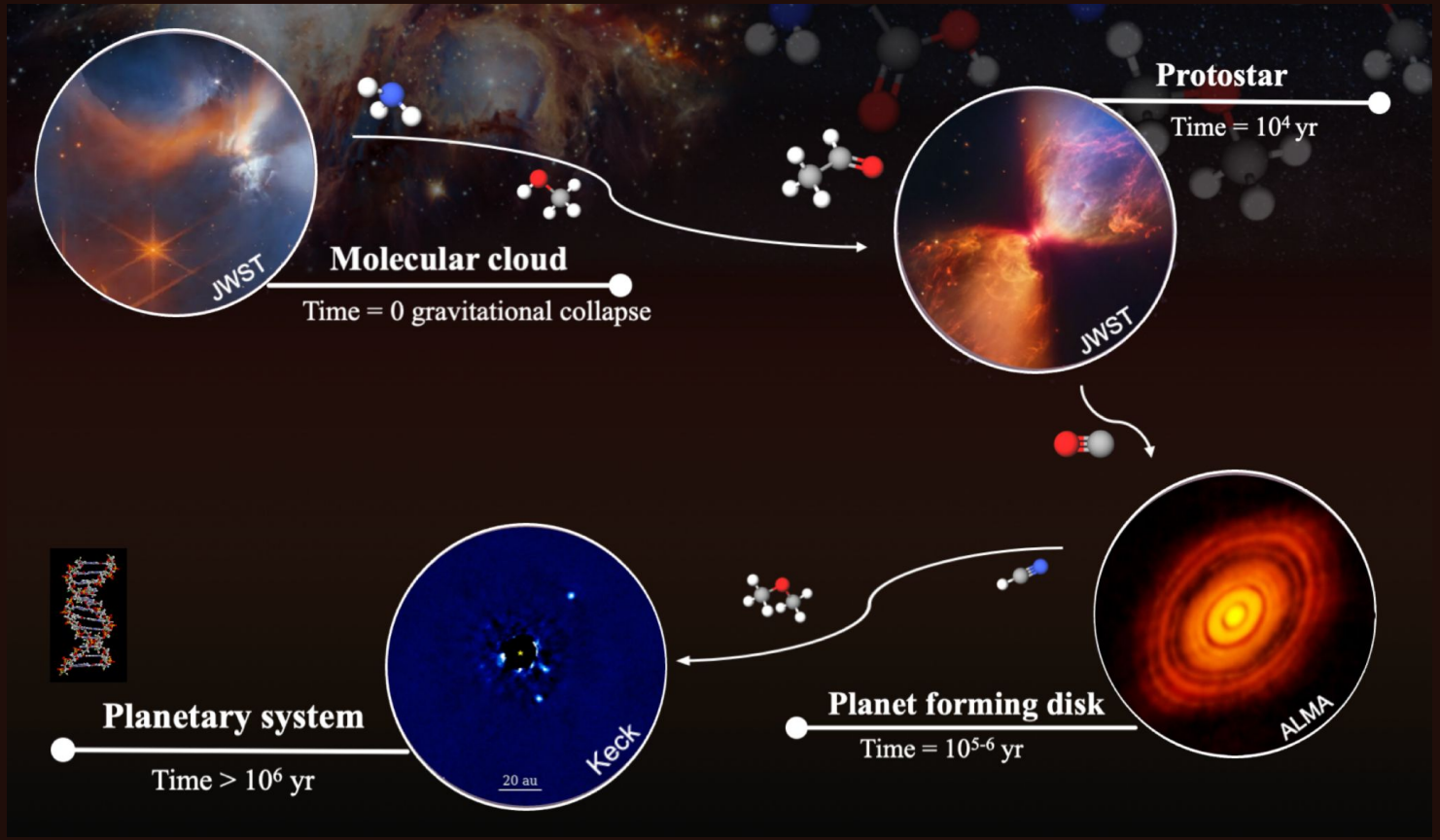
Star and Planet Formation



What are the global star formation properties in the Milky Way?

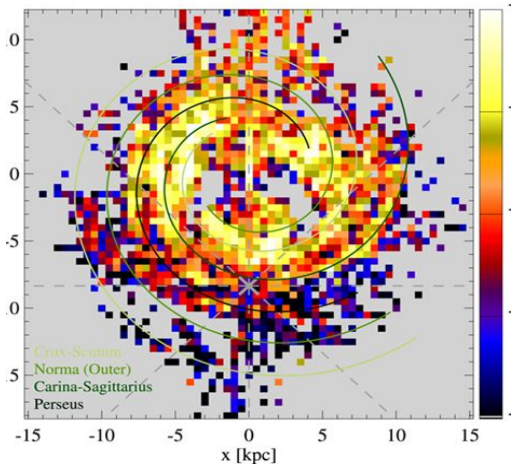
Aim: to build a global scheme of the star formation in the Milky Way that can be used as template for other galaxies

