Protostar Variability

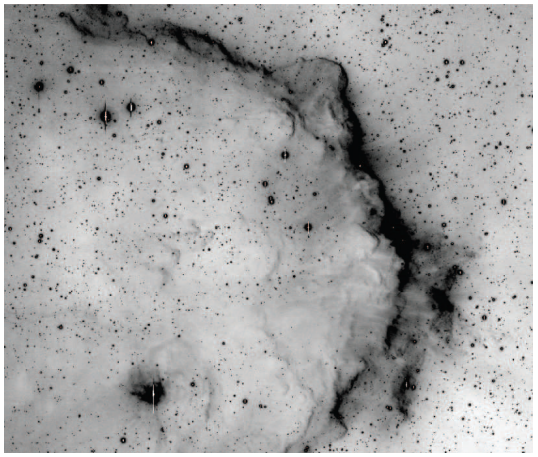
- Accretion Instability and Extinction Variations -

Klaus Hodapp, Rolf Chini, and the IRIS team

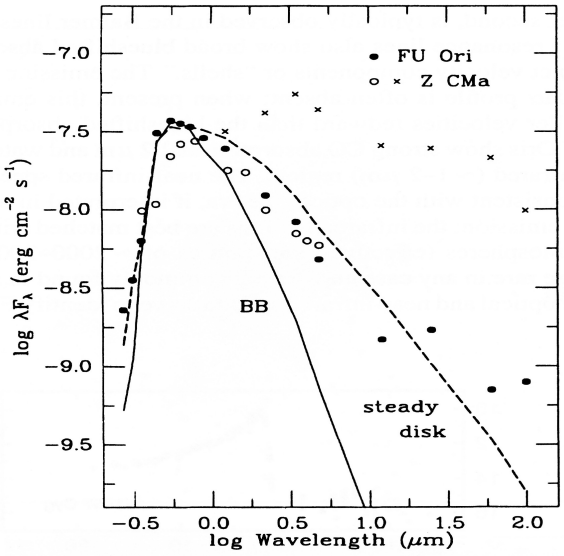
- Under what conditions do stars accumulate most of their mass ?
- What is the thermal history of proto-planetary disks ?

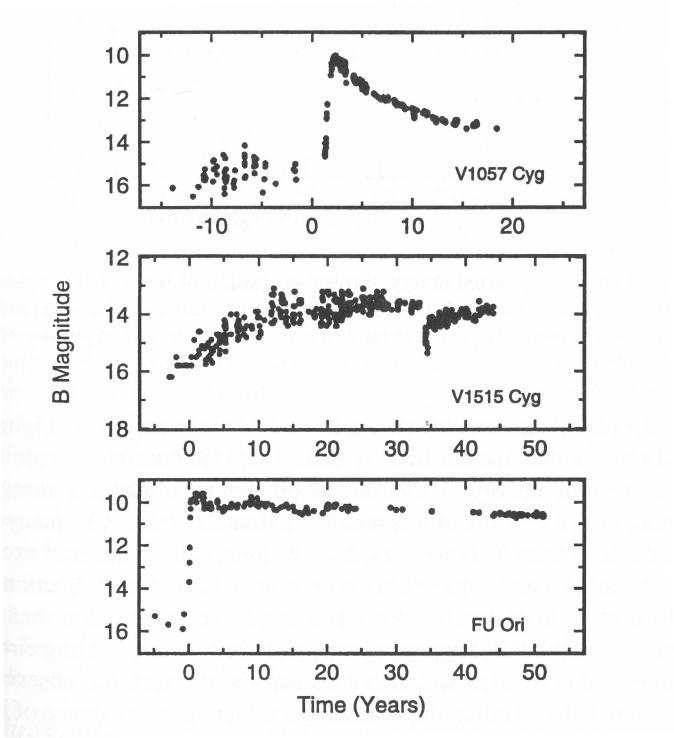
Credit: NASA/JPL-Caltech/R. Hurt

FU Orionis Outbursts: Long Outburst Duration



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

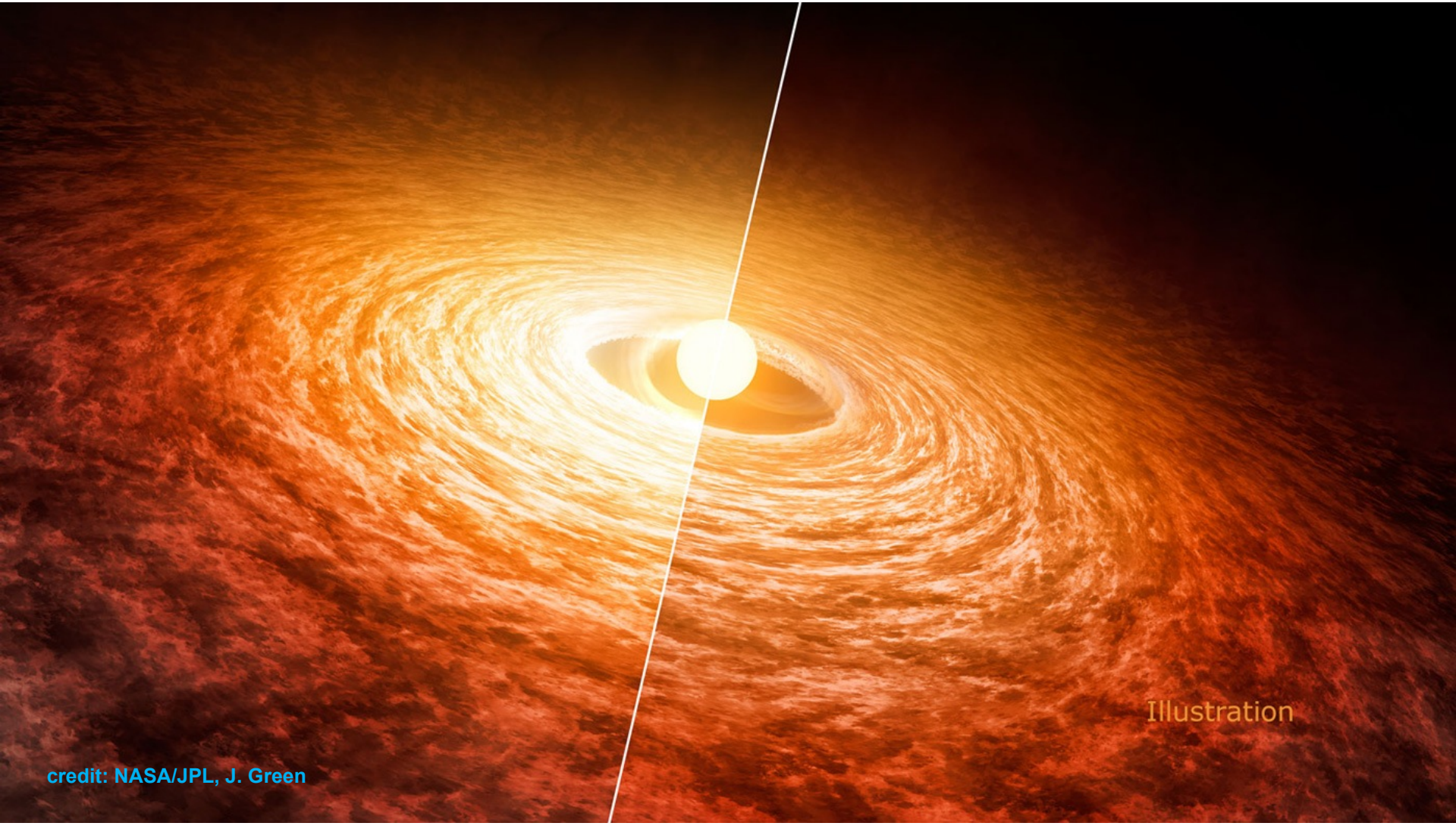




Fuor light curves and SEDs
From Herbig 1977 and
Hartmann & Kenyon 1996

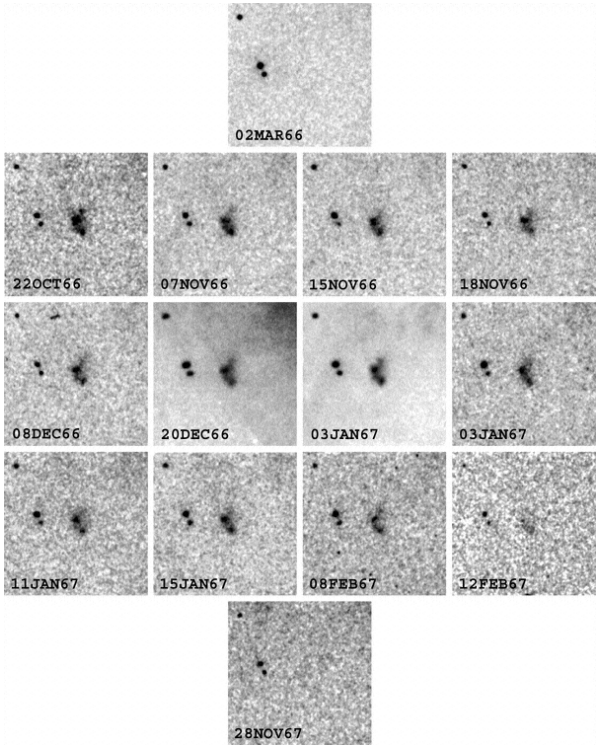
FU Orionis has a disk, but is not embedded in a large envelope of cold molecular material. Z CMa, in contrast, is embedded in more colder molecular material.

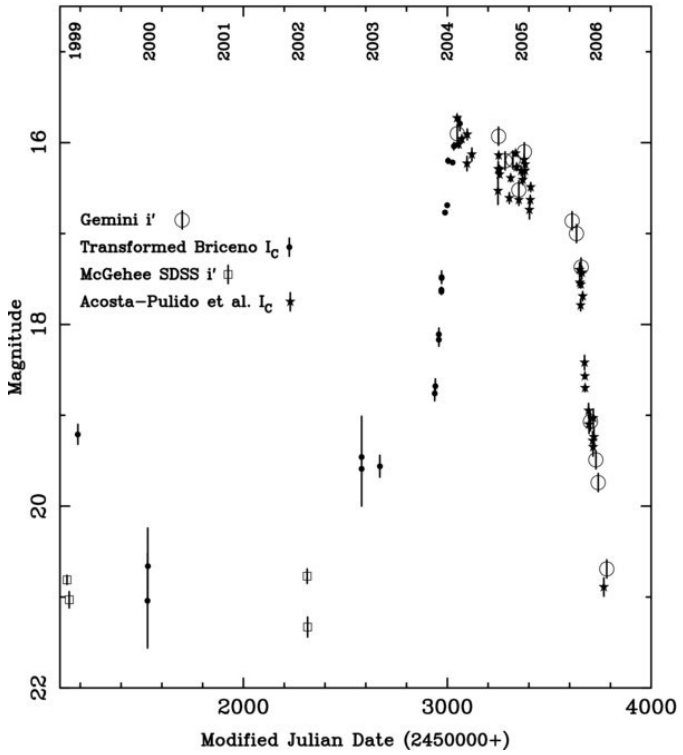
FUor Mechanism: An optically thick inner accretion disk becoming luminous as a result of an increase in the accretion flow.

