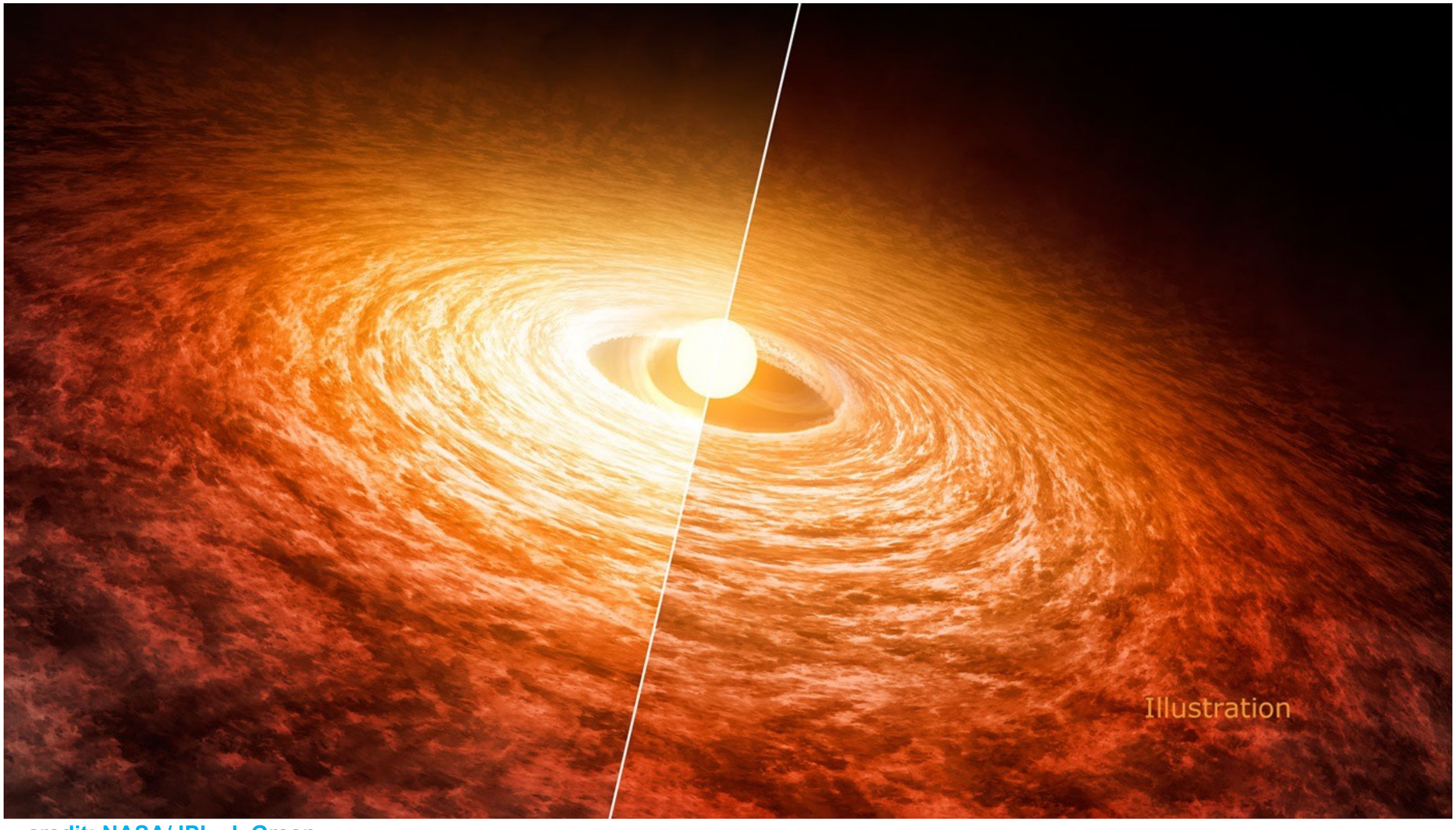


FUor light curves (from Herbig 1977)

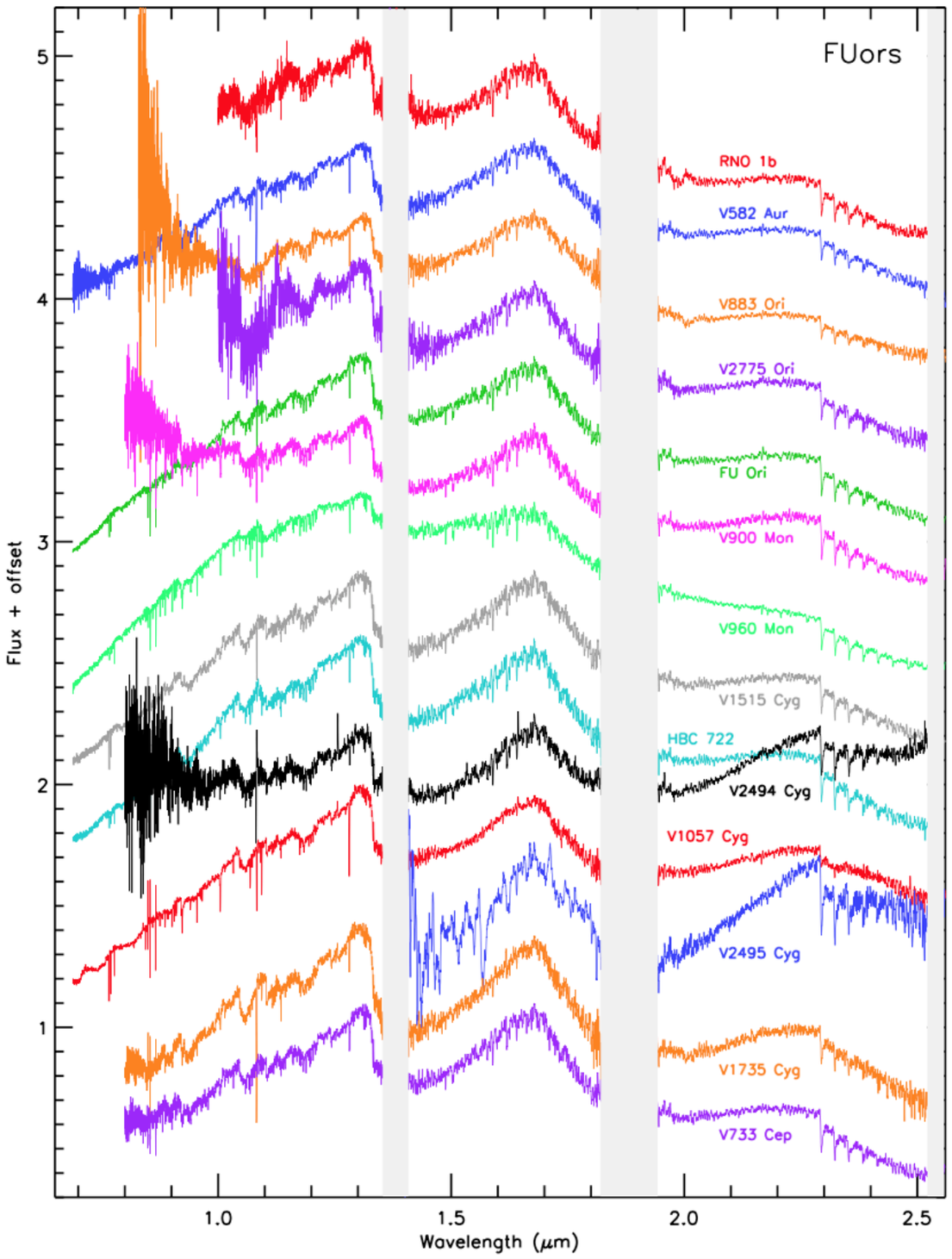


EXor light curves (from Kospal et al. 2011)