Large scale surveys of the Galactic plane and nearby star forming regions in continuum/polarimetry and molecular lines (MeerKAT, MeerKAT+, SKA, Roman, PRIMA, LOFAR, ngVLA, ASKAP, ALMA, AtLAST, GAIANIR, LETO)

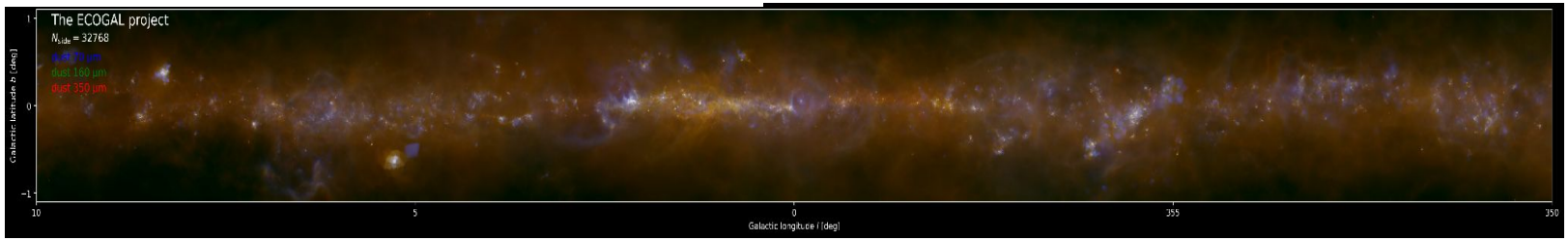
→ To derive global properties across the Galactic plane

Development of **advanced theoretical models of the MW** and production of **synthetic observations** for a direct comparison with observations

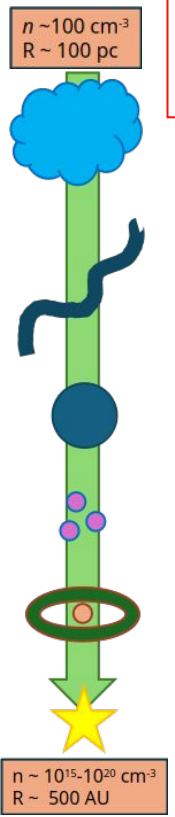
Map of the SFR density in MW (Elia+2022, 2025)



3-colors simulation of Galactic plane (*Pelkonen, in prep.*)



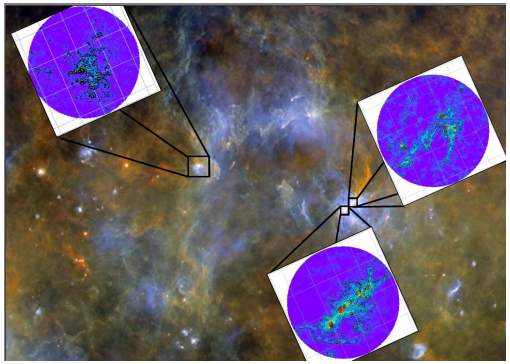
What is the role of the forces involved in star formation (gravity, turbulence, feedback, and magnetic fields) in shaping the ISM and driving the matter condensation?



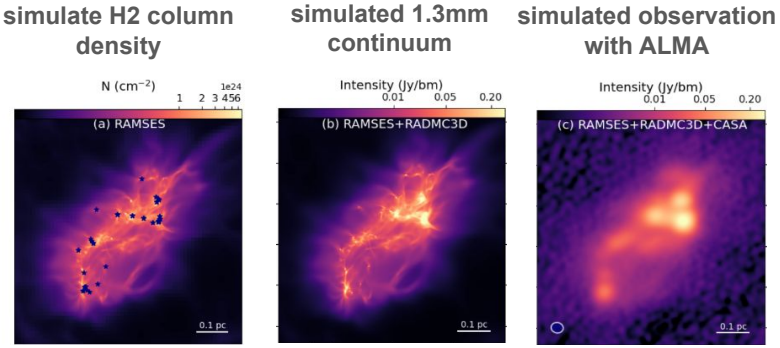
Aim: to trace the fragmentation cascade from large to small scales, connecting results and simulations of the different dense structures.

Large statistical surveys in continuum and spectroscopy of hundreds of high-density structures with different spatial scales from **filaments** (tens pc) to **clumps** (pc) and **cores** (thousands AU).

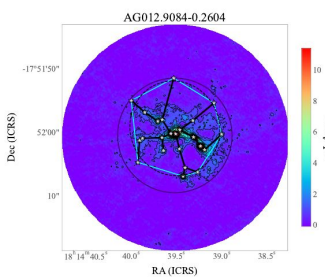
Development of **advanced theoretical models of star forming clumps** and production of **synthetic observations** for a direct comparison with observations



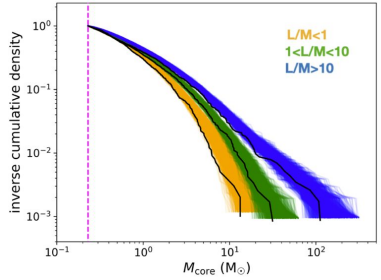
Continuum map Galactic Plane with zooming in compact clumps



