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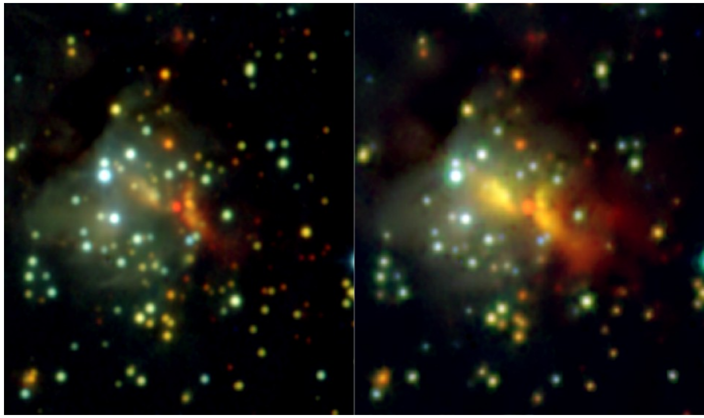
First disk-mediated accretion burst from a massive protostar: how accretion turns into ejection



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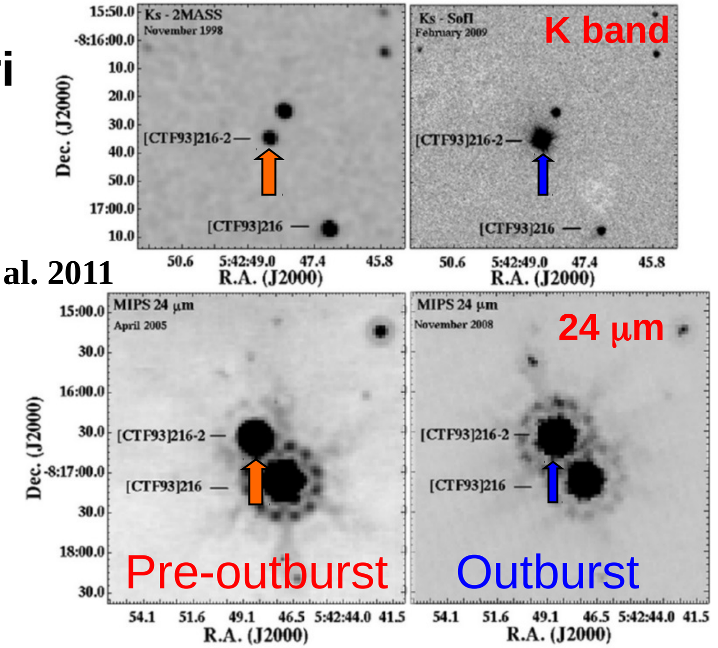
Why episodic accretion in HMYSO?

- Episodic accretion is a common phenomenon in low-mass YSOs (EXors, MNors, FUors).

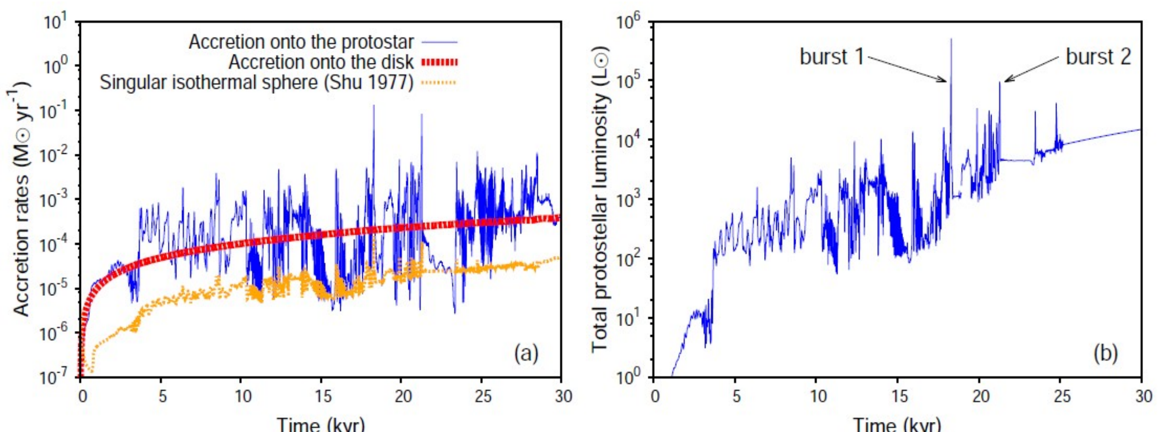
- Origin still debated (thermal/gravitational instabilities, disk fragmentation, companion induced disk perturbations), but linked to accretion disks.

