Far-IR Molecular Lines from Low- to High-mass Star Forming Regions observed with Herschel

Agata Karska[1,2], F. Herpin[3], S. Bruderer[1], J. R. Goicoechea[4], G. J. Herczeg[5], E. F. van Dishoeck[1,2], I. San José García[2], A. Contursi[1], H. Feuchtgruber[1], D. Fedele[1], and WISH / high-mass team

[1]MPE, Garching, Germany [2]Sterrewacht Leiden, The Netherlands [3]CNRS / Université de Bordeaux, France [4]Centro de Astrobiología, Spain [5]Peking University, China

Main questions

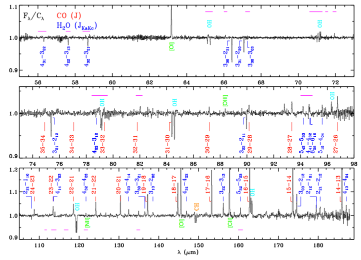
- What are the dominant cooling channels for high mass star forming regions at different evolutionary stages?

- What physical components do we trace? What gas conditions cause the excitation of the observed lines?

- Are there any similarities with low- and intermediate-mass young stellar objects?

Rich line spectrum

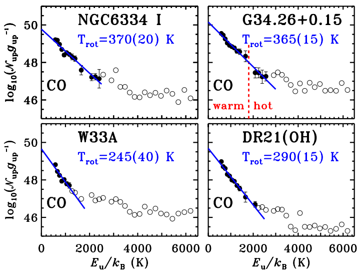
Detections of CO, H_2O, OH, CH, OI, CII



W3 IRS5
d=2 10^3 pc
L_{bol}=2 10^5 $L_\odot$
M_{env}=4 10^2 $M_\odot$

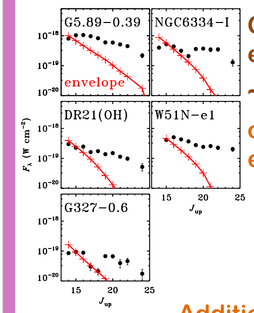
~50 H_2O lines detected!

CO diagrams



- Lack of hot component seen in low-mass protostars (but note upper limits)

Envelope emission

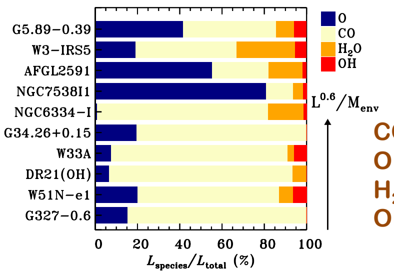


Quiescent envelope: ~45-85 % of total CO emission.

- Additional physical component needed!

Far-IR gas cooling

Relative contributions of CO, H_2O, OH, OI (calculations at the center of PACS array)

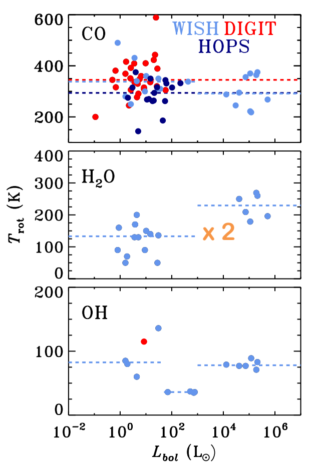


CO 75 %
OI 20 %
H_2O <1 %
OH <1 %

- CO dominates the gas cooling
- Contribution of OI increases for more evolved sources

From low- to high-mass:

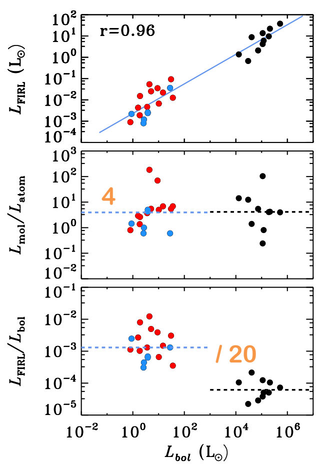
Molecular Excitation



CO: T_{rot}~300 K, similar for all!

H_2O: T_{rot}~120 K for low-mass, x 2 for high-mass sources

Far-IR gas cooling



Factor of 20 decrease in total far-IR gas cooling (L_{FIRL}) over bolometric luminosity (L_{bol})

Conclusions

- Far-IR gas cooling of high-mass objects is dominated by CO and to smaller extent by OI, in contrast with low-mass objects, where H_2O, CO, and OI contributions are comparable;

- Emission from quiescent envelope accounts for at least half of the total CO luminosity; in low-mass objects less than 10%; shocks needed to explain high-J CO;

- Far-IR gas cooling strongly correlates with L_{bol} in the ~1-10^6 $L_\odot$ luminosity range; in agreement with studies on low-mass objects;

-The ratio of molecular and atomic cooling is ~4; gas to dust ratio decreases an order of magnitude for high-mass src.