Numerical simulations of photoevaporating molecular clumps

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In collaboration with:
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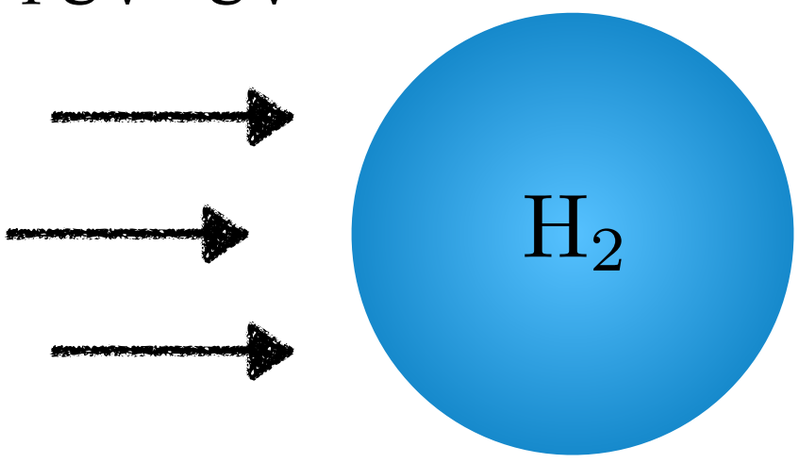
SCUOLA NORMALE SUPERIORE

