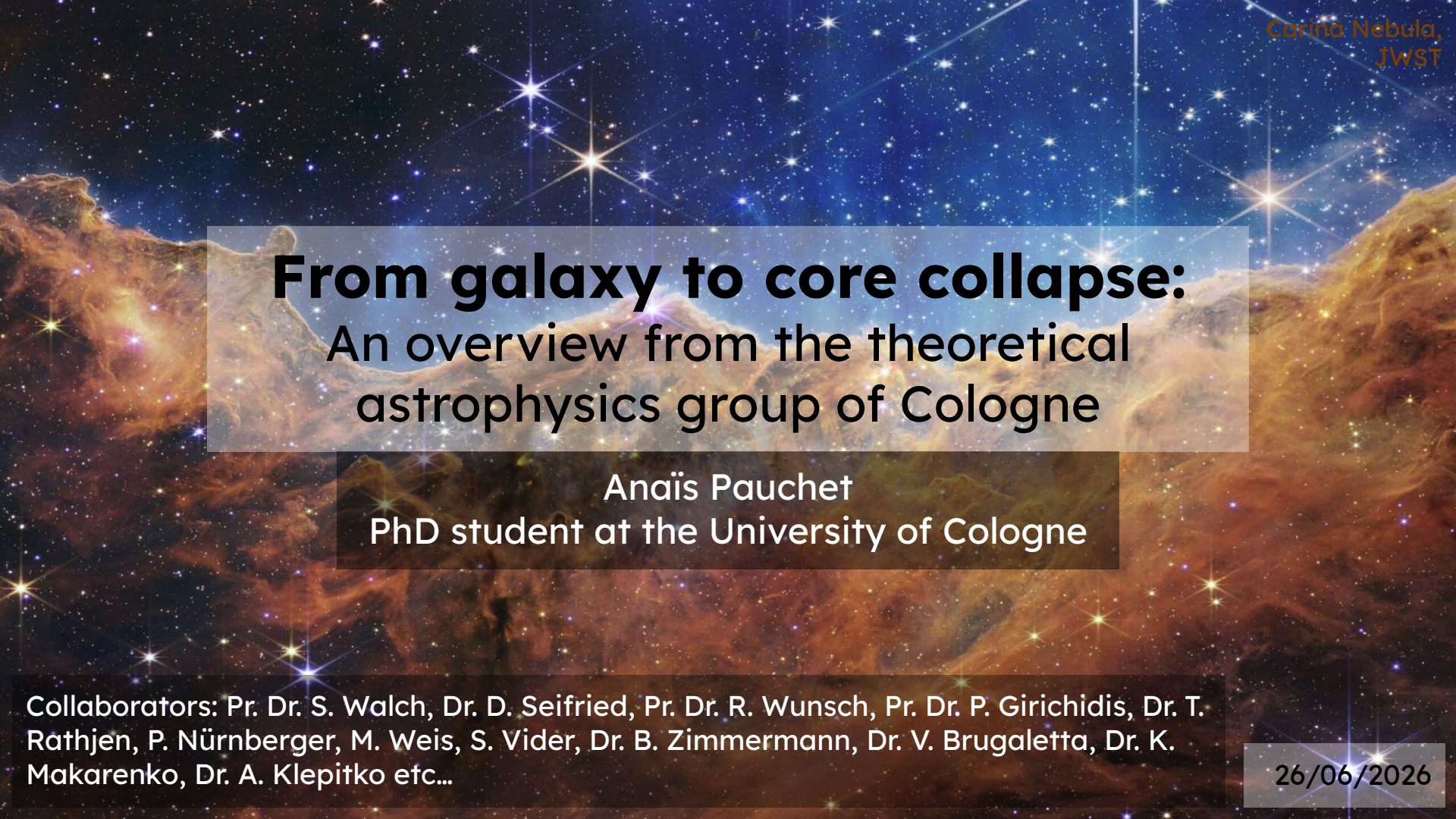


From galaxy to core collapse:
An overview from the theoretical astrophysics group of Cologne

Anaïs Pauchet
PhD student at the University of Cologne

Collaborators: Pr. Dr. S. Walch, Dr. D. Seifried, Pr. Dr. R. Wunsch, Pr. Dr. P. Girichidis, Dr. T. Rathjen, P. Nürnberger, M. Weis, S. Vider, Dr. B. Zimmermann, Dr. V. Brugaletta, Dr. K. Makarenko, Dr. A. Klepitko etc...

26/06/2026

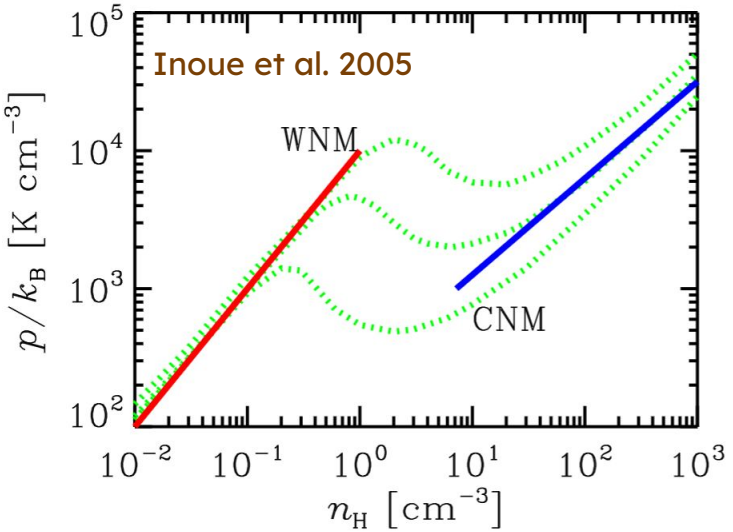
ISM

- ISM phases:

- Cold Neutral Medium (CNM) < 300 K & Molecular Clouds (MCs) < 50 K
- Warm Neutral/Ionized Medium (WNM) > 5000 K
- Hot ionized Medium (HIM) > 10^6 K

- ISM chemistry:

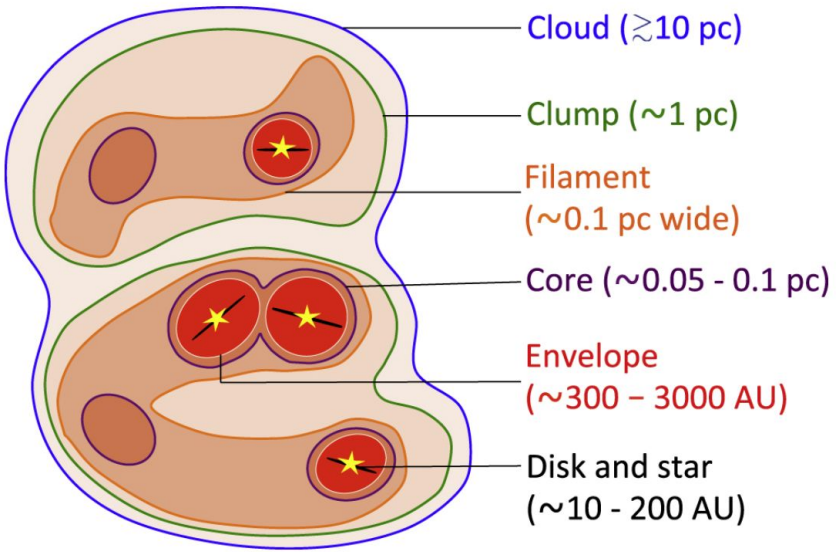
atomic and molecular diversity → used as tracers