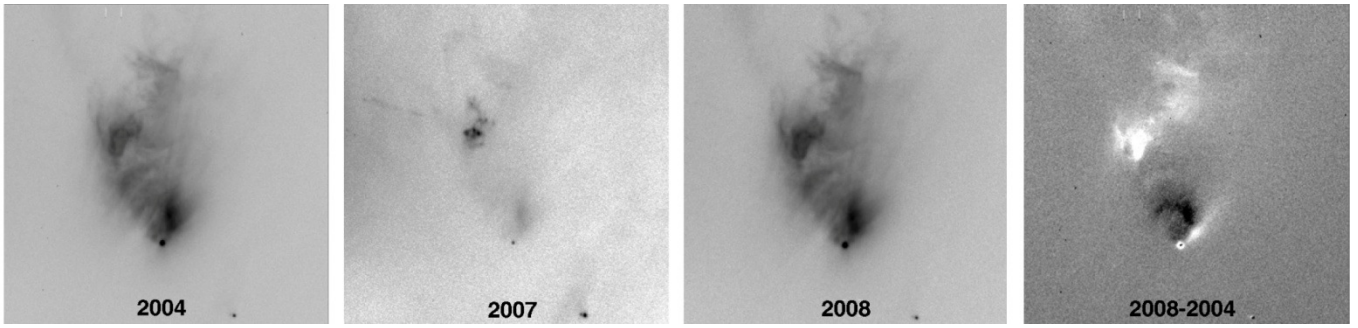


credit: NASA/JPL, J. Green

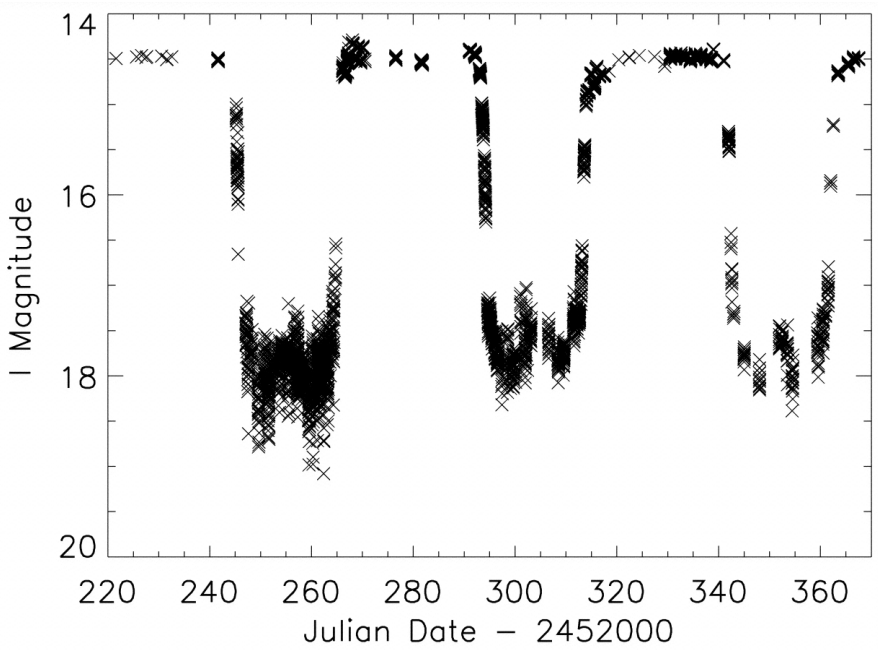
V1647 Ori (McNeil's Nebula): A repetitive Exor, Aspin et al. 2006, 2009



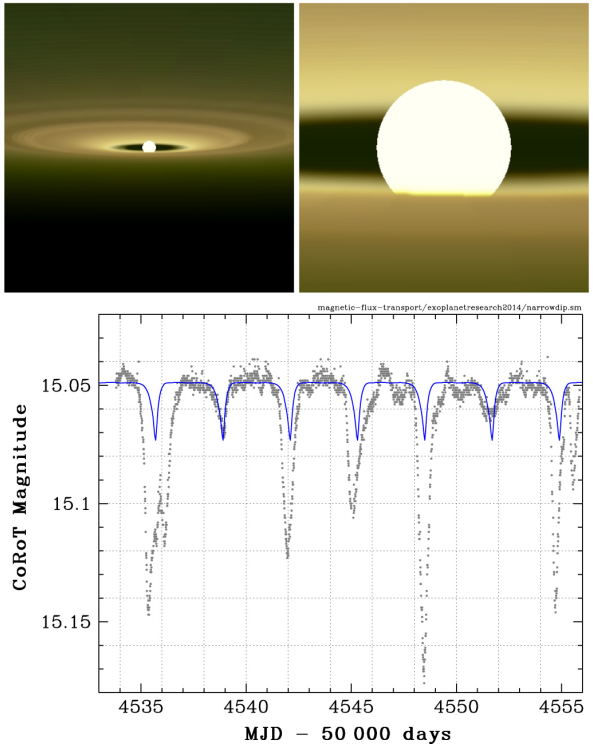




Science Case: Fades, Dippers and other Occultations

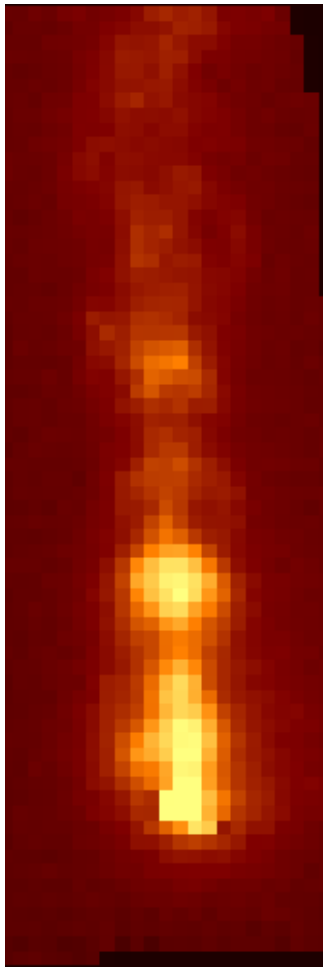


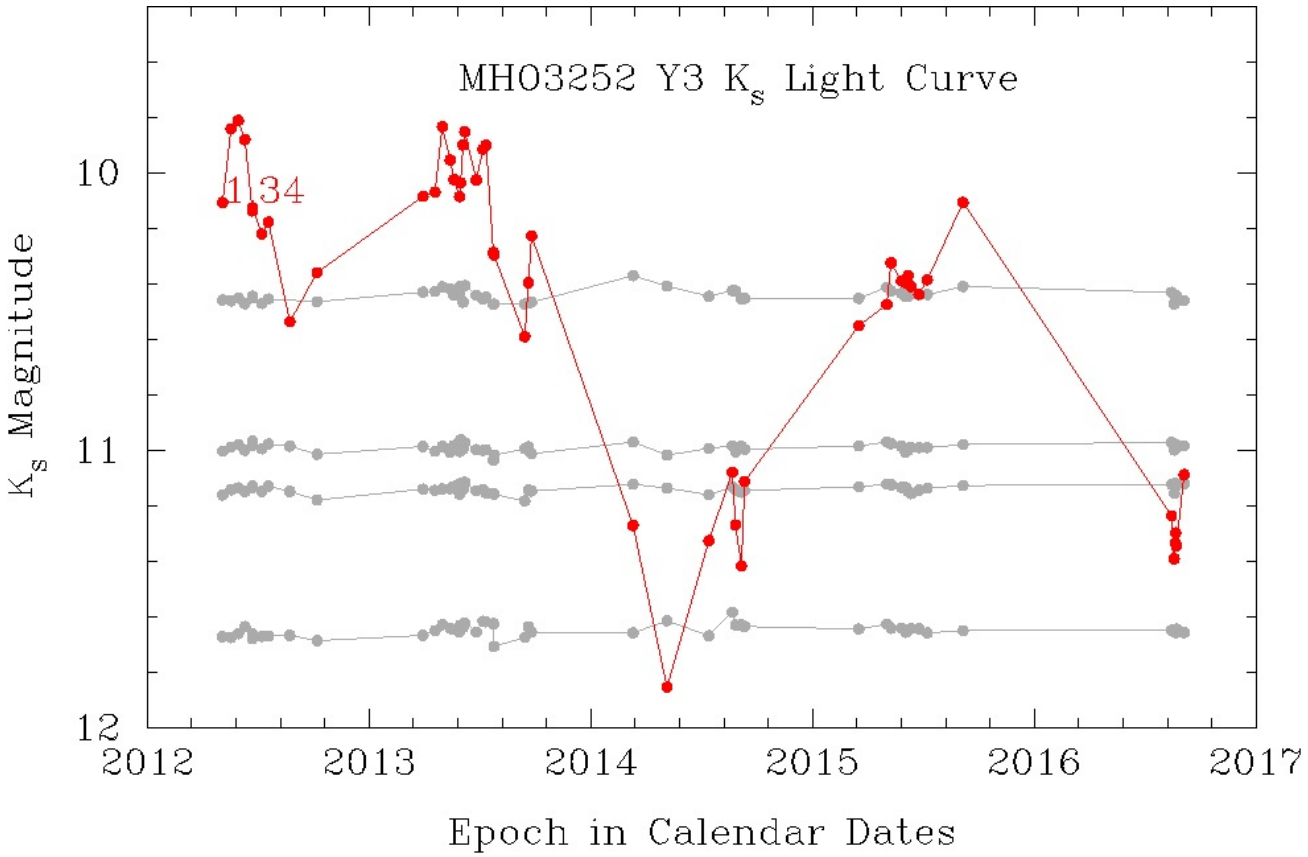
The young star KH15D displays long and deep eclipses due to occultations by the rim of its circumstellar disk, the figure is from Herbst et al. (2002) PASP 114, 1167



