Induced star formation towards the HII region RCW120

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Massive stars and feedback ($M > 8M_{\odot}$)

- Rare (~20 high-mass per 1000 of low-mass stars)
- Short life (a few 10^{6-7} yrs)

Importance

- Reionization of the universe
- Star Formation Rate
- Chemical enrichment, metallicity

Feedback

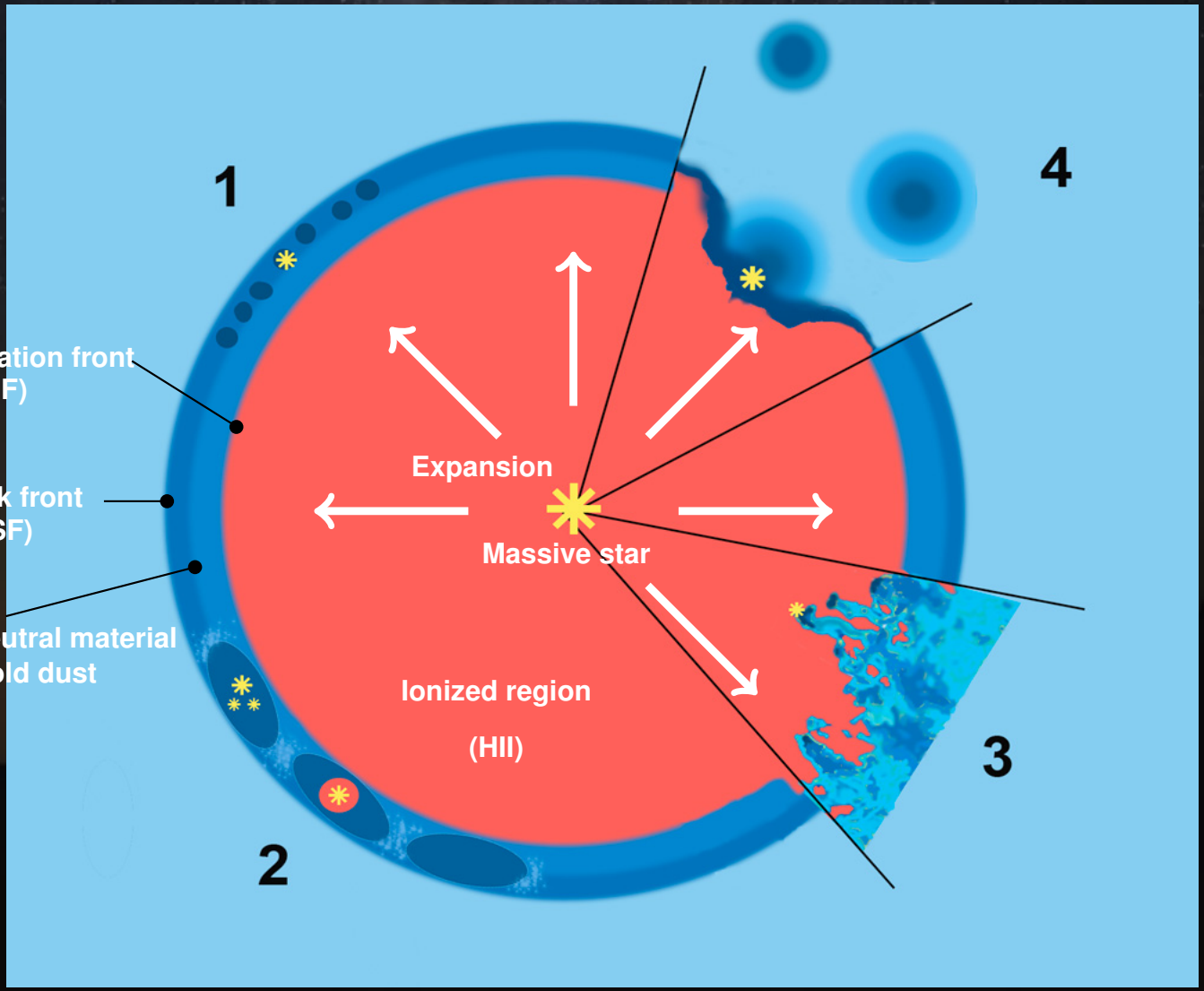
- Stellar winds
- Radiation pressure
- Photoionization
- Supernova

High mass stars feedback strongly modifiy their environment and affect the star formation [Krumholz et al., 2014]

The impact on star formation is still an open question (weight, SFR, SFE → support/disrupt star formation?)

