The Galactic dynamics

revealed by the filamentary structure in the

atomic hydrogen (HI) emission

Juan Diego Soler
Istituto di Astrofisica e Planetologia Spaziali

THOR collaboration: H. Beuther, J. Syed, Y. Wang, Th. Henning, L. D. Anderson, N. M. McClure-Griffiths, P. F. Goldsmith, M. Heyer, K. M. Menten, M. Rugel, J. S. Urquhart, J. Stil, R. Shanahan
ECOgal collaboration: S. Molinari, R. S. Klessen, P. Hennebelle, S. C. O. Glover, A. Trafficante, E. Schisano, D. Elia, M. Sormani, R., Tress, P. Girichidis, R. J. Smith, T. Colman

Epistemology tab

Soler & Nicoglou. Société d'histoire et d'épistémologie des sciences. 2022

How do the Sun and other stars form?

- What is the Sun made of?

The composition of the Sun

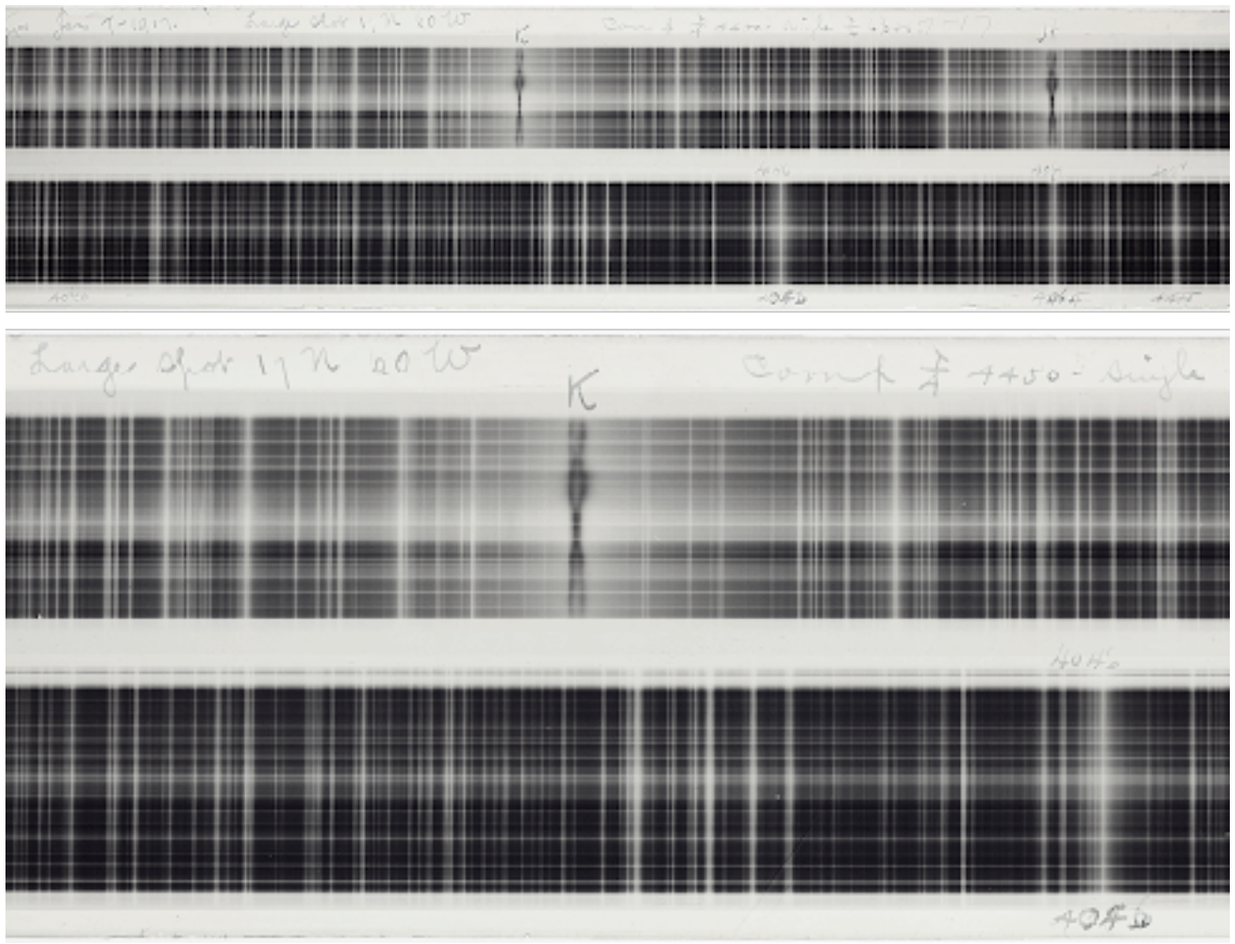
Payne, C. 1925. PhDT. Radcliffe College.