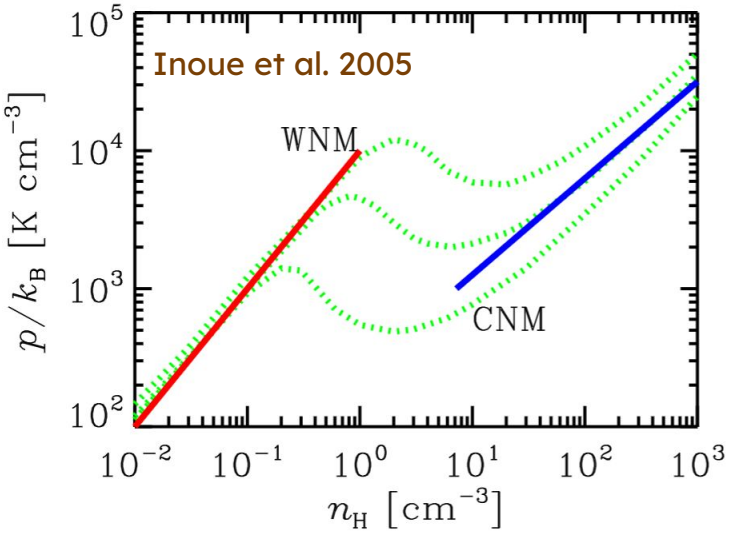


ISM

- **ISM phases:** WNM, CNM, MCs, WIM, HII regions, HIM
- **ISM chemistry**: atomic and molecular diversity

Rosen et al. 2020



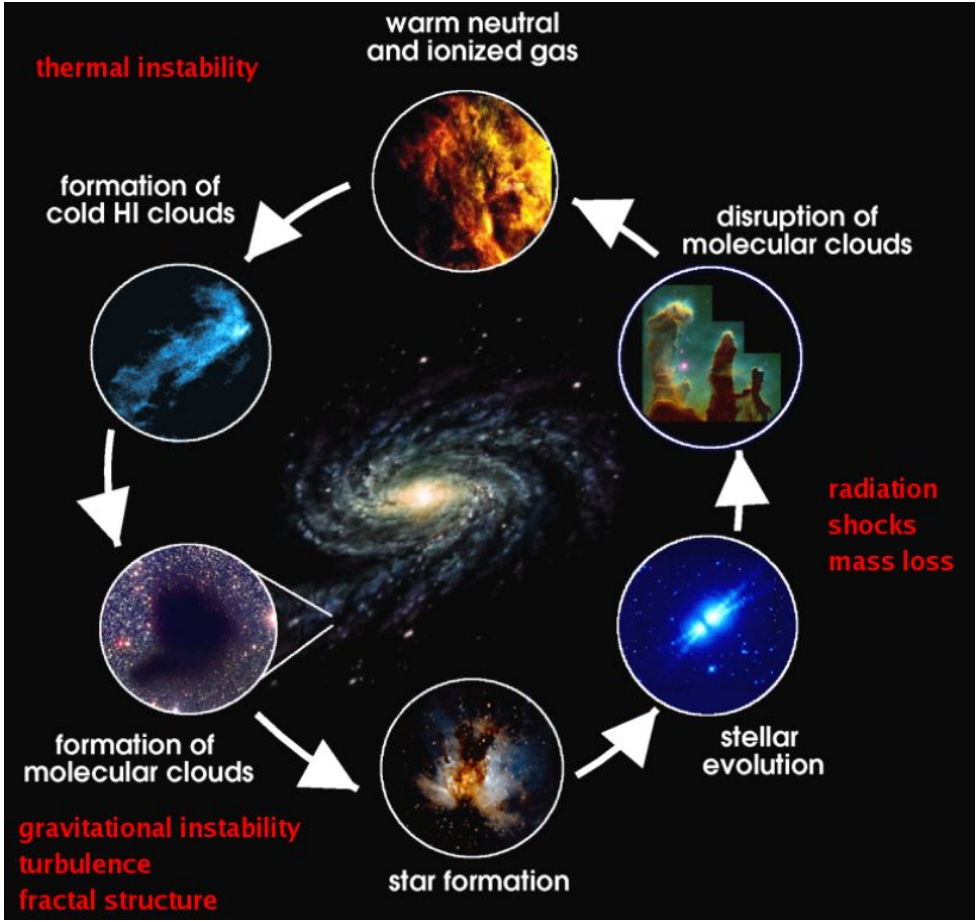


- **ISM physics**: star formation cascade, feedback

Dynamic ISM

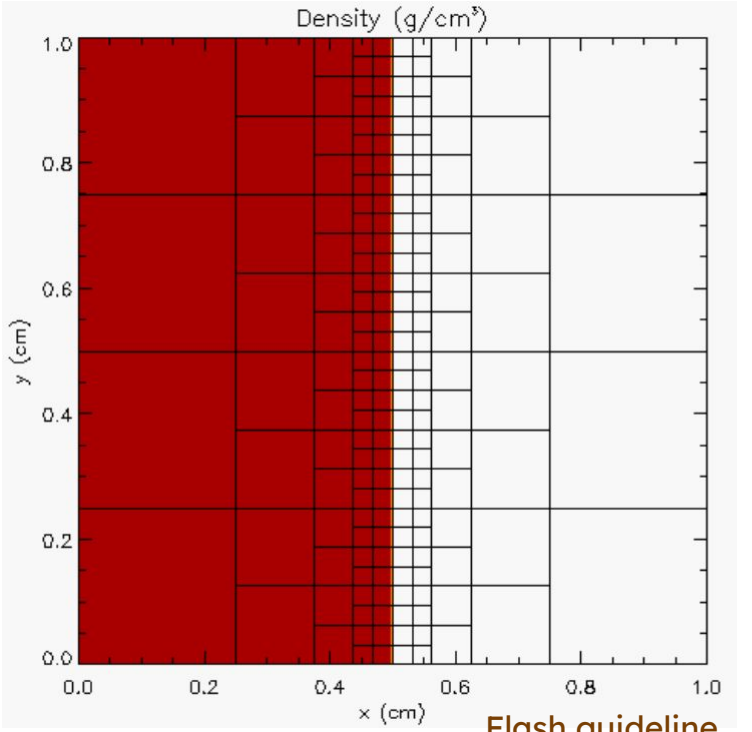
Credit: the HEAT team (the High Elevation Antarctic Terahertz telescope)

- **Life cycle of matter in the ISM:** constantly destroyed and recovered
- **Evolution time scale far beyond human life**



FLASH code (Fryxell et al. 2000)

- **AMR** (Adaptive Mesh Refinement) grid, blocks of 8^3 cells are refined
- **3D MHD** (Magneto-HydroDynamic)
- **inter-operable modules** that can be combined



Flash guideline

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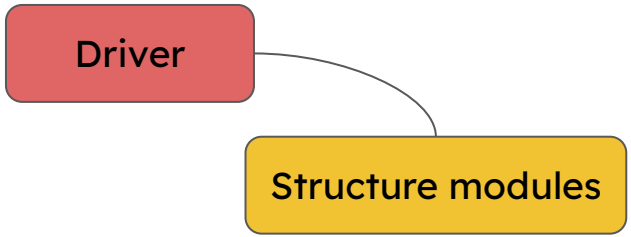