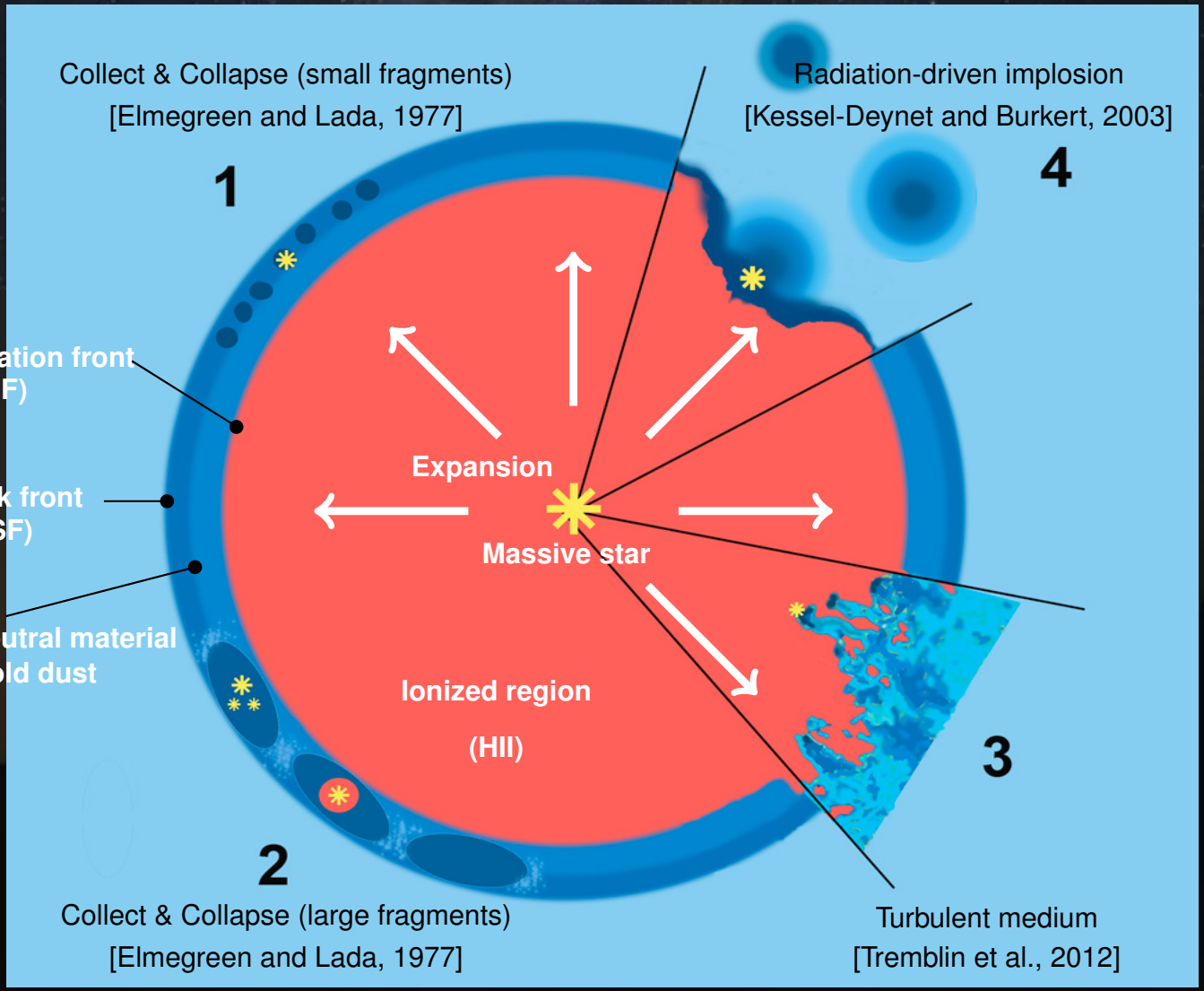
Massive star and H II region

[Deharveng et al., 2010]