STELLAR ATMOSPHERES

A CONTRIBUTION TO THE OBSERVATIONAL STUDY OF HIGH TEMPERATURE IN THE REVERSING LAYERS OF STARS

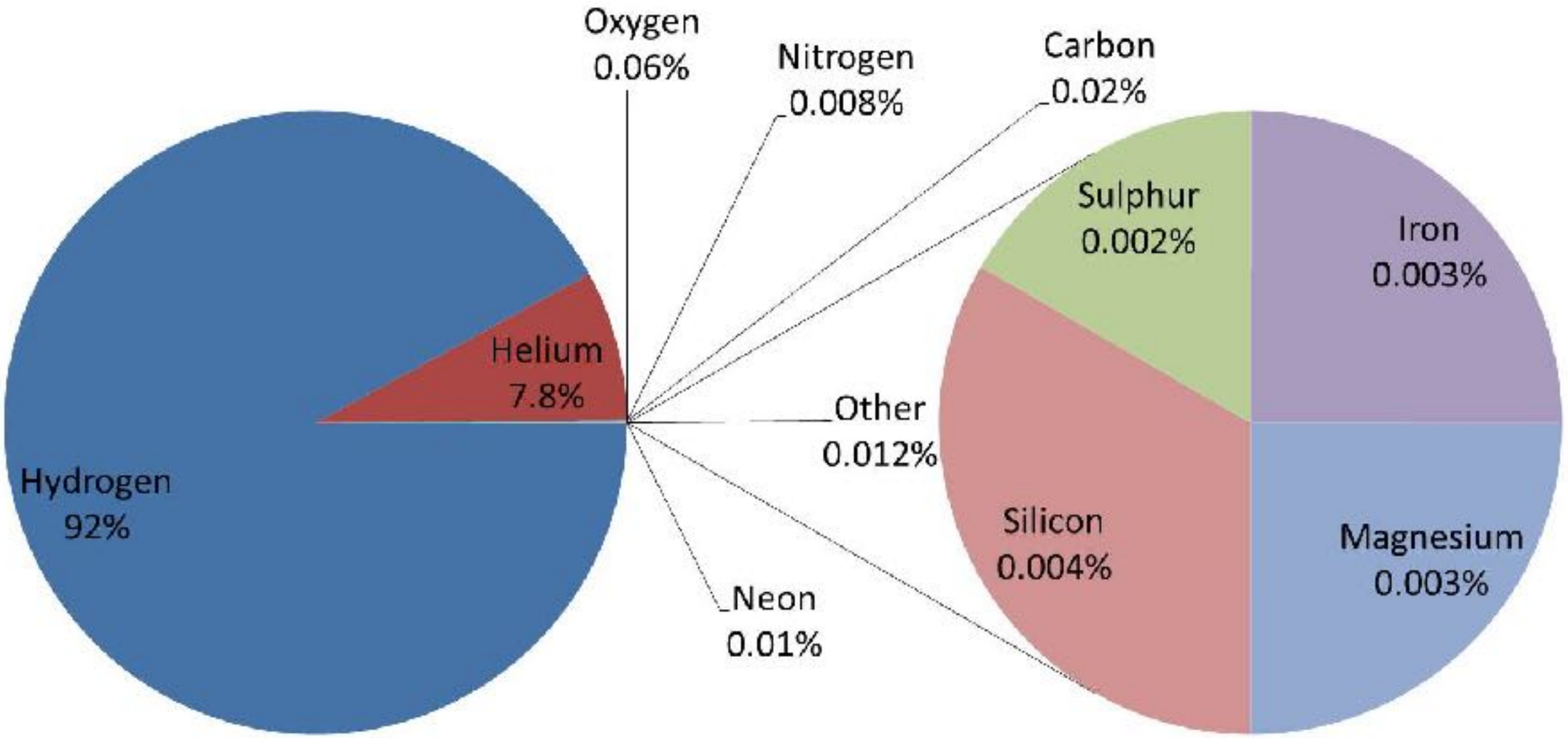
BY

CECILIA H. PAYNE



The composition of the Sun (by number of atoms)

M. Asplund, A. Amarsi, and N. Grevesse 2021, A&A, 653, A141



Epistemology tab

Soler & Nicoglou. Société d'histoire et d'épistémologie des sciences. 2022

How do the Sun and other stars form?

- What is the Sun made of?
  Mostly hydrogen ($n \sim 10^{25}$ cm^{-3})

- Where is the hydrogen before it becomes a star?

Atomic hydrogen emission

Netherlands. June, 1941.

Photo: Nationaal Archief

Juan D. Soler (IAPS, Rome)