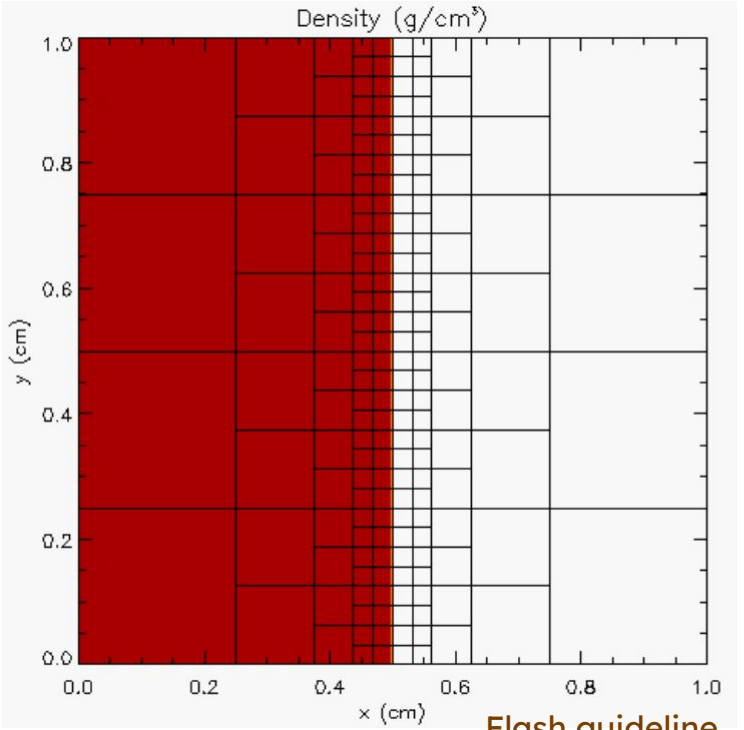

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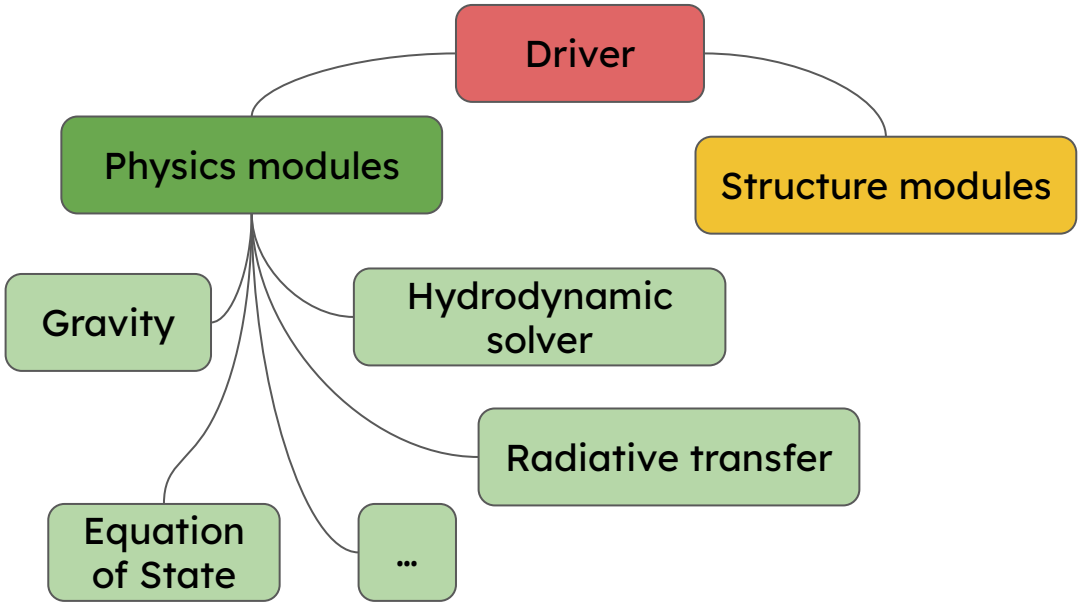
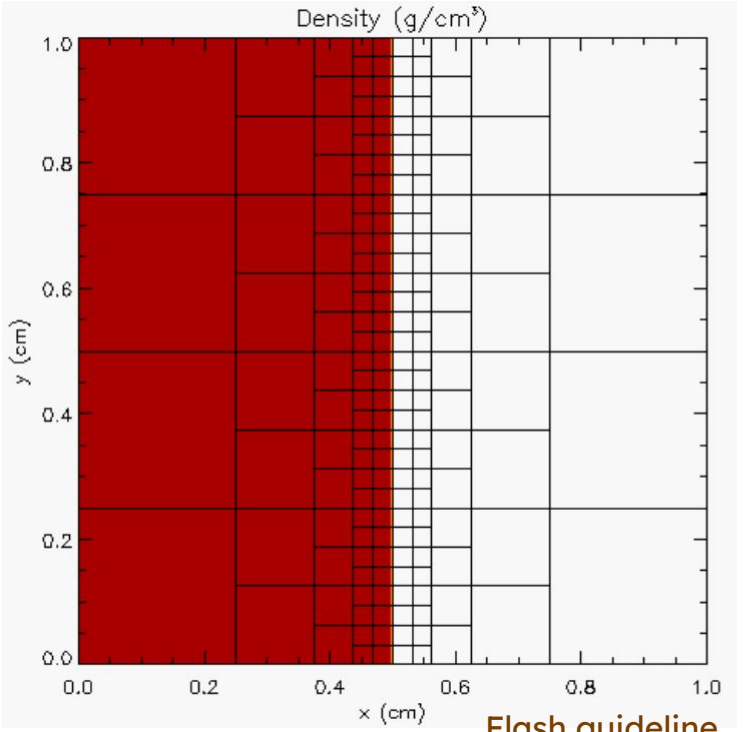
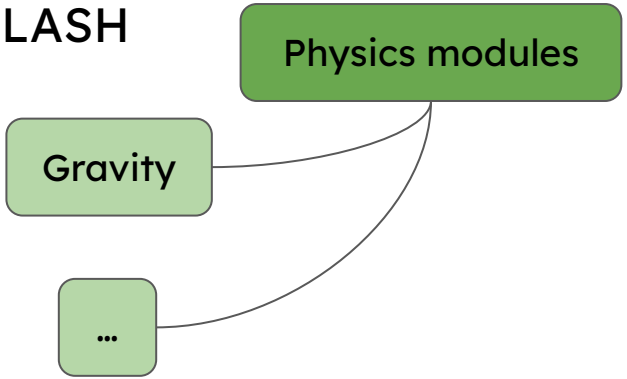




Flash guideline

Additions to FLASH



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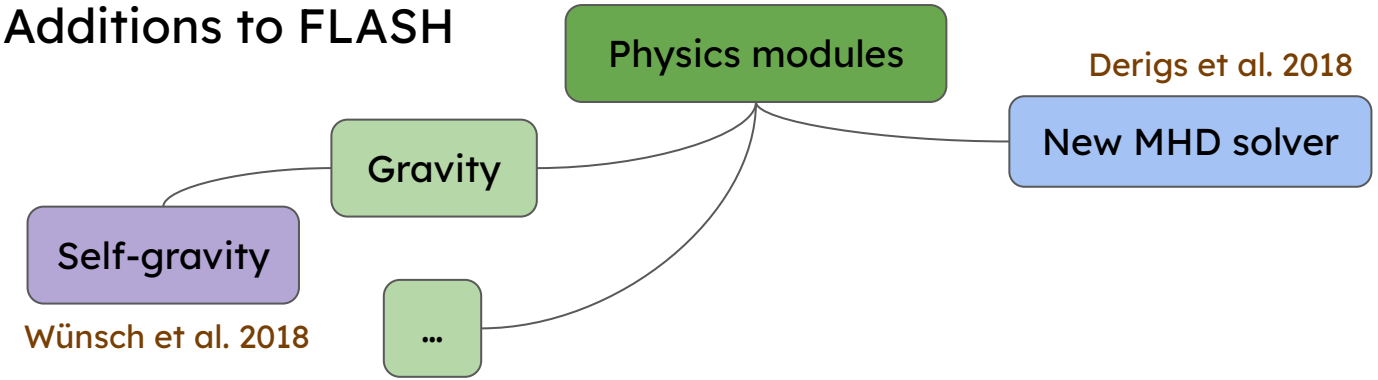