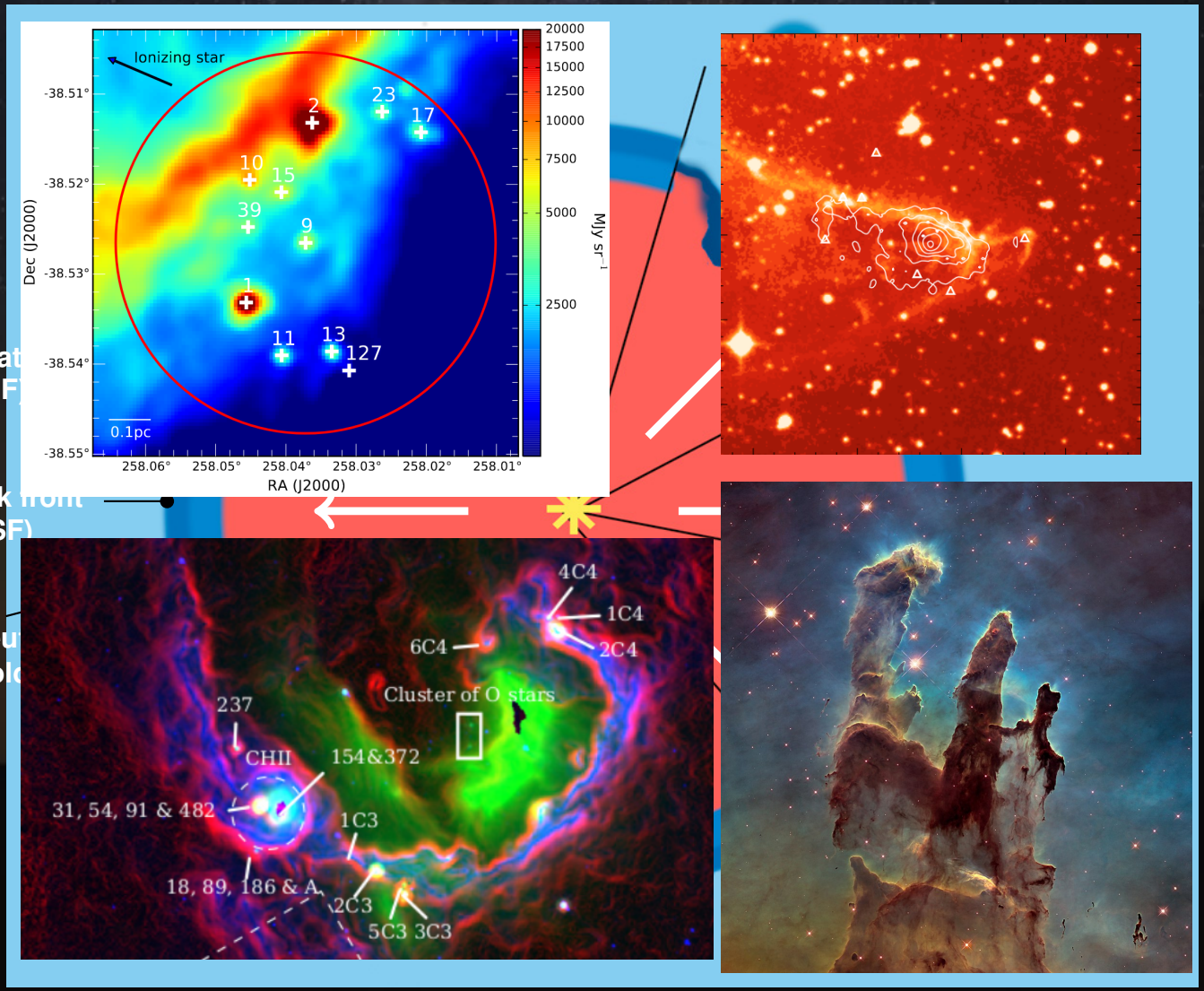
Triggering mechanisms

[Deharveng et al., 2010]