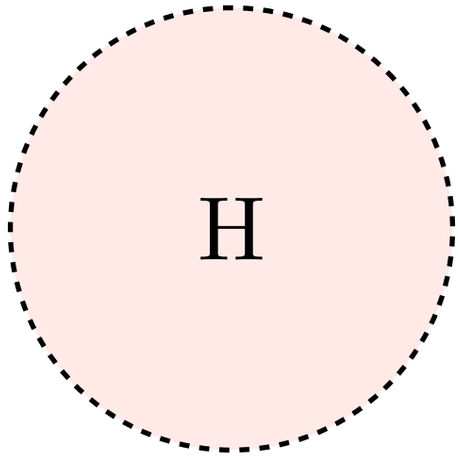
Photoevaporation of molecular clumps

FUV - UV



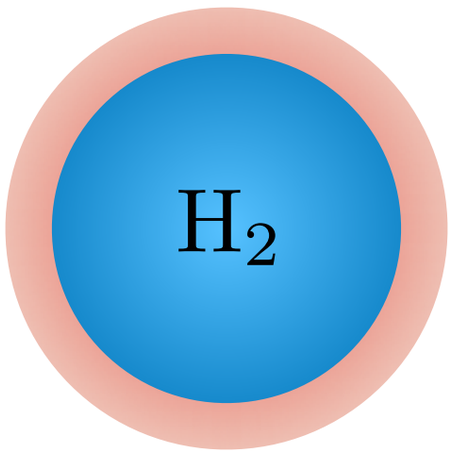
$$n_{\rm cl} R_{\rm cl} \leq N_0$$

Sudden photodissociation



$$n_{\rm cl} R_{\rm cl} > N_0$$

Photoevaporation

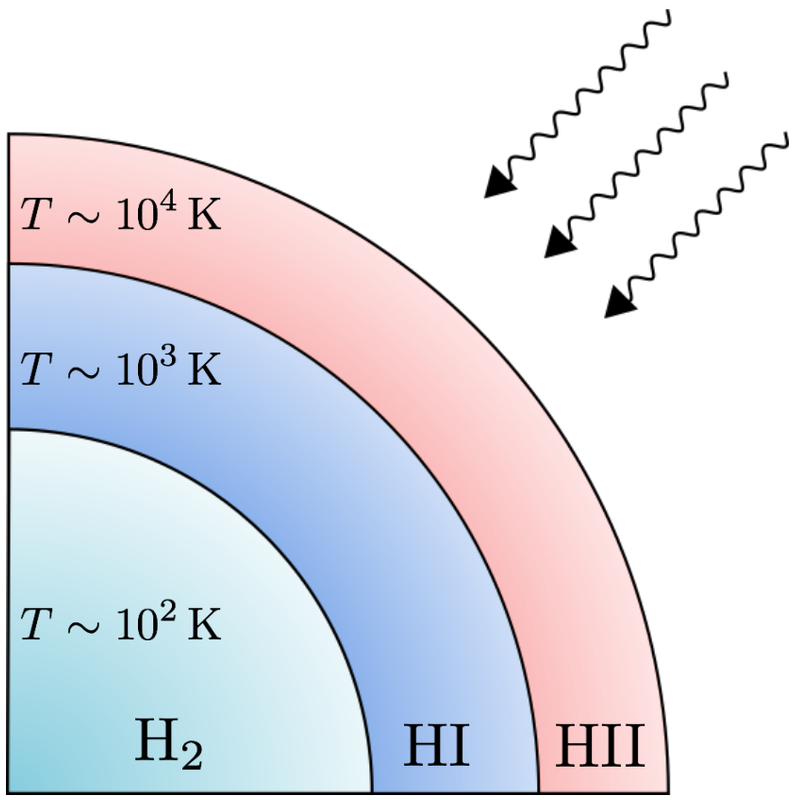


$$N_0 \simeq 10^{21}\,{\rm cm}^{-2}$$