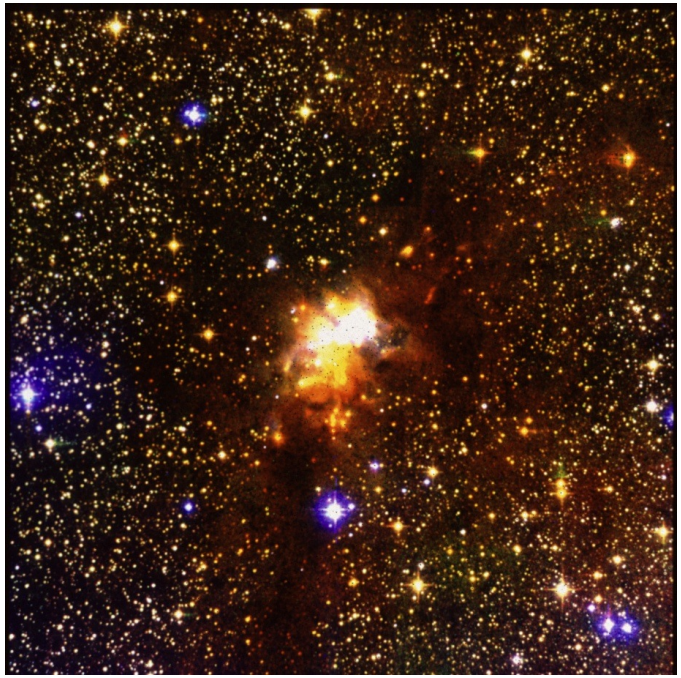
COROT Mon-21 light curve, credit: Stauffer et al. 2016, 149, 130

The outflow source MHO3252Y3 in Serpens South shows a pattern of long-duration dipping.

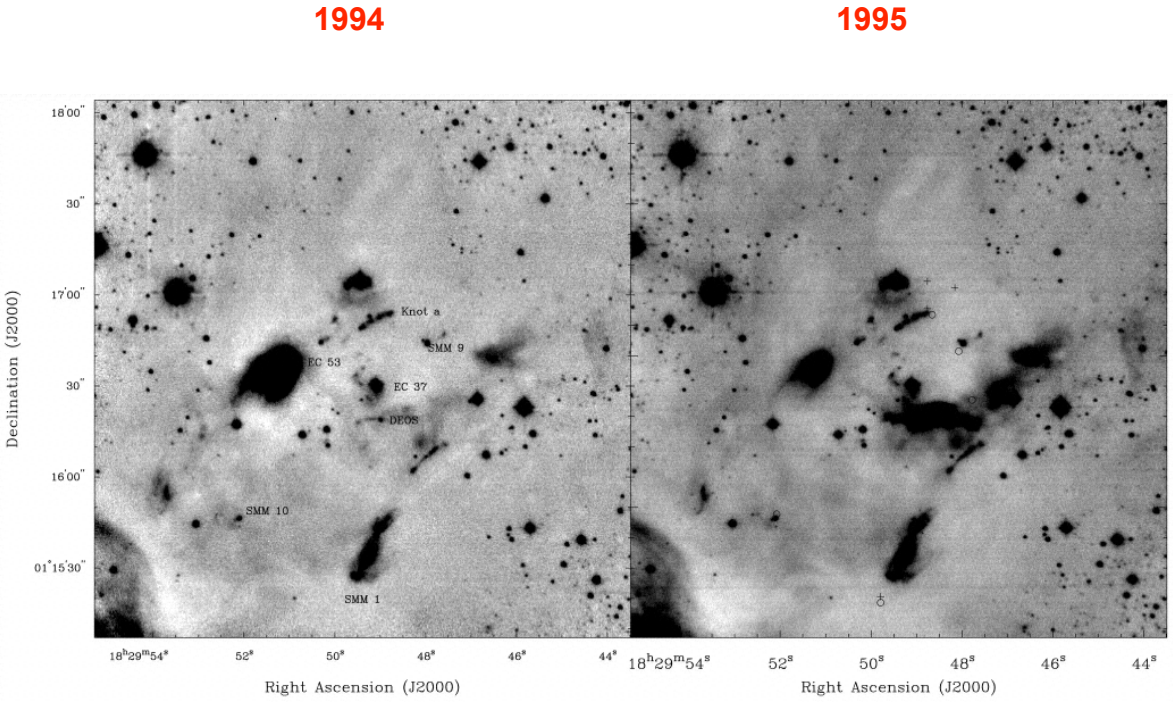




OO Serpentis: A deeply embedded FUor-like Object

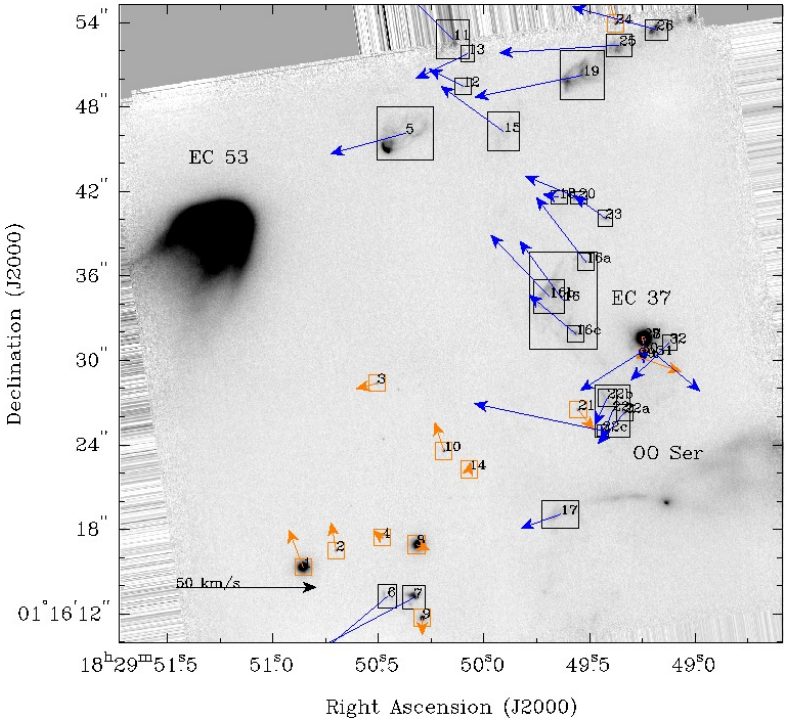


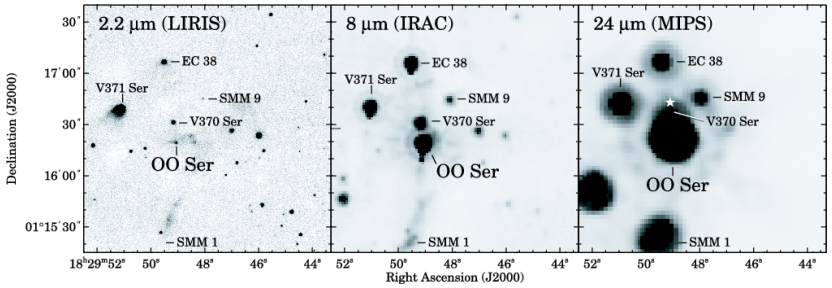
Overview of the Serpens star-forming region



The deeply embedded outburst star (DEOS), no called OO Serpentis, was discovered at infrared wavelengths in 1995

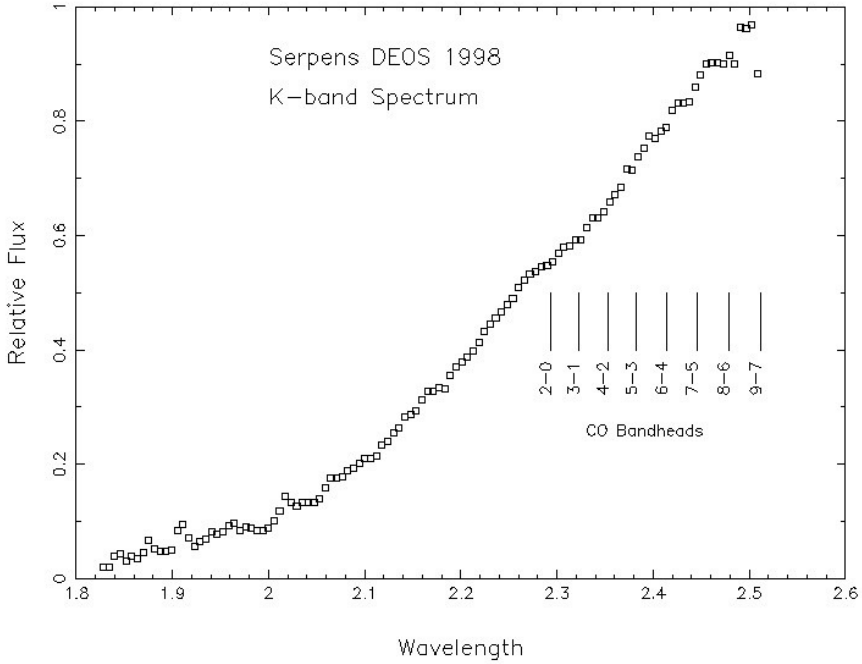
OO Ser is an outflow source seen nearly edge-on.
At FIR wavelengths, it is the brightest object in Serpens NW.

