# Merging mid-infrared observations with modelling to study Massive Young Stellar Objects (MYSOs)

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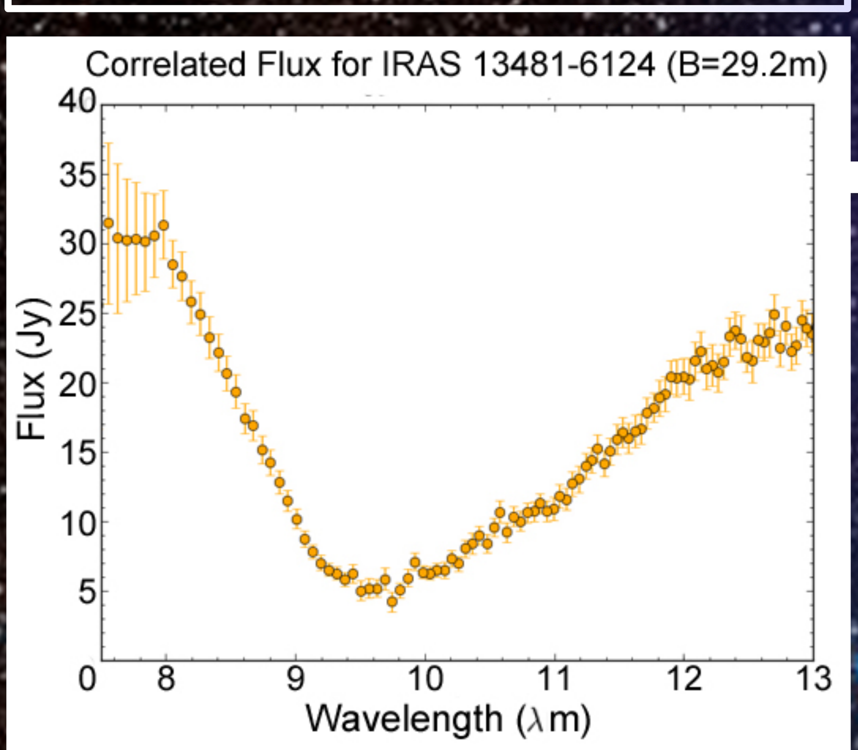
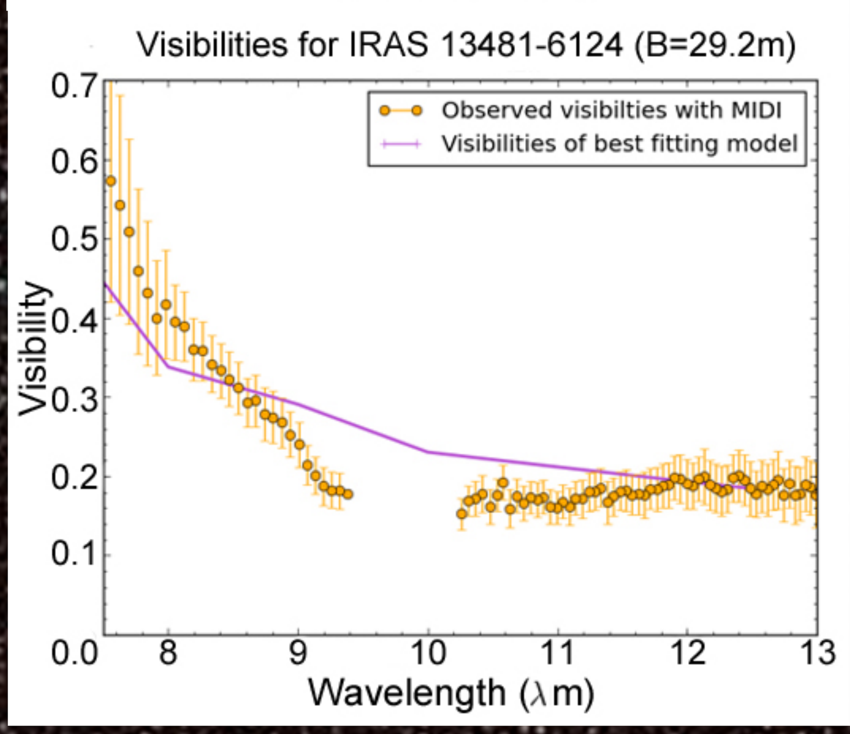
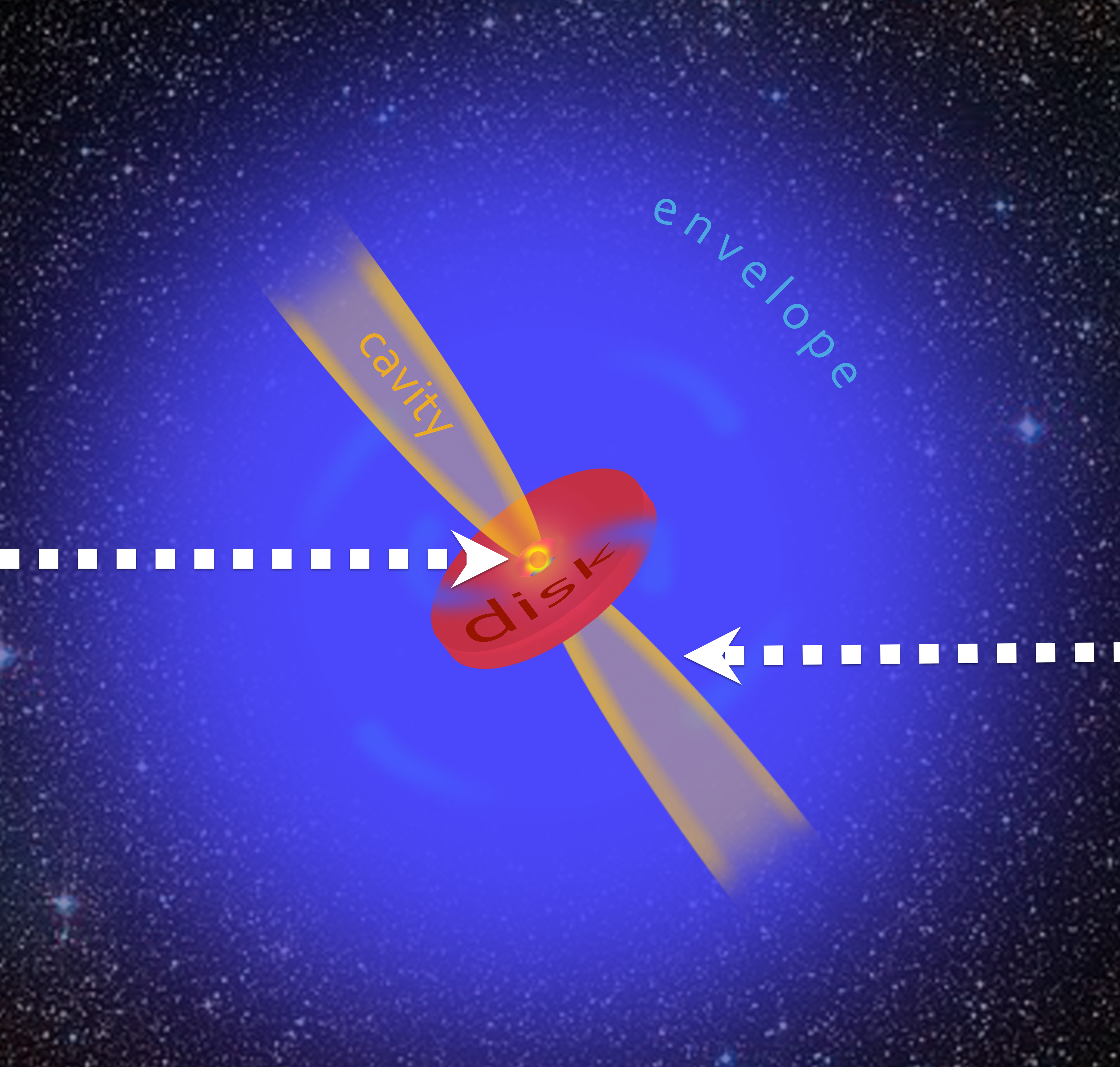
The large luminosities, temperatures and pressures of stars >10$M_\odot$ make them influential at both a local and galactic level, but the fact that they are rare and often deeply embedded has limited our understanding of their formation. Several studies have compared observations to models, but one set of observations alone cannot decidedly determine the characteristics of an MYSO. We fit 3D radiative transfer (RT) models generated in HOCHUNK [3] to three sets of observations; interferometric data from the MID-Infrared Interferometer (MIDI), images from the Very Large Telescope Imager and Spectrometer for the InfraRed (VISIR) and a wide range of data provided by the RMS Survey [4]. By fitting multi-wavelength data to one model we much better constrain the features an MYSO must have to create such observational features, thereby shedding light on their mysterious formation process.