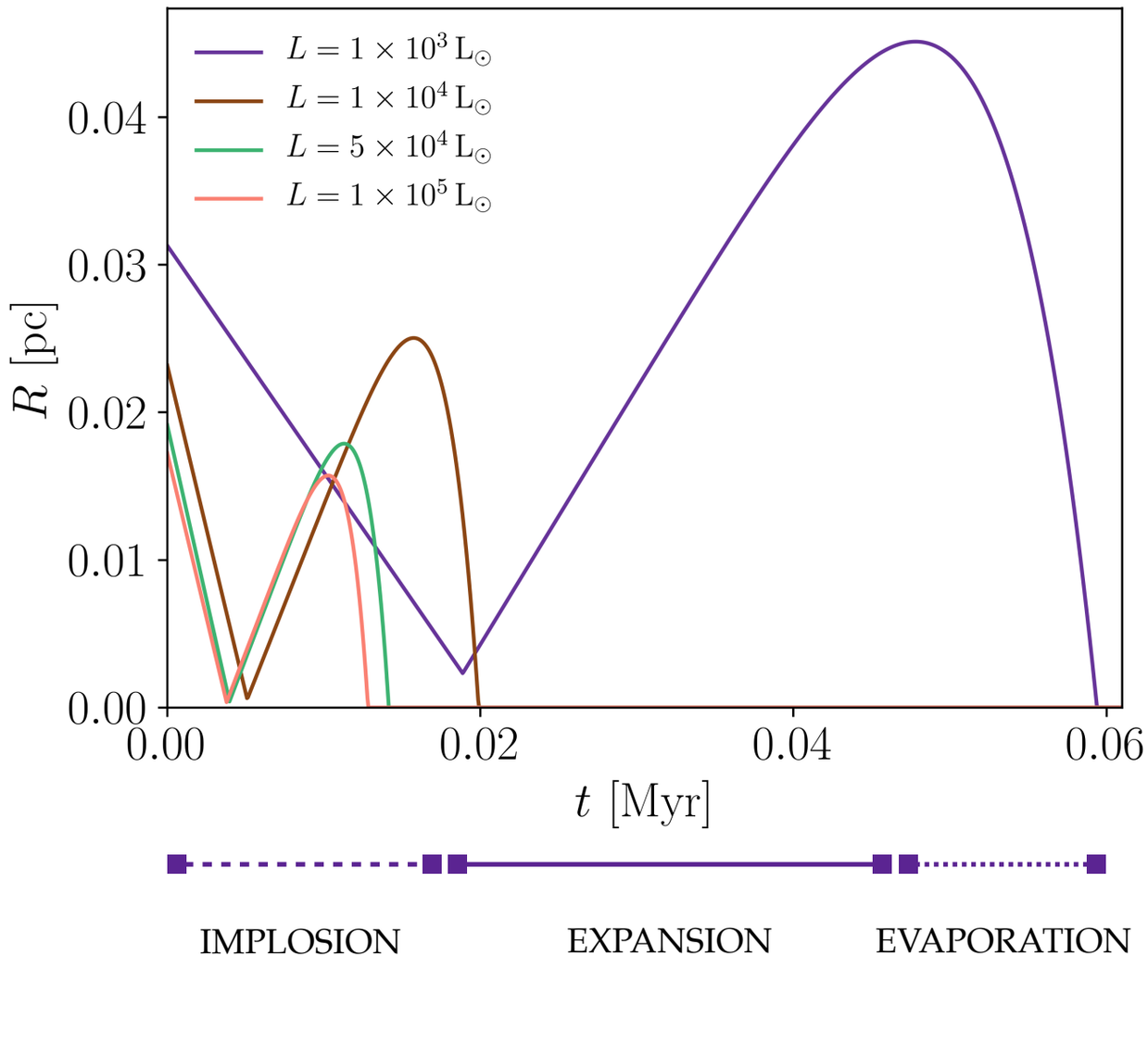
Effect of radiation on clump structure

ISOTROPIC RADIATION FIELD

$$D = 0.3\,\mathrm{pc}$$
$$M_{\mathrm{cl}} = 0.1\,\mathrm{M}_\odot$$



Decataldo et al. 2017



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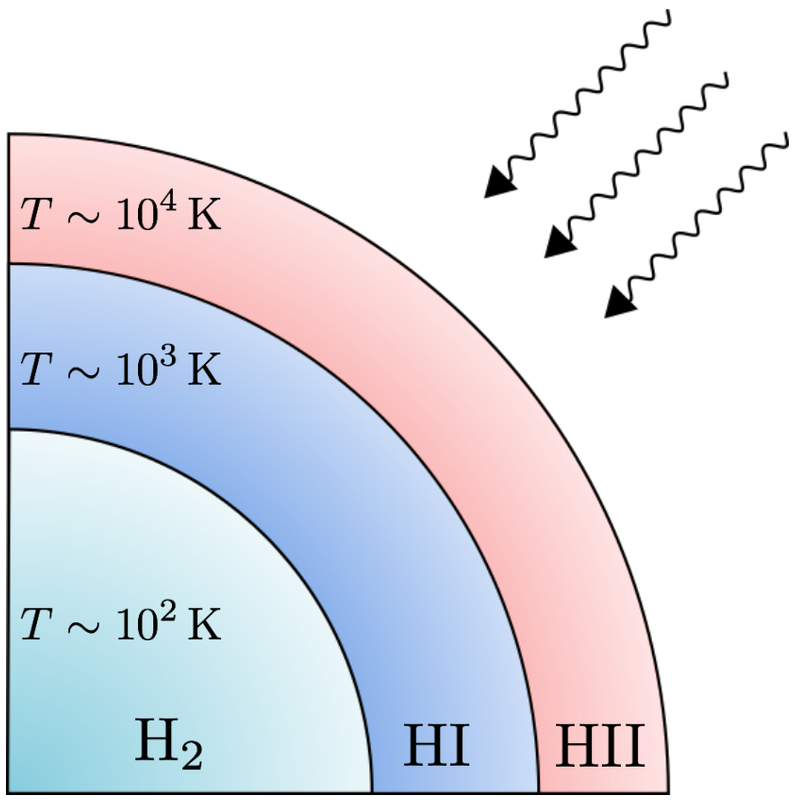
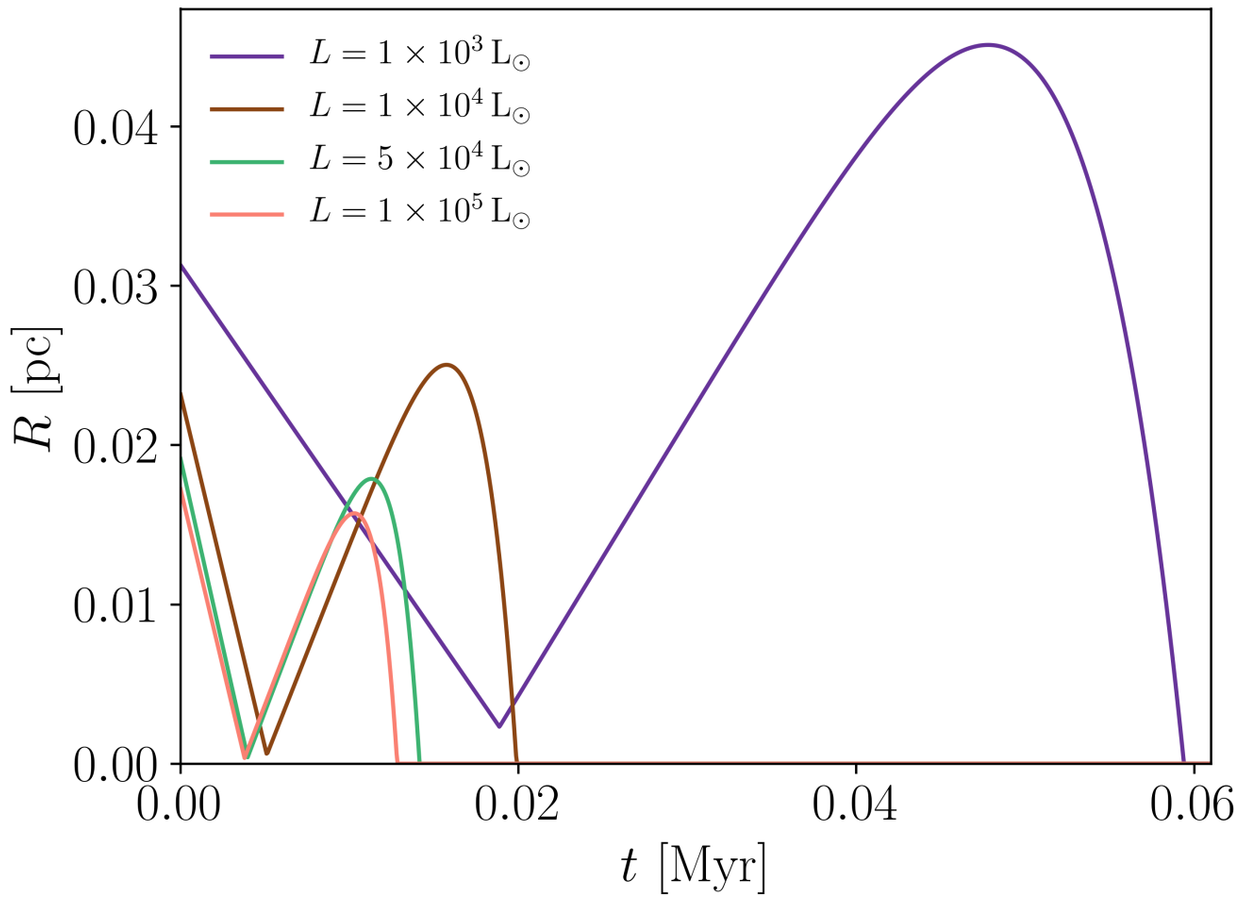