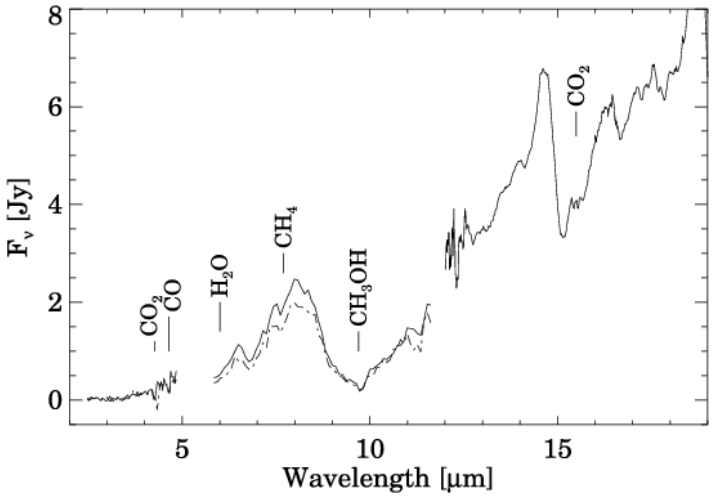




Kospal et al. 2007, AA 470, 211

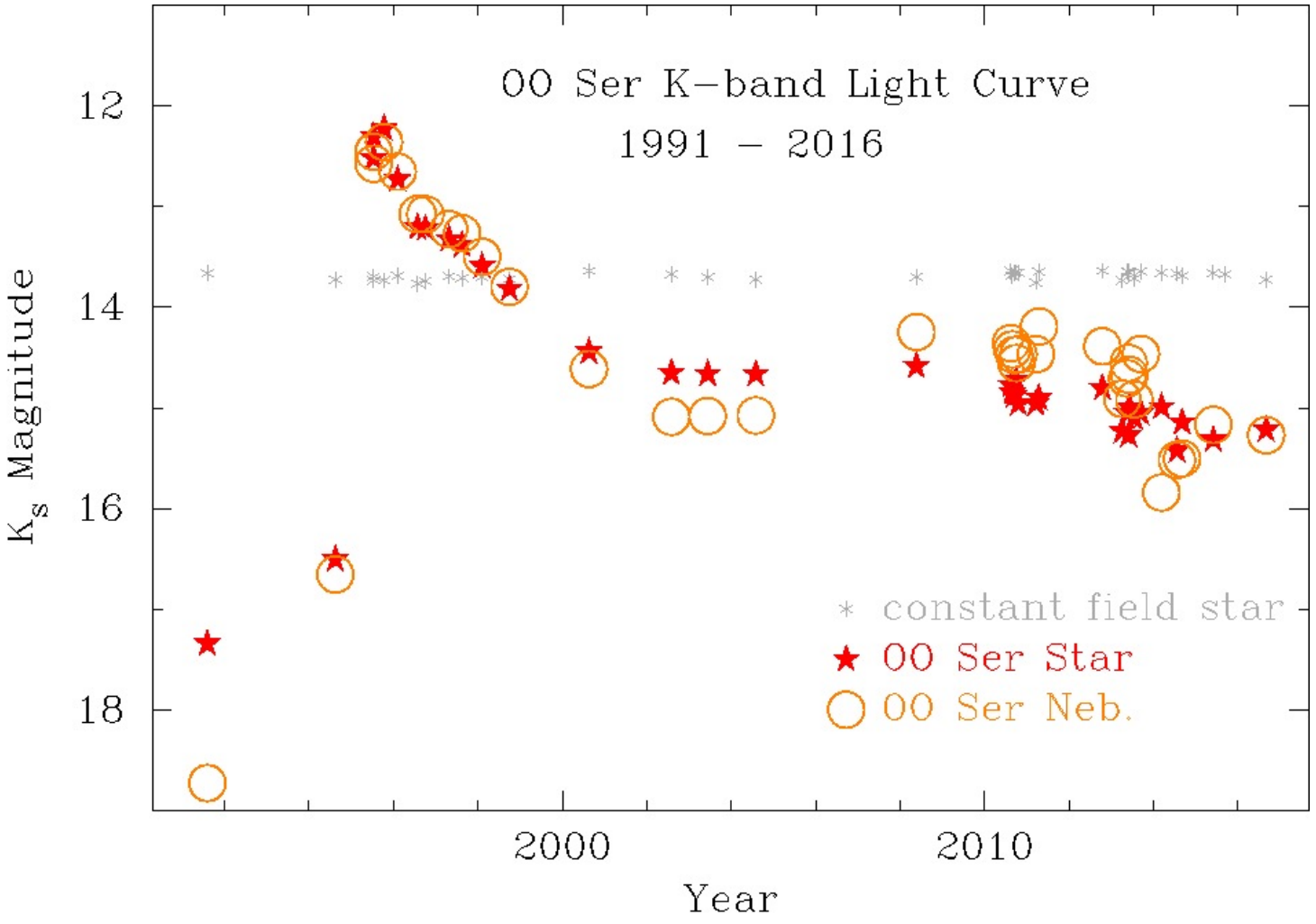
During the last outburst, the spectrum of the central object showed indications of CO absorption bands, indicative of FUor like spectrum. It suffers very substantial extinction along the line of sight and shows deep ice absorption features.