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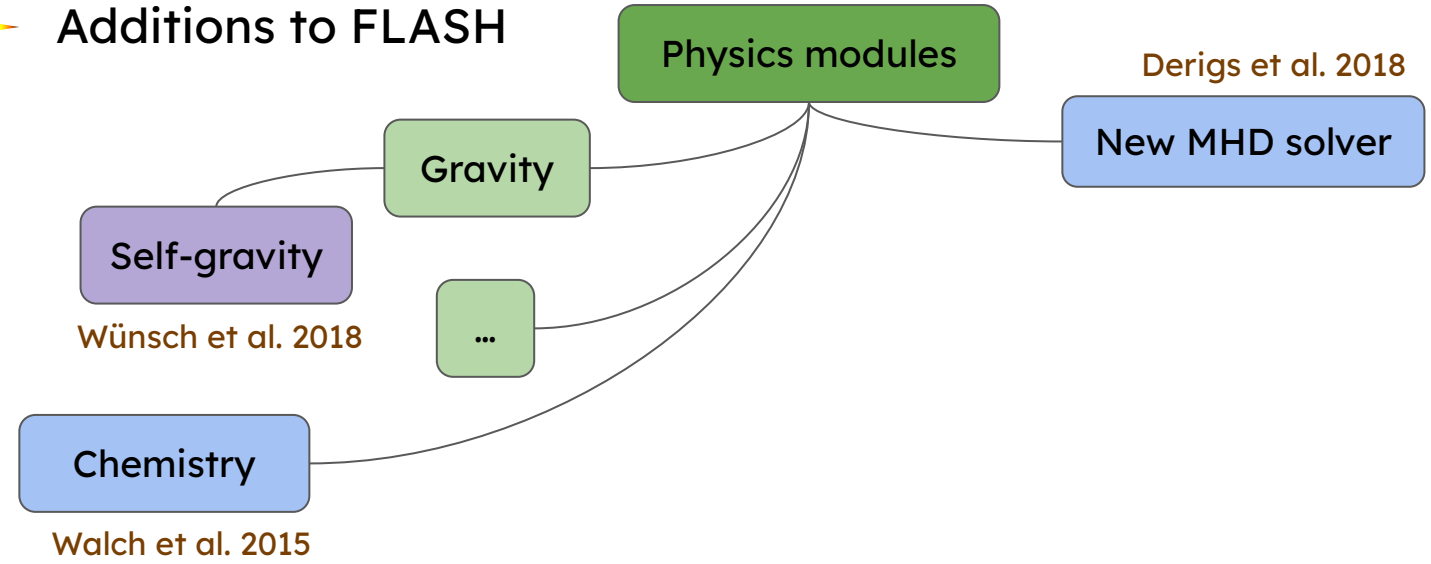

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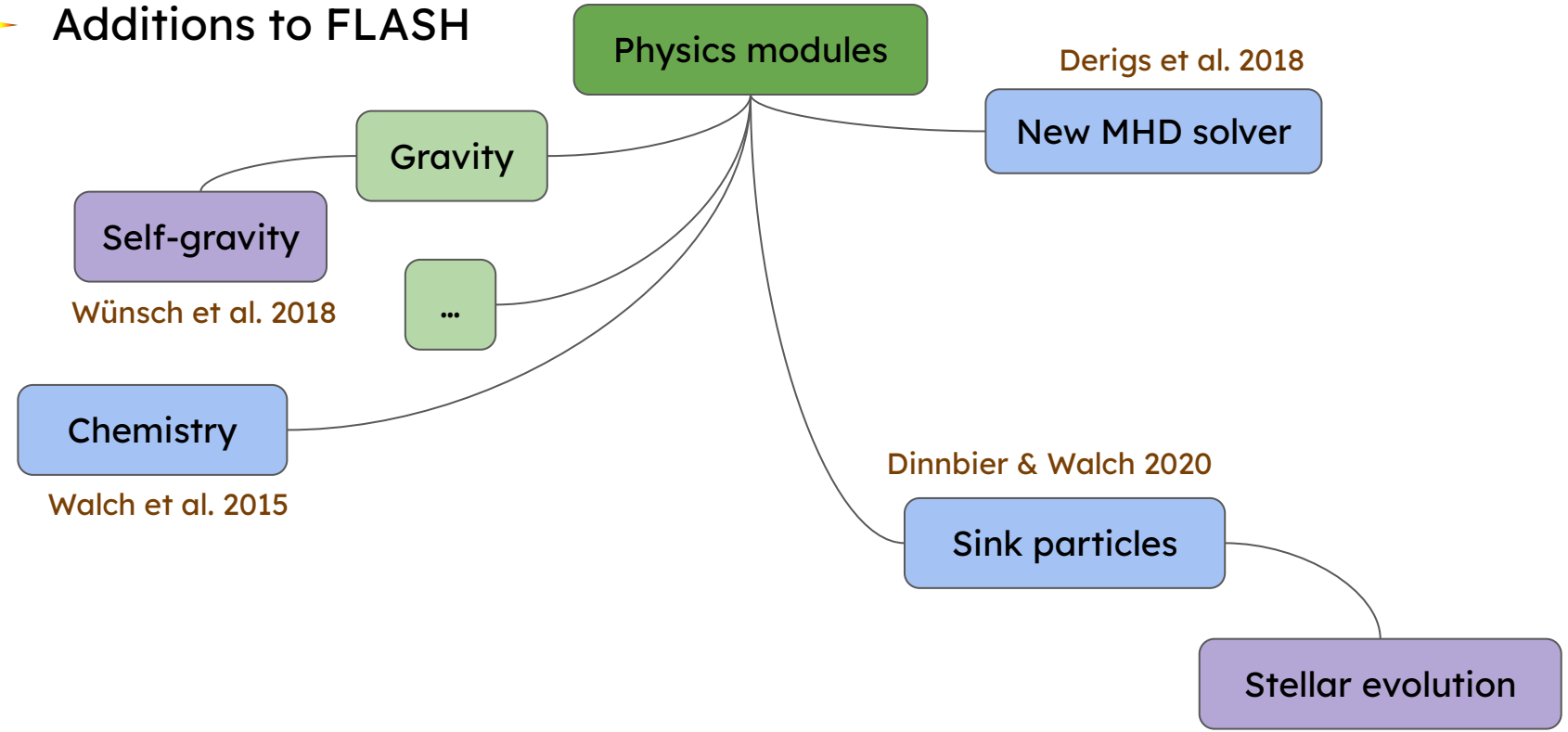