Decataldo et al. 2017



✗ NO cloud self-gravity

✗ NO time evolution of dissociation front

Coupling Ramses-RT and Krome

Every RT time-step:

Propagating photons — RAMSES

↓

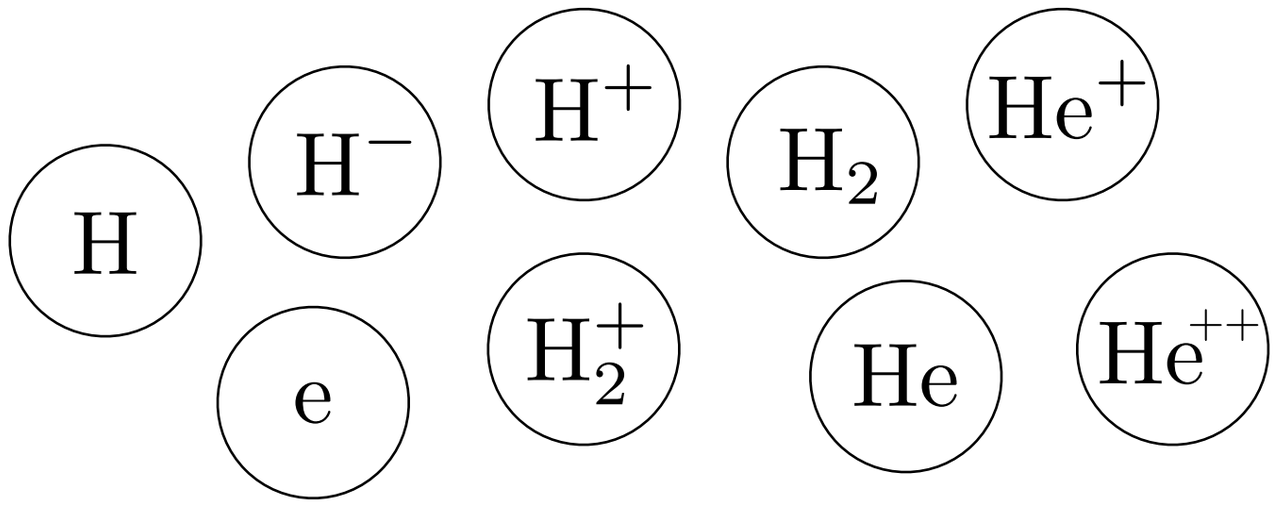
Reducing flux — RAMSES with KROME cross sections