Simulation of collapsing clump (*Nucara+2025*)



Spatial distribution of cores in high-mas clumps (*Schisano+2025*)

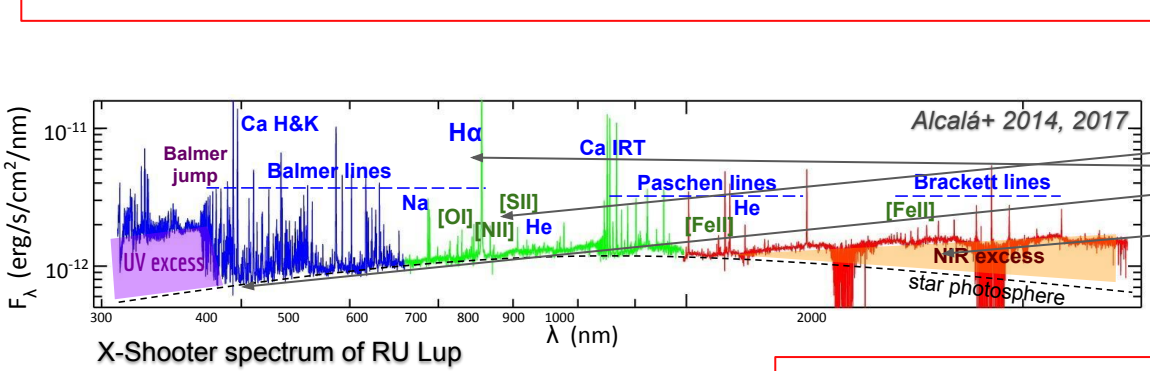


Core mass distribution (*Coletta+2025*)

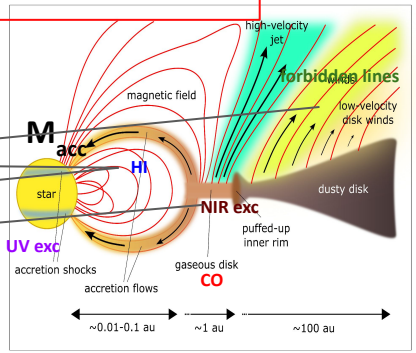
What are the processes that lead to the formation of individual stars?

Aims:

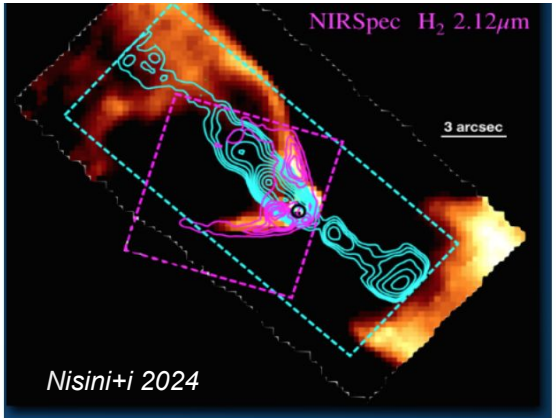
- to study all the components of the accretion/ejection regions (SoXS, X-Shooter,TNG)



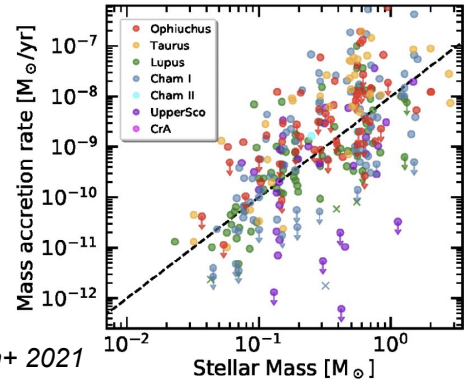
X-Shooter spectrum of RU Lup



- Surveys of SFR (ERIS, MOONS, 4MOST, KMOS, and in the future VLT: MAVIS, HRMOS,CUBES; ELT: ANDES, MORFEO; WST)

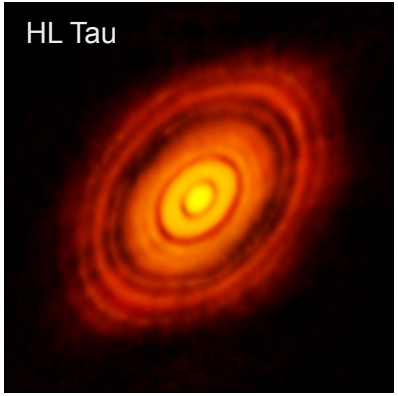


- to probe the jet launching regions in very embedded and young sources through near- and mid-infrared observations (JWST)



Manara+ 2021

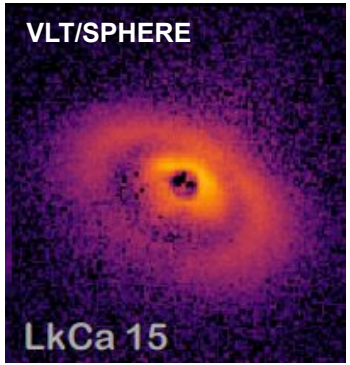
What are the conditions for the formation of planets ?