Atomic hydrogen emission

Harold Ewen y Edward Purcell.
Lyman Laboratory - Harvard University. March, 1951

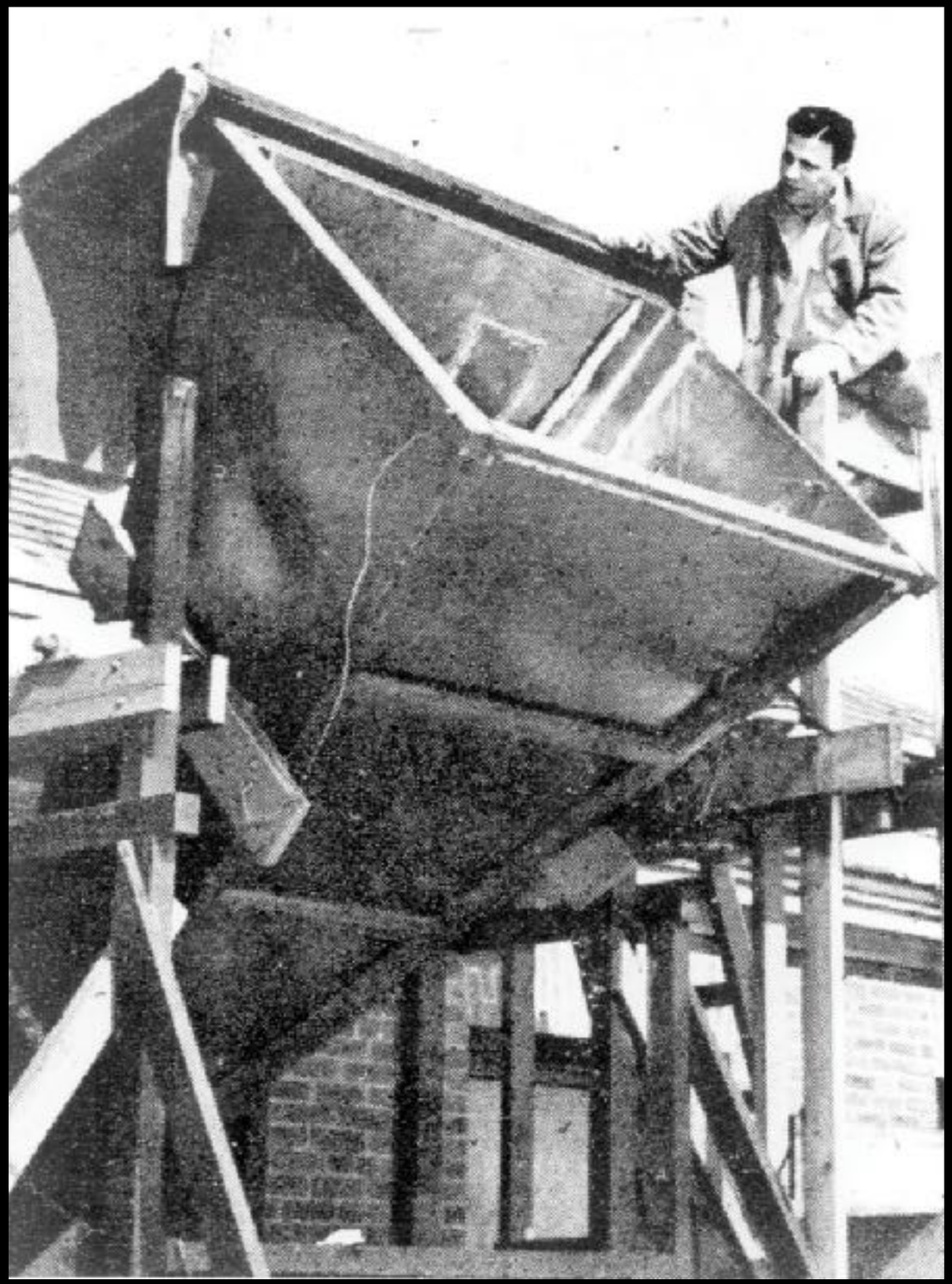
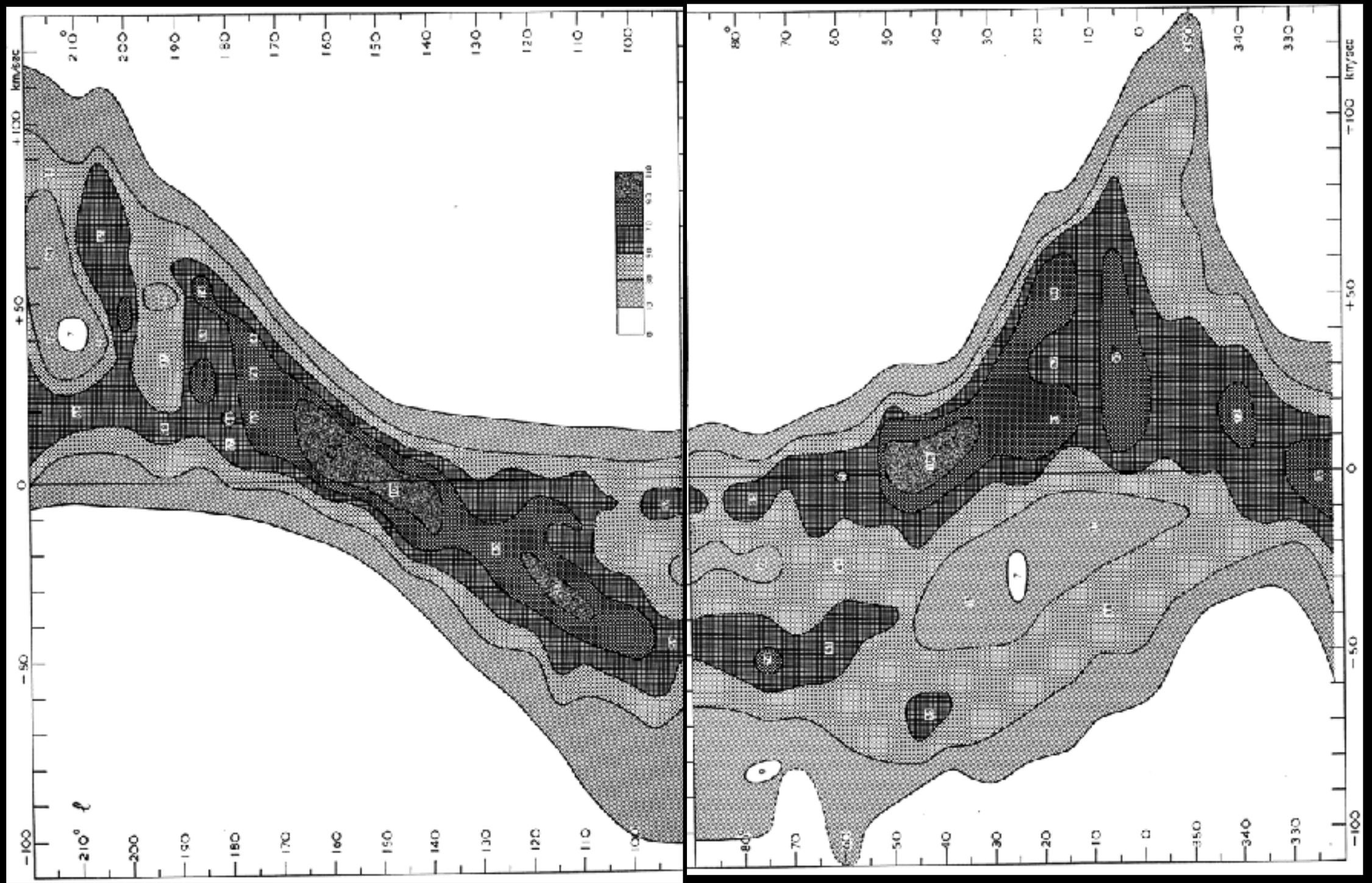


Photo: NRAO

Atomic hydrogen emission toward the Milky Way

van de Hulst, Muller & Oort (1954).



Epistemology tab

Soler & Nicoglou. Société d'histoire et d'épistémologie des sciences. 2022

How do the Sun and other stars form?