↓ Passing fluxes to KROME

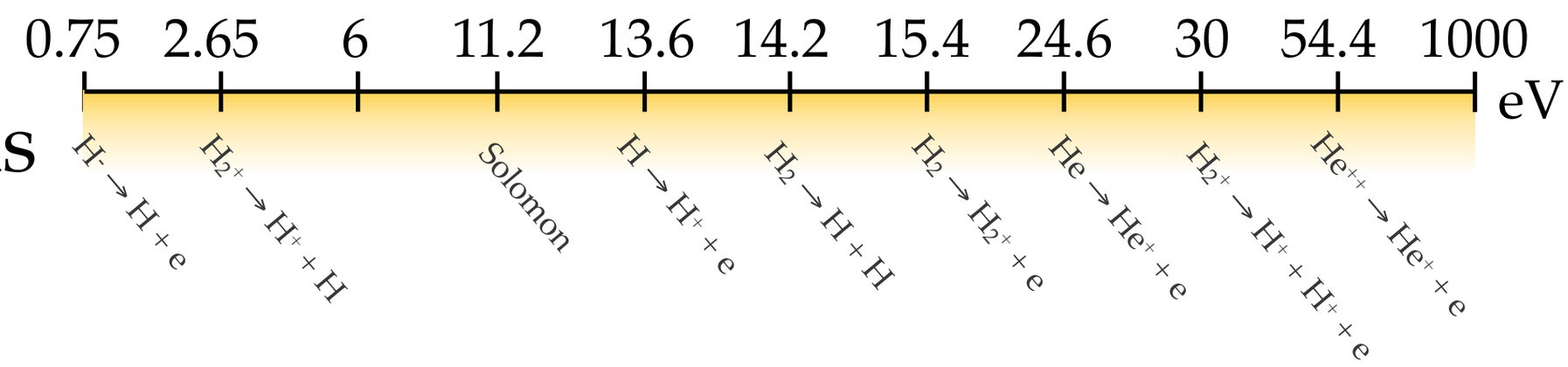
Computing new abundances and T — KROME

Physical model

9 Chemical Species

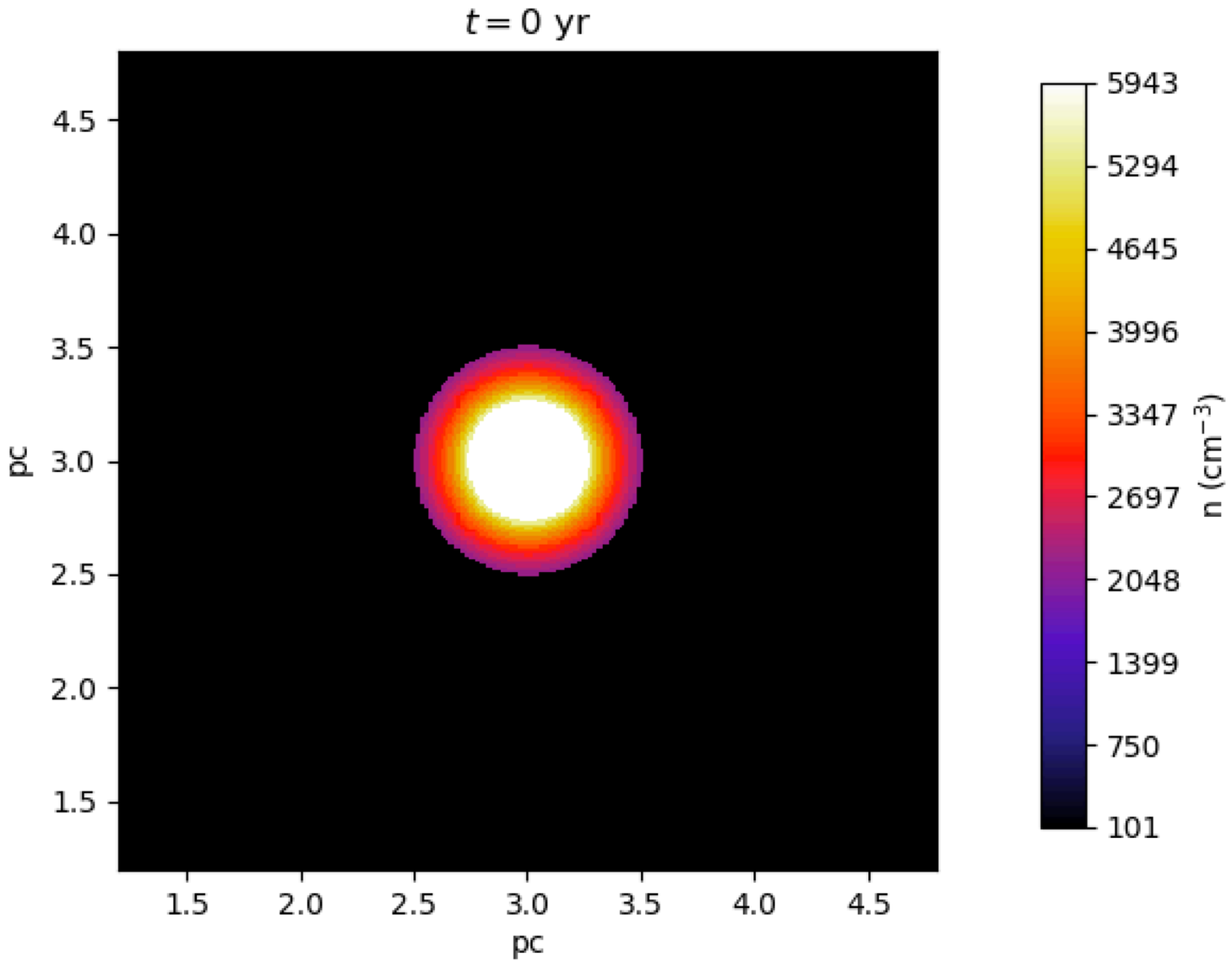


10 Photon Bins



Chemical network: 53 reactions (9 photoreactions)
+ cosmic rays

3D simulation of photoevaporating clumps



$$M_{\rm cl} = 50\,{\rm M}_\odot \qquad R_{\rm cl} = 0.5\,{\rm pc}$$