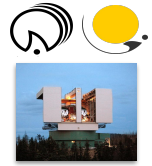
Aims

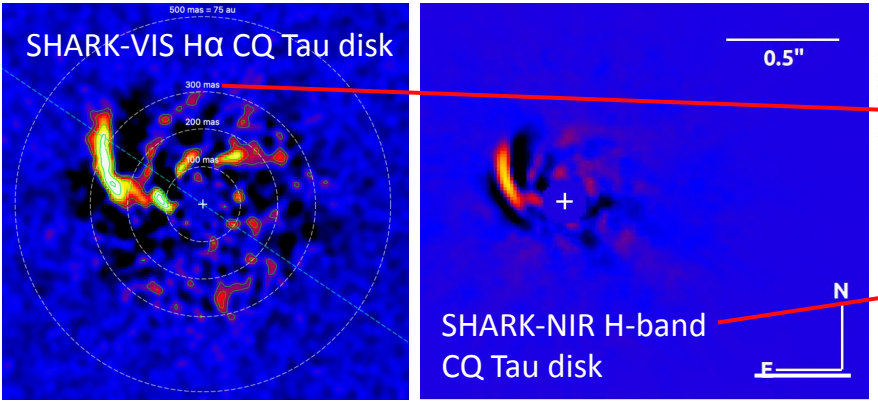
- to understand how and where planets form inside the protoplanetary disks (ALMA)

- to direct imaging of protoplanetary disks (SHARK-VIS, SHARK-NIR, VLT/SPHERE, VLT/ERIS, ELT/MORFEO)

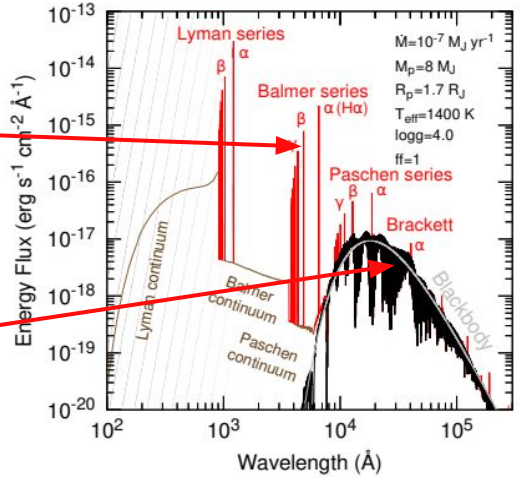


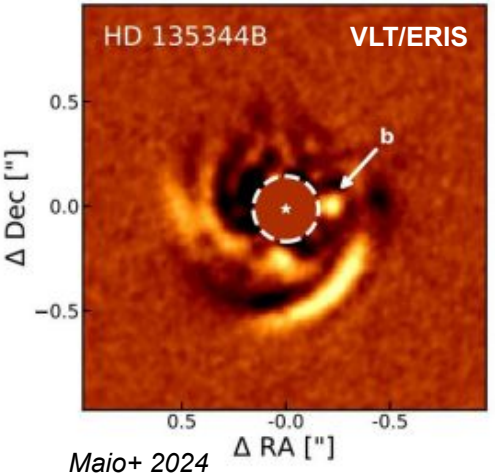
Garufii+ 2024





Antoniucci+ in prep.