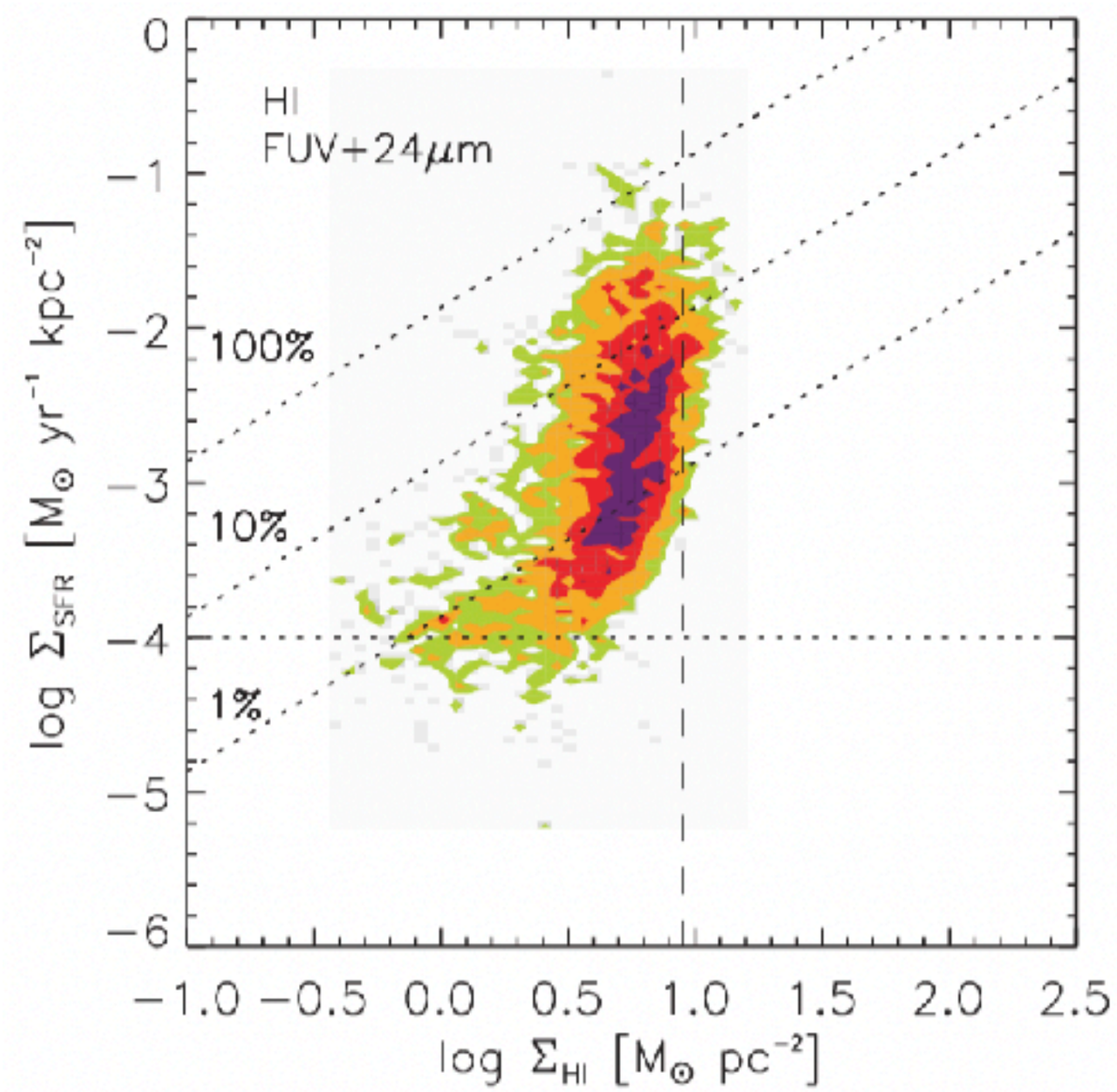
- What is the Sun made of?
  Mostly hydrogen ($n \sim 10^{25}$ cm^{-3})

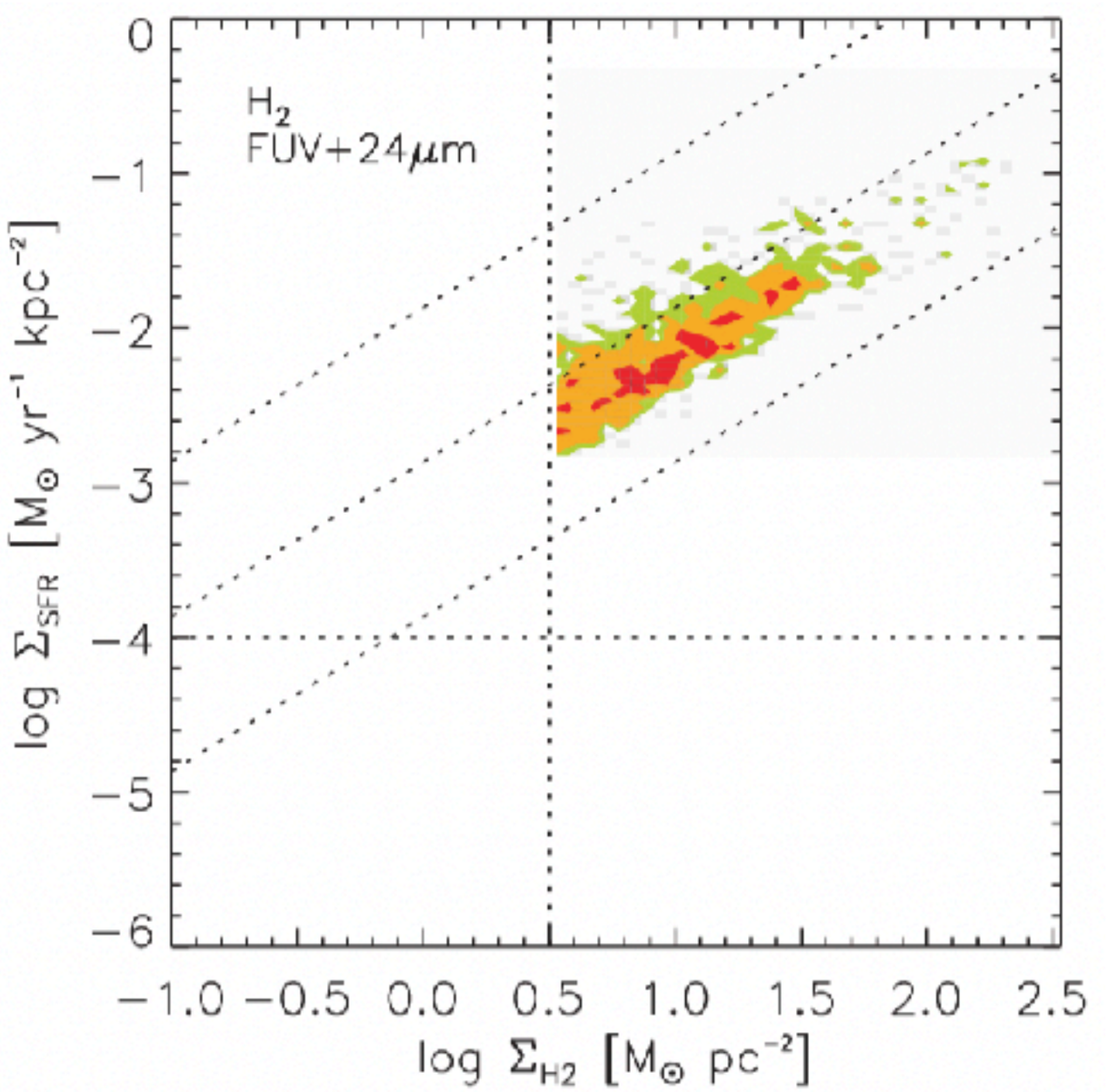
- Where is the hydrogen before it becomes a star?
  Almost everywhere in the Milky Way ($n \sim 1$ cm^{-3})

- How is the hydrogen becoming stars?