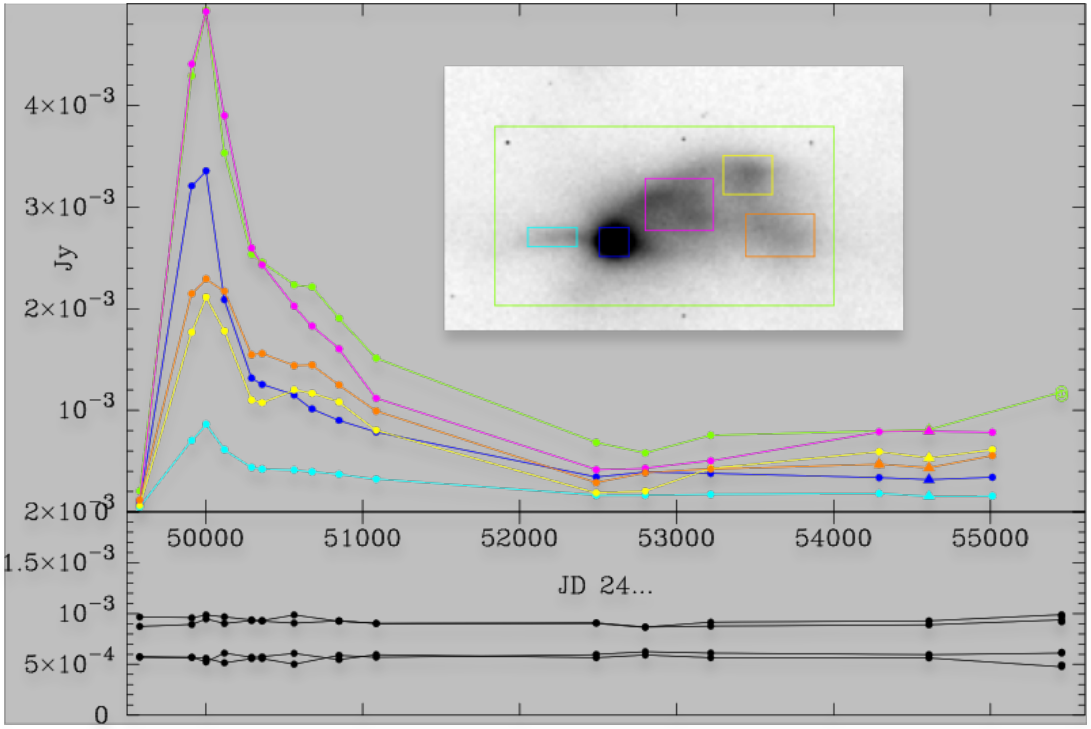


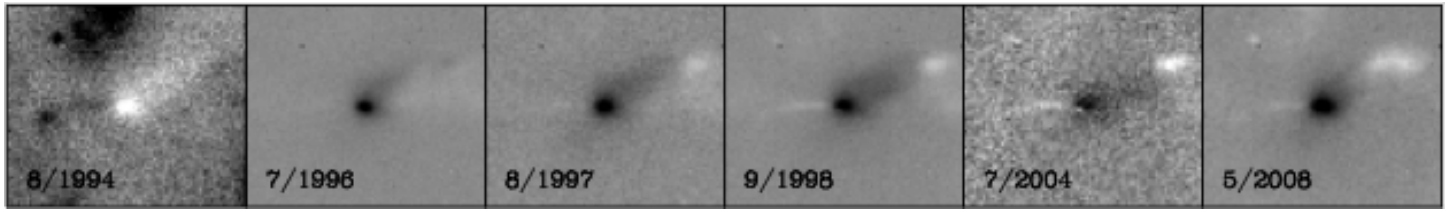
Kospal et al. 2007, AA 470, 211

OO Ser has not yet returned to pre-outburst brightness

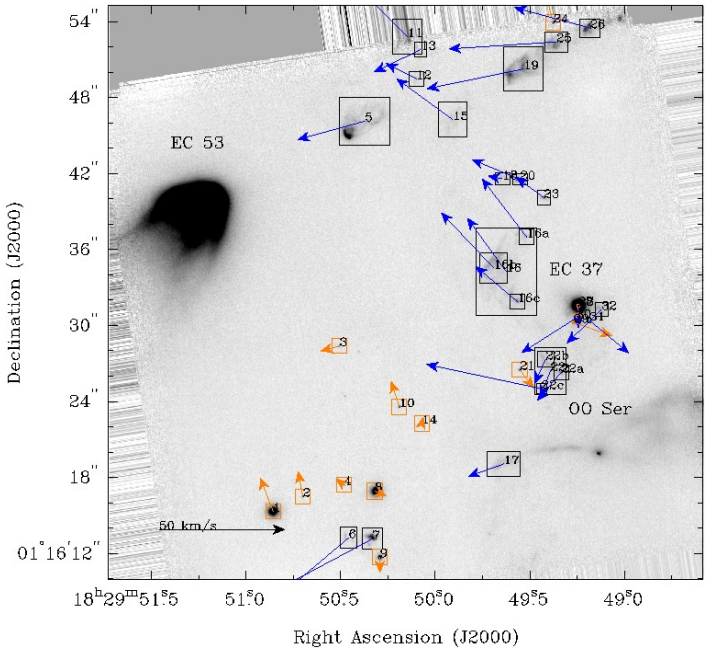


Variable illumination in the OO Ser reflection nebula



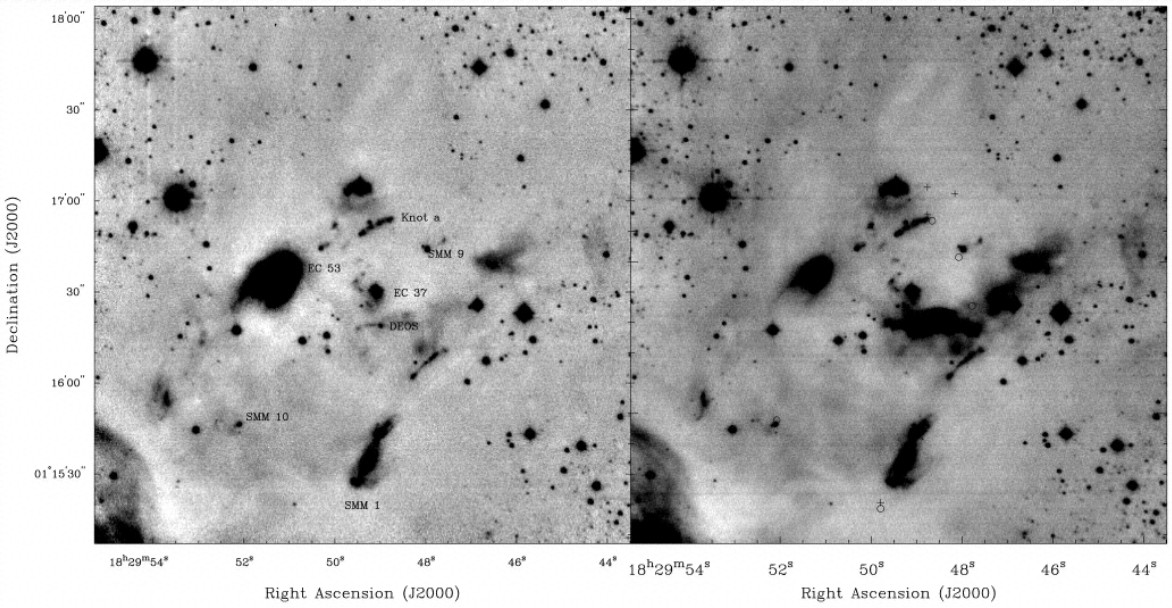


EC 53 = V371 Ser
A YSO in the outflow phase appearing as a “cometary” nebula

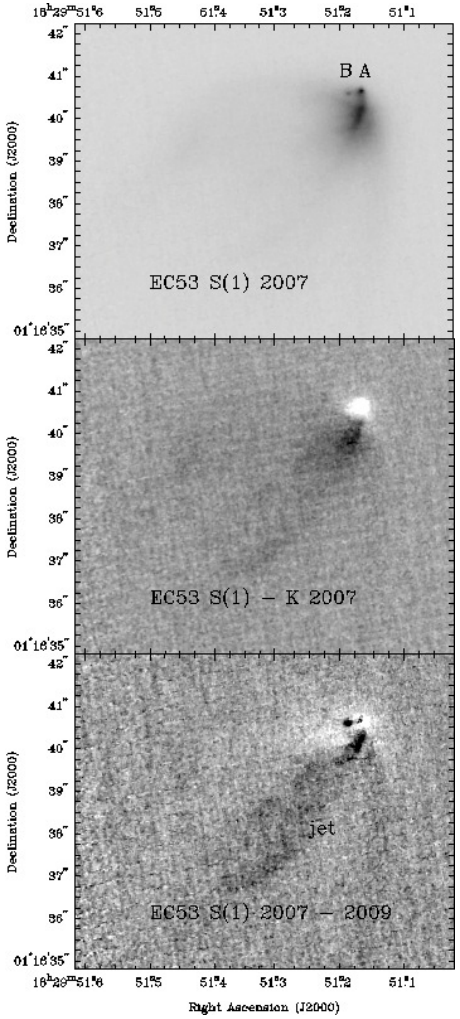


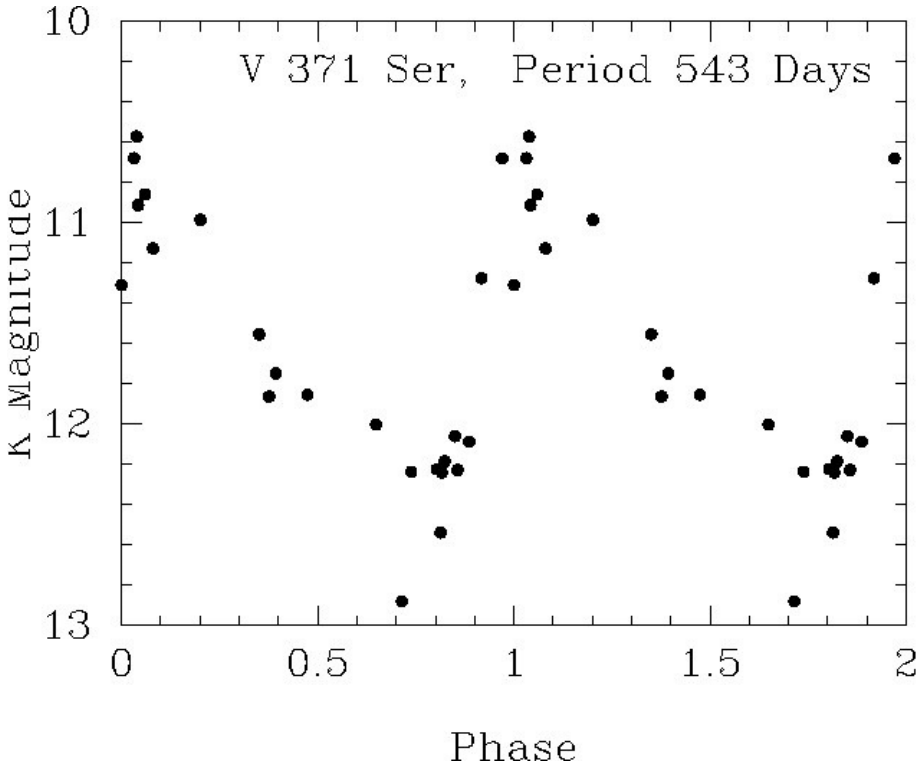
Keck NIRC2 AO K-band Image

1994 1995

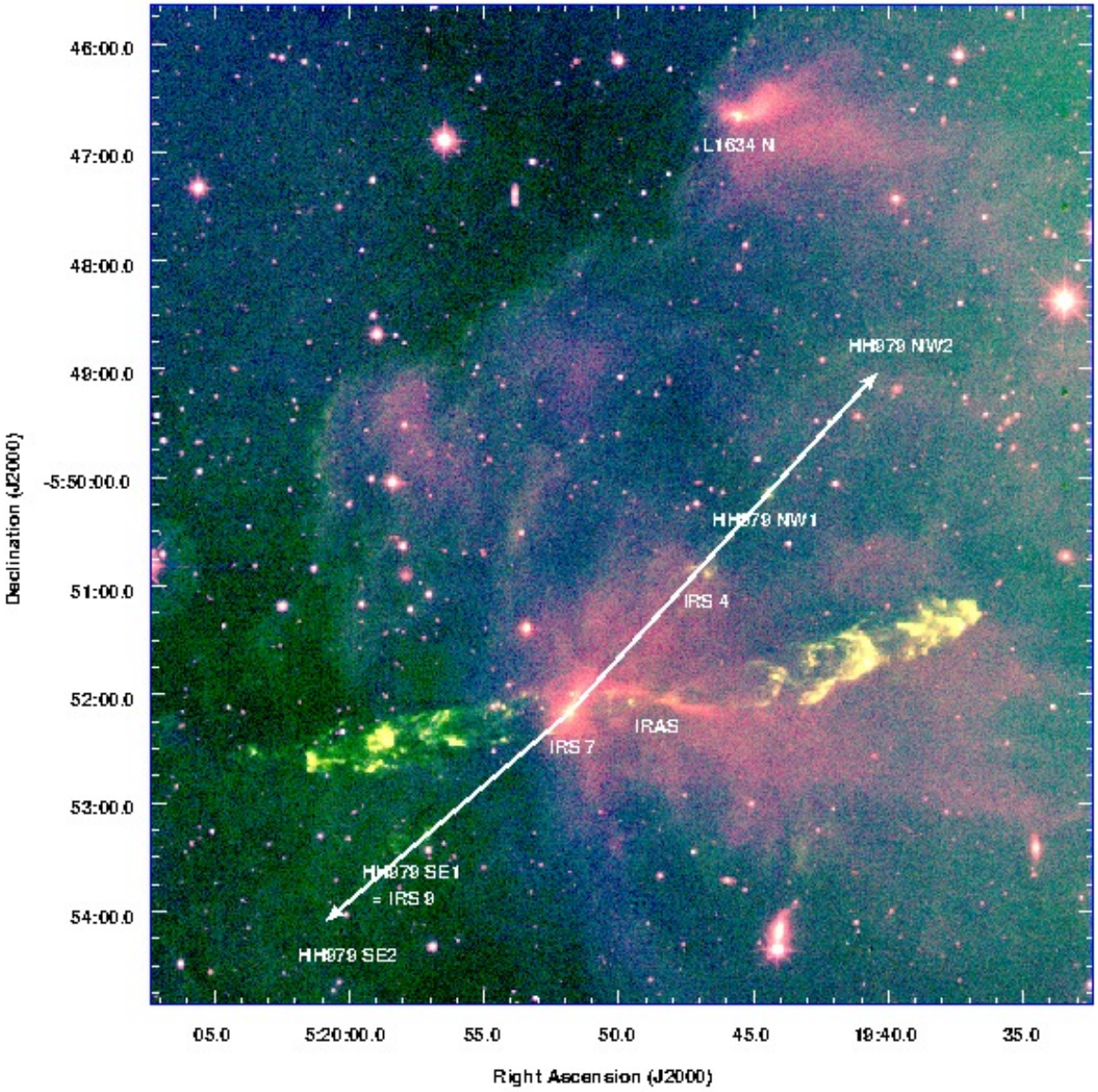


EC 53 = V371 Ser
is a double star with the primary component being periodically variable.