- *If* HMYSOs form through accretion disks, then we should expect accretion bursts! (e.g. Meyer et al. 2016)

V2775 Ori



Caratti o Garatti et al. 2011

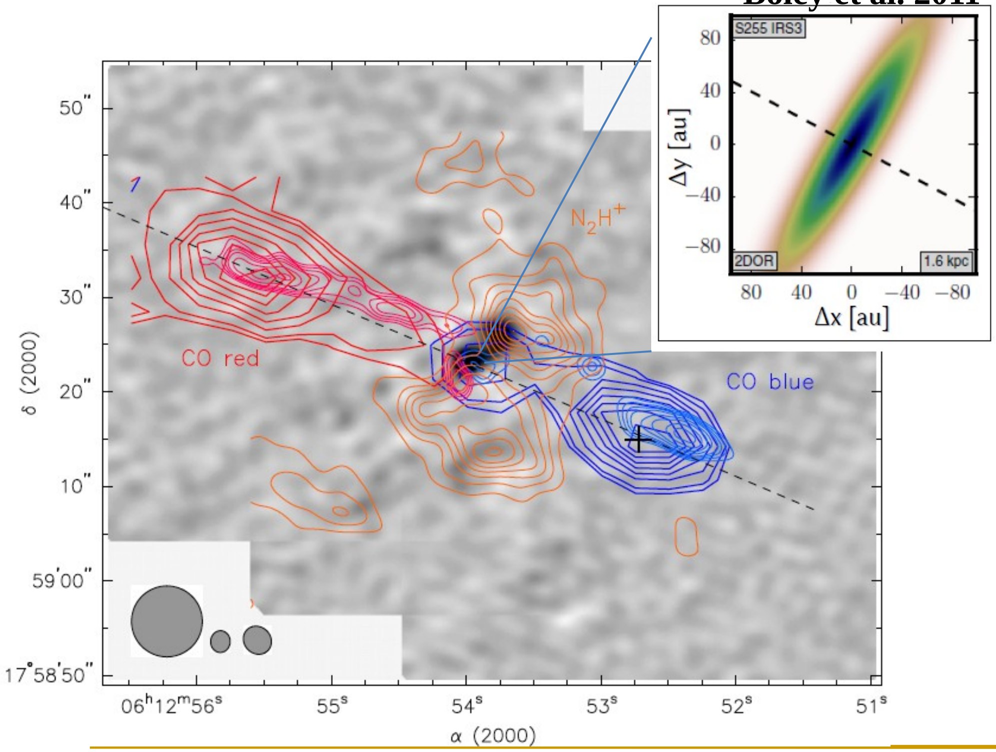


Meyer et al. 2016

Introducing the HMYSO S255IR-NIRS3

- L_{bol}= 2x10^4 $L_\odot$; M_*~20 $M_\odot$; d=1.8±0.1 kpc (Burns et al. 2016)
- Disk, jet and outflow
- CH_3OH masers (6.7 GHz) (Menten 1991)