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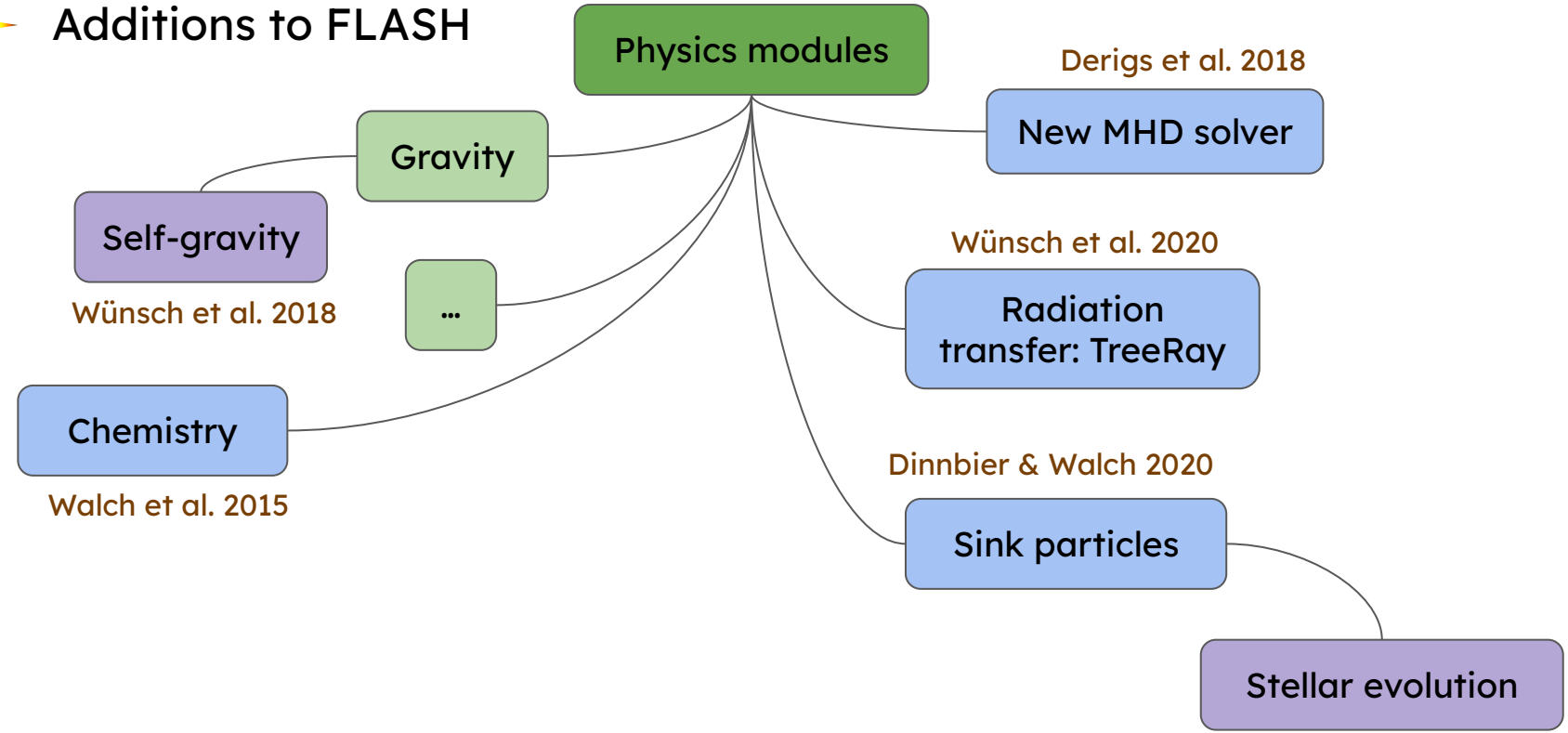

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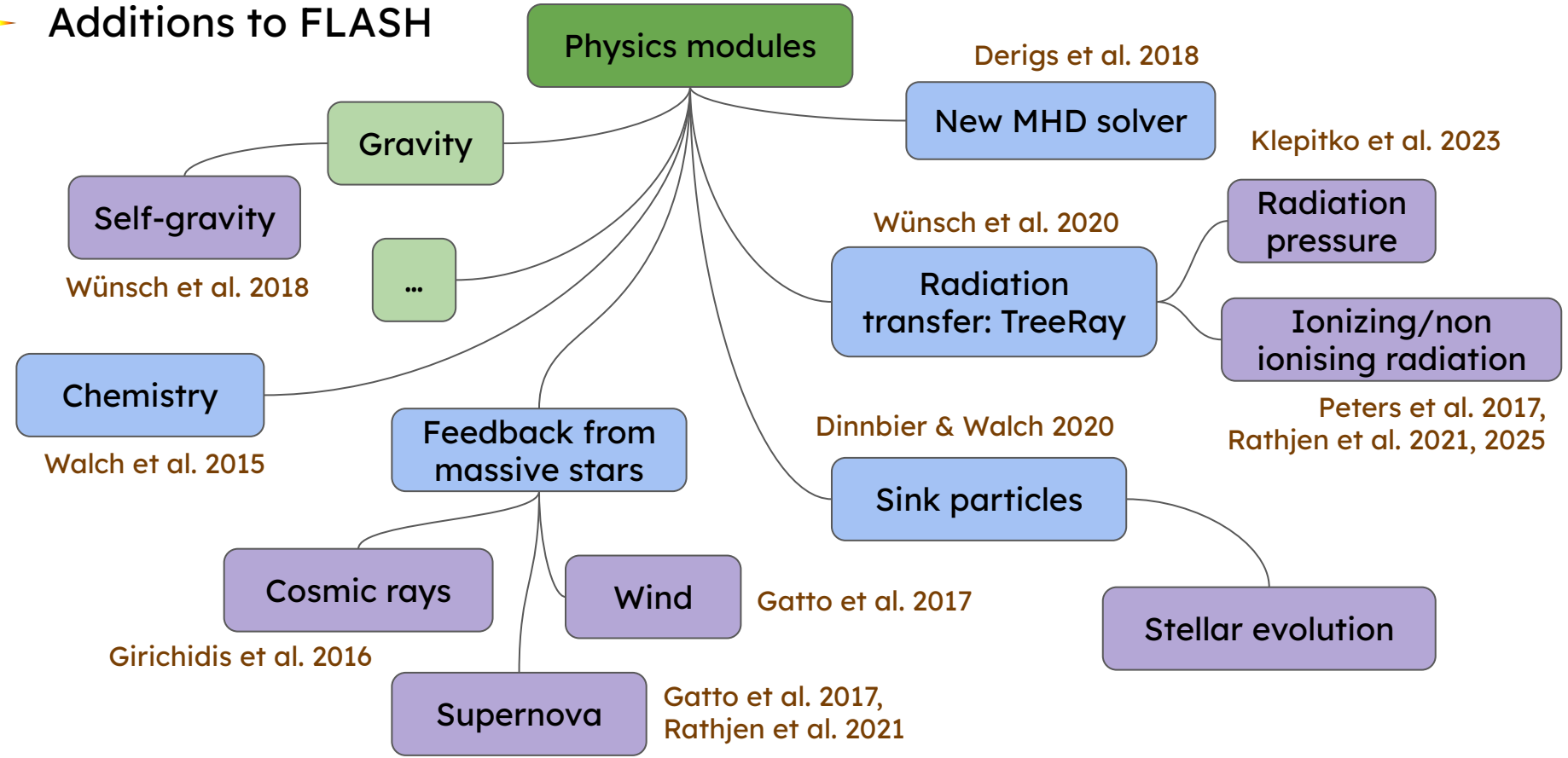
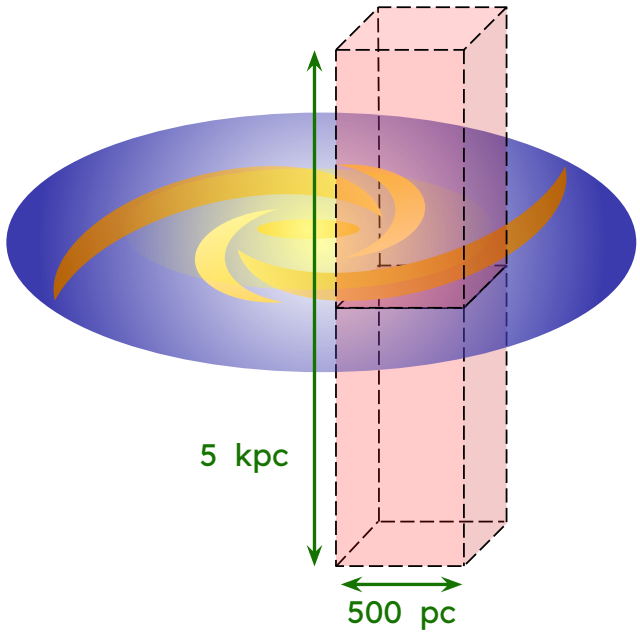
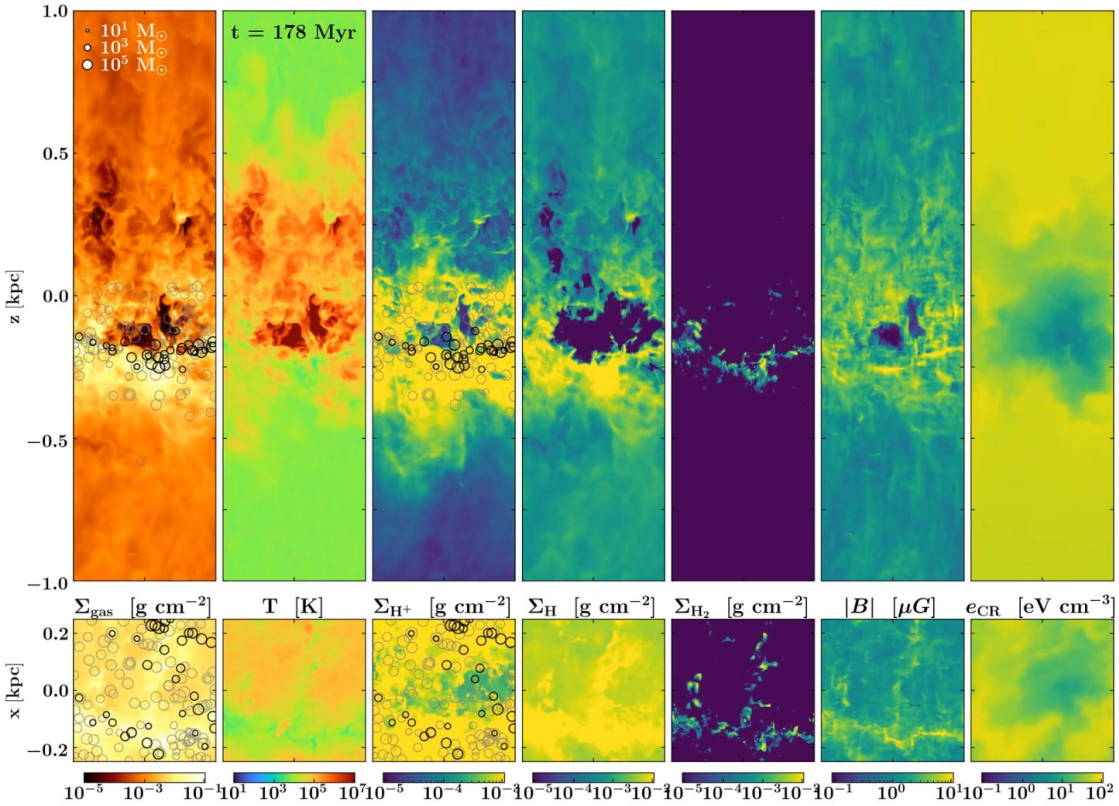