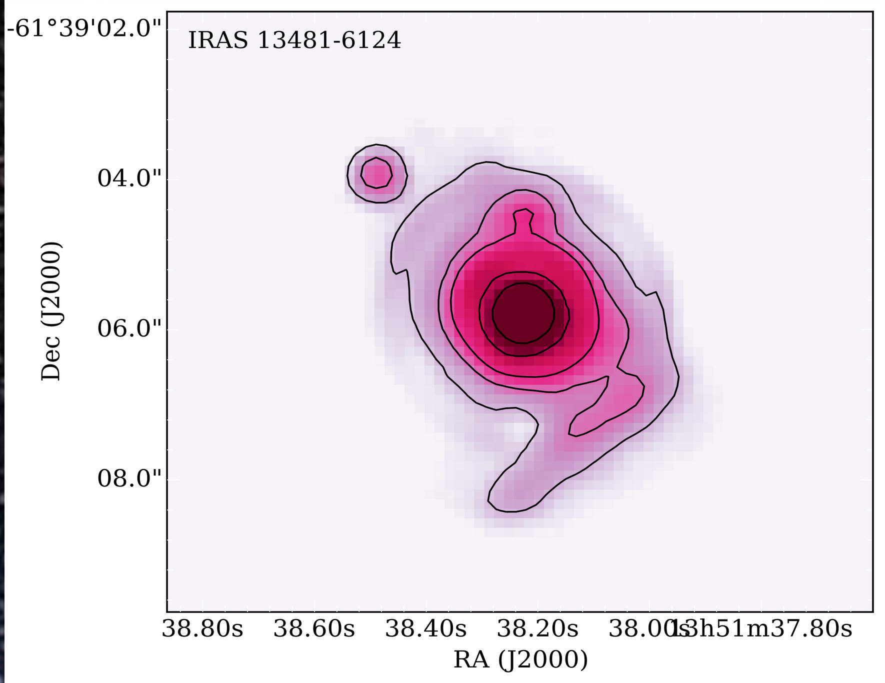
## 1. MIDI: Tracing the Circumstellar Material

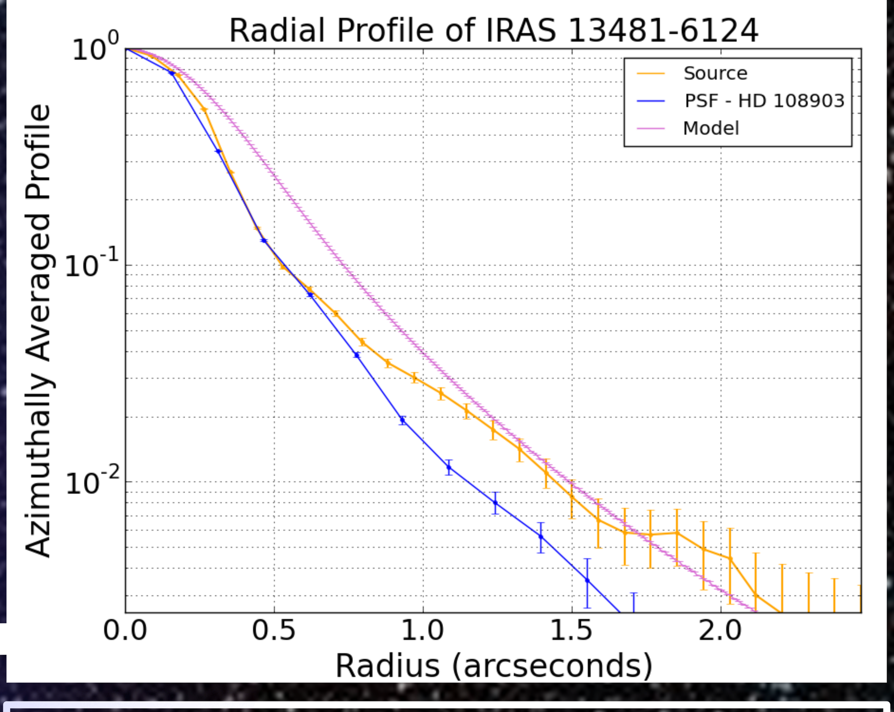
- Combines beams from two telescopes at baselines up to 130m.
- Peak spatial resolution of 0.01".
- N-band measurements (8-13μm) shown to trace the inner most cavity walls [5].
- Shown here are the correlated flux and visibilities for IRAS 13481-6124.