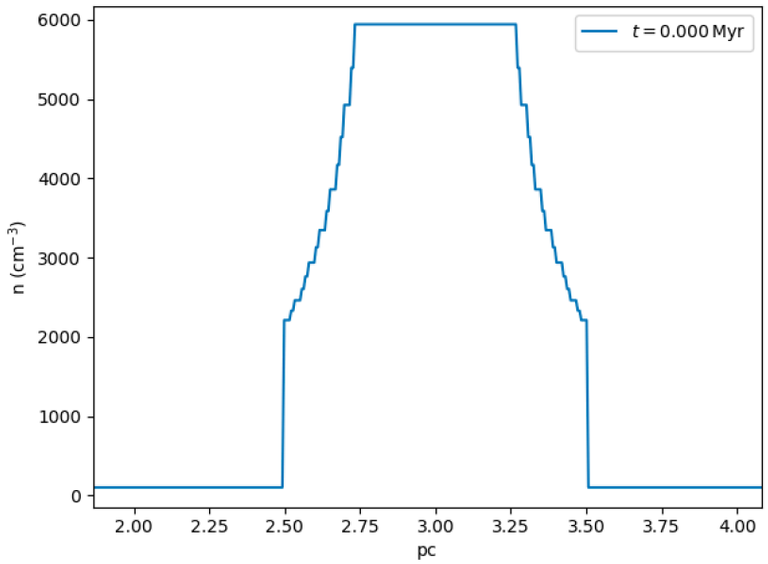
Resolution: $2^7 \rightarrow 2^8$

$\Delta x_{min} = 2.3 \times 10^{-2}\,{\rm pc}$

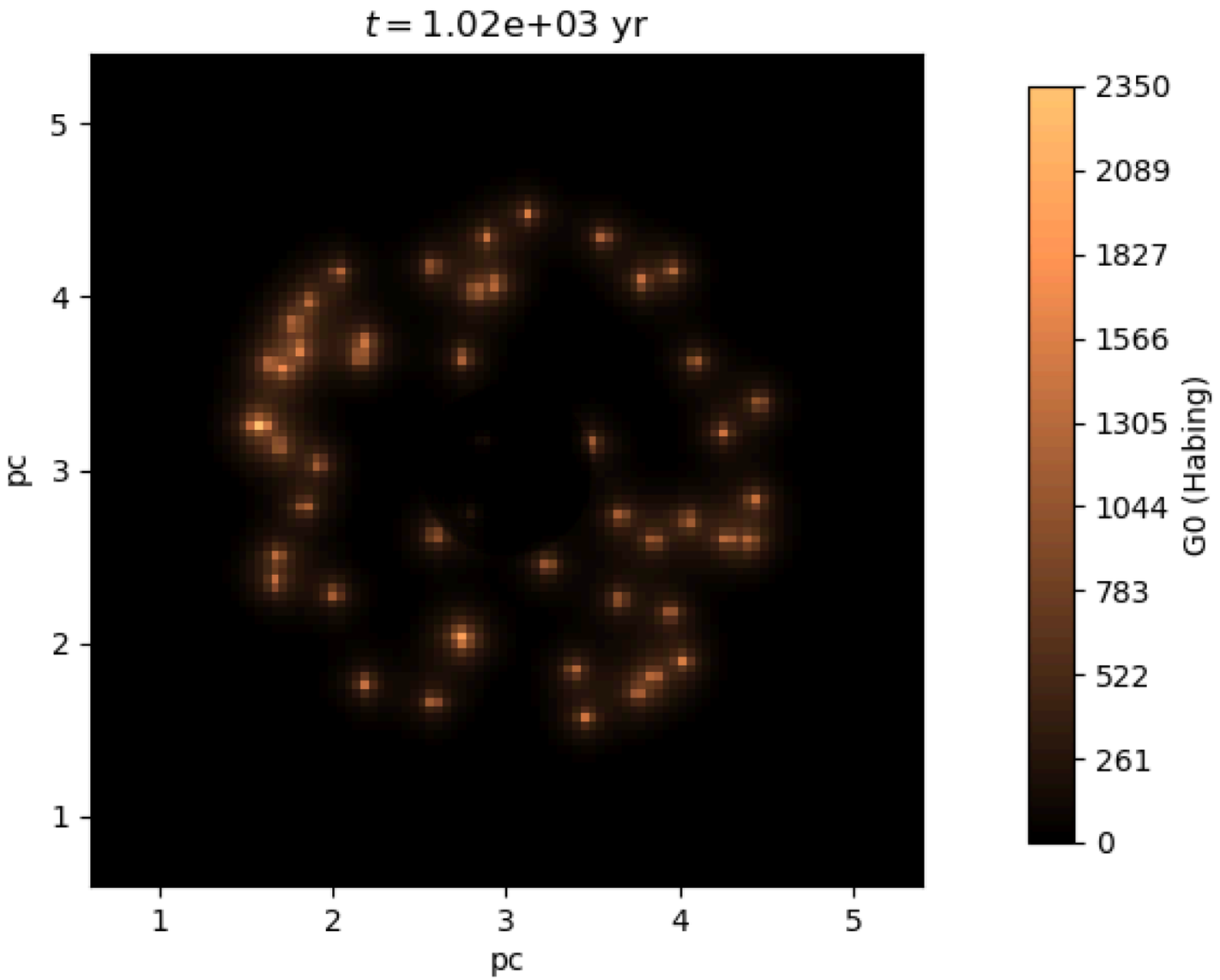
Box size: $6\,{\rm pc}$

Refinement on $\nabla x_{\rm H_2}$

Density profile



Radiation field in the simulation



50 stars

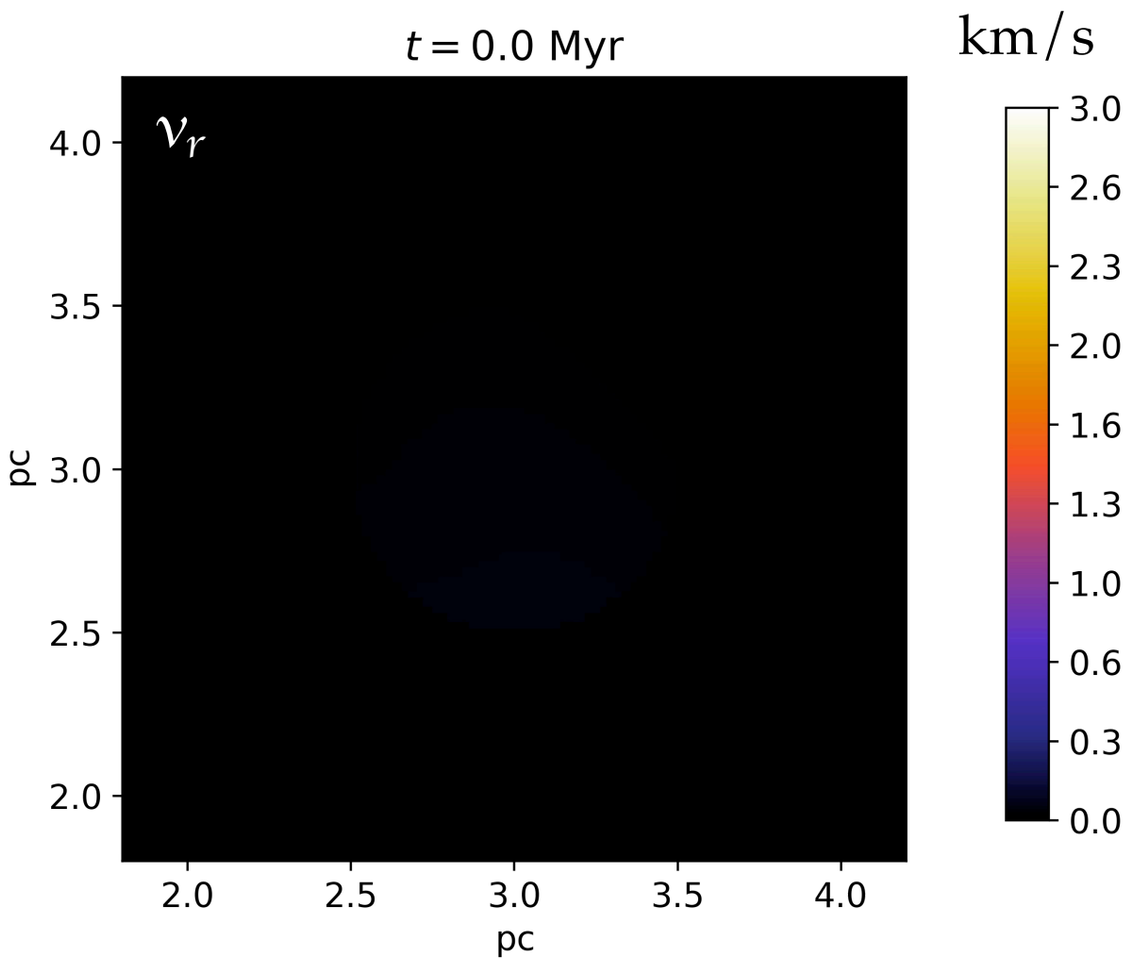
with isotropic distribution