SILCC (SImulating the Life Cycle of molecular Clouds)

hera.ph1.uni-koeln.de/~silcc/



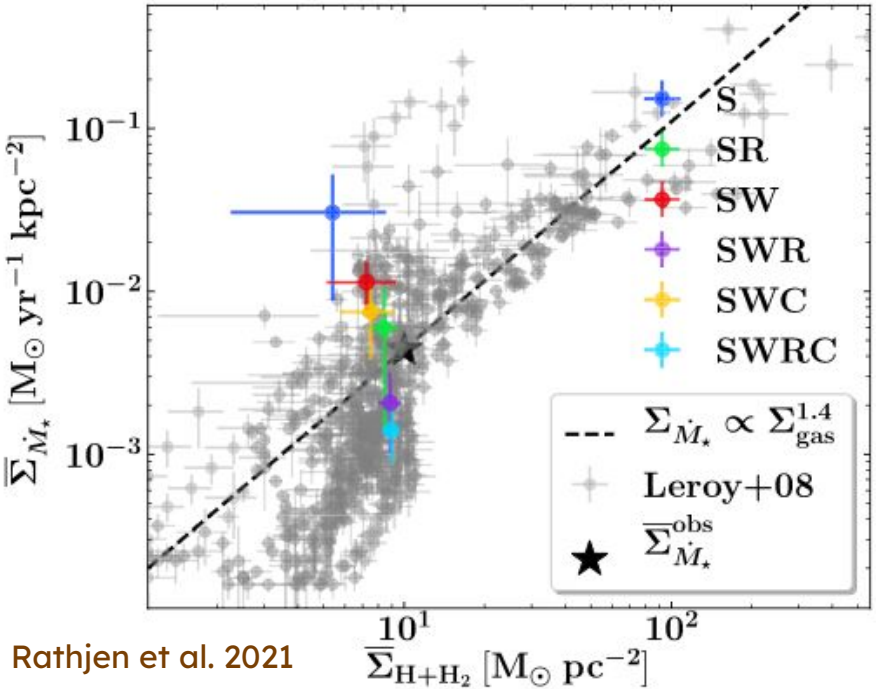
Rathjen et al. 2023



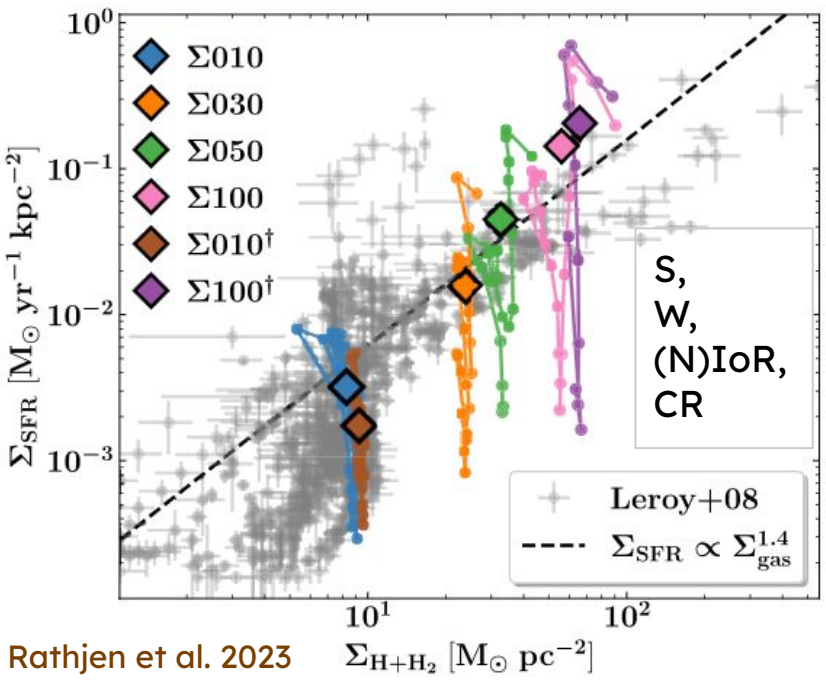
The majority of the modules presented before are included in SILCC

SILCC (SImulating the Life Cycle of molecular Clouds)