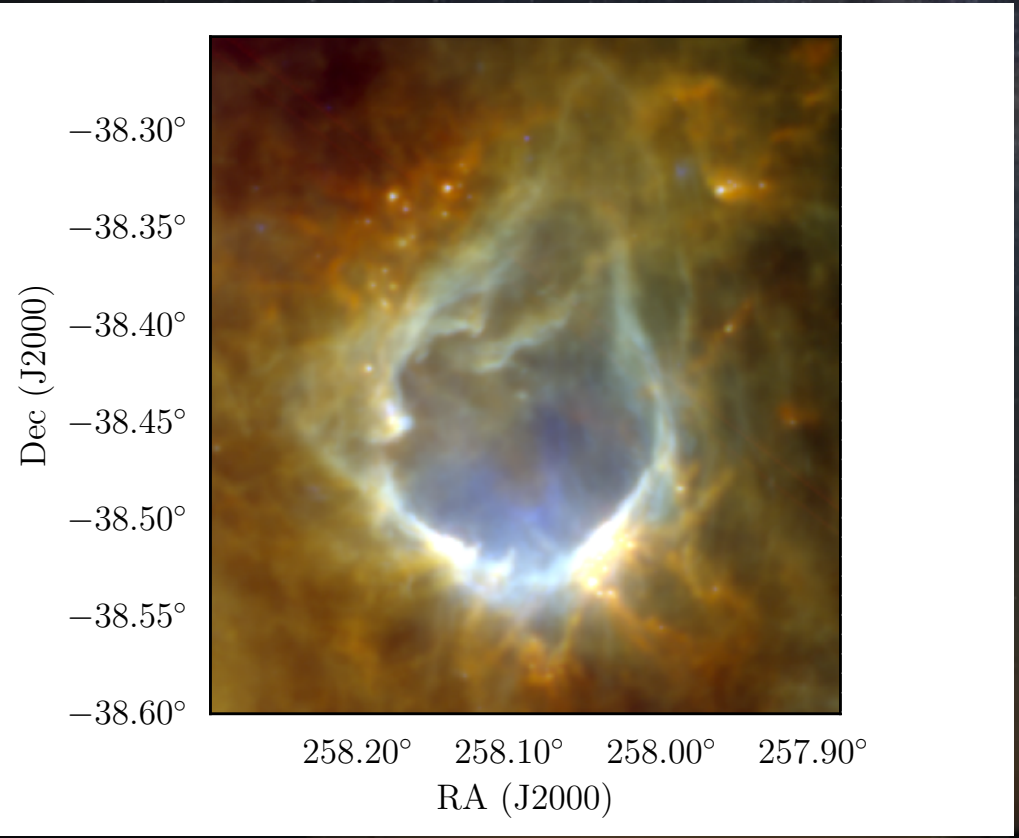


Observations of feedback effect

[Deharveng et al., 2010]



The Galactic HII region RCW 120



Properties of RCW 120

- $D_{hel} = 1.34$ kpc
- Single O8.5V ionizing star
- Massive source at the edge ($\sim 200 - 300\ M_{\odot}$)
- Champagne flow (northern part)

Closeby
(~ perfectly) spherical
Ideal case

Deharveng et al.+09, Zavagno et al.+07,+10, Anderson et al.+12, Figueira et al.+17, Marsh & Whitworth+19 (Submillimeter)