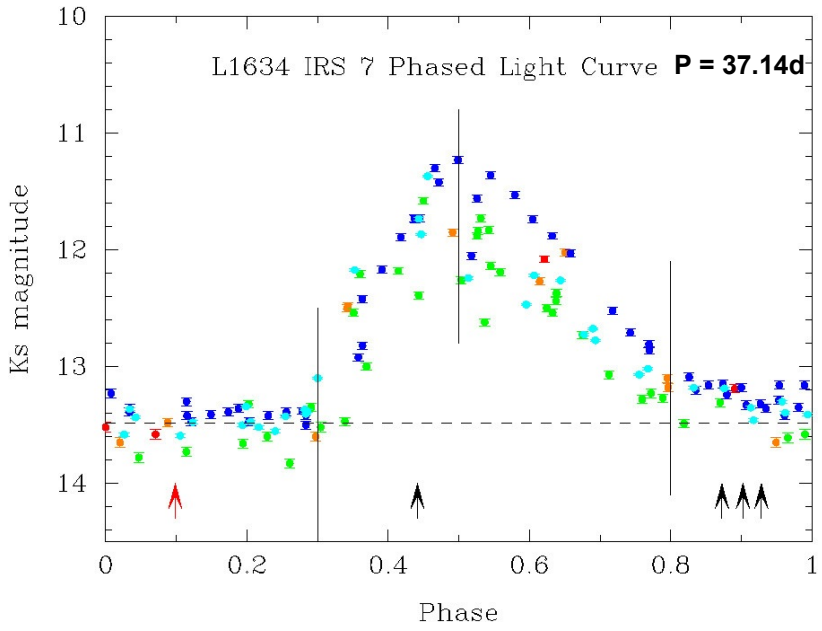




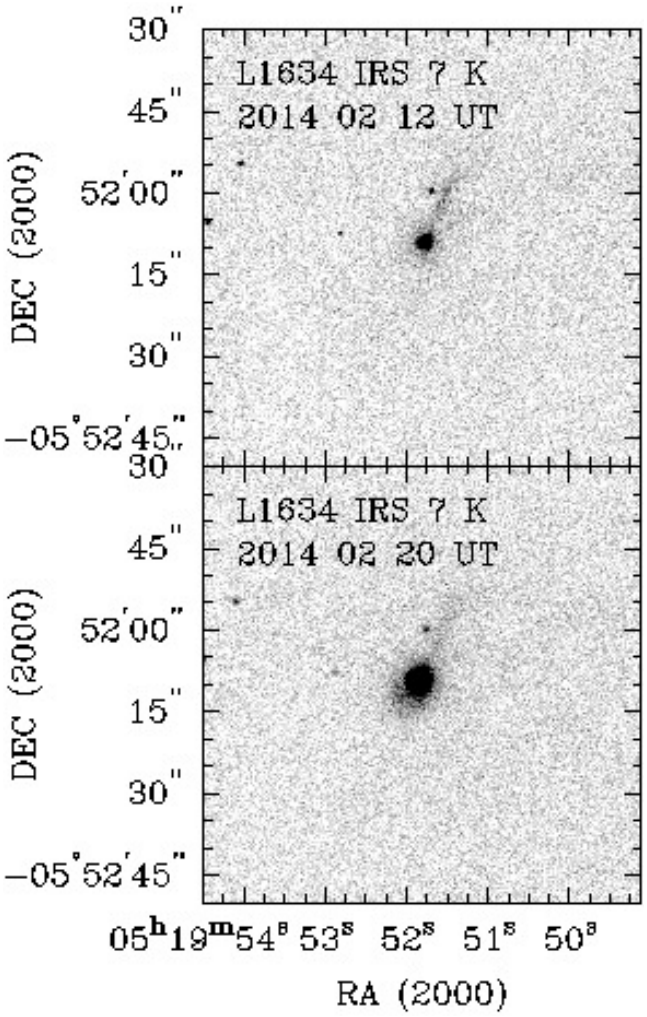
L1634 has two overlapping outflows



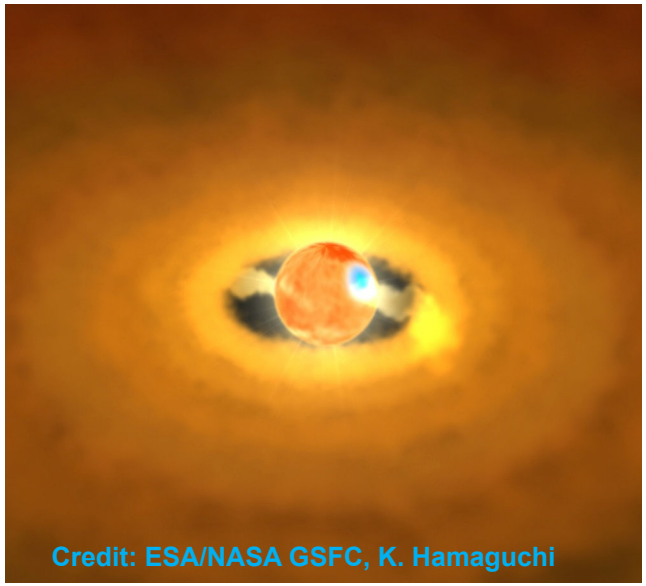
The driving source of the smaller outflow is periodically variable.

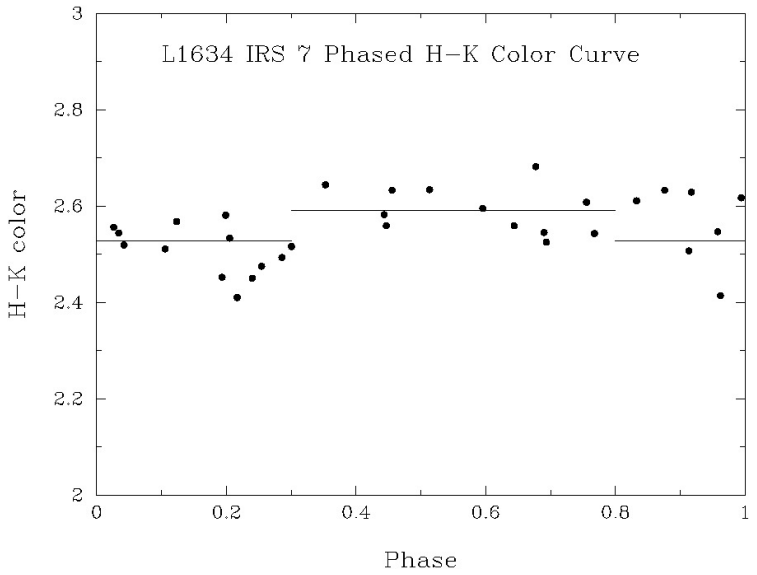


L1634 IRS 7 is periodically variable with a period of 37.14 days and small variation between maxima.

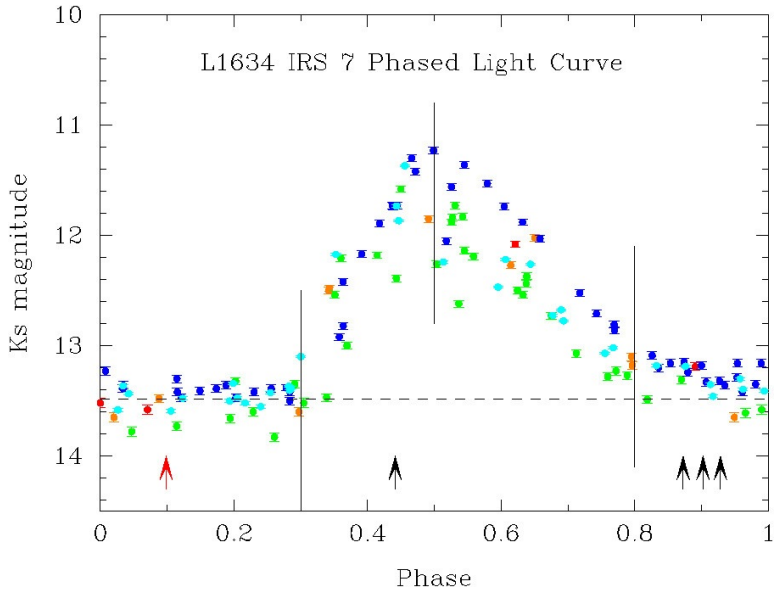


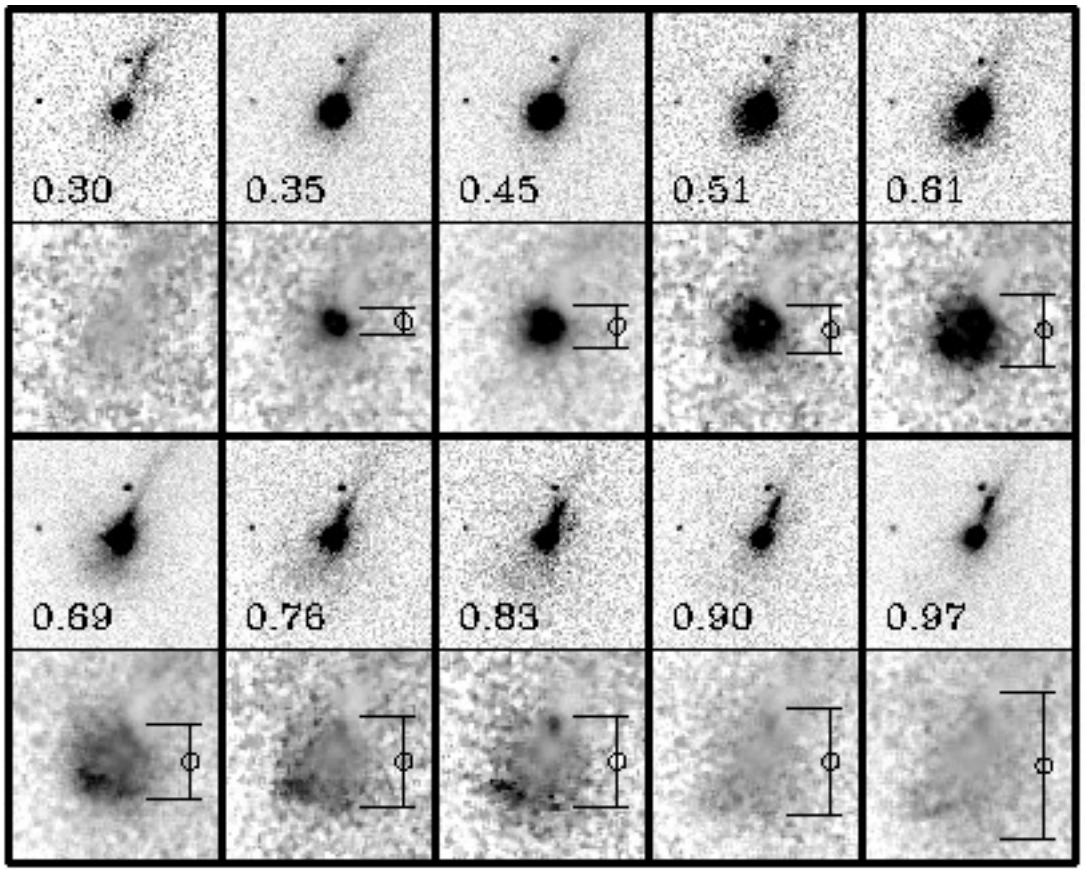
The variations of IRS7 are not due to a hotspot on the star.