Star formation and gas surface density

Bigiel et al. 2008; 18 nearby galaxies (2 < d < 15 Mpc), 750 pc resolution





Epistemology tab

Soler & Nicoglou. Société d'histoire et d'épistémologie des sciences. 2022

How do the Sun and other stars form?

- What is the Sun made of?
  Mostly hydrogen (n~10^{25} cm^{-3})

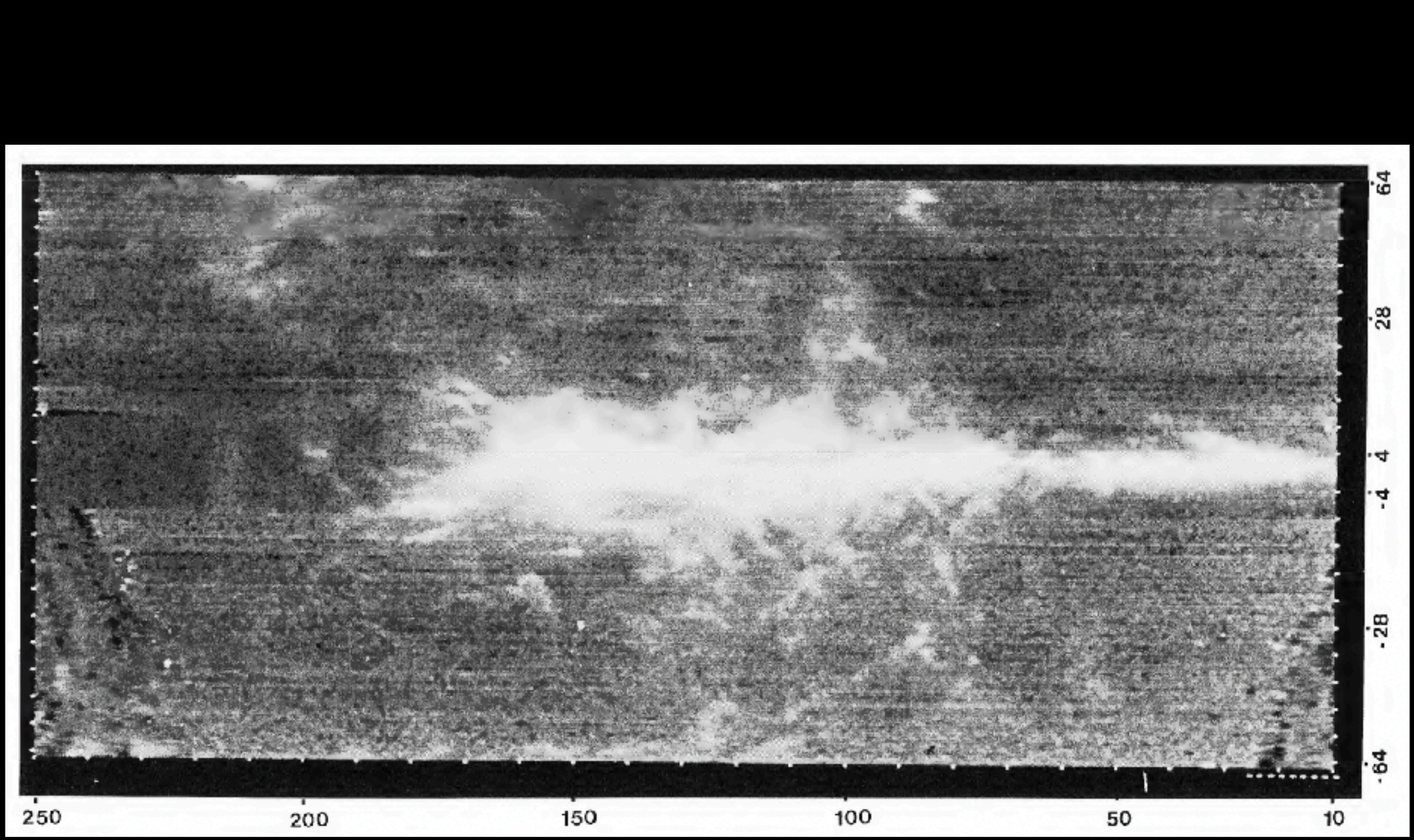
- Where is the hydrogen before it becomes a star?
  Almost everywhere in the Milky Way (n~1 cm^{-3})

- How is the hydrogen becoming stars?
  Hard question.

- How is the hydrogen before becoming stars?

Atomic hydrogen emission toward the Milky Way

Heiles (1984).