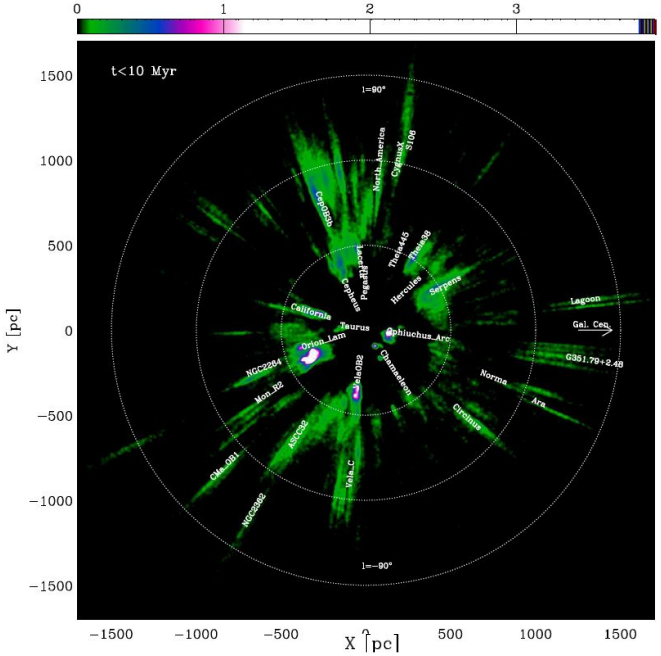




Maio+ 2024

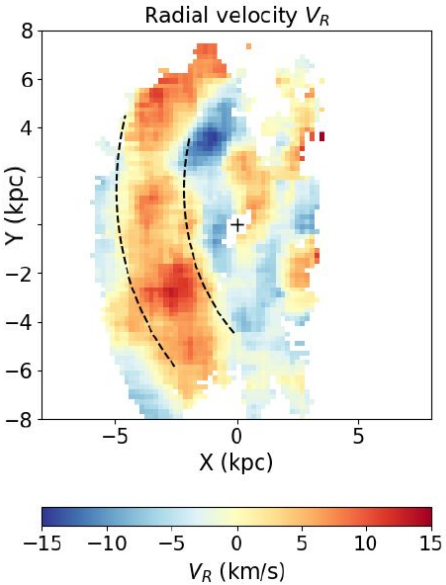
What are the effects of the star formation environment on the properties of stars and planets?

Do stars form in dense massive clusters or low-density associations?



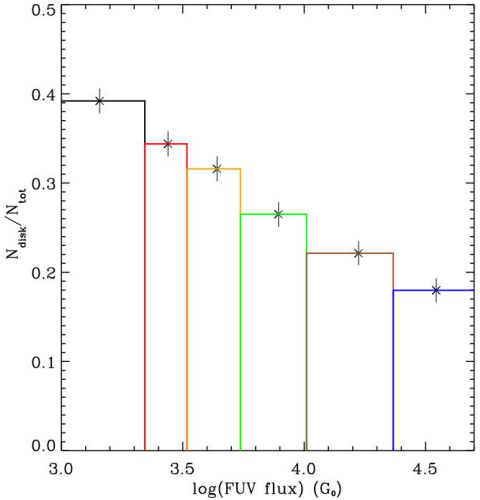
Prisinzano+2022

How the formation of stars is related with the large scales structures of the Galaxy?



Poggio+2025

What are the effects of the environment on protoplanetary disks?



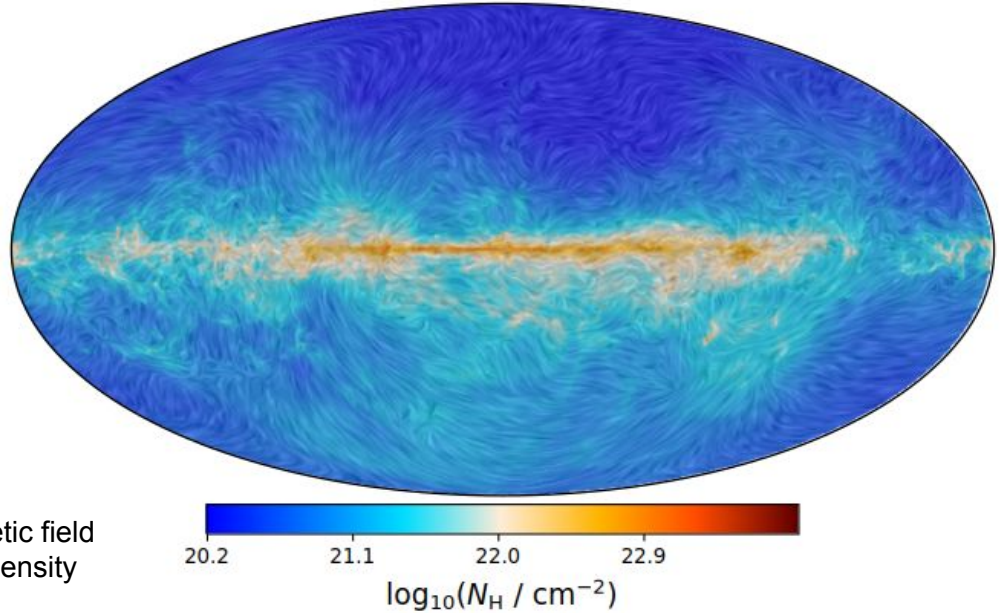
Guarcello+2023

Instruments: Gaia, JWST, Chandra, FLAMES, and in the future LSST, 4MOST MOONS, WEAVE, and WST

What is the role of magnetic fields?

Aim:

- to study the magnetic fields during formation processes via simulations and obs (NOEMA, ALMA, VLBI with masers)

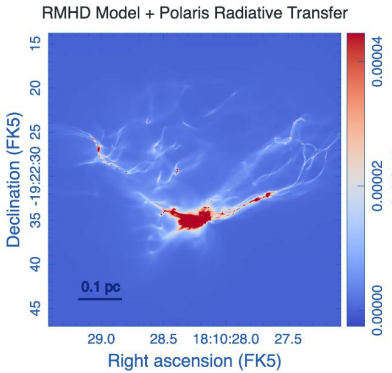


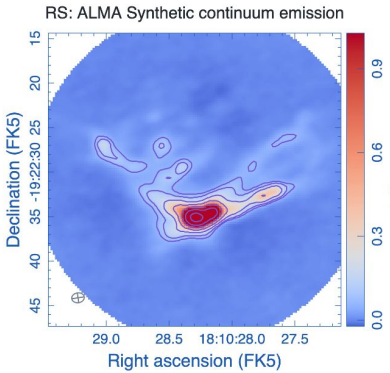
Full sky simulation of magnetic field orientation and H2 column density (*Pelkonen, in prep.*)