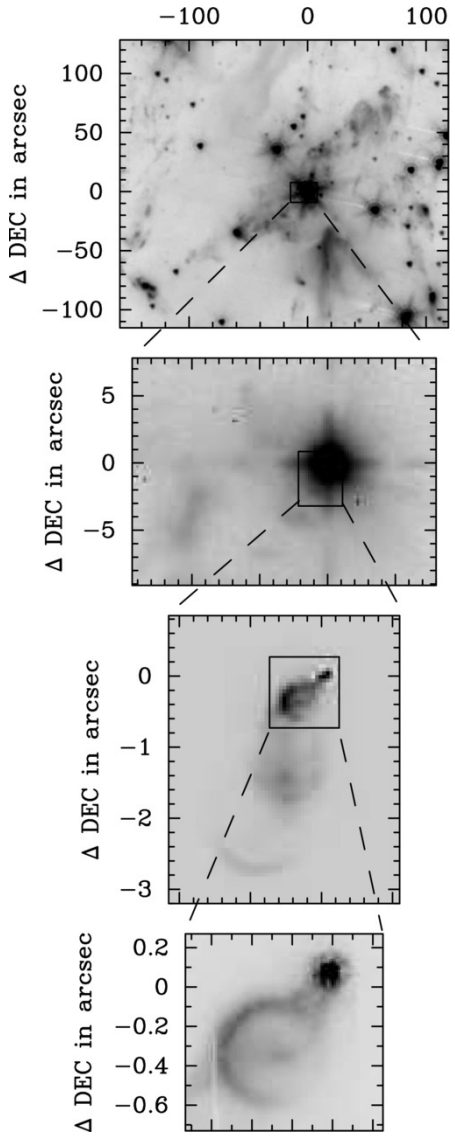


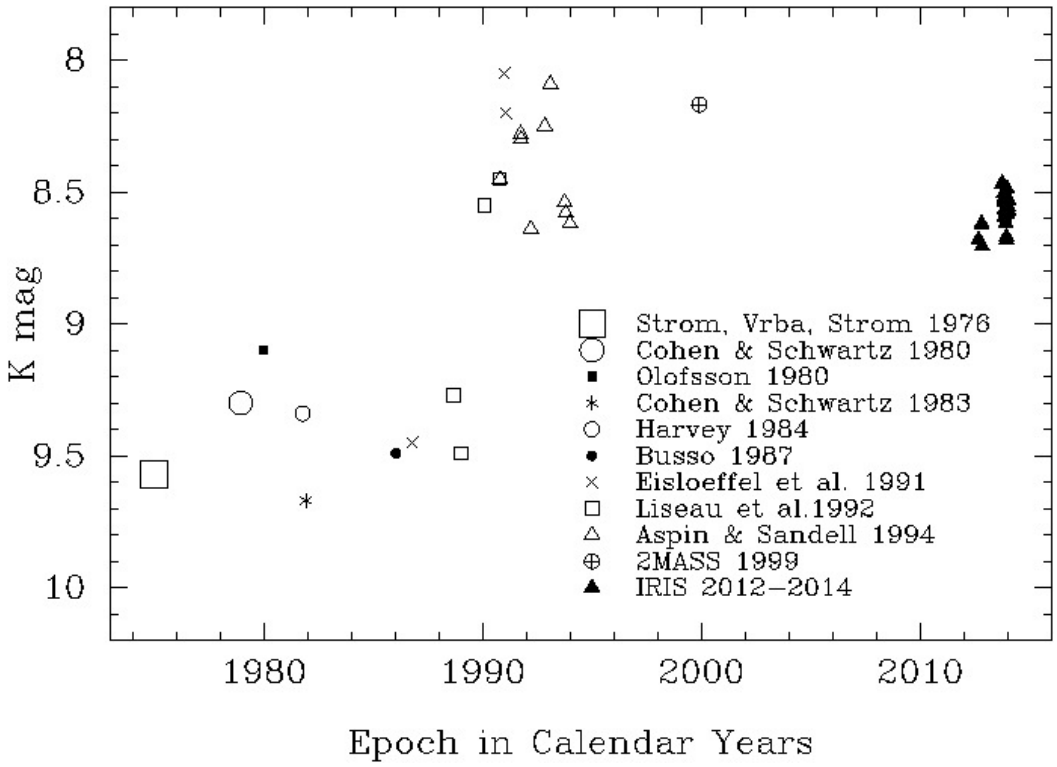
Light Echoes of the IRS7 variations are not consistent with a rotationally modulated hotspot.





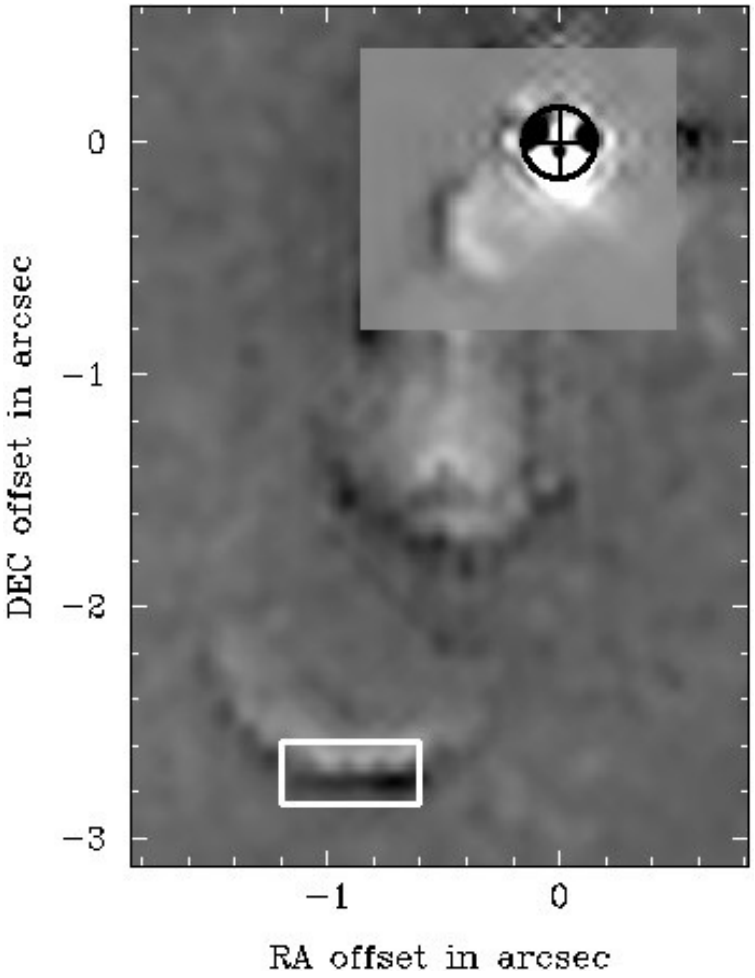
NGC1333 SVS13 (aka V512 Per)
An outflow source with periodic jet activity

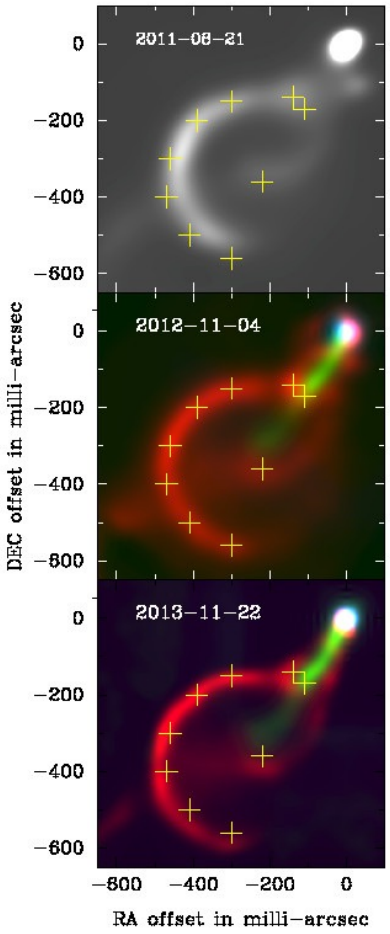


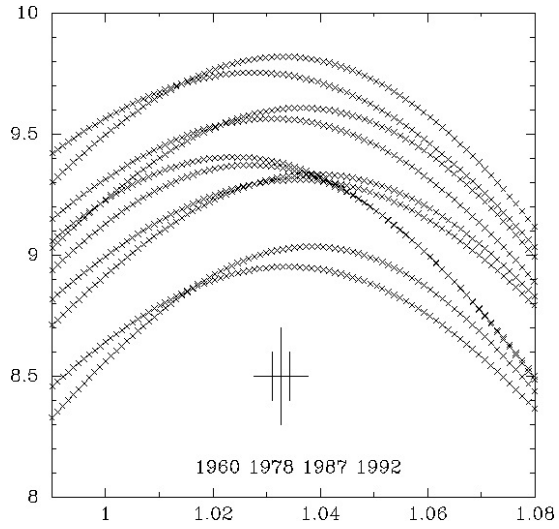


Lightcurve of 1990 outburst
SVS13 has not yet returned to its pre-outburst brightness

SVS 13 has ejected multiple shock fronts in the recent past (100 years). The youngest bubble is plausible related to the 1990 outburst. The next outburst may be expected within a decade.







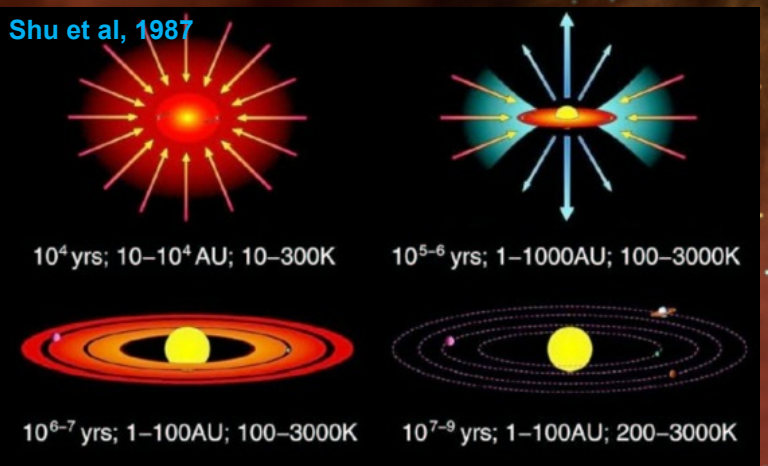
Assuming constant velocity, the bubble formed around 1980. With some deceleration, this is consistent with the observed 1990 photometric outburst.

Credit: NASA/JPL-Caltech/R. Hurt

MIR and FIR photometric monitoring, using FORCAST and HAWC+ , is needed to distinguish luminosity from extinction variations.

