ZOOMING INTO THE POWER HOUSES OF HIGH-MASS STAR FORMATION

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SFB 1601

A complete understanding of high-mass (> 8 MSun) protostellar feedback remains elusive. It is particularly challenging to characterize **radiative feedback** within cores and to determine **luminosities at core scales**.

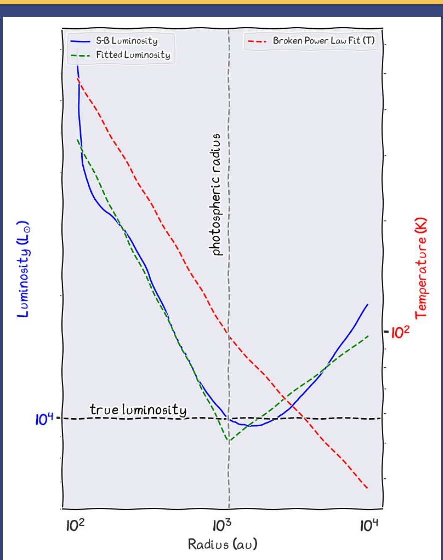

Figure 1
Red: Broken power-law fit to the temperature structure of a source with a density power law and L = 10,000 LSun. *Blue*: S-B luminosity. *Green*: Luminosity derived from the broken power-law temperature fit.

METHOD

The rotational temperature (Trot) at a specific radius within a core can be measured via observations of molecular line emission, particularly of lines from vibrationally excited states.

The **Stefan-Boltzmann** (S-B) law is not valid *within* a core, but its minimum approximates the real luminosity well (Fig. 1).

In addition, at the **photospheric radius** (radius at which the Rosseland mean opacity becomes < 2/3), the slope of the core temperature profile changes and the SB luminosity is equal to the intrinsic luminosity of the central source (Fig. 1; *Osorio+1999, ApJ 525.2, 808*).

<u>This is true only at the photospheric radius.</u>

WE MEASURE THE KINETIC TEMPERATURE STRUCTURE AT DIFFERENT RADII BY USING THE ROTATIONAL TEMPERATURE (TKIN) TO DETERMINE THE CORE TEMPERATURE STRUCTURE AND HENCE LUMINOSITY...

...utilizing the eXtended eXtended CASA Line Analysis Software Suite (**XCLASS**; *Möller+2017, A&A 598, A7*) to fit **ALMAGAL** (217~221 GHz, Θ=0.4") and **TEMPO** (226~243 GHz, Θ=0.9") survey data.

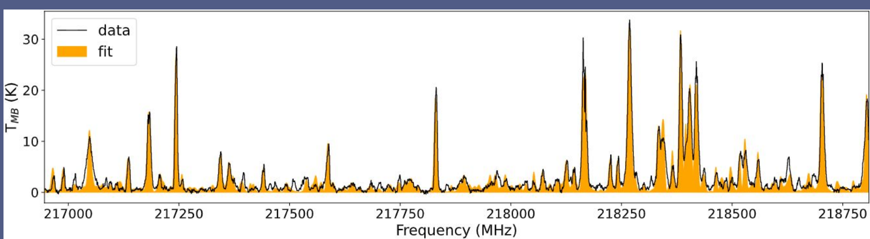

Figure 2: example XCLASS fit for one spectral window.

We used the TEMPO data of one core for testing (Fig. 3):

★ The minimum S-B luminosity calculated from our fit is 9.2×104 L_{Sun}.

★ The Hi-GAL luminosity of the core is 3.5×104 L_{Sun}.

★ The scatter in Tkin is too large to determine the photospheric radius.

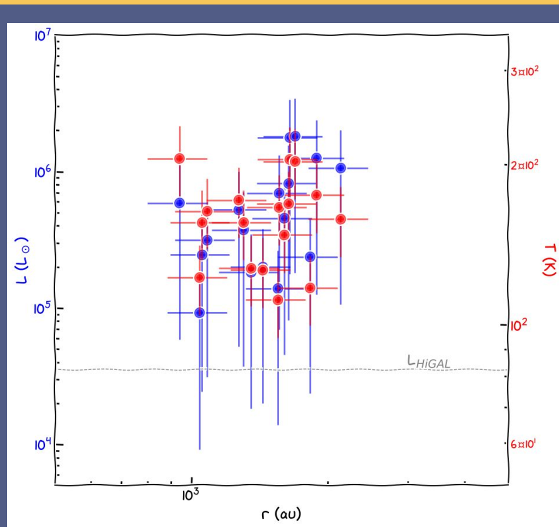

Figure 3: SB luminosity (LS-B, blue) calculated from the Tkin obtained with XCLASS (red). The dashed gray line shows the Hi-GAL core luminosity. The error bars show a 15% systematic error in the size and temperature fit.

NEXT STEPS

Sample: Include the ALMAGAL data and apply the method to ~20 cores.

Trad estimations: Using vibrational excited states we will get Tvib and determine Trad, (i.e., IR field mapping).

Models: Using neural networks trained with synthetic data generated by radiative transfer models we strive to determine the physical source structure.

AREAS OF IMPROVEMENT

Broader frequency coverage: For a more accurate determination of both temperature and radius.

Spatial coverage: Needed to probe the innermost regions of the core via observations of rotational lines in **vibrational states** (excited by IR photons).

Zooming in: Vibrational states, excited only at hot gas very close to the core, would allow us to determine the photospheric radius.

<u>Surveys used in this work:</u> **ALMAGAL**: Molinari+2025, A&A, 696, A149; Sánchez-Monge+2025, A&A, 696, A150. **TEMPO**: Avison+2023, MNRAS, 526, 2278. **Hi-GAL**: Molinari+2010, PASP, 122, 314; Elia+2021, MNRAS, 504, 2742.