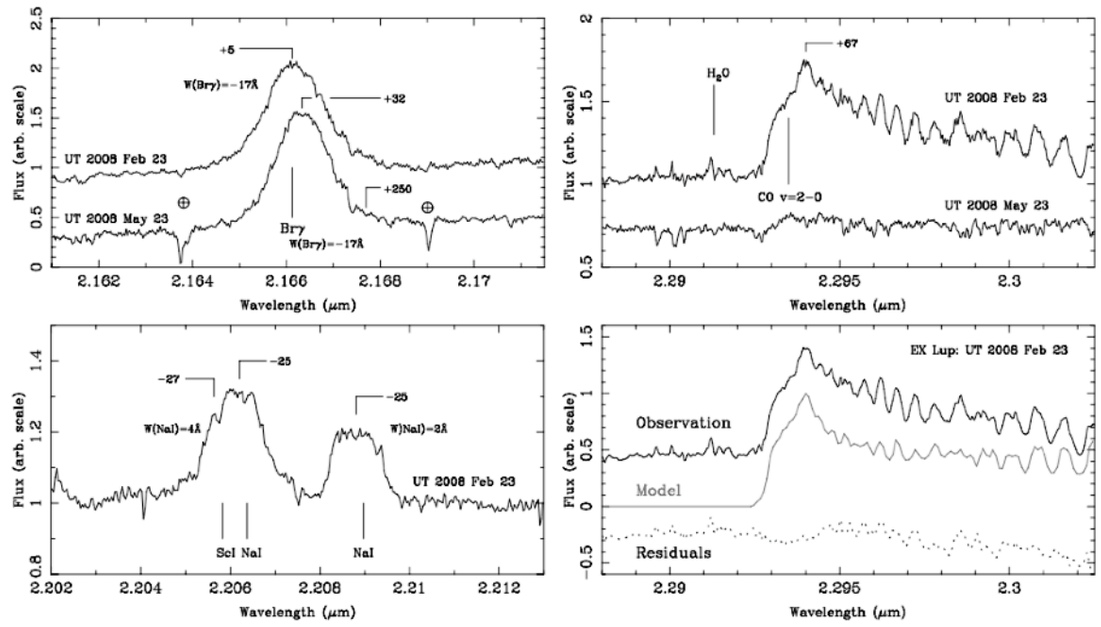
FUor: An optically thick inner accretion disk becoming luminous as a result of an increase in the accretion flow: Absorption Spectrum
EXor: Increade in continuum component in a still optical thin environment: Emission Spectrum



credit: NASA/JPL, J. Green

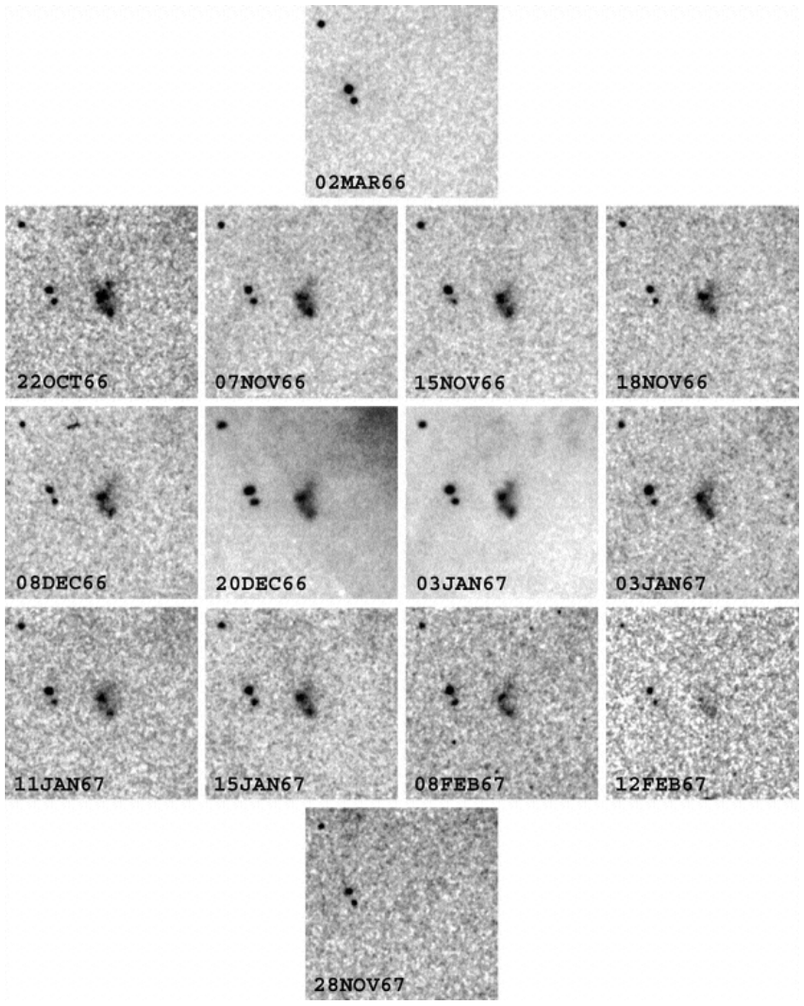


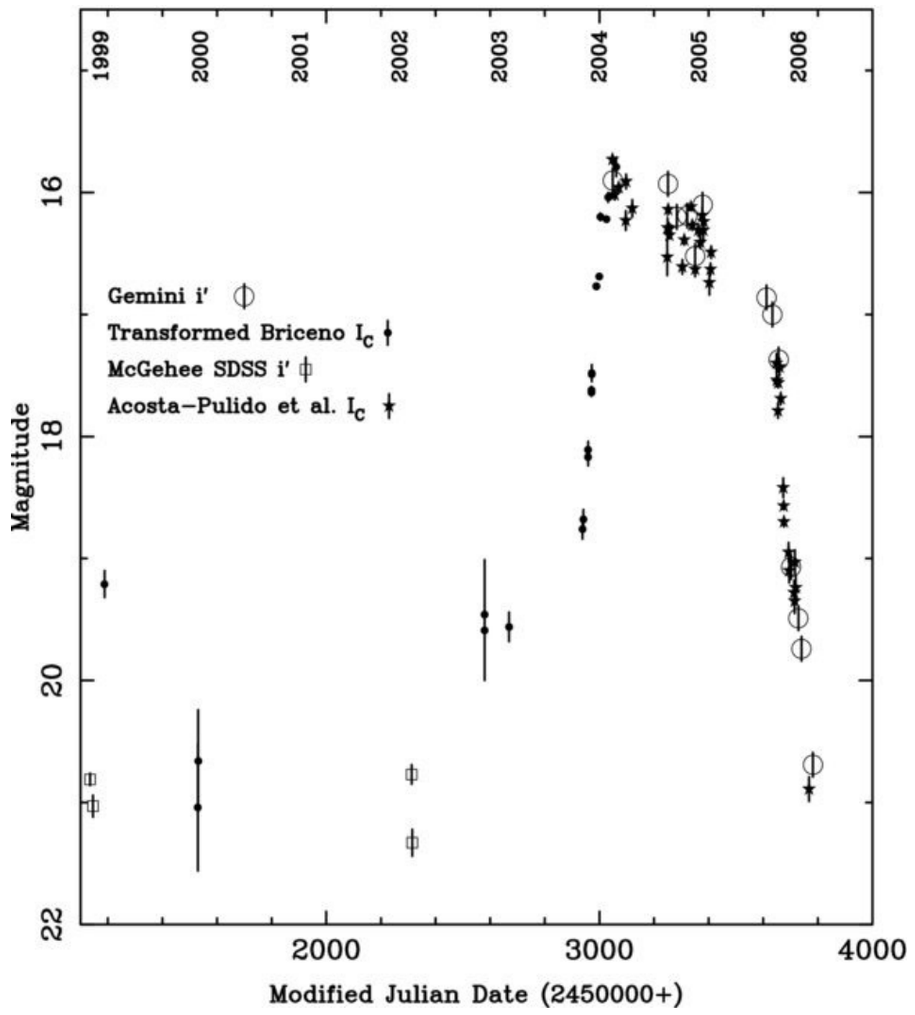
The more substantial FUor outbursts show an absorption line spectrum (from Connelley & Reipurth 2018)