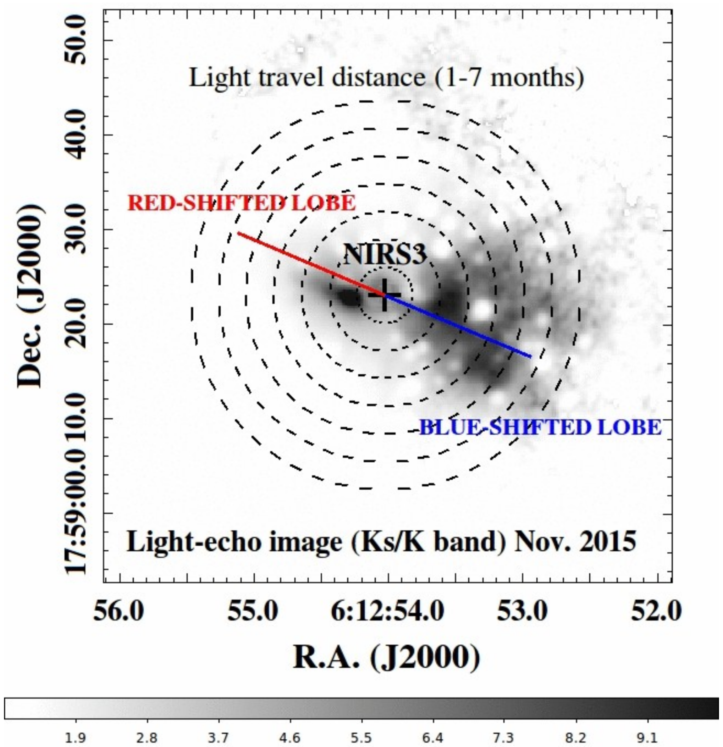
Boley et al. 2011

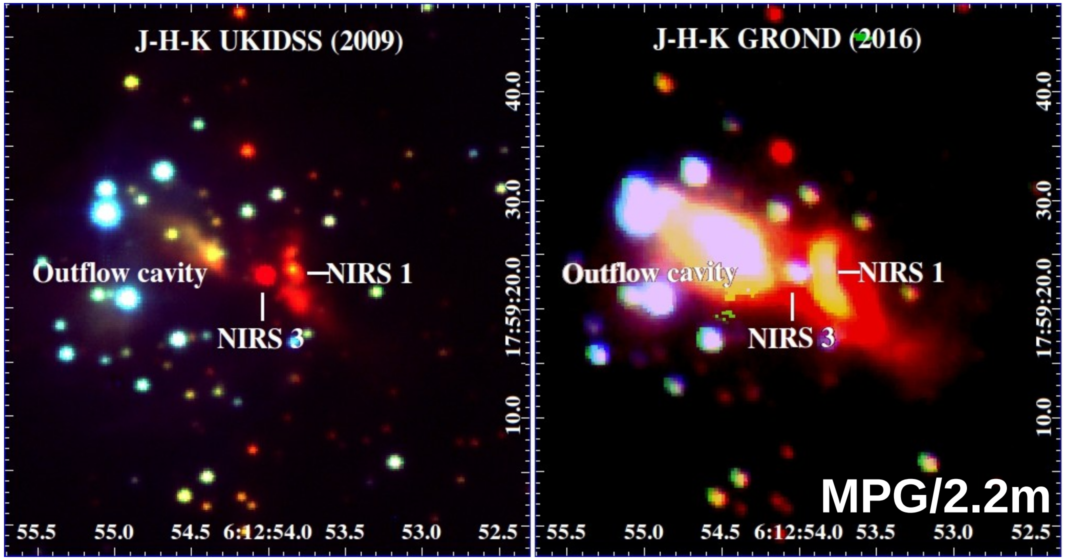


- CH_3OH masers should be pumped by IR radiation
- CH_3OH flare (Fujisawa et al. 2015) triggered our observations....

First disk-mediated accretion burst in a high-mass YSO

- UKIDSS (Dec. 2009) vs. PANIC (Nov. 2015): ΔH=3.5 mag, ΔK=2.5 mag





Caratti o Garatti et al. 2017, Nature Phys.

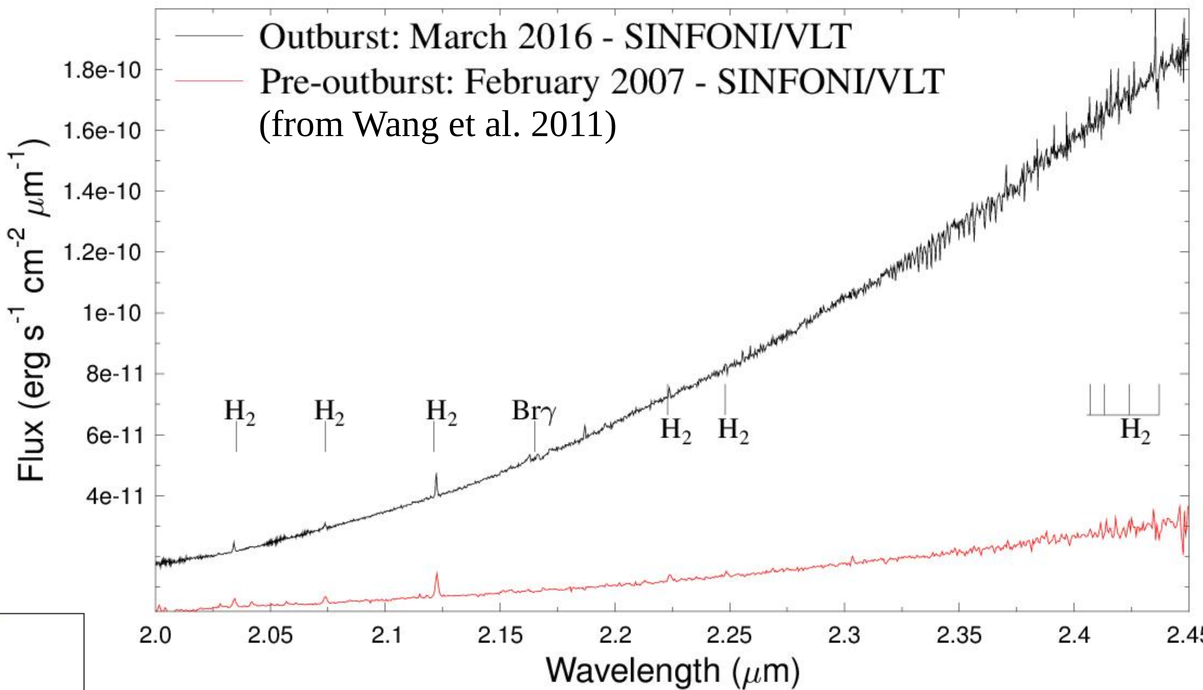
- Accretion burst → flash-light from outflow cavities.
- Light echo motion indicating outburst started before the maser flare (mid-June 2015 vs Sept. 2015)

On source K-band spectroscopy

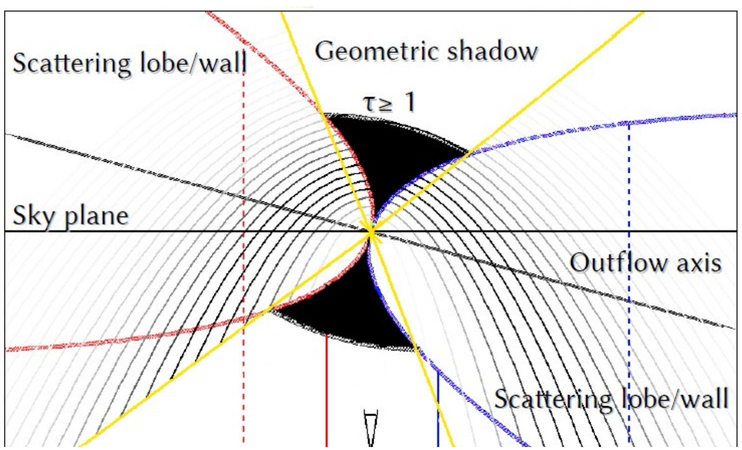
On source spectroscopy almost featureless (H_2, Brγ) with a rising continuum.