10/10/2016

Protostellar Objects seen nearly edge-on: Variable Extinction and Scattering



Credit: NASA/JPL-Caltech/R. Hurt

Types of YSO Variability in the Timescale - Amplitude Diagram

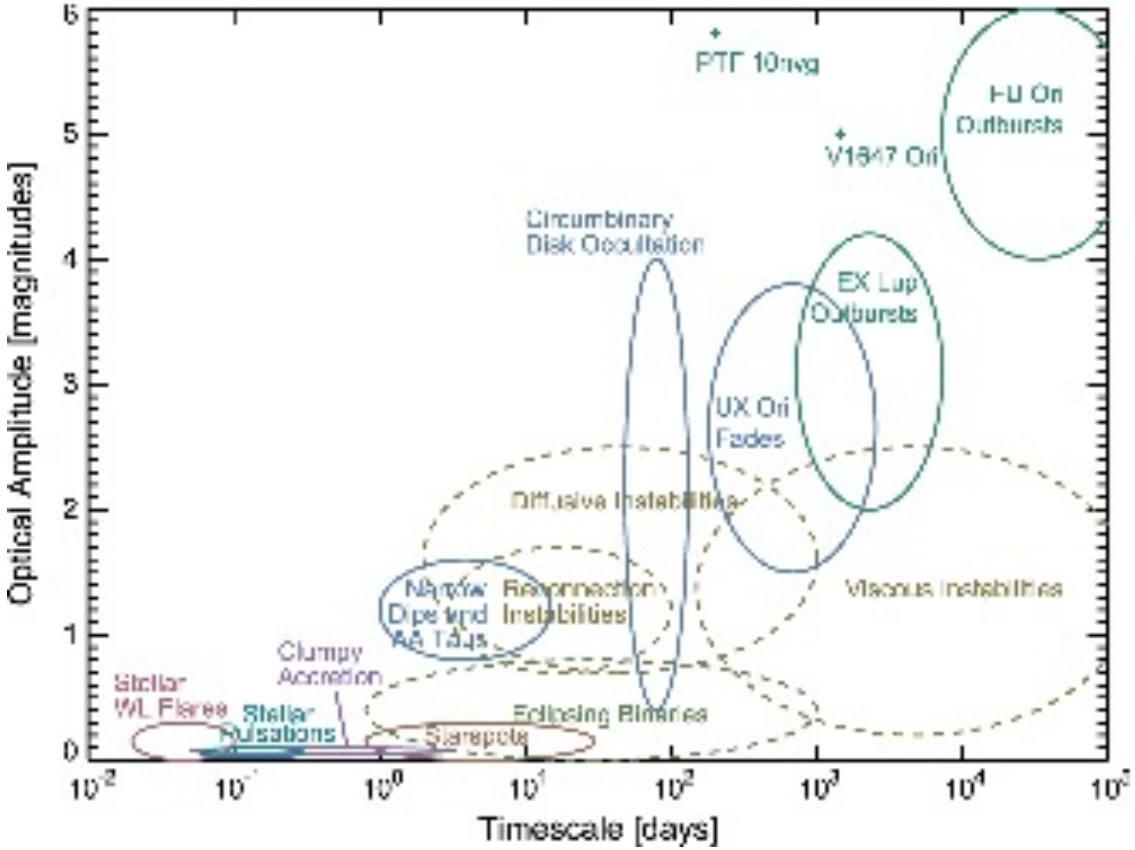
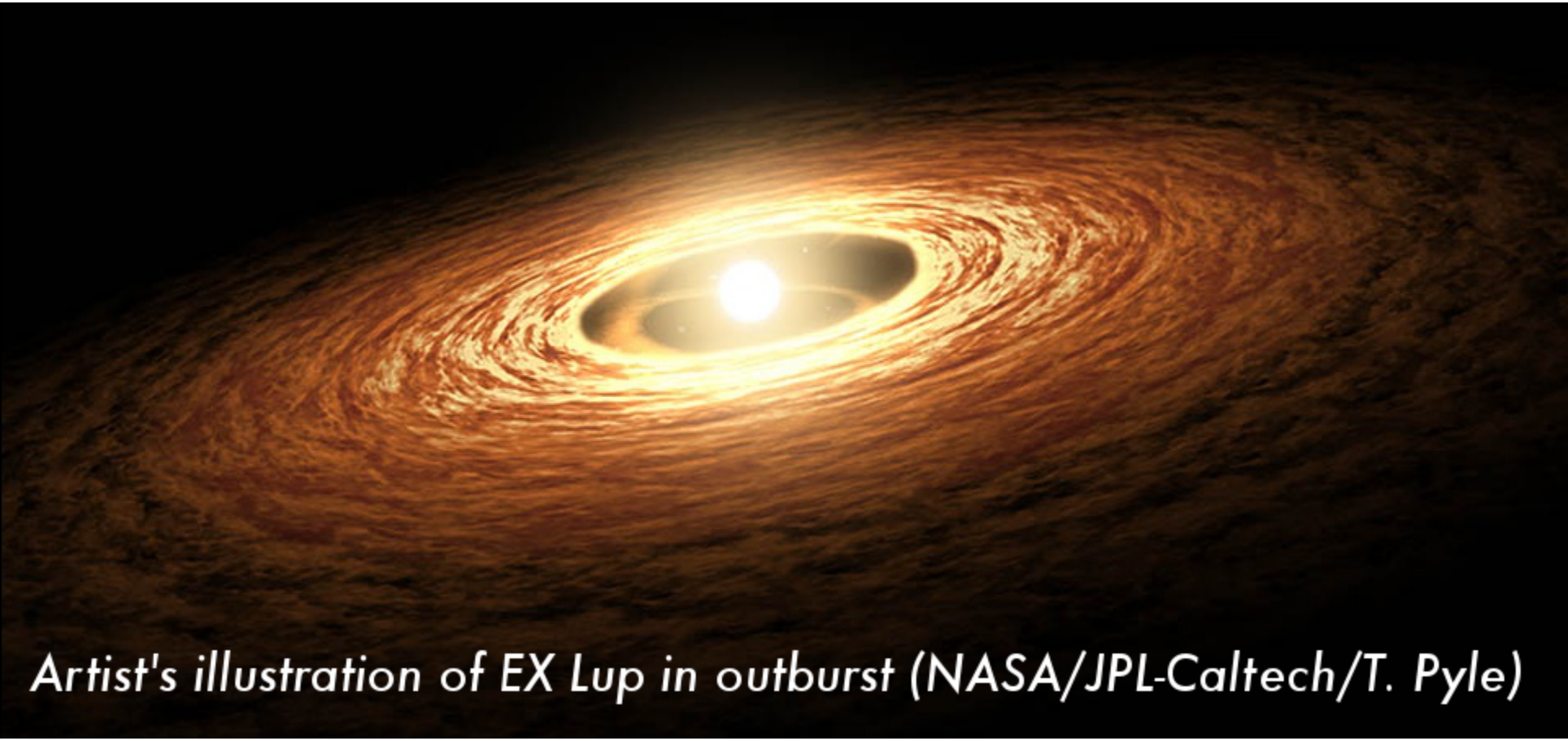


Figure from Hillenbrand & Findeisen 2015

The Infrared Imaging System (IRIS)

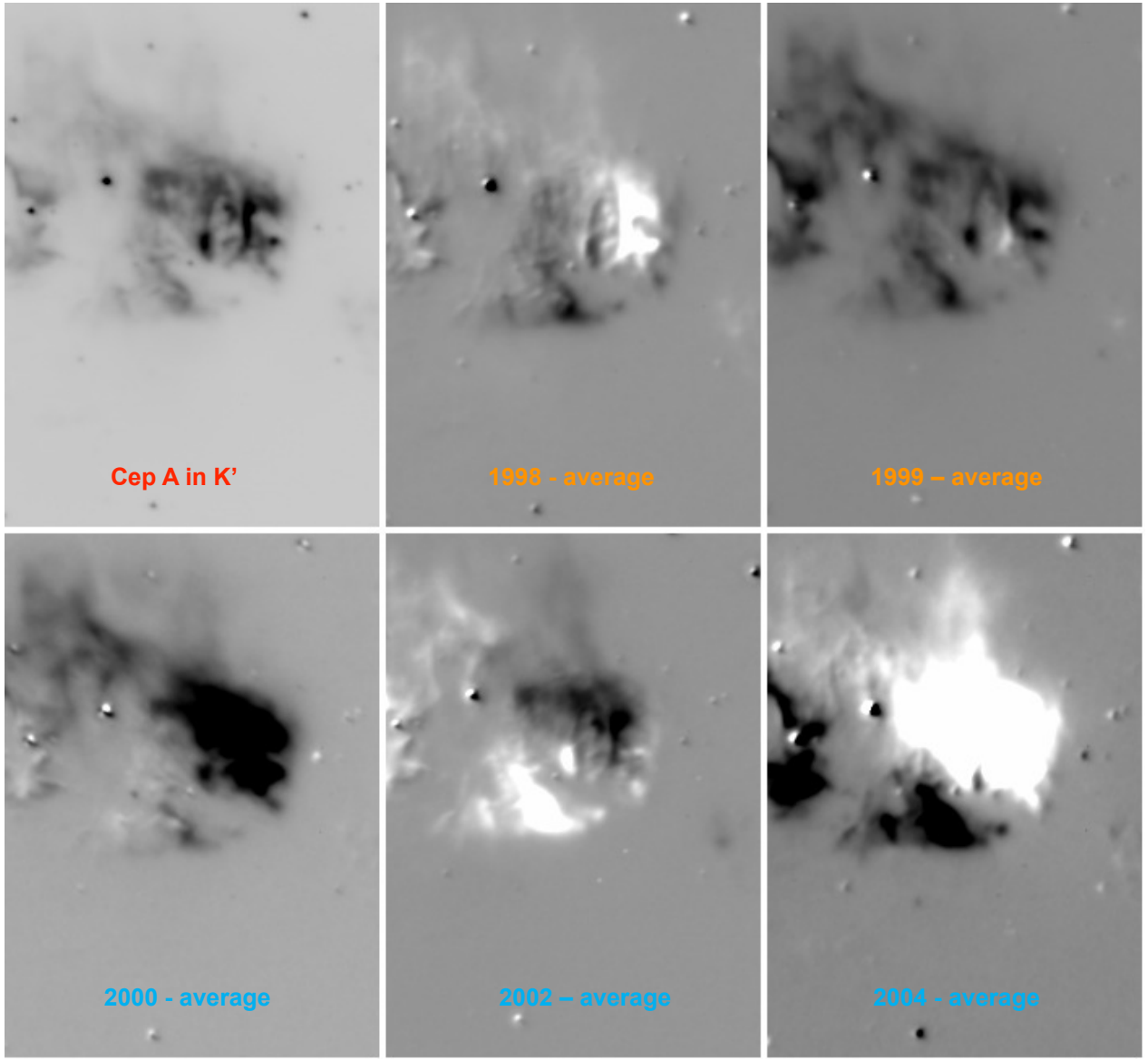
The IRIS telescope and IR camera in its enclosure at OCA
IRIS is a collaborative project of AIRUB, IfA, and UCN
1K IR Camera on 0.8m telescope on Cerro Armazones, Chile


2/28/2011



Artist's illustration of EX Lup in outburst (NASA/JPL-Caltech/T. Pyle)

Variability of Reflection Nebulae: Cep A




Cerro Armazones Observatory, an observatory operated entirely on renewable energy sources.