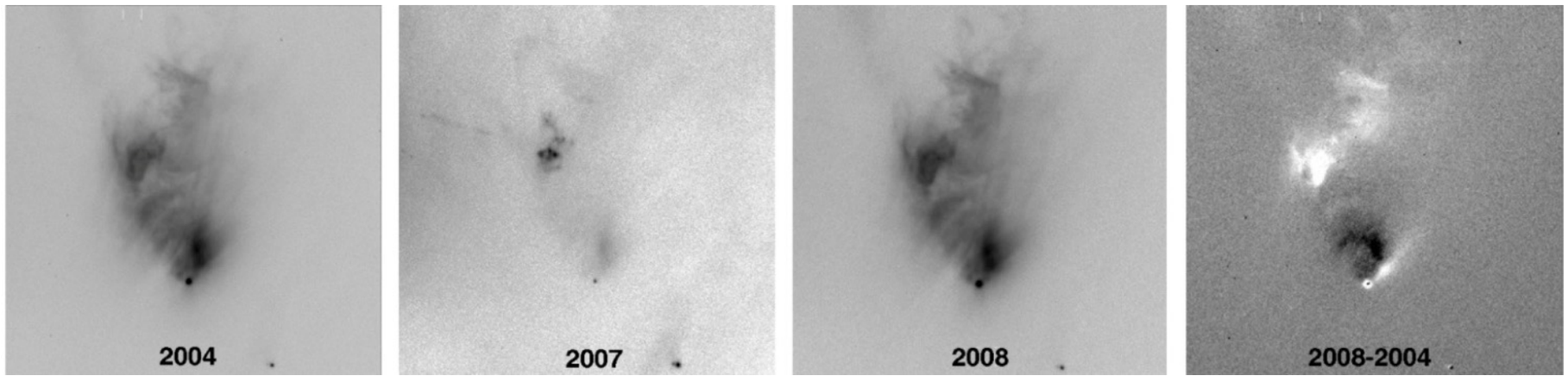


The smaller EXor outbursts are characterized by an emission line spectrum (from Aspin et al. 2010)

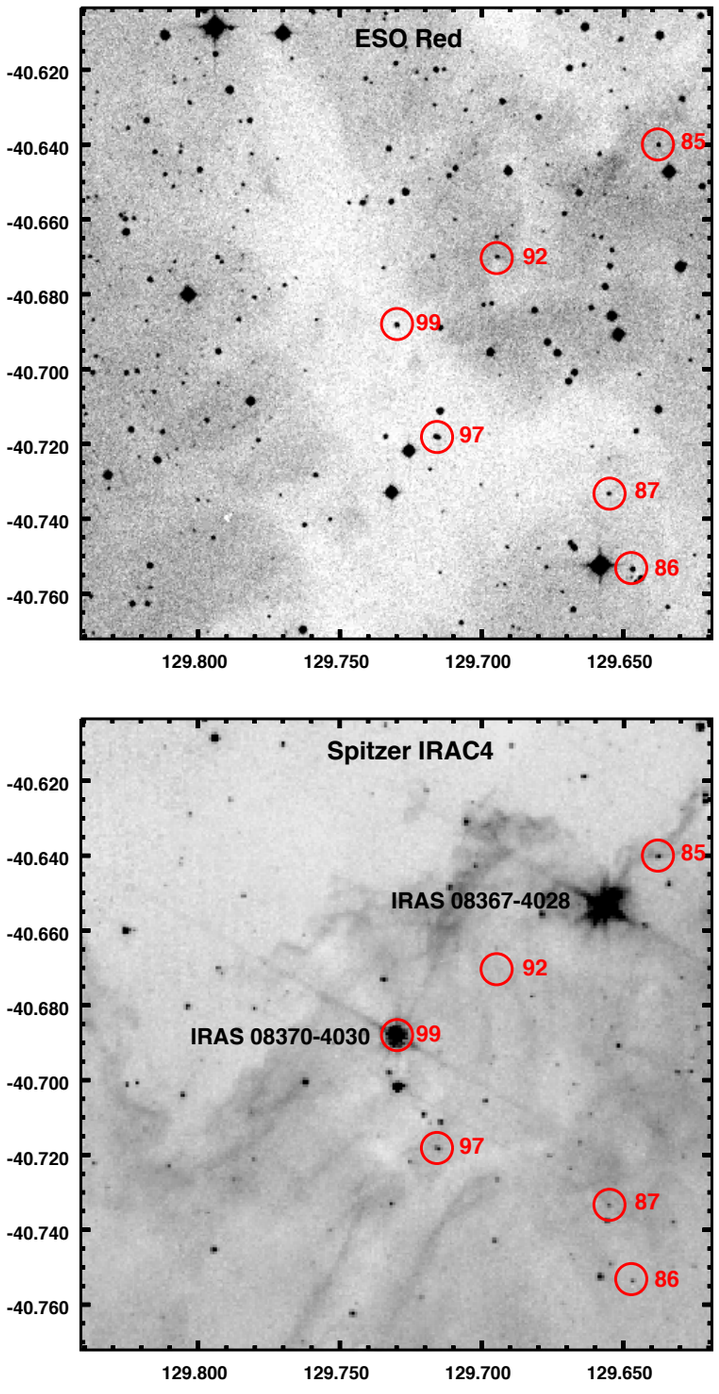
V1647 Ori (McNeil's Nebula): A repetitive Exor, Aspin et al. 2006, 2009
A "New Exor" (Lorenzetti) or "MNor" (Contreras Pena)