Extinction towards source does not change: A_V=44±16 mag

S255IR NIRS 3 on source spectrum



Caratti o Garatti et al. 2017, Nature Phys.



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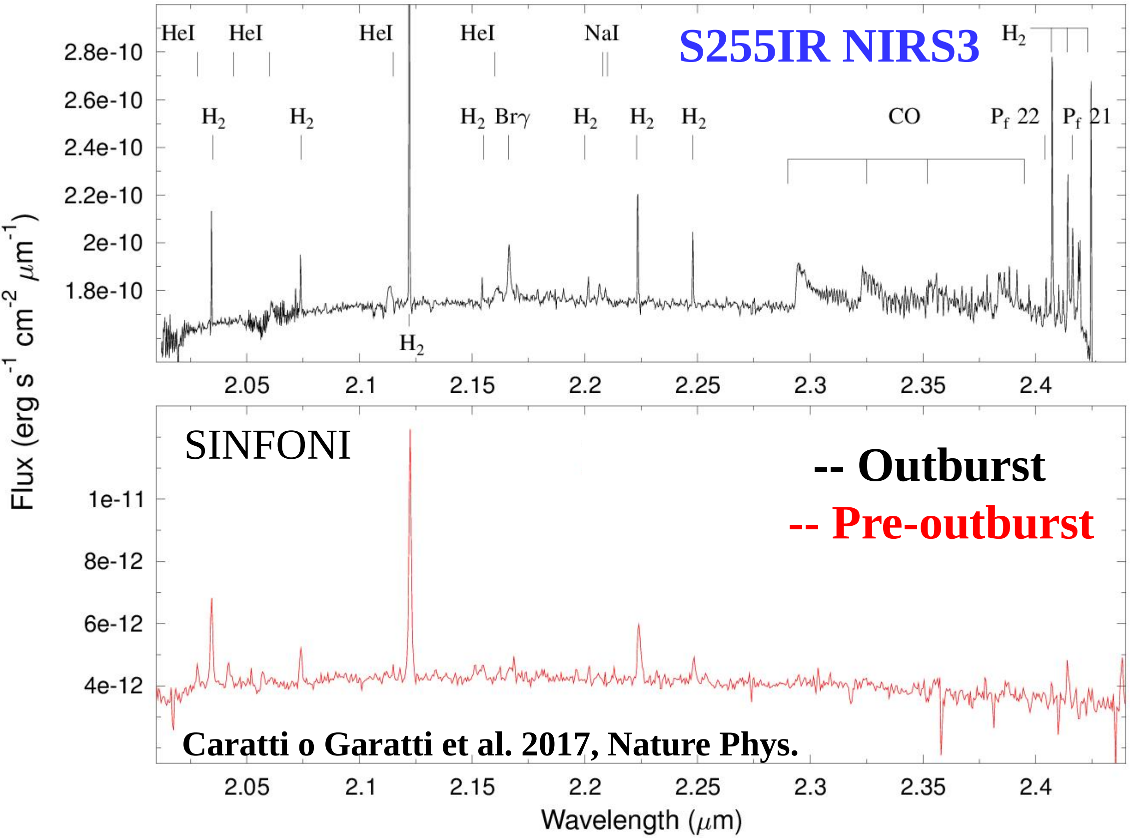
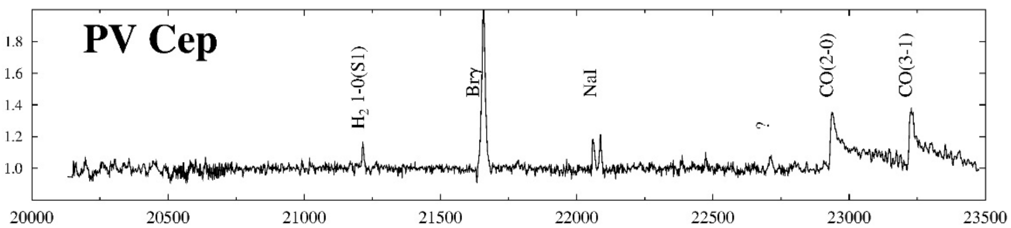
K-band spectrum of the outflow cavity





Caratti o Garatti et al. 2013 Wavelength (Å)

- CO & NaI lines → presence of a disk.
- HI & HeI lines → increased accretion and wind activity
- H_2 emission from shocks + UV pumping.
- Same lines as in EXors but 10^3-10^4 times more luminous.