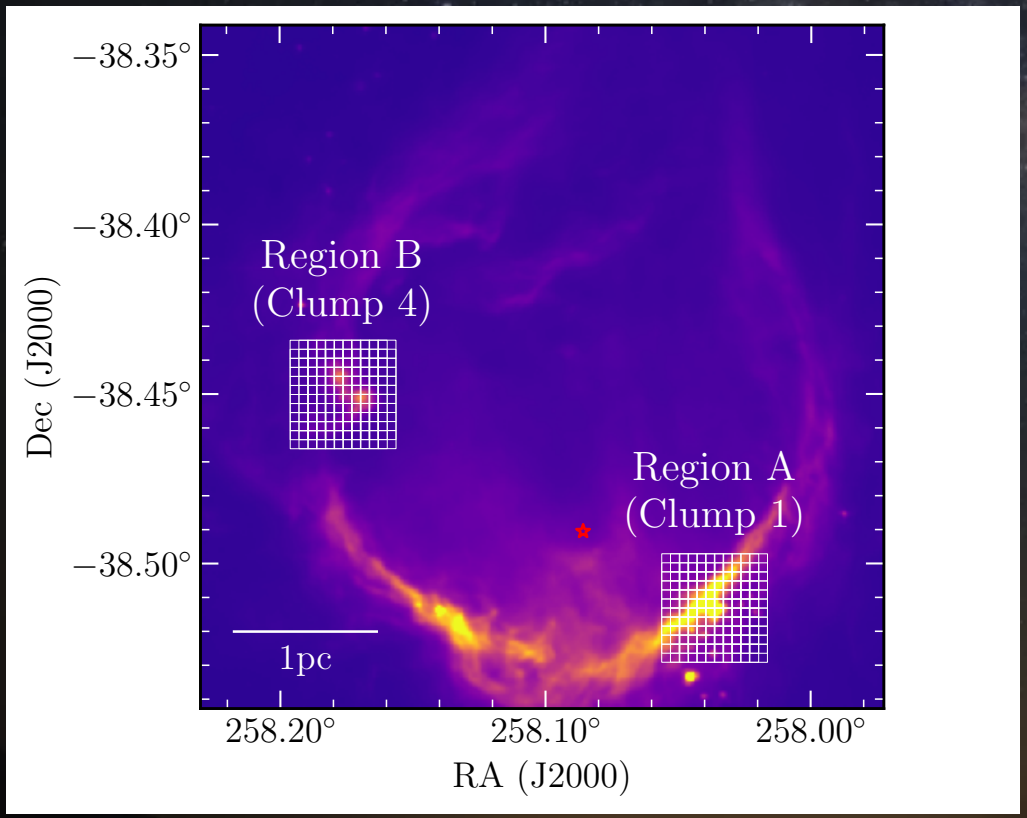
Figueira et al.+18 (ALMA), Zavagno et al.+22 (ArTeMIS), Anderson et al.+14, Figueira et al.+20 (CO)

Kabanovic et al.+21, Luisi et al.+21 (SOFIA)

Kirsanova et al.+14,+19, Torii et al.+15, Walch et al.+15, Mackey et al.+16 (Simulations)

Chen et al.+22 (Magnetic field)

Atacama Pathfinder EXperiment (APEX) observations



APEX observations

- **Date:** October 7,9,11 2016
June 21, September 24 and 25 2017
- **Lines:** ^{12}CO(3 – 2), ^{13}CO(3 – 2), C^{18}O(3 – 2)
- **Front-end:** SHeFI (front-end)
- **Back-end:** XFFTS
- **PWV:** 0.9 ≤ **PWV** ≤ 1.6
- **OFF:** one OFF per 3 ON (position-switching)
- **Size:** 11×11 pixels (∼ 105" × 105")
- **Time:** ∼ 13 hours
- θ_{beam}=18.2" and η_{MB}= 0.73