The HI, OH, and Recombination-line (THOR) survey

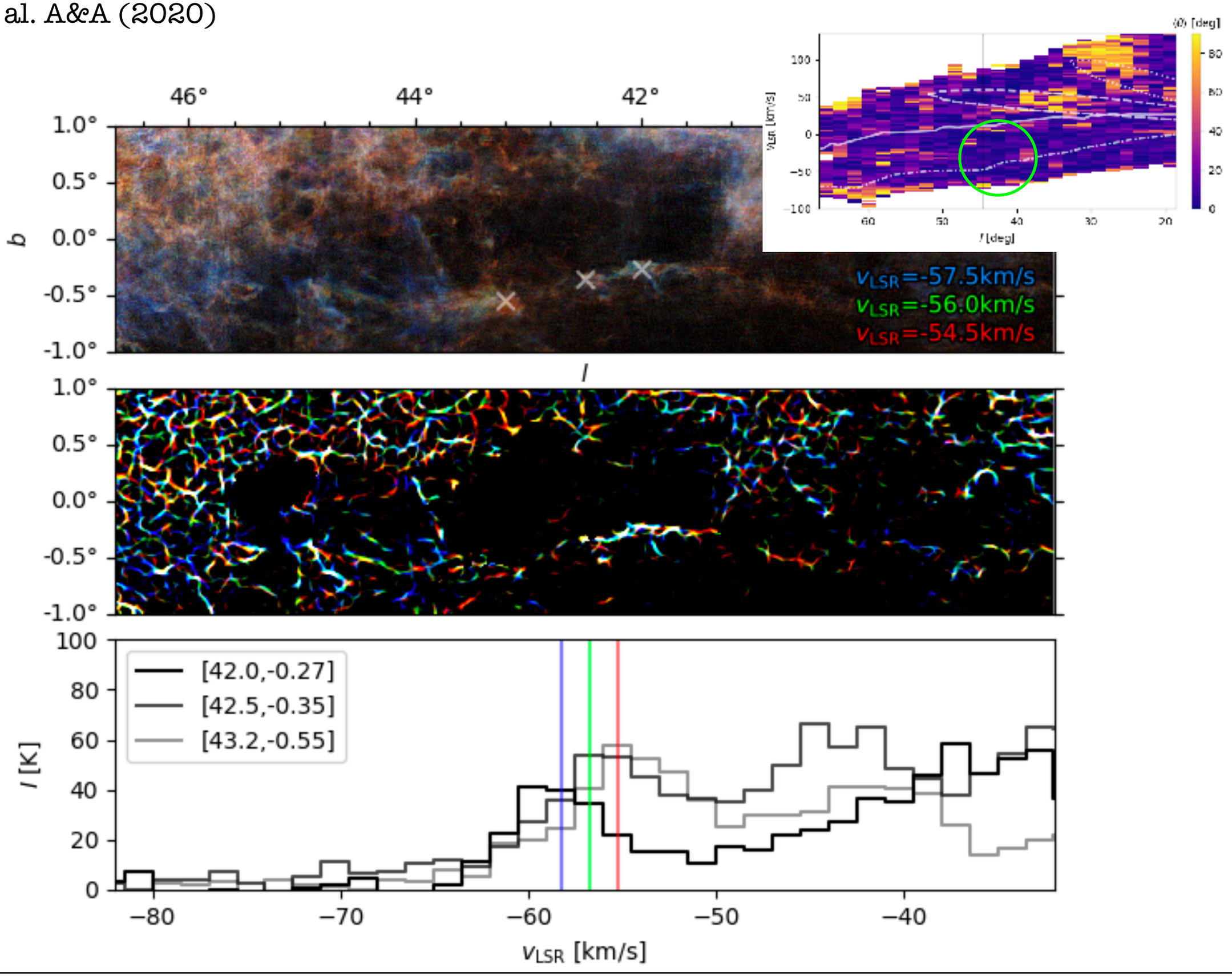
Wang, Y., et al. A&A 2020.

Video: J.D. Soler & T. Müller

Juan D. Soler (IAPS, Rome)

The Magdalena filament

Soler, J.D. et al. A&A (2020)



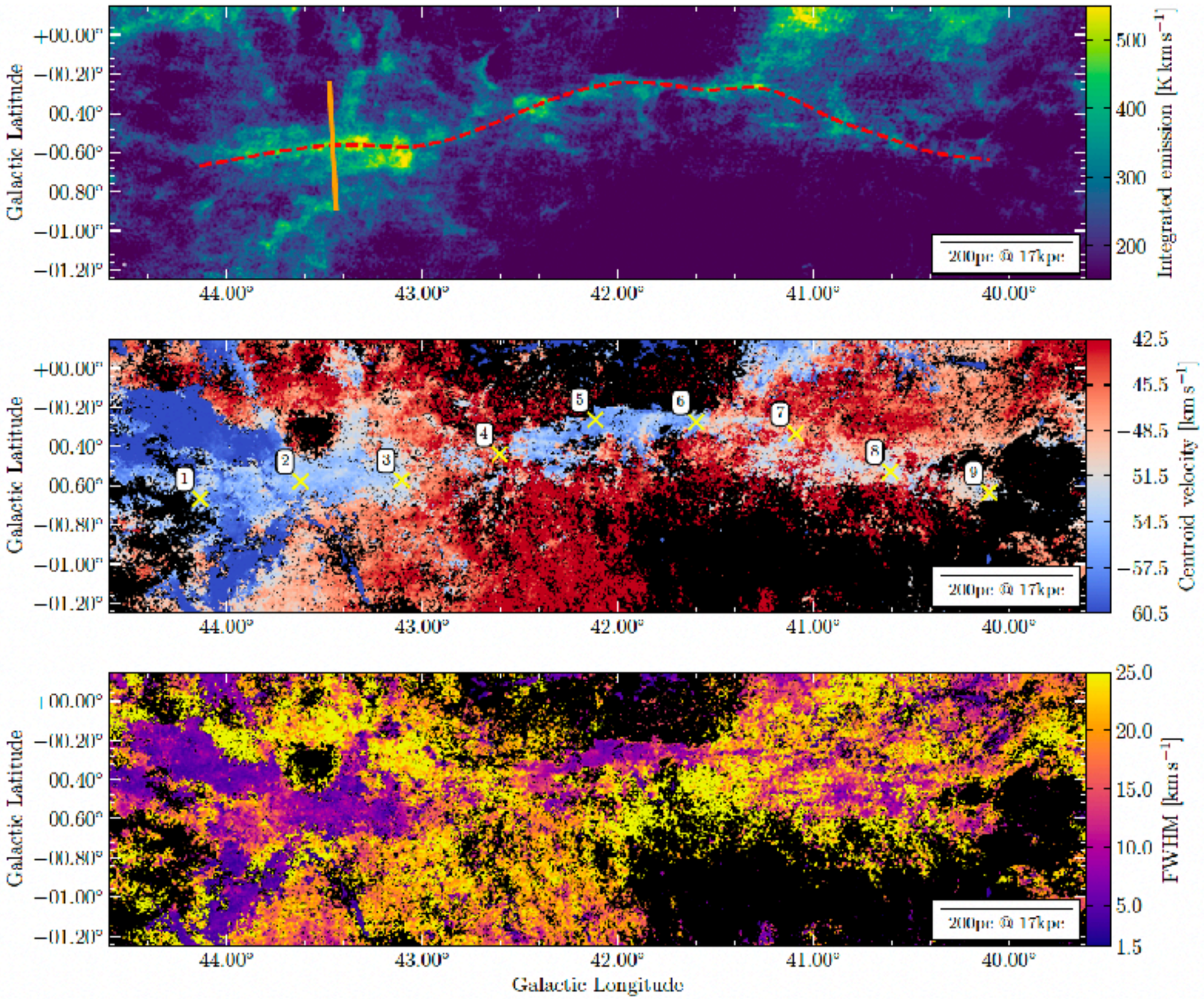
The Magdalena filament

Syed, J., et al. (2022)