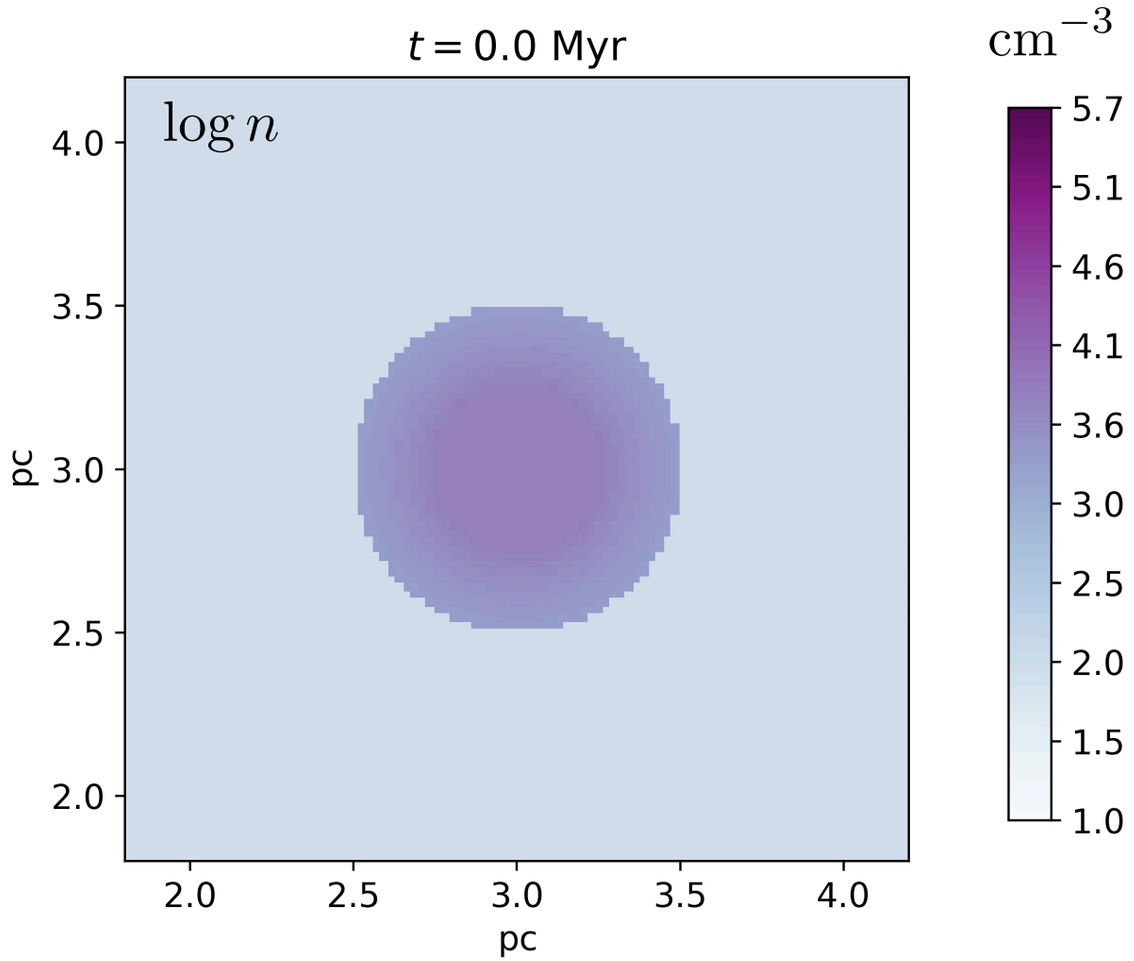
at 1.5 pc from the center

only FUV

$$G_0 = 2 \times 10^4$$

Clump dynamics



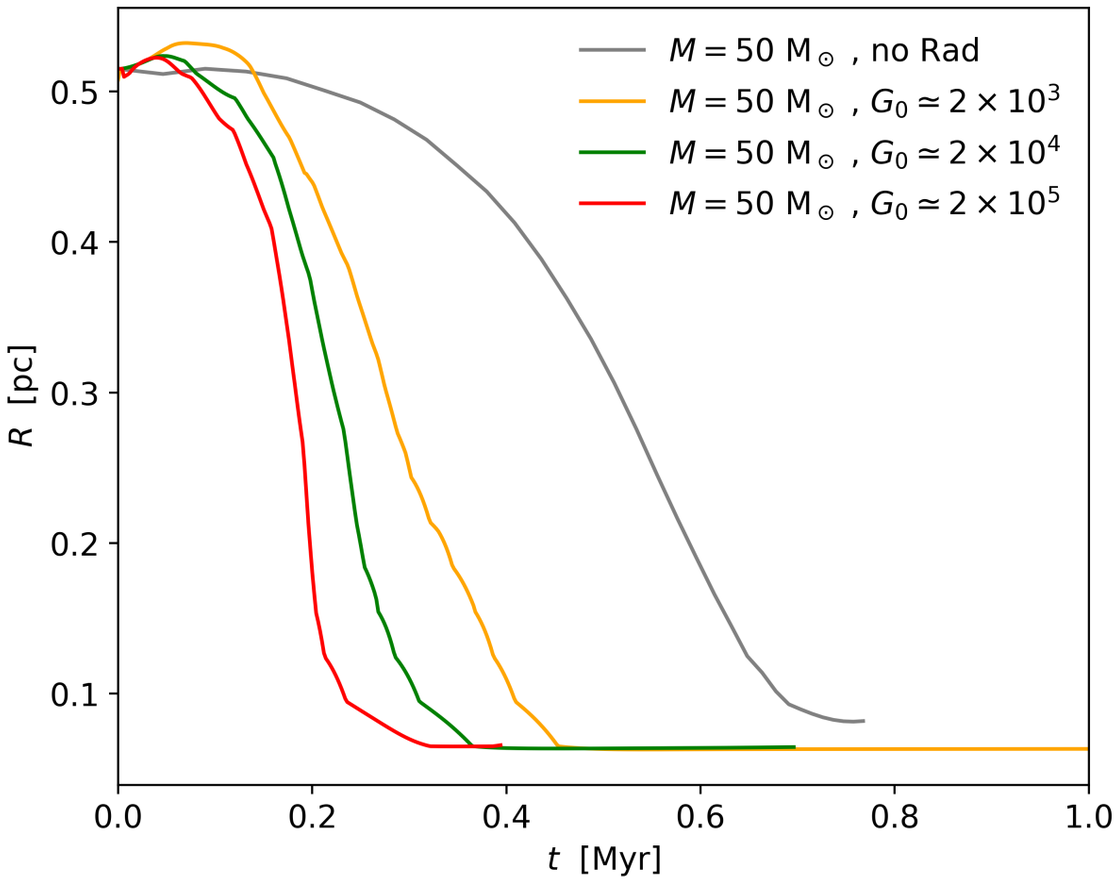


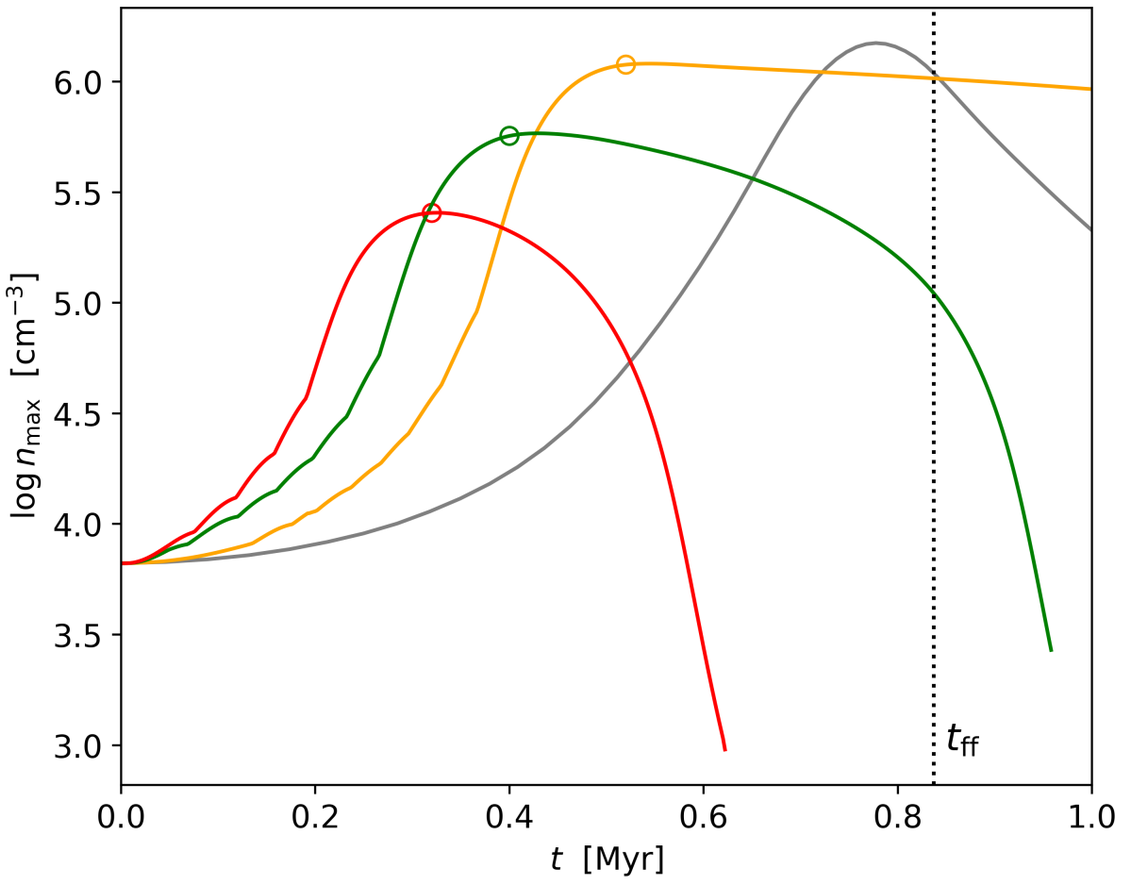
$$M_{\rm cl} = 50\,{\rm M}_\odot \qquad R_{\rm cl} = 0.5\,{\rm pc}$$

$$t_{\rm evap} \simeq 0.96\,{\rm Myr}$$

Changing G_0

Decataldo et al., in prep.