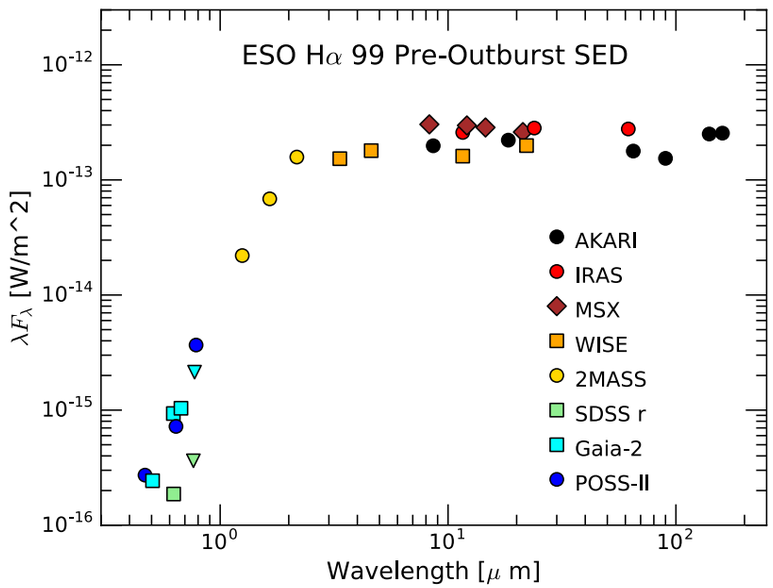


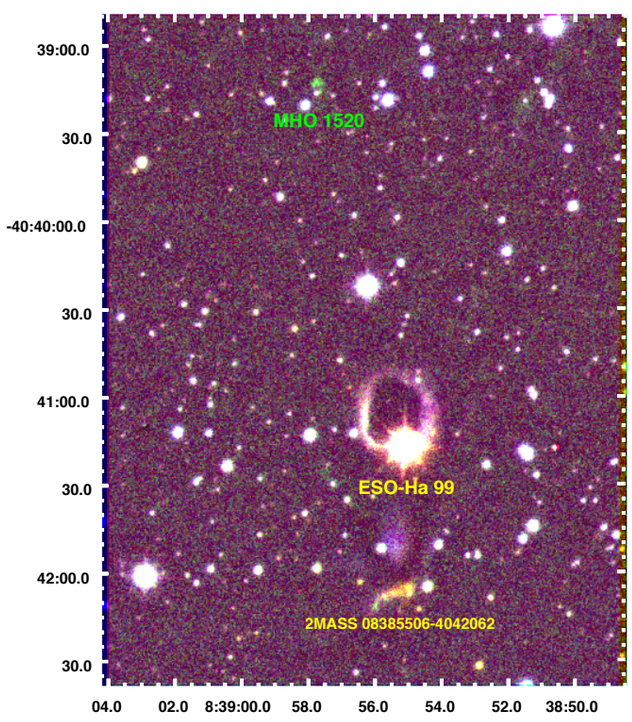




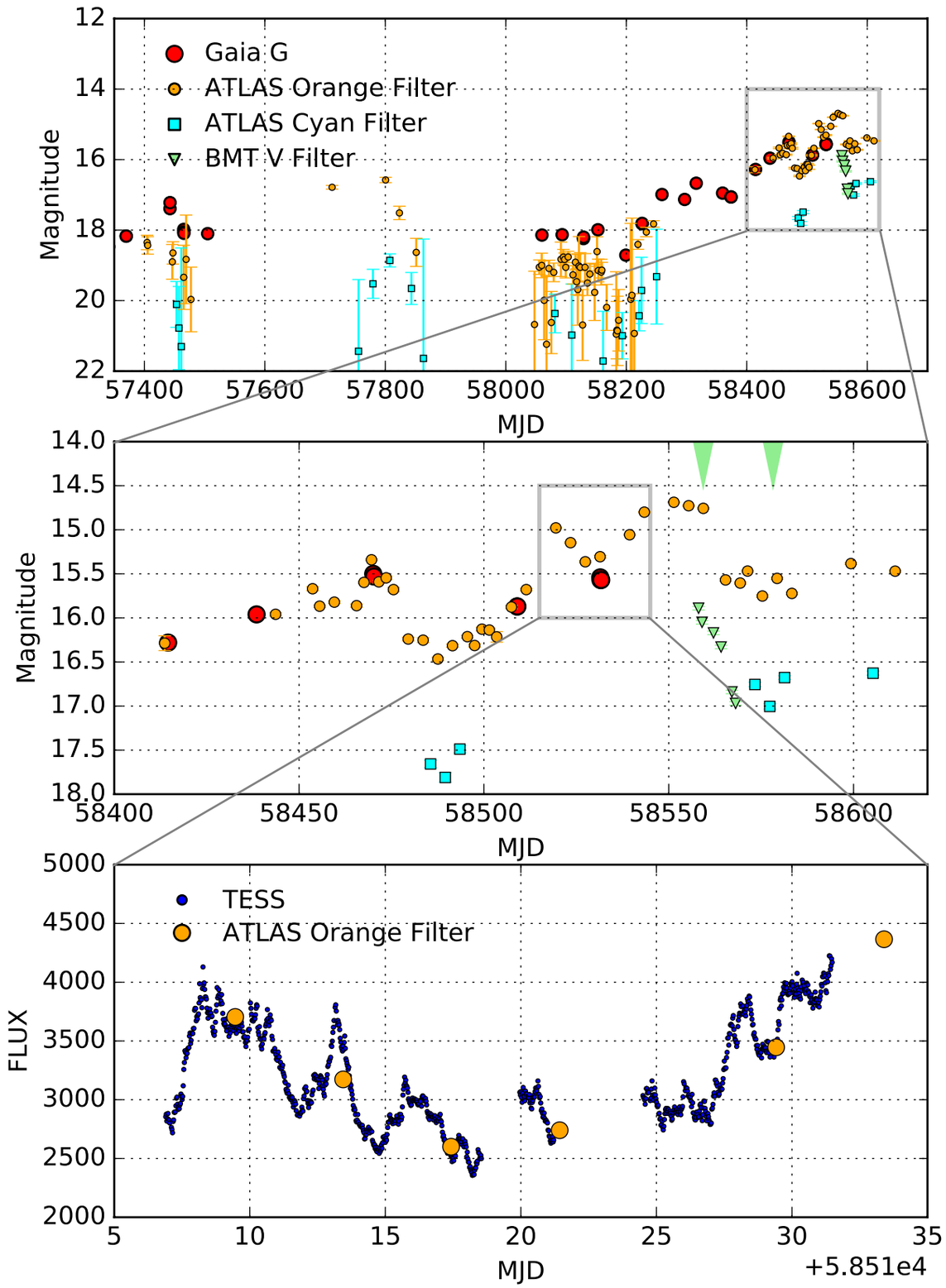
The T Tauri Star ESO Hα 99 in the Sandquist 1 Molecular Cloud







ESO Hα 99 Light Curve



Gaia and ATLAS over the past 4 yrs

Prior outburst

Minimum before current outburst

Current Outburst:

Gaia18dvz

Intermediate minima

TESS Data:

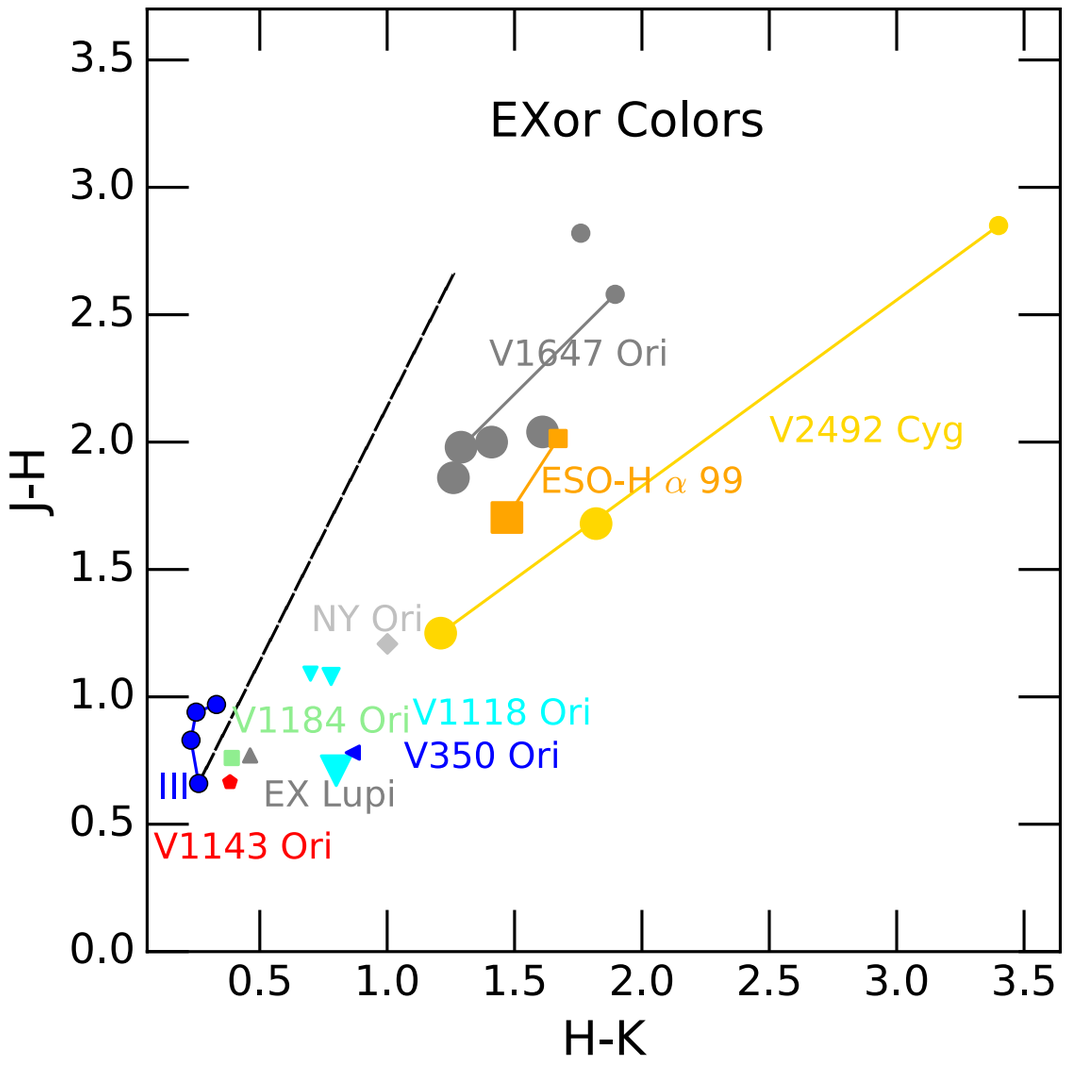
Final intermediate minimum before outburst maximum