- Kennicutt-Schmidt relation: needs all forms of feedbacks to match observations

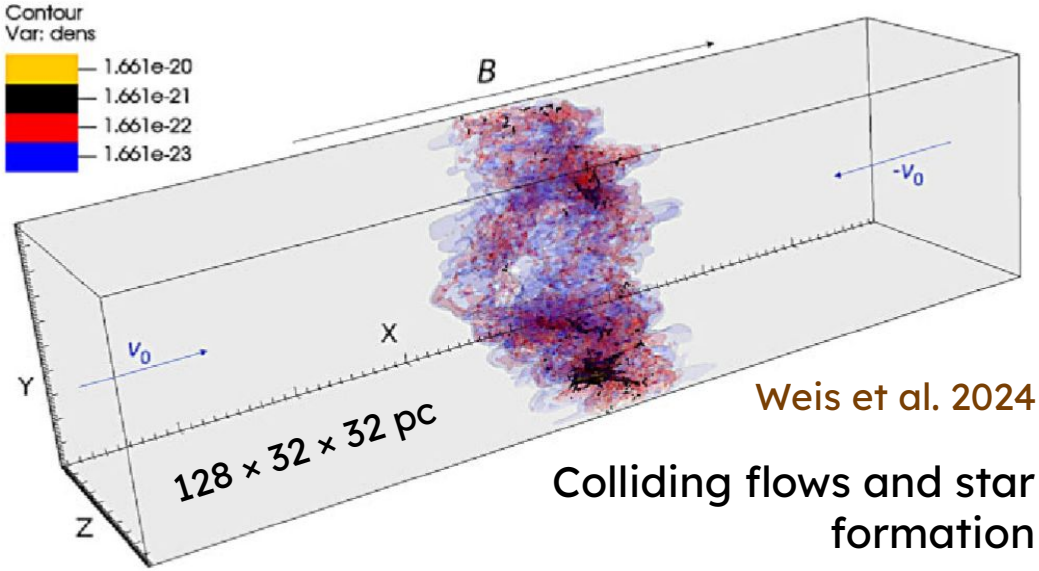


Rathjen et al. 2021



Rathjen et al. 2023

Cores formation

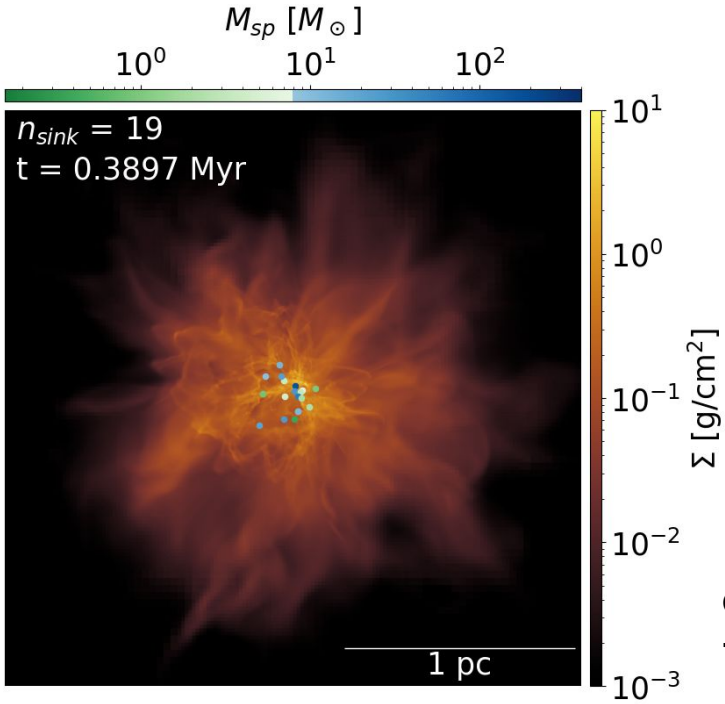


Weis et al. 2024

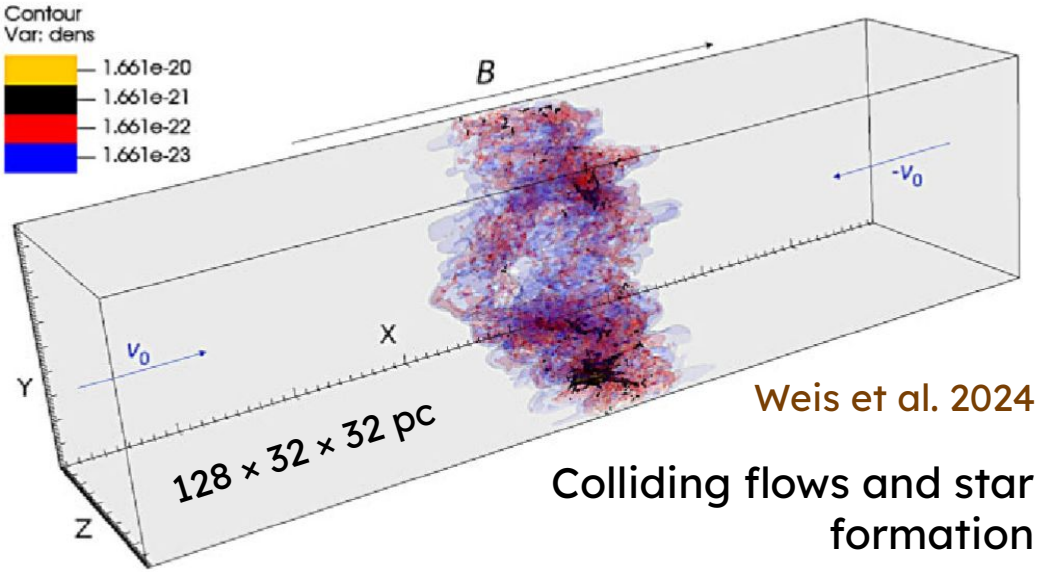
Colliding flows and star formation

Cores formation

Zimmermann et al. 2025



Dense core collapse and massive stars formation



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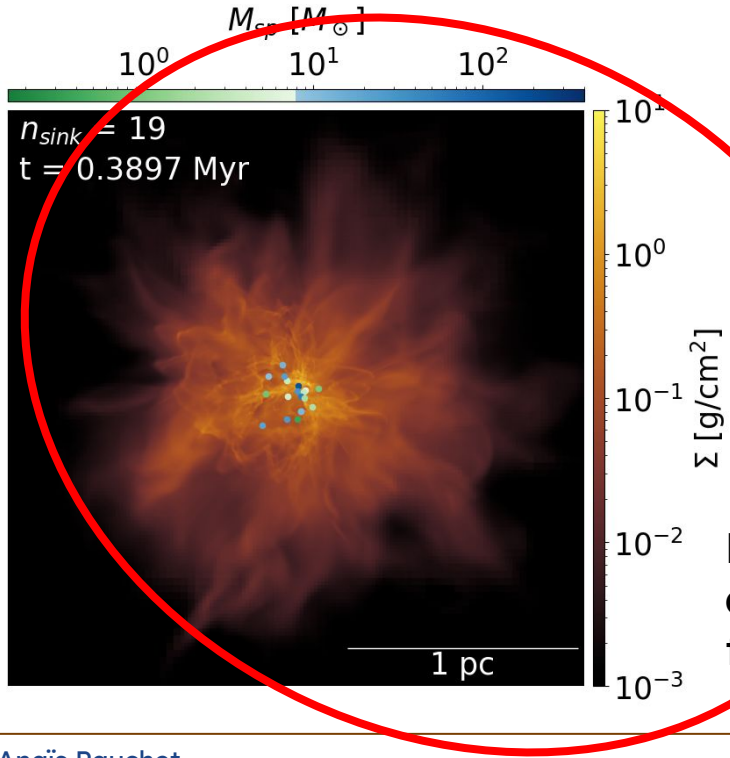
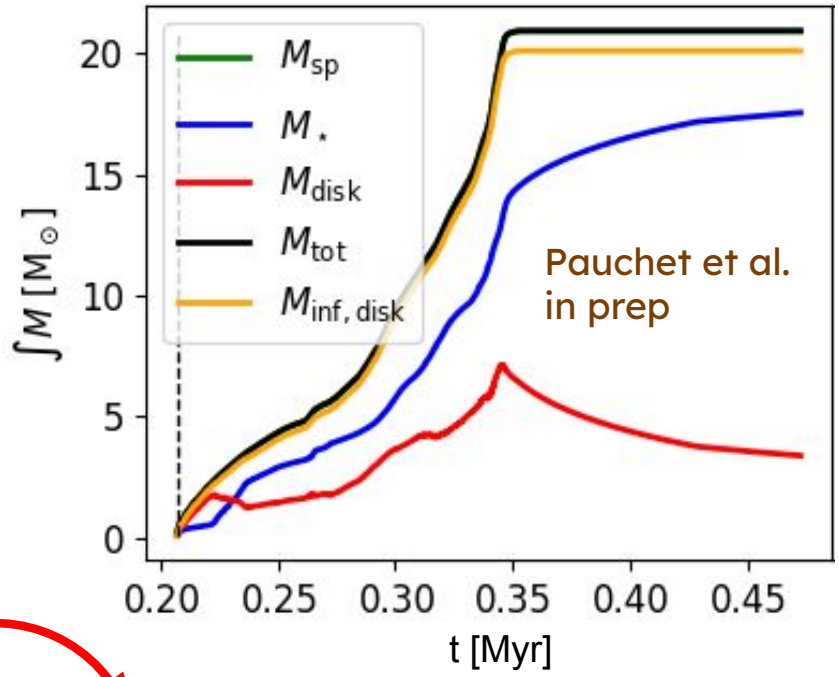