Higher G_0 induces

- a stronger implosion
- higher density in the center
- faster photoevaporation

$$M_{\mathrm{cl}} = 50\,\mathrm{M}_\odot$$

Changing G_0

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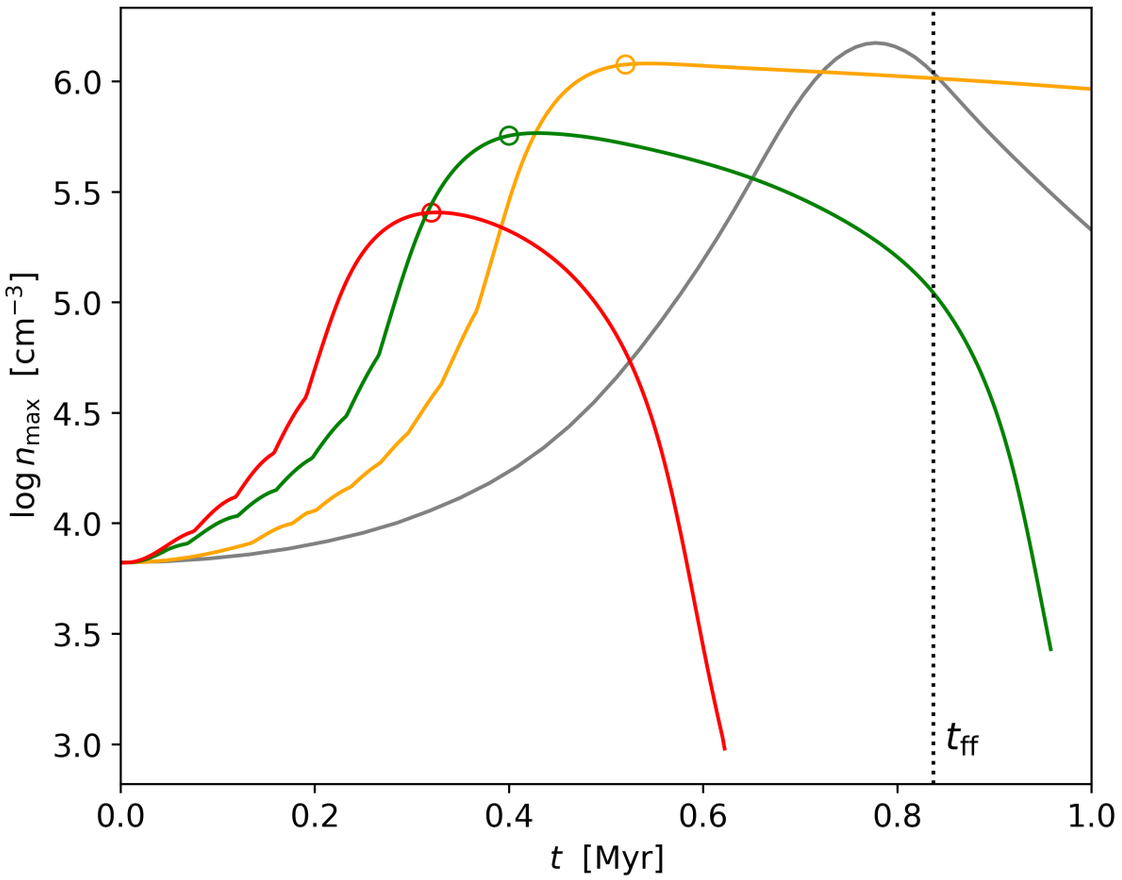

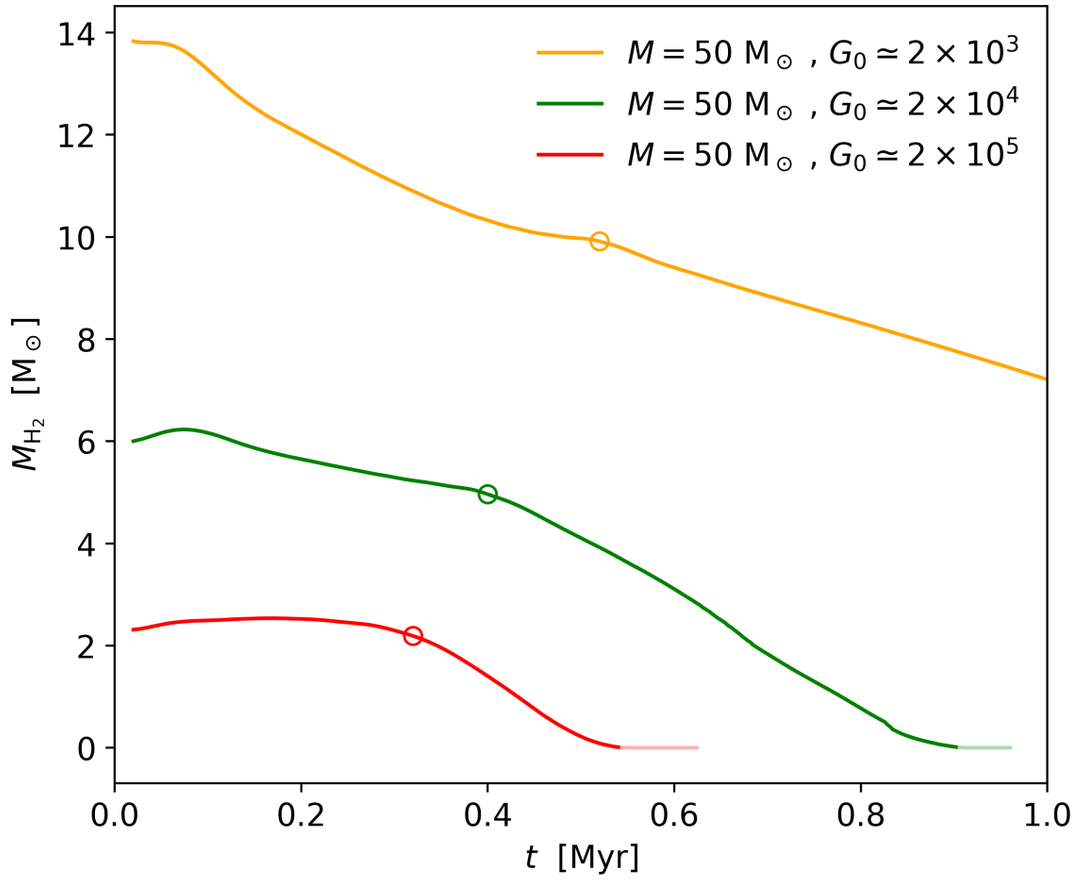

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Conclusions

RAMSES-RT

+

KROME

Simulations with on-the-fly RT and complex chemical network

Accurate treatment of photoevaporation

→ Triggered star formation

→ Molecular outflows in AGNs

Thank you for the attention...