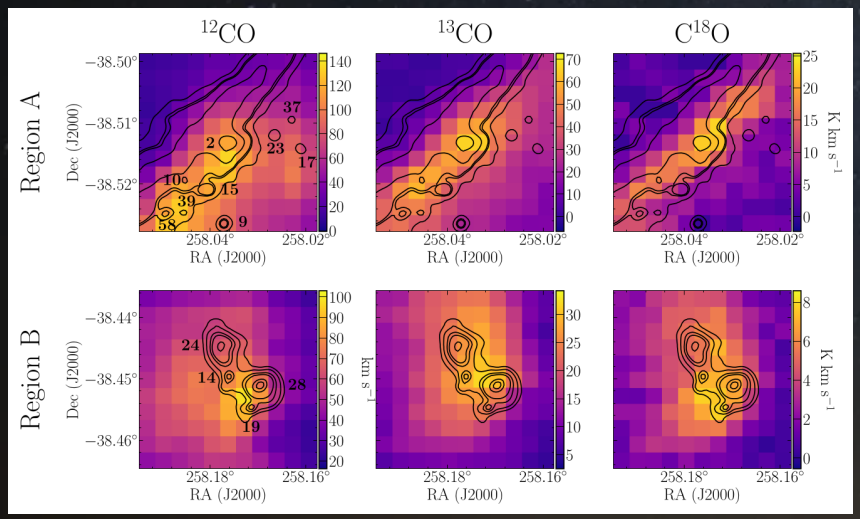
Different star formation mechanisms

Region A $\Longrightarrow$ Massive young YSOs closer to the ionizing star

Region B $\Longrightarrow$ Low-mass evolved YSOs further from the ionizing star

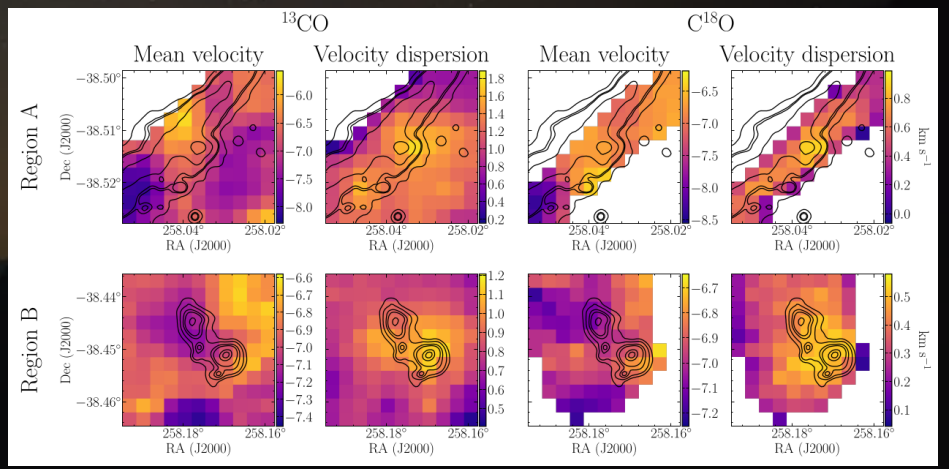
Spatial and velocity distributions

Gas spatial distributions



- Good correlation gas and dust, where star formation is observed

Mean velocity / Velocity dispersion



- **Mean velocity:** No velocity difference observed / expansion stopped or very slow
- **Velocity dispersion:** Dynamics is higher towards the center, where stars are forming

Physical properties of the clumps A and B

Radiative transfer equation:

$$I_\nu(s) = (B_\nu - I_0)(1 - e^{-\tau}) \quad (1)$$

We use the radiative transfer equation to estimate the excitation temperature (T_{ex}), the optical depth (τ) and the column density (N)

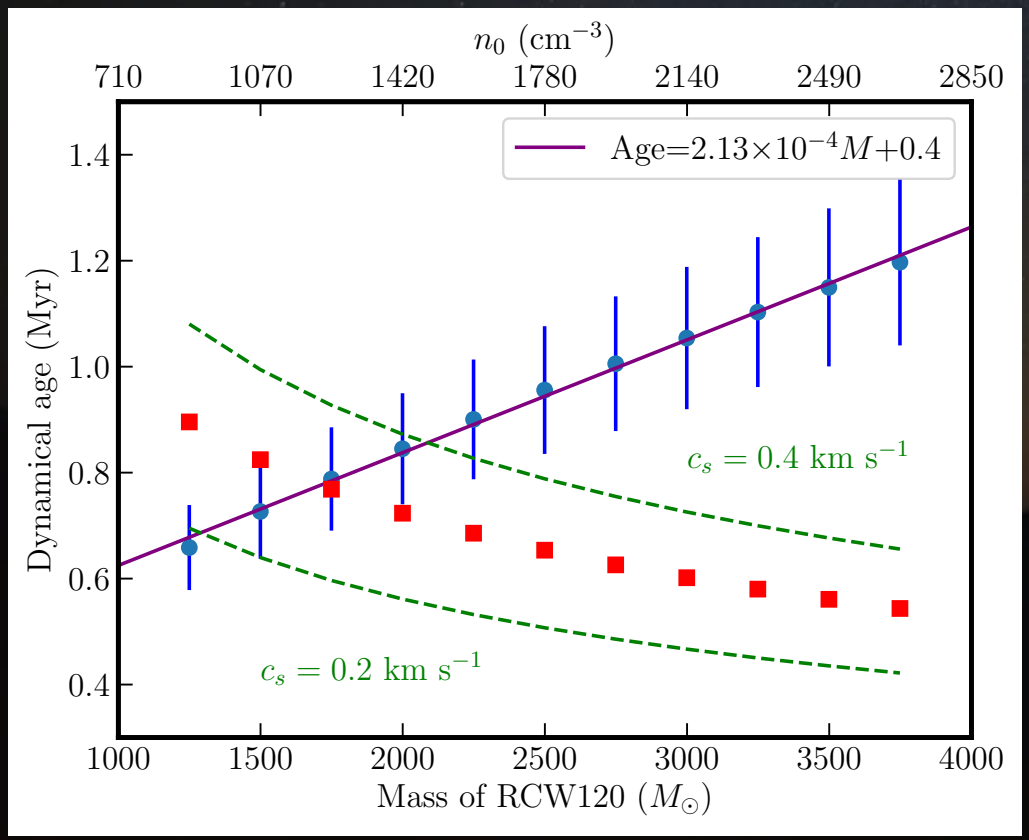
	T_{ex}^{12} (K)	T_{ex}^{18} (K)	τ_{13}^{LTE}	τ_{18}^{LTE}	$N(^{13}CO)^{LTE}$ (cm^{-2})	$N(C^{18}O)^{LTE}$ (cm^{-2})
Region A	22.8	24.8	0.7	0.3	2.2×10^{16}	6.5×10^{15}
Region B	20.7	19.9	0.7	0.2	1.3×10^{16}	2.1×10^{15}