Fluctuations with 10-20% amplitude and time constants 1 - 10 days

No periodicity

If the decline in brightness does indeed continue, the light curve is typical of a fairly long EXor outburst.

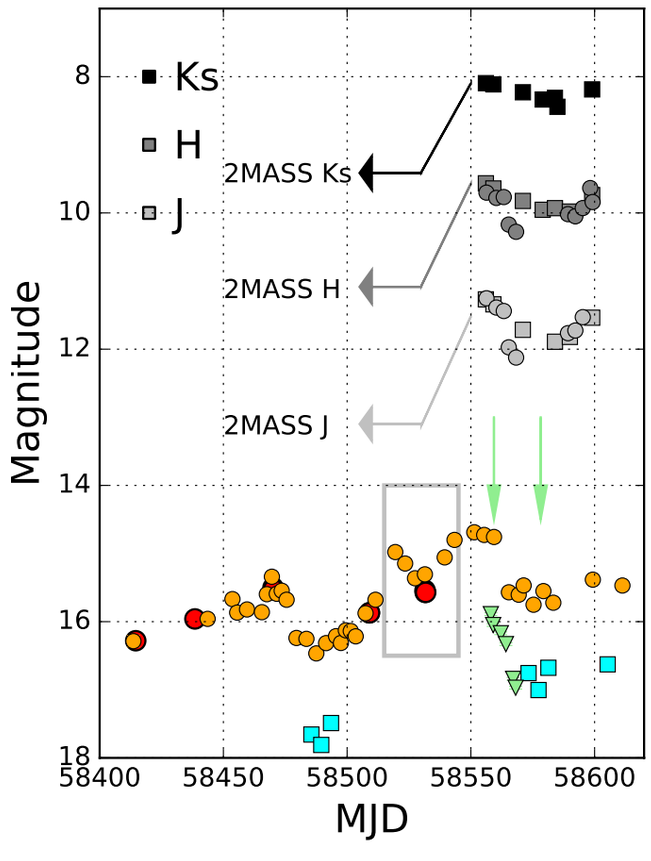
Near-Infrared Colors



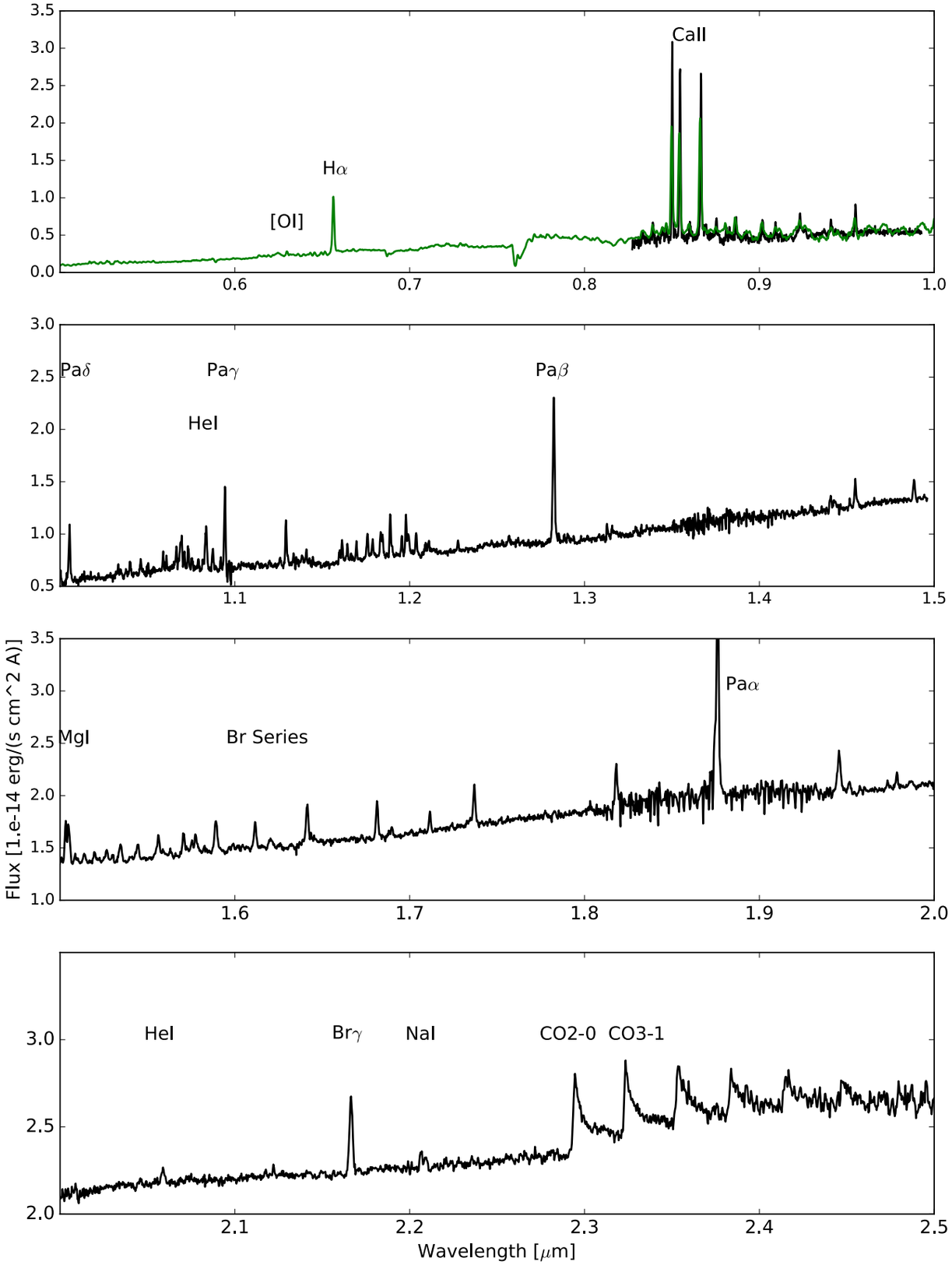
Comparison objects are from Lorenzetti et al. 2011

NIR Color-Color Diagram

The locus in the J-H vs. H-K color-color diagram, and the path between pre-outburst and outburst colors characterize ESO Hα 99 as among of the most reddened EXors known.