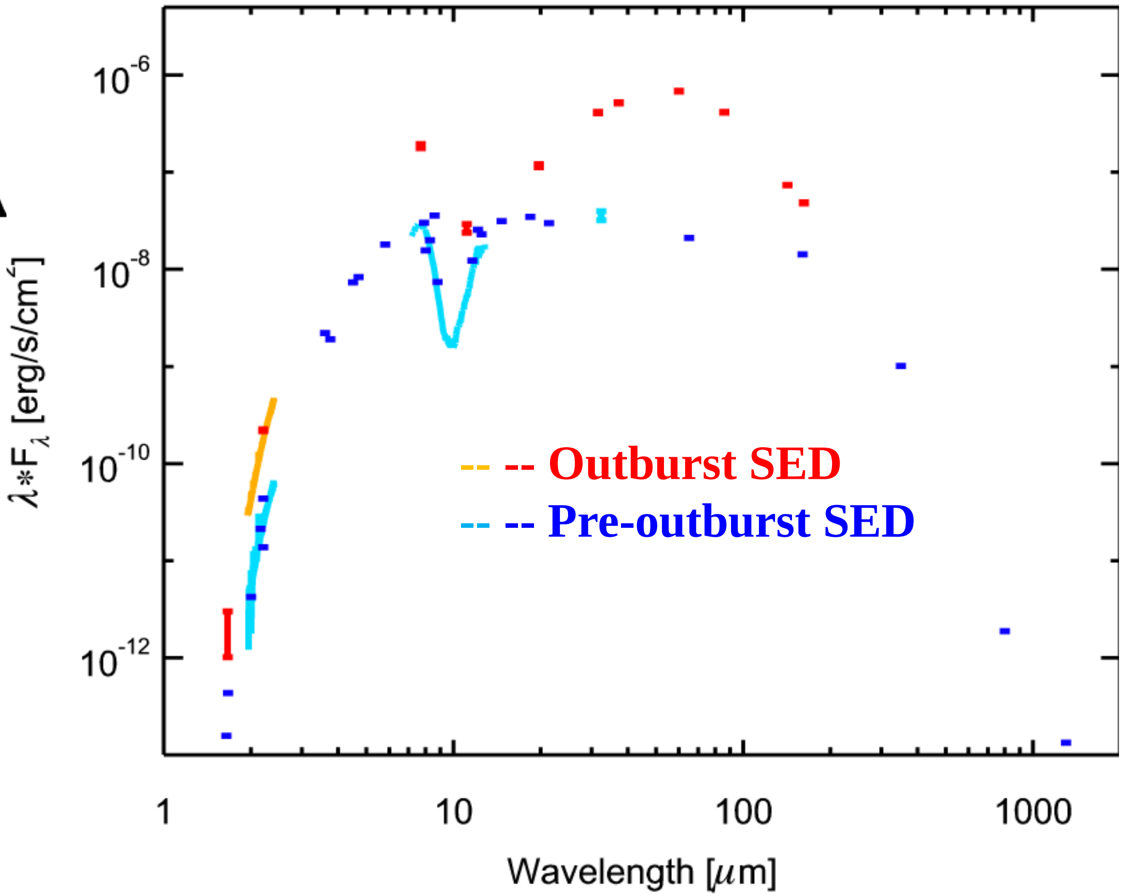
K-band spectrum of a low-mass EXor

SED and outburst parameters

- Additional MIR + FIR photometric data from FORCAST & FIFI-LS SOFIA

- Burst parameters:

L_{bol}=(1.6±0.3)x10^5 $L_\odot$
ΔL_{acc}=(1.3±0.4)x10^5 $L_\odot$
$\dot{M}_{acc}$=(5±2)x10^{-3} $M_\odot$/yr
(with M_*=20 $M_\odot$ & R_*=10 $R_\odot$)
Energy released ~ 10^{46} erg
Accreted mass ~ 2 $M_{Jupiter}$



Caratti o Garatti et al. 2017, Nature Phys.