N_{H}

$\langle v \rangle$

σ_v



Epistemology tab

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How do the Sun and other stars form?

- What is the Sun made of?
  Mostly hydrogen ($n \sim 10^{25}$ cm^{-3})

- Where is the hydrogen before it becomes a star?
  Almost everywhere in the Milky Way ($n \sim 1$ cm^{-3})

- How is the hydrogen becoming stars?
  Hard question.

- How is the hydrogen before becoming stars?
  Static properties: density, temperature, velocity*.
  Dynamics properties: ?

Epistemology tab

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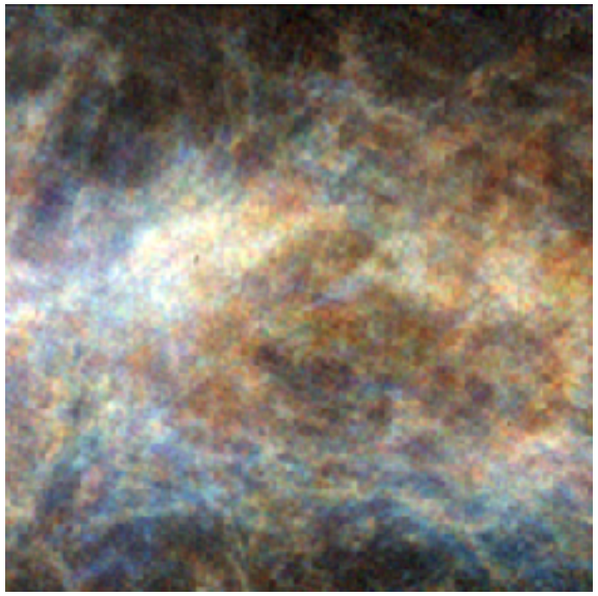
  Dynamics properties: ?

With two eyes

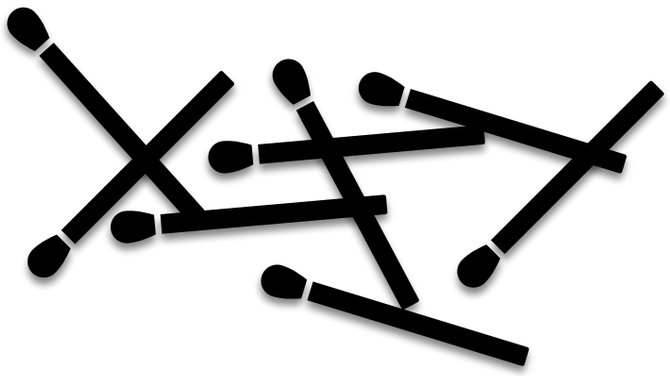
Epistemology tab

Soler & Nicoglou. Société d'histoire et d'épistémologie des sciences. 2022

Observations



Characteristics



Knowledge

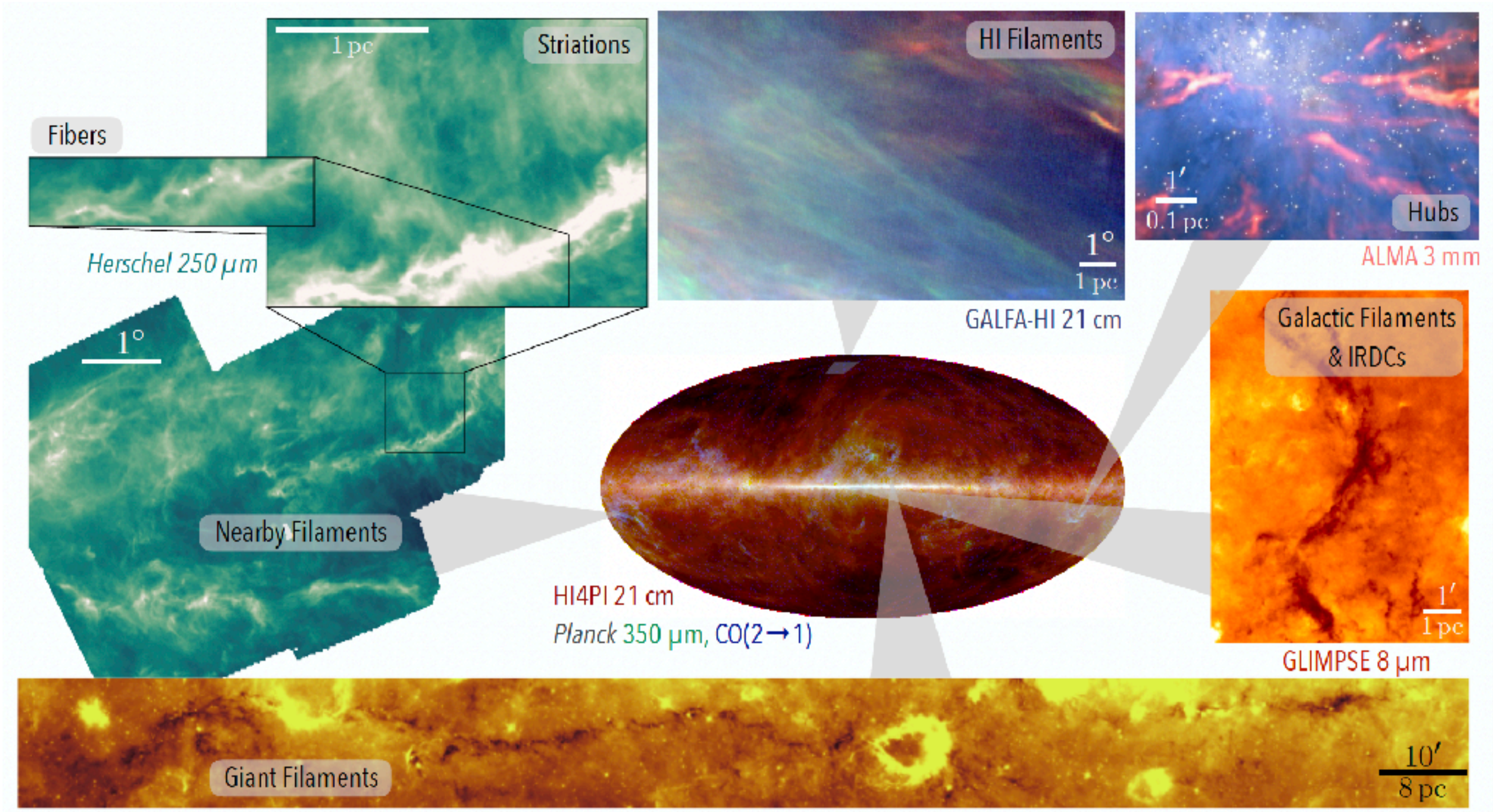
Why sticks?