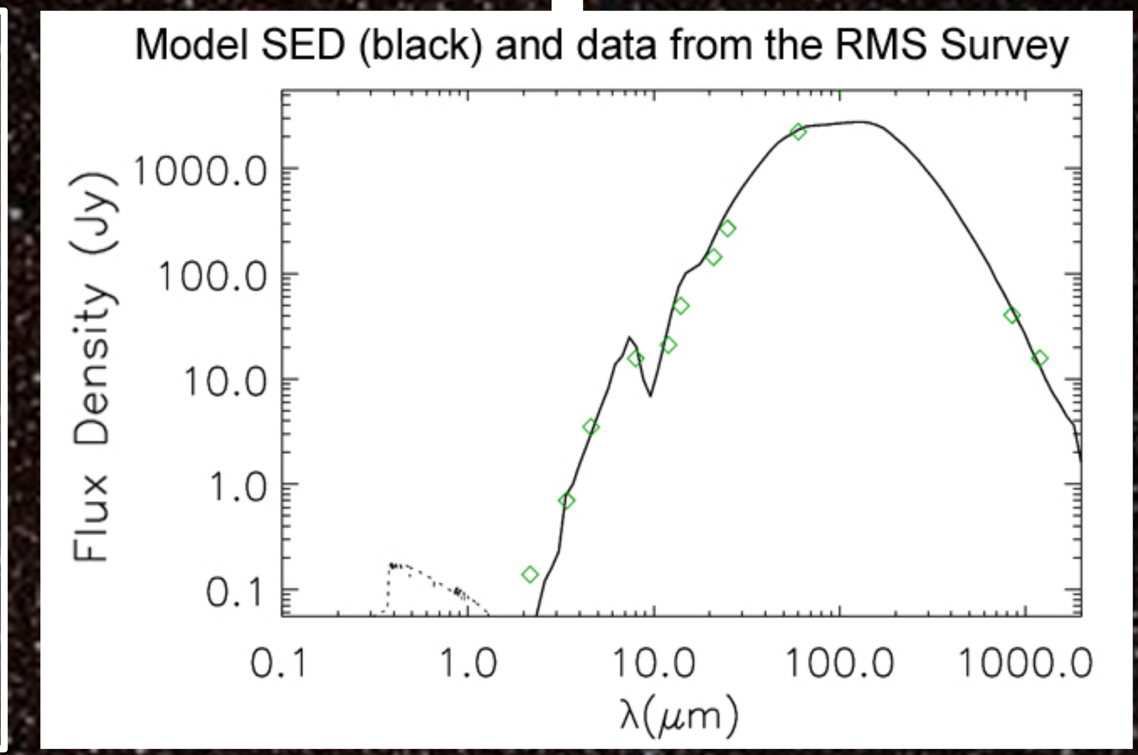




## 2. VISIR: Tracing the Cavity and Envelope

- VISIR provides imaging at high sensitivity in the Q-band.
- Image contours represent 2%, 5%, 10%, 25% and 75% of the mean flux.
- Radial profiles allow easy comparison of observed 20μm emission to the RT model. As we can see here the model used by Boley et al. (2016) to fit MIDI data for this object does not fit our VISIR data.

## 3. Spectral Energy Distribution (SED): Emission from the whole envelope

- SEDs cover multiple wavelengths but give us no spatial information and hence must be complemented by spatially resolved observations.
- We fit the model SED to data points provided by the RMS Survey [4] across a wide wavelength range.




## 4. Combination

- By fitting one model successfully to each type of observation we retrieve the physical characteristics of the MYSO.
- By then comparing the best fitting models of a number of objects we can better constrain the massive star formation process.

## Conclusions & Imminent Work

Different observations trace different regions of protostellar environments. By combining them we ascertain the specific features an MYSO needs to have to produce what is observed, and therefore constrain how they form. Our work so far has focused on combining three types of high-resolution observations to study a couple of individual objects. Once the best fitting model has been determined for one object the same analysis will be done for a sample of ~20 MYSOs, and we shall start to look for trends which can help confirm the massive protostellar formation process.

References:
1) University of Leeds
2) European Southern Observatory
3) Whitney, B. A., Robitaille, T. P., Bjorkman, J. E., et al. 2013, ApJS, 207, 30
4) Lumsden et al. 2013, ApJS, 208, 11
5) de Wit, W. J., Hoare, M. G., Oudmaijer, R. D., & Lumsden, S. L. 2010, A&A, 515, A45

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