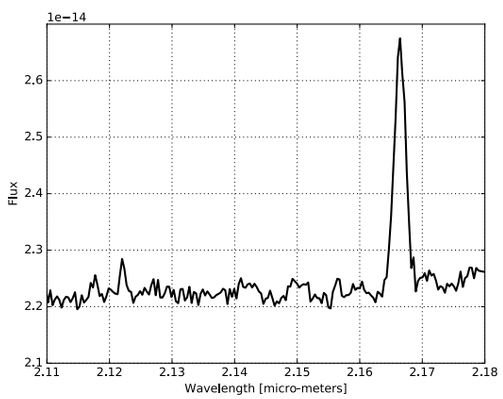
Spectrum of ESO Hα 99



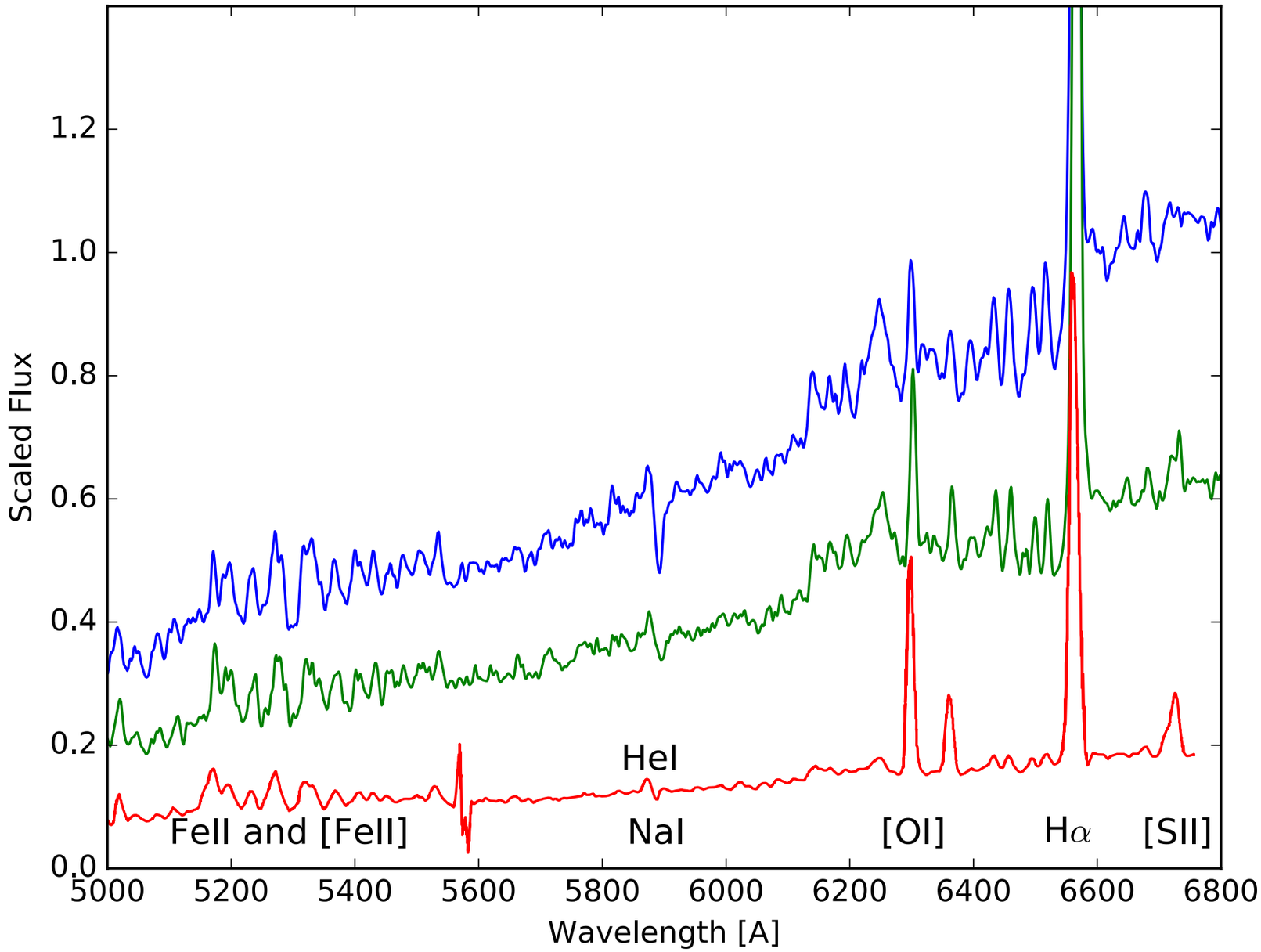
Combined optical Faulkes Telescope and near-infrared IRTF/ SPEX spectrum

It is dominated by emission lines, most notably the hydrogen lines, and CaII and CO band heads.

This characterizes ESO Hα 99 as an EXor.



At maximum brightness, emission lines are suppressed !