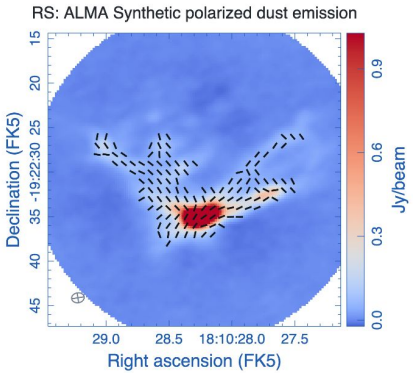
What is the role of magnetic fields?

Aim:

- to study the magnetic fields during formation processes via simulations and obs (NOEMA, ALMA, VLBI with masers)

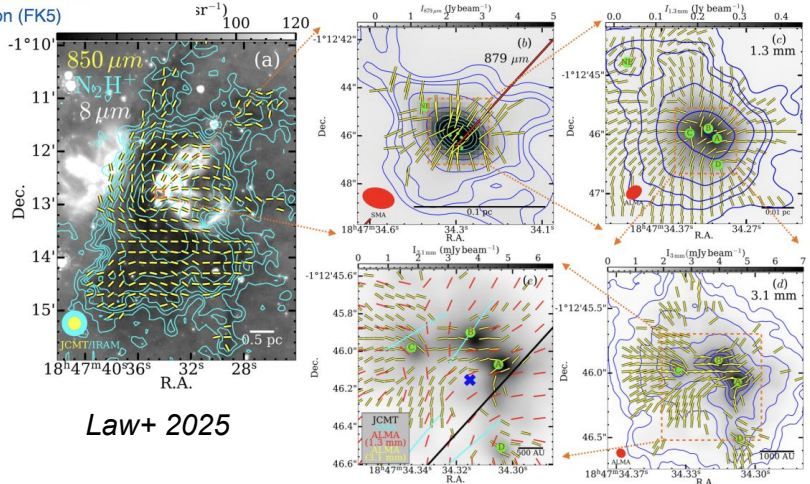






Simulation of magnetic field orientation and H2 column density in a high mass star forming clump (*Nucara, in prep.*)

G31.41+0.31

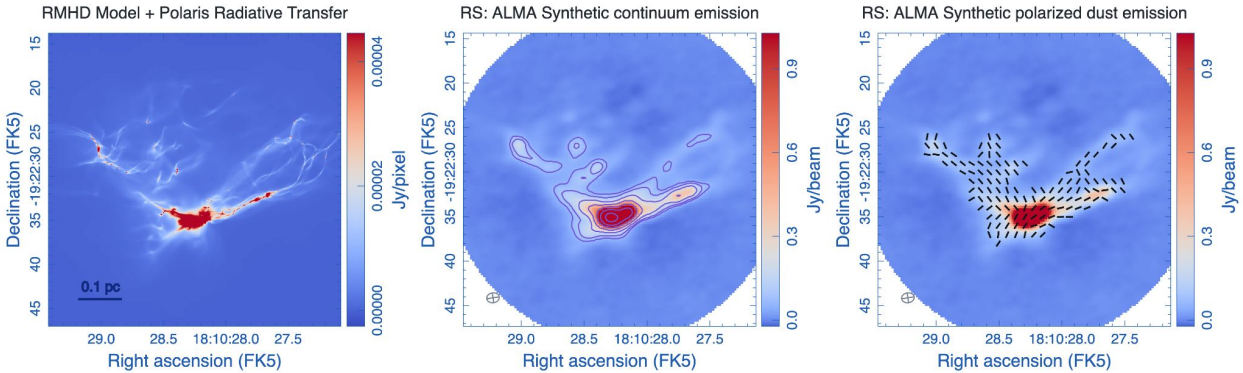


Law+ 2025

What is the role of magnetic fields?

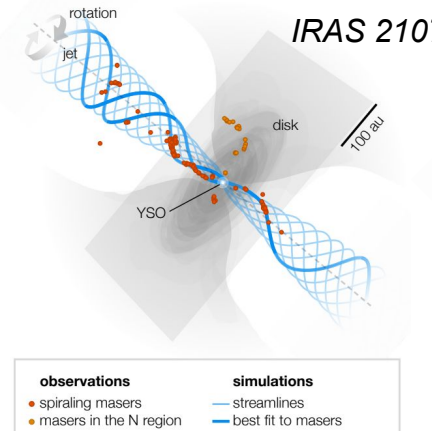
Aim:

- to study the magnetic fields during formation processes via simulations and obs (NOEMA, ALMA, VLBI with masers)

