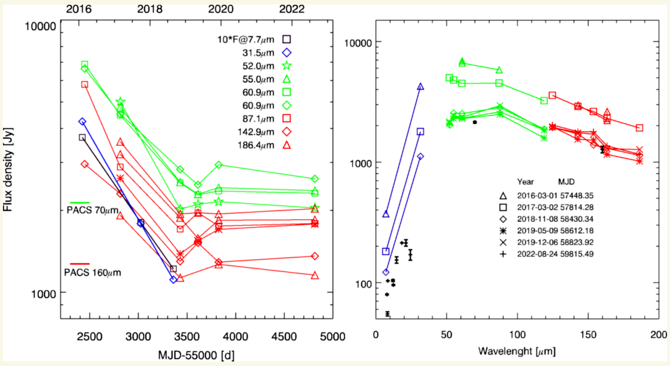
The IR View on the S255IR NIRS3 Accretion Burst – 10 Years after

Introduction

A decade ago, two massive young stellar objects (MYSOs), S255IR NIRS3 and NGC6334I-MM1, began simultaneous accretion bursts, marked by 6.7 GHz methanol maser flares. We confirmed the NIRS3 burst by NIR imaging, derived initial parameters from the first SOFIA data[1], and have been monitoring the dust emission for nearly seven years. Our time-dependent radiative transfer (TDRT) modeling reproduces significant features, such as emission time lags at different wavelengths. We summarize the burst history and present revised parameters. Evidence suggests that the burst was not spherical and may have permanently altered the MYSO environment, indicating a more complex dust distribution than the typical disk/envelope model.

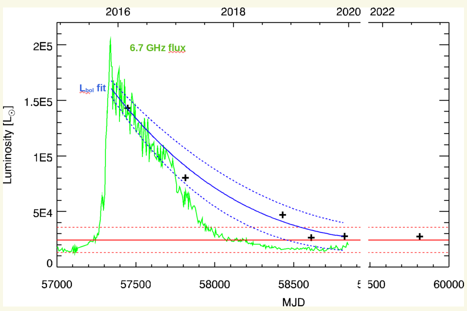
Light Curves and SEDs

The plots below show the light curves (left) and SEDs (right) established from our FORCAST and FIFI-LS observations which covered the burst decline. The flux decreases faster at shorter wavelengths, in accordance with the heating/cooling time scales of our TDRT simulations. The recalibration of the PACS point source catalog[2] removed an inconsistency with the 70 µm pre-burst flux, which previously suggested an increased post-burst continuum.



Luminosity Evolution

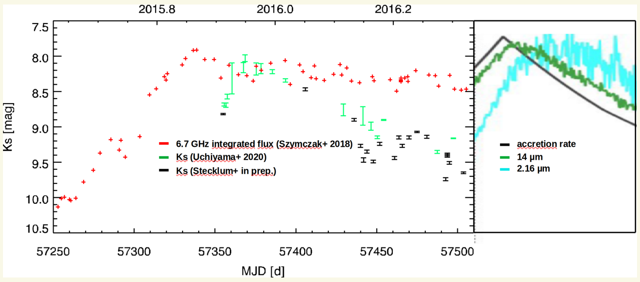
The evolution of the apparent $L_{\rm bol}$ (crosses) and the matched integrated maser flux[3] is shown to the right. The dashed lines indicate the luminosity range implied by the extinction uncertainty.



The red line marks the pre-burst value. The comparison shows the presence of an afterglow and a post-burst $L_{\rm bol}$ exceeding the pre-burst one by ∼20%. The final burst energy is at least twice that of our initial estimate of $\mathbf{1.2{\times}10^{46}}$ erg[1], and so is the accreted mass. As the TDRT considers the emission anisotropy due to the disk and the outflow cavities, they will increase further. Probably, NIRS3 incorporated about five $M_{\rm Jup}$.

Emission Time Lags

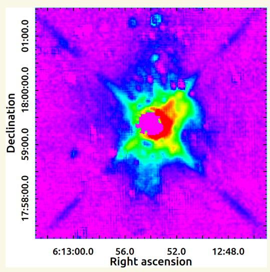
The dust optical properties imply high optical depths at shorter wavelengths. Thus, frequent scattering and absorption/re-emission slow down the energy transfer and introduce time lags. This effect is most pronounced for YSOs seen close to edge-on, e.g., NIRS3.



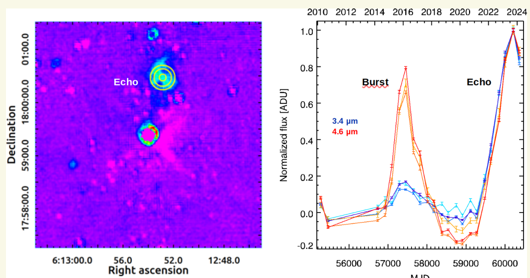
Left: Matched integrated maser flux and Ks light curves. The latter lags behind the 6.7 GHz flux by ∼30 d. **Right:** TDRT modeling reproduces wavelength-dependent delays. The mid-IR emission excites the 6.7 GHz maser[4].

Environmental Impact

The burst led to a new area of maser emission NW of NIRS3, while nearby maser spots on either side of the MYSO ceased[3]. Moreover, a quick rise of 0.9 mm dust continuum emission unexpectedly occurred in this direction[5]. For the canonical YSO geometry, TDRT predicts a delay of the FIR/submm increase. The NEOWISE 2016 to 2014 3.4 µm ratio image exhibits a comparable feature, suggesting that a directional burst might have lowered the dust optical depth in the NW direction.



Greetings from the Past



The NIRS3 burst was accompanied by a bipolar light echo seen in the Ks band but not by NEOWISE. In 2021, a feature appeared in the ratio images ∼1′ north of the MYSO. Its light curves confirm a burst echo with a delay of ∼7.5 yr. It is due to scattering from S255N which, according to the delay, is situated 1 pc behind NIRS3. After the end of the NEOWISE mission, this echo might be followed-up by NEO Surveyor given its ecliptic latitude of -5.4°.

References

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[2] G. Marton, et al. (2024) *A&A* 688:A203.

[3] M. Szymczak, et al. (2018) *A&A* 617:A80.

[4] D. M. Cragg, et al. (2005) *MNRAS* 360(2):533.

[5] S.-Y. Liu, et al. (2018) *ApJ* 863:L12.

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