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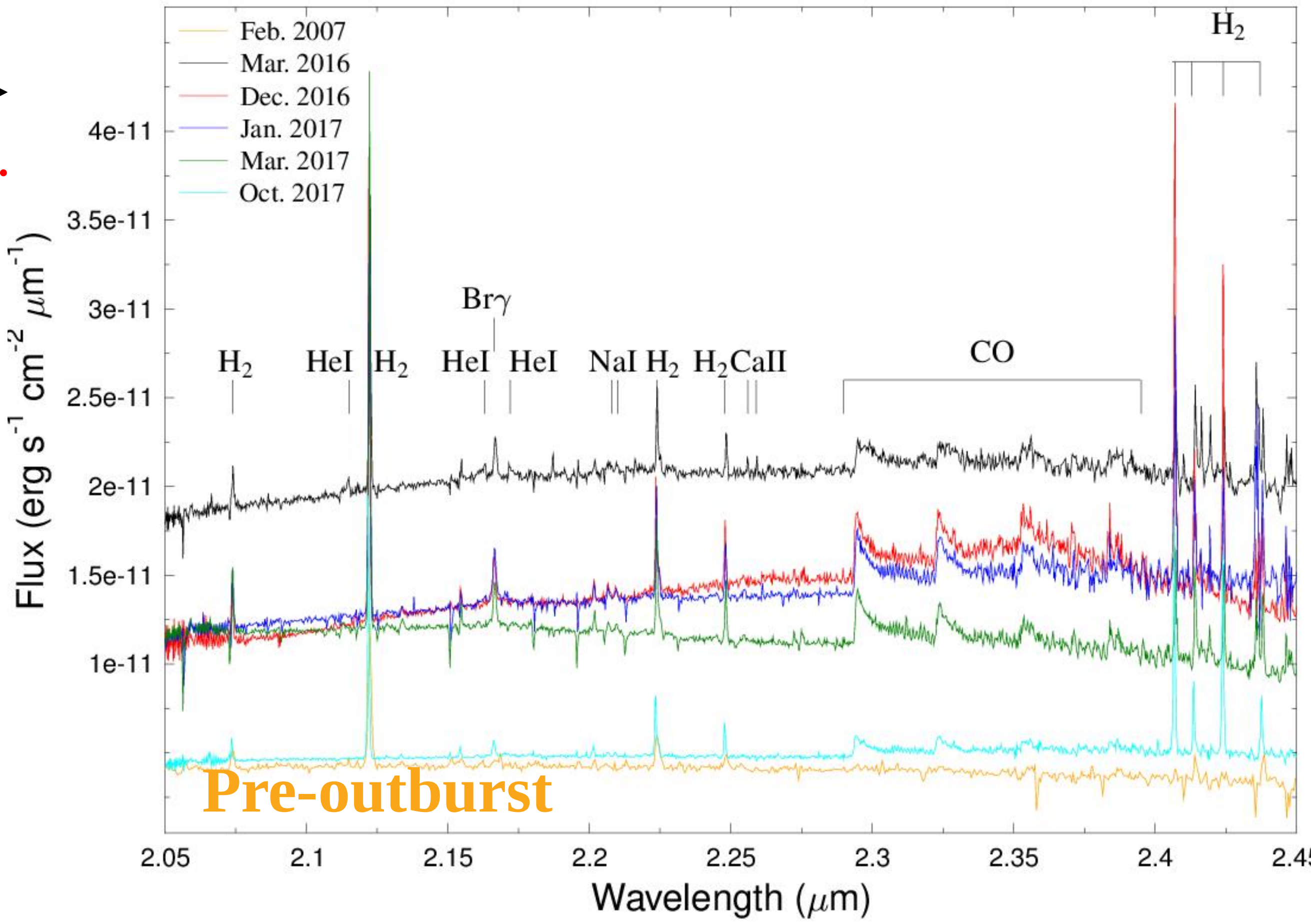
Spectral evolution of the burst in the NIR

- NIR continuum flux back to pre-outburst values (Jan. 2018) → accretion burst is over.

- Line evolution: HI & HeI accretion/wind lines fading or disappeared; inner gaseous disk is cooling (CO band-heads); H_2 line intensities are increasing: jet activity?

SINFONI/VLT K-band multi-epoch spectra



Caratti o Garatti et al. in prep.

CH_3OH maser flare with VLBI

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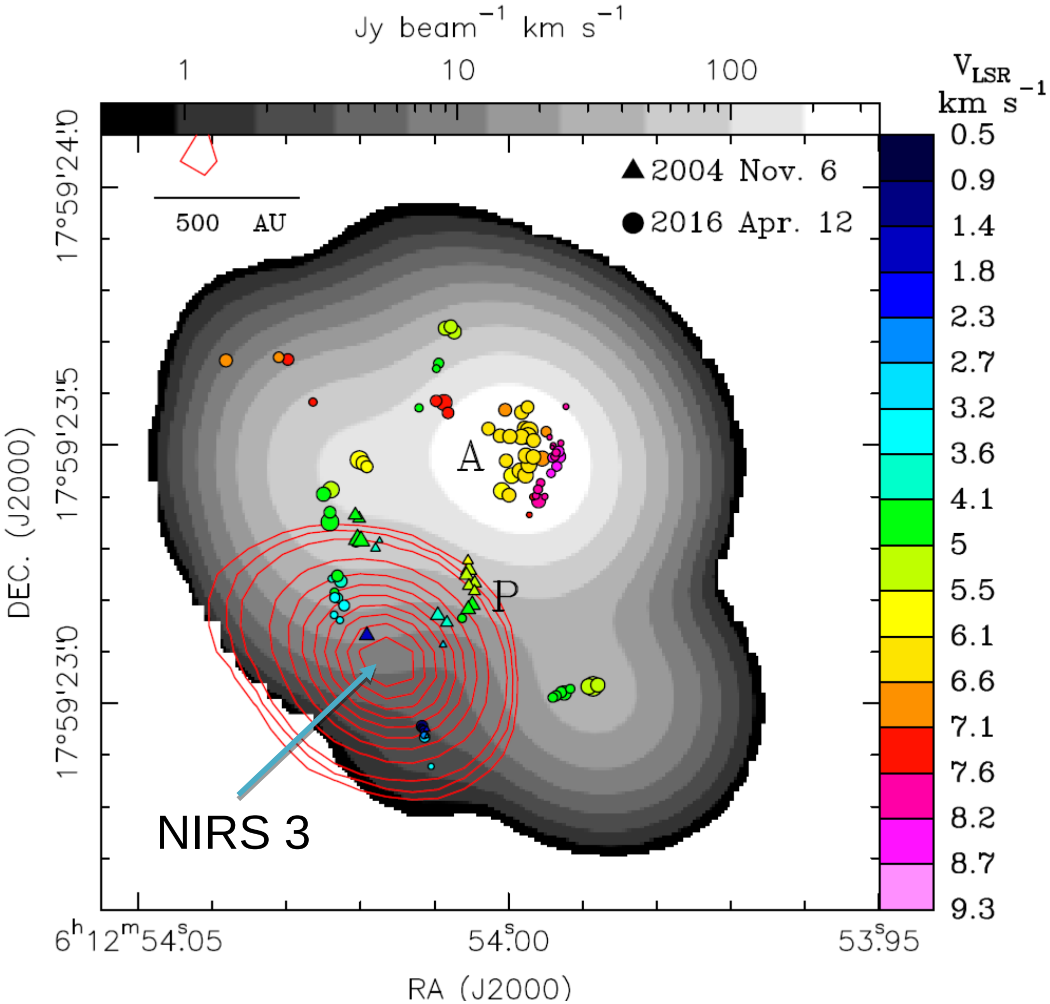