- T_{ex} higher towards Region A (closer to ionizing source-star-formation inside)
- ^{13}CO and $C^{18}O$ are optically thin ($\sim$ moderately for ^{13}CO)
- $N(^{13}CO)$ and $N(^{13}CO)$ comparable to other star-forming regions

The Collect and Collapse process

Comparison between the age of the H II region (t_{dyn}) and the fragmentation time (t_{frag}

Did the fragmentation occur ($t_{frag} \leq t_{dyn}$) ? or not ($t_{frag} \geq t_{dyn}$)?



Density of RCW 120:
~1 to 3×10^3 cm^{-3}

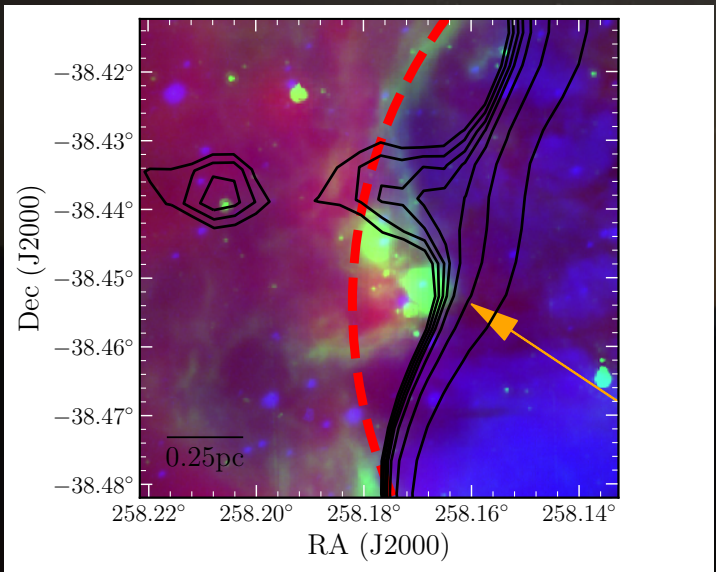
$t_{dyn} = 0.96 \pm 25$ Myr

C&C process is still viable

This does not mean that C&C is the major star-forming mechanism around RCW 120 (open question)

The Radiation Driven Implosion model

- Ionized Boundary Cloud $\Longrightarrow$ No Hα but n_e high enough
- PDR through PAHs $\Longrightarrow$ Yes
- $T_{ex}^{12} > T_{ex}^{18} \Longrightarrow$ Yes but not convincing (22 / 19 K)
- Multiple gas components $\Longrightarrow$ No but $P_{clump} \sim P_{ion}$
- Cluster of intermediate mass star $\Longrightarrow$ Yes
- Distorsion $\Longrightarrow$ Yes at 8 μm and 36 cm
- Old YSOs $\Longrightarrow$ Yes, no need for Collect, just Collapse



Region B is a good candidate for RDI mechanism

Conclusions

- Analysis of $^{12}CO(3-2)$, $^{13}CO(3-2)$, $C^{18}O(3-2)$ towards two sub-regions of RCW120

- Increase of T_{ex} towards the center of the regions, where stars are forming and a similar increase of velocity dispersion is observed, higher towards Region A where a massive star is forming

- The Collect & Collapse mechanism is a possible mechanism, that would explain the formation of massive cores at the edge of the region

- Region B is a possible candidate for the radiation driven implosion mechanism

Thank you