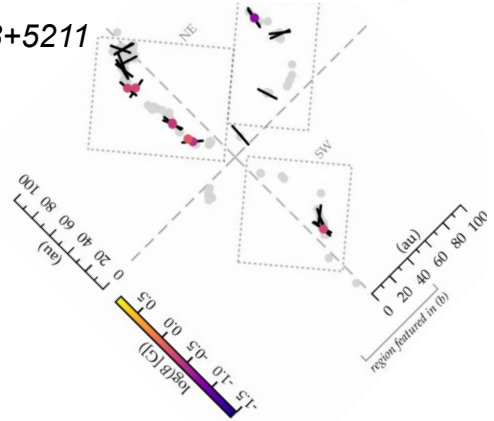


Simulation of magnetic field orientation and H2 column density in a high mass star forming clump (*Nucara, in prep.*)

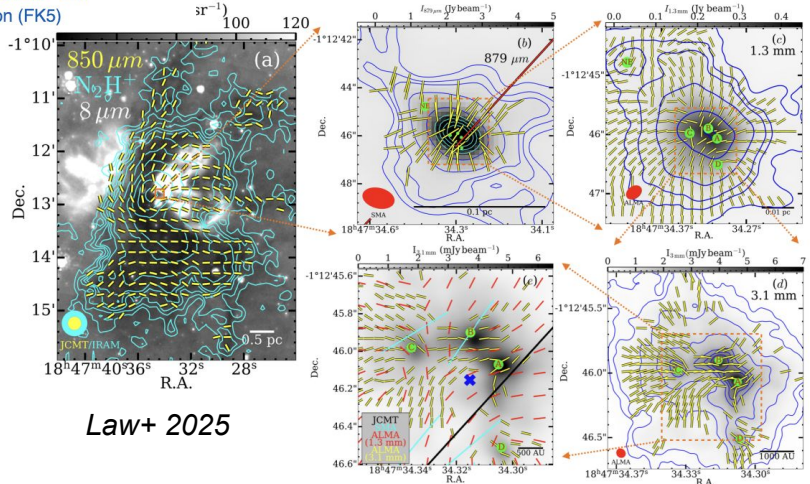
G31.41+0.31



IRAS 21078+5211

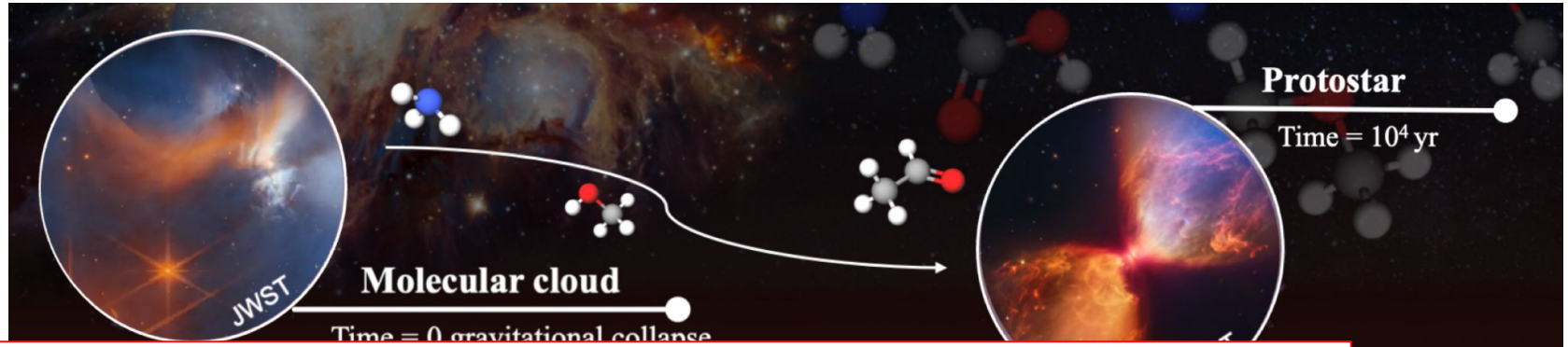


Moscadelli + 2023, 2024

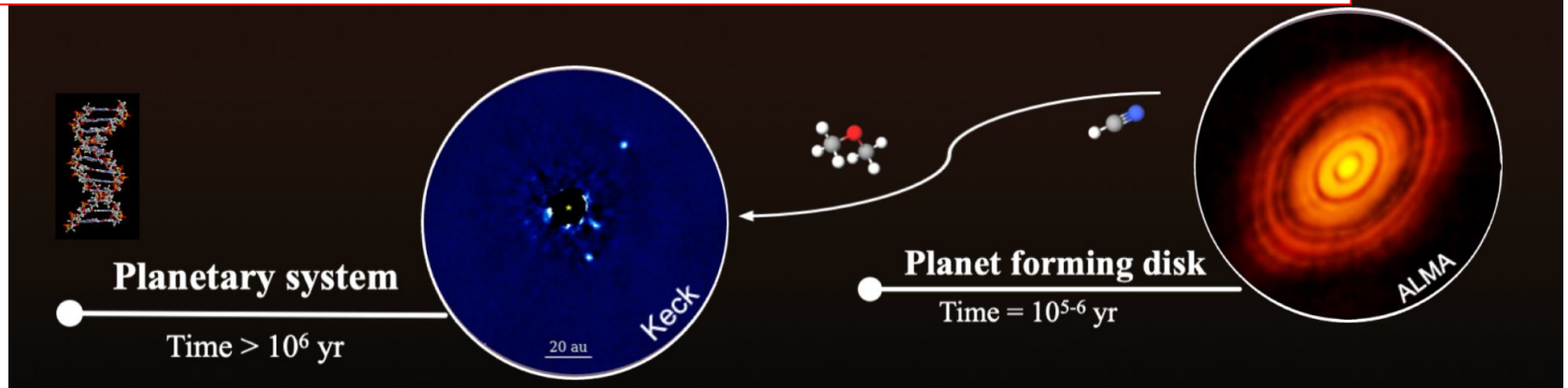


Law+ 2025

How does Astrochemistry reveal the origins of stars and planets?

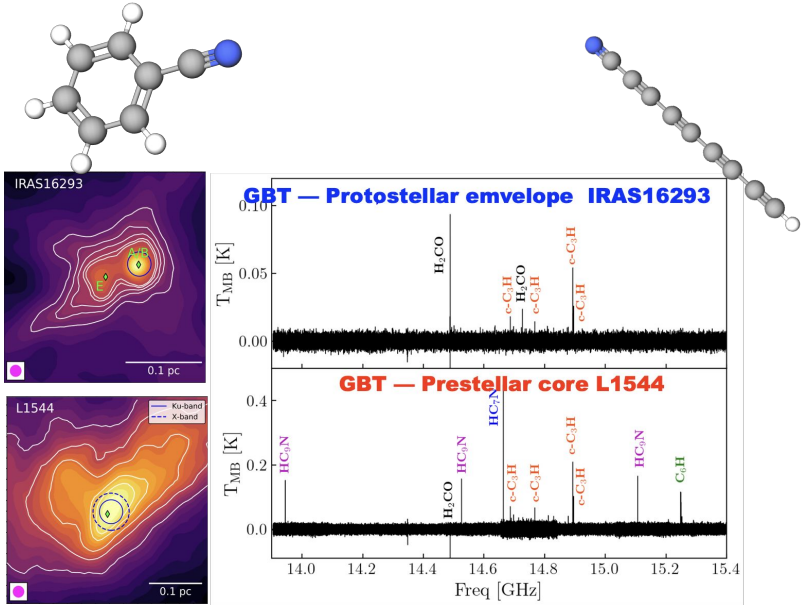


- How do chemical tracers reveal the physics and dynamics of star and planet formation?
- How does chemical complexity build up from prestellar cores to planets?
- Planetary composition: **chemical reset** or **inheritance**?



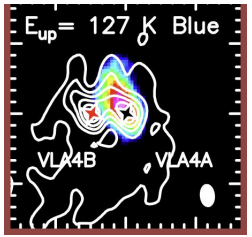
How does Astrochemistry reveal the origins of stars and planets?

Astrochemistry with ALMA revealed the physical processes and chemical complexity of star- and planet-forming regions



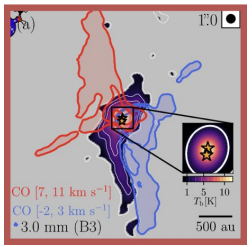