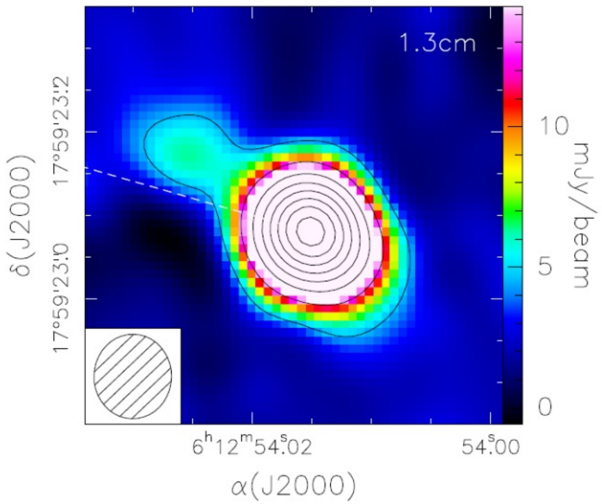
Moscadelli et al. 2017

The environment of NIRS 3 is completely transformed by the accretion burst:

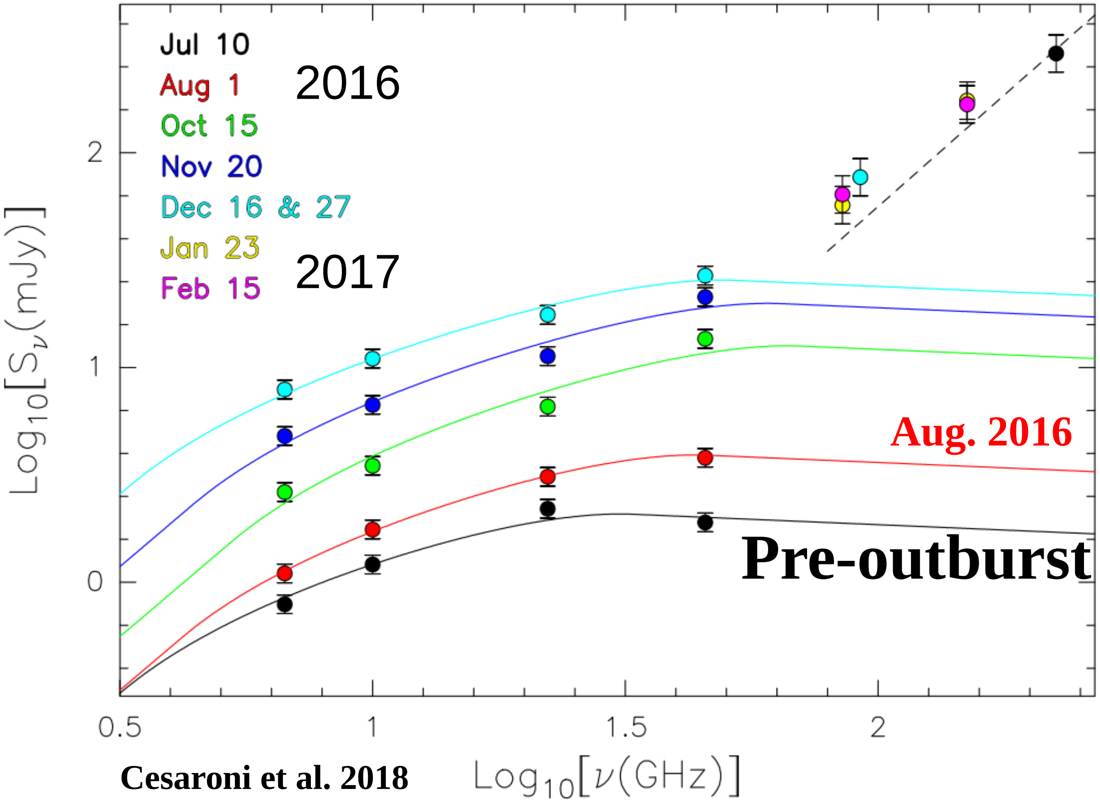
- CH_3OH emission (cluster P) close (~300 au) to source disappears, likely destroyed by UV radiation.
- New cluster of masers (cluster A) excited (at ~1500 au from source) produces the observed flare pumped by IR radiation

Radio jet burst: accretion turns into ejection

- Radio continuum flux increases from Aug. 2016 i.e. *~13 months after* the accretion outburst begins.
- Wind re-collimation produces the radio jet
- Spectrum slope typical of a thermal jet.



