# The physical and chemical fingerprint of planet-forming disks

*Elizabeth Artur de la Villarmois* (elizabeth.artur@nbi.ku.dk), Jes Jørgensen, Lars Kristensen, Ted Bergin, Daniel Harsono, Nami Sakai, Ewine van Dishoeck & Satoshi Yamamoto*

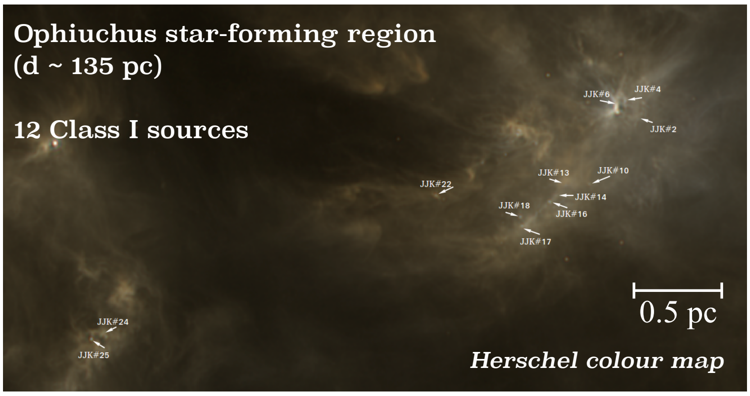
*Niels Bohr Institute & Centre for Star and Planet Formation - University of Copenhagen

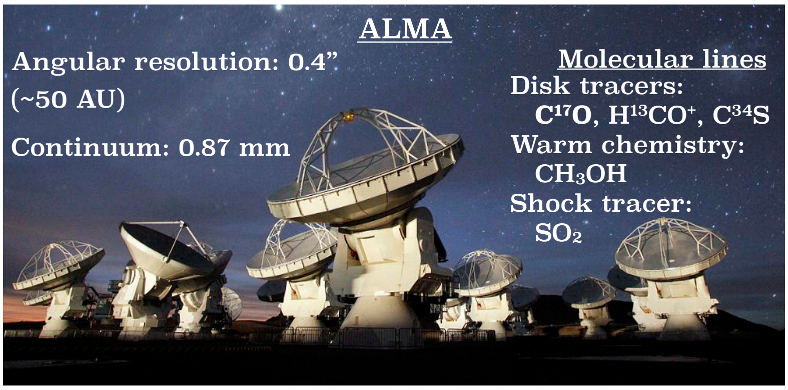
## Introduction

The formation of low-mass stars involves physical and chemical processes that affect the evolution of the disk and set the initial chemical conditions for planet formation *[**1**,**2**]*. However, the physical processes on small disk scales (< 500 AU) are still not well understood *[**3**,**4**]*.

*How is the envelope material incorporated into the disk? Which physical and chemical processes dominate on disk scales?*

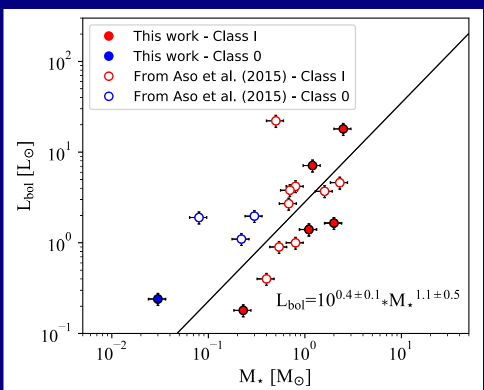
## Observations




## Results

### Mass evolution

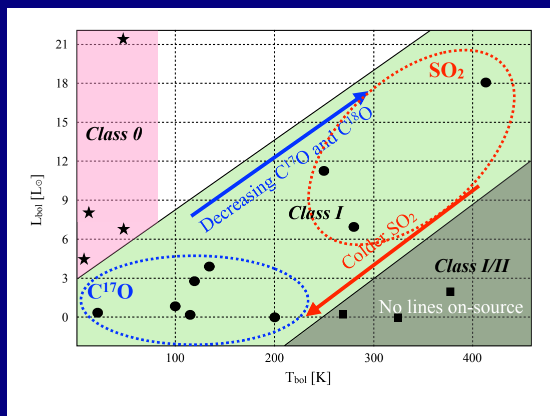



$$\dot{M}_{\rm acc} = \frac{L_{\rm bol} R_\star}{G M_\star}$$

Linear correlation between luminosity and protostellar mass gives $\dot{M}_{acc}$ = 2.4 ± 0.6 × $10^{-7}$ $M_\odot$ $yr^{-1}$ for Class I sources *[5]*.

A constant $\dot{M}_{acc}$ cannot explain the observed luminosities and protostellar ages → **Episodic accretion bursts:** accretion rate varies with time and the protostar gains a significant amount of material in a short period of time *[6]*.

### Chemical evolution




Chemical differentiation between $C^{17}O$ and $SO_2$.

$C^{17}O$ traces high gas column densities and is detected towards the youngest sources.

Warm, compact, and high velocity $SO_2$ emission is related with high luminosities and, therefore, high $\dot{M}_{acc}$.

## Conclusions

- A typical protostar will spend most of its lifetime in a quiescent state of accretion.
- $SO_2$ may be tracing accretion socks in the envelope-disk interface and highlighting sources with high accretion rates.

***The formation of disks results in characteristic chemical imprints.***

**References:** *[1] Jørgensen, J. et al., 2008, ApJ, 683, 822; [2] Bergin, E. & Cleeves, I., 2018, haex.bookE, 137B.; [3] Jørgensen J. et al. 2009, A&A, 507, 861; [4] Yen H.-W. et al. 2015, ApJ, 799, 193; [5] Artur de la Villarmois, E. et al. 2019, A&A, 626, 71; [6] Kenyon, S. J. & Hartmann, L. 1995, ApJS, 101, 117.*