Red: Pre Outburst

Blue: Maximum

Green: Post Maximum

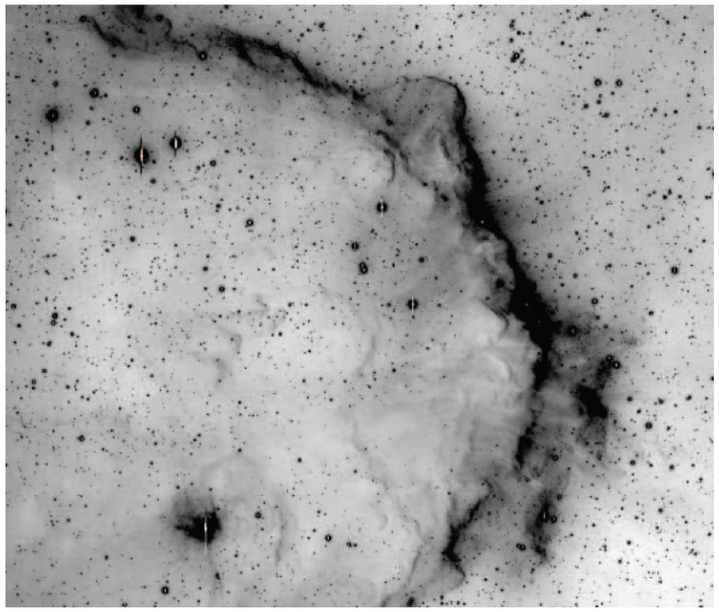
Conclusions

ESO Ha 99

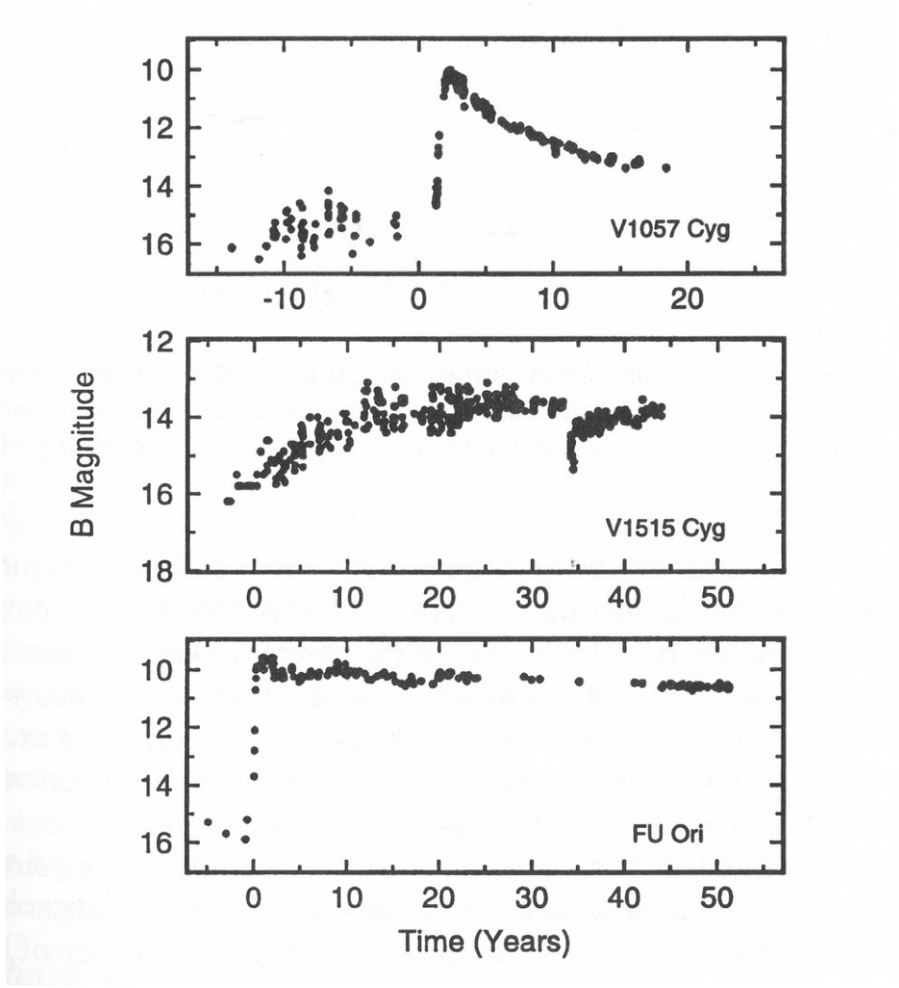
- is a deeply embedded flat spectrum YSO
- s undergoing a major outburst at the upper limit of classical EXor outbursts.
- Its light curve shows details on timescales from months down to one day.
- Its spectrum changed from a emission line rich T Tauri spectrum during quiescence
- to a spectrum with more continuum and quenched forbidden lines.

ESO-Ha 99

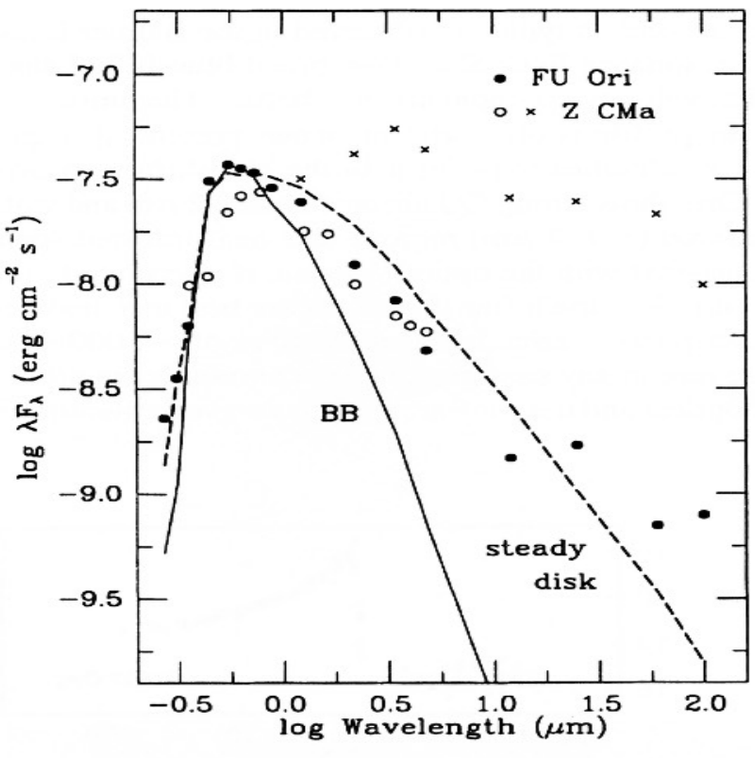
FU Orionis Outbursts: Long Outburst Duration



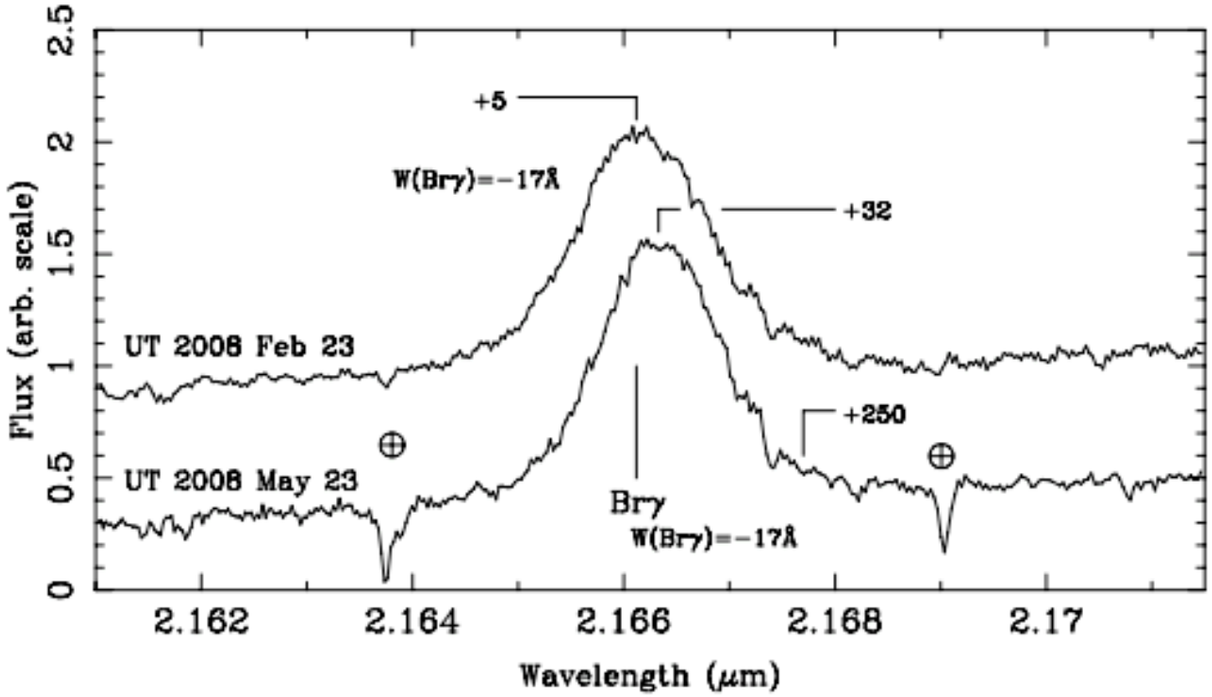
Subaru Hα image by B. Reipurth showing nebulosity and association with molecular cloud