JVLA multi-epoch spectrum of the jet



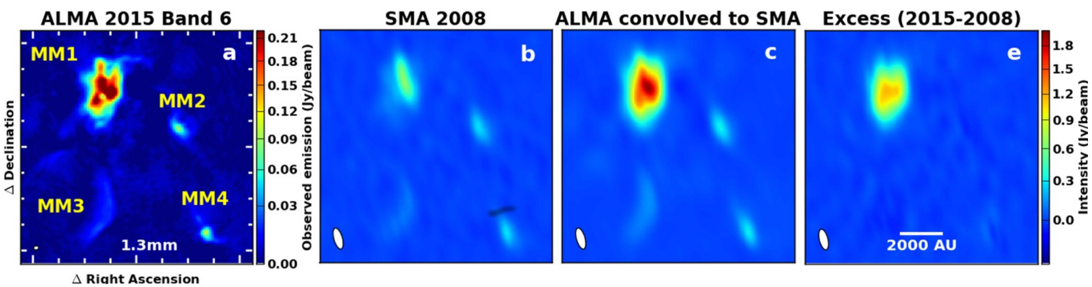
Cesaroni et al. 2018

- A new knot has appeared (Dec. 2016).

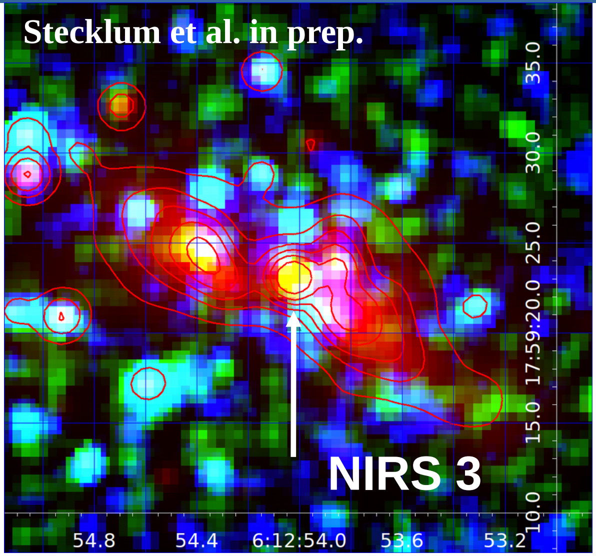
Accretion has turned into ejection!

What's next?

- Comparison of Chandra pre-outburst (2009) and outburst (2017) ACIS images (1.49-5.9 keV) show previously undetected X-ray emission (yellow, orange & red in Fig.) from source and lobes (under analysis).

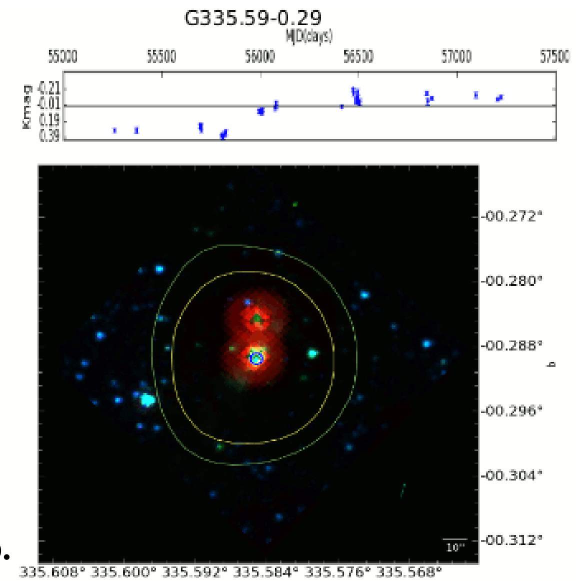


Hunter et al. 2017



- After S255 more outbursting HMYSOs have been discovered: in the mm (Hunter et al 2017) and in the NIR with the VVV survey (41 candidates - to be confirmed spectroscopically! Teixeira et al. submitted).

- Need for proper statiscs on HMYSO bursts!



Teixeira et al. A&A sub.

Conclusions

- S255IR NIRS3 accretion burst shows that HMYSOs form through accretion disks, as low-mass YSOs.

- Accretion/ejection mechanisms are linked. They might not be steady but rather episodic also in HMYSOs.

- Accretion bursts change the HMYSO environment (CH_3OH, radio jet, NIR continuum/lines as outburst tracers).

Thank you!