Bianchi+2022, Giani+2025

YOUNG DISKS



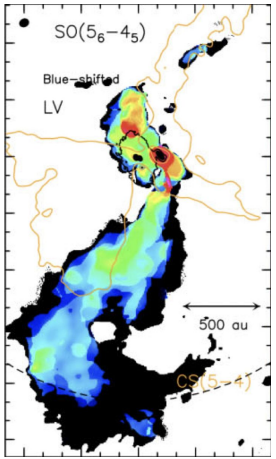
Bianchi+2022

DUST CAVITIES

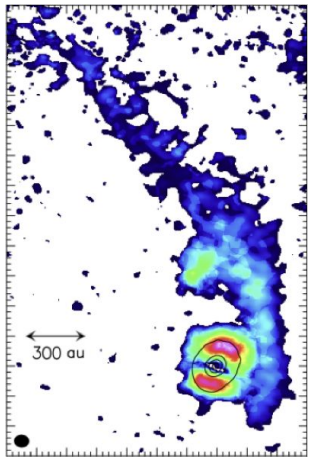


Sabatini+ 2024, 2025

STREAMERS



Podio+ 2024



Codella+ 2024

Observations at cm revealed an unprecedented chemical complexity of carbon chains and rings in the cradles of Sun-like protostars

Summary

- What are the global star formation properties in the Milky Way?
- What are the role of the forces involved in the star formation process (gravity, turbulence, feedback, and magnetic fields) in shaping the ISM and driving the matter condensation?
- What are the processes that lead to the formation of individual stars?
- What are the conditions for the formation of planets ?
- What are the effects of the star formation environment on the properties of stars and planets?
- What is the role of magnetic fields?
- How does Astrochemistry reveal the origins of stars and planets?