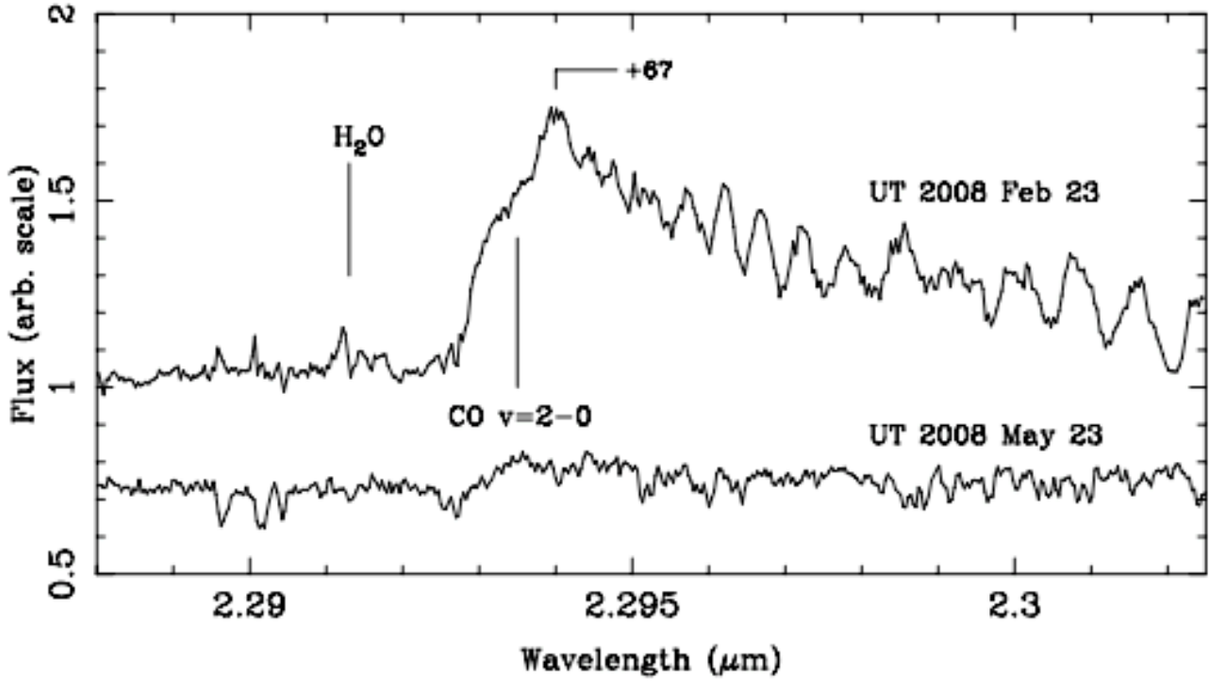


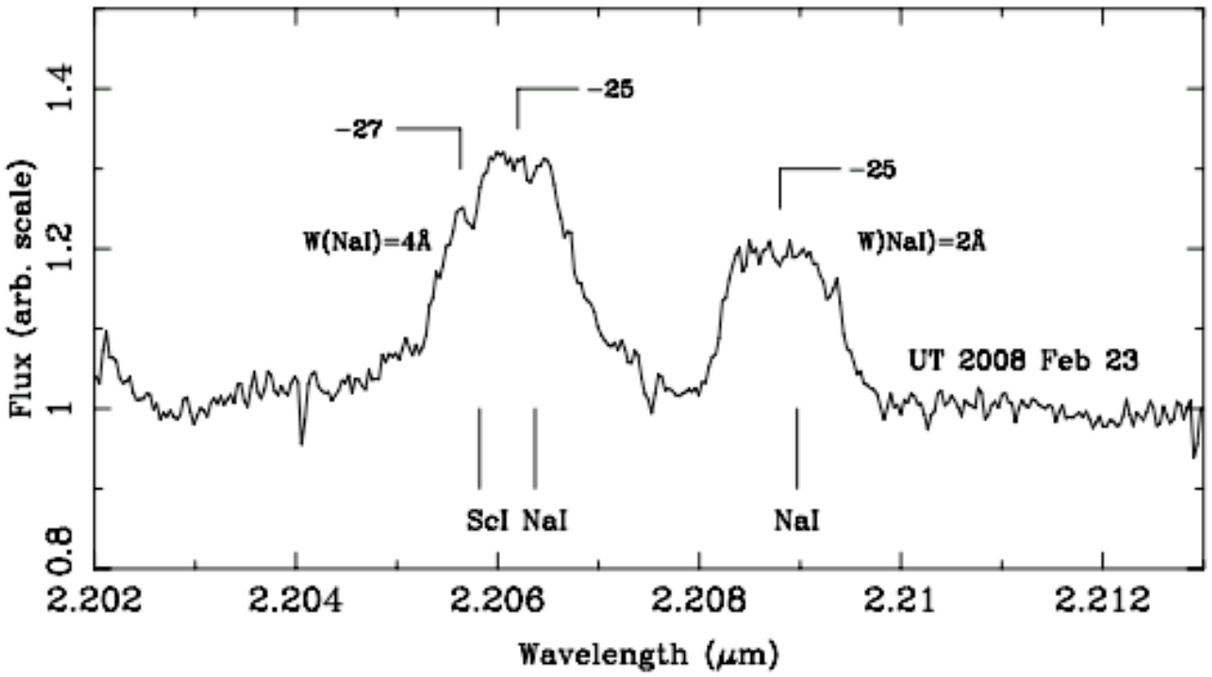
Fuor light curves and SEDs From Herbig 1977 and Hartmann & Kenyon 1996

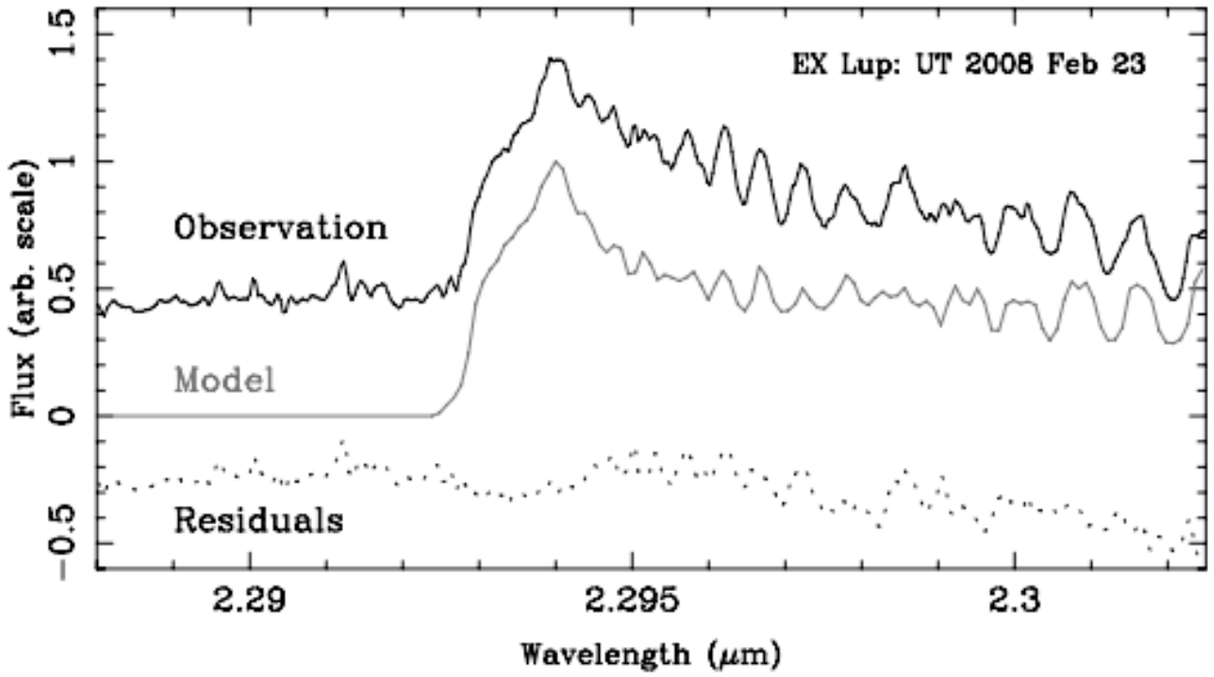


FU Orionis has a disk, but is not embedded in a large envelope of cold molecular material. Z CMa, in contrast, is embedded in more colder molecular material.









from Aspin et al. 2010

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