Hacar et al. 2022. Protostars and Planets VII

"To a worm in horseradish the world is horseradish."

Why sticks?

Hacar et al. 2022. Protostars and Planets VII



Atomic hydrogen emission

GALFA-HI survey; Peek et al. 2018

Observations:
The Galactic Arecibo L-band Feed Array HI (GALFA-HI) Survey
Data set obtained with the Arecibo L-band Feed Array (ALFA) on the Arecibo 305m telescope.
Peek, J.E.G., et al. 2018 ApJS, 234:2

Music:
Gabriela Supelano

Movie:
Juan Diego Soler / IAPS-INAF

Epistemology tab

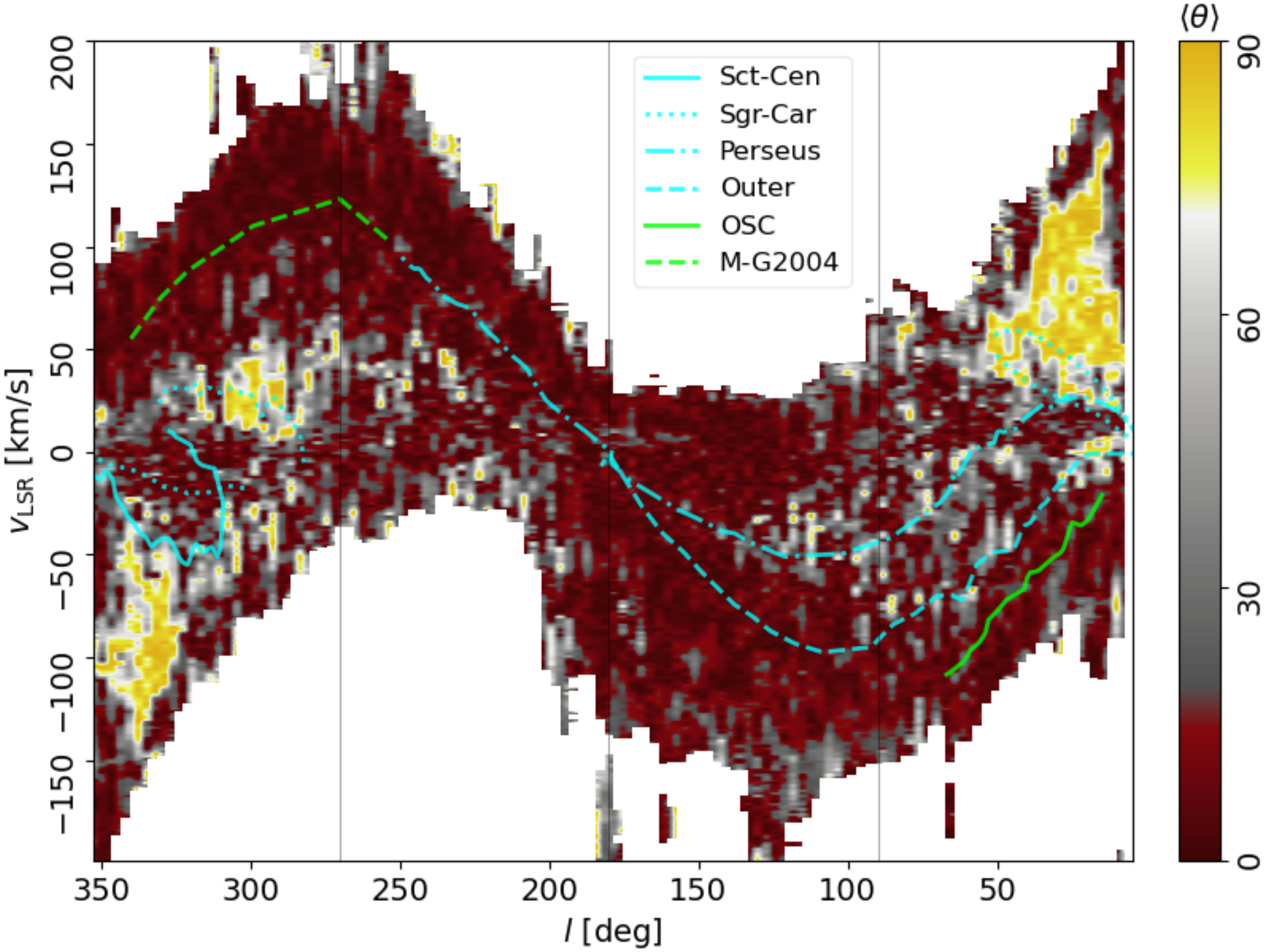
Soler & Nicoglou. Société d'histoire et d'épistémologie des sciences. 2022

How do the Sun and other stars form?

- What is happening to the hydrogen before becoming stars?
  It looks like a bunch of sticks.
- What is important about the sticks?
  - They are features in a 2D scalar field.
  - Properties:
    - Width
    - Length
    - Orientation ←