my work!

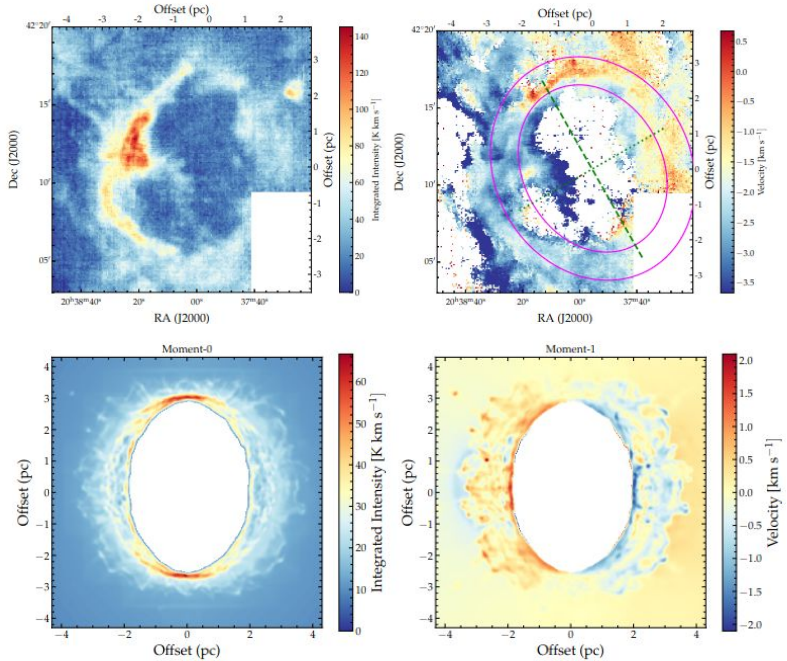


Dense core collapse and massive stars formation

Better description of sink particles to include protostellar disk physics

Feedback bubbles

Dannhauer, Vider et al. 2025



Diamond ring: observations vs simulations

Feedback bubbles

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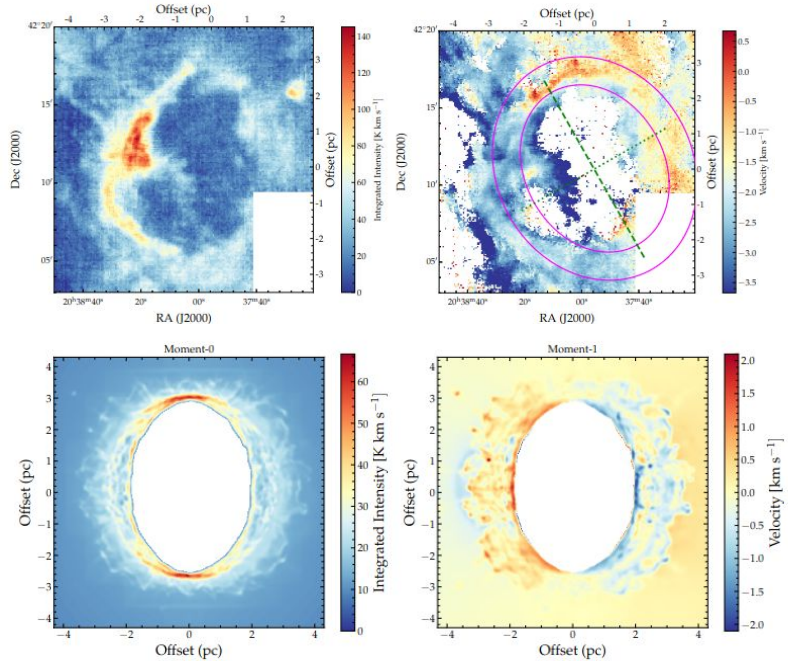
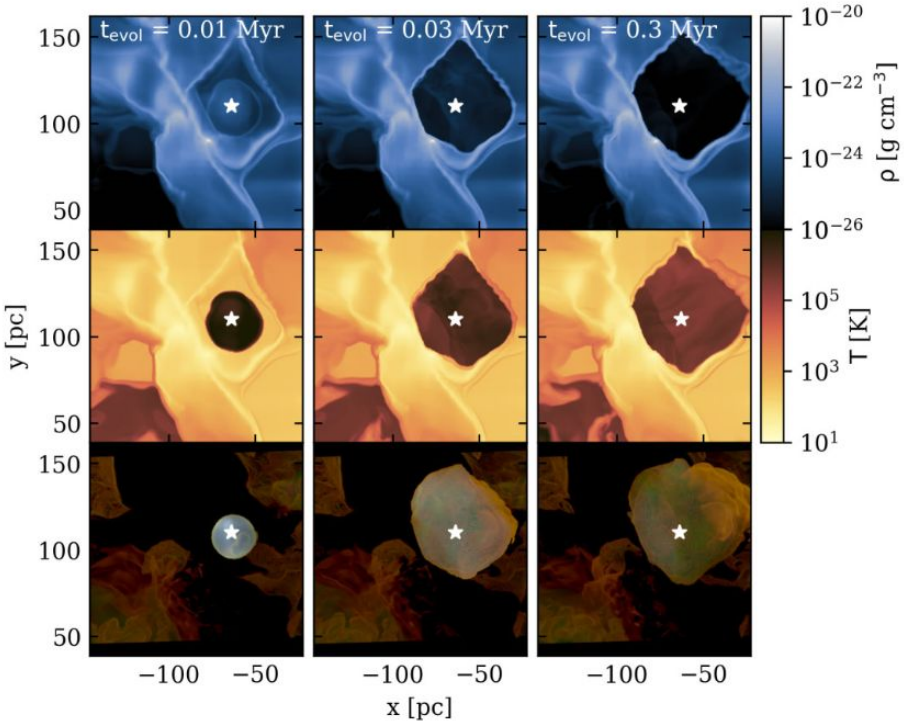


Diamond ring: observations vs simulations

Improved description of Supernova remnant cooling



Makarenko et al. 2023

Summary

- Large range of scales from au to kpc, yrs to Gyrs
- Large range of different environments, density, metallicity, turbulence…
- Large range of different physical conditions, feedbacks, magnetic field…
- Work closely with observations

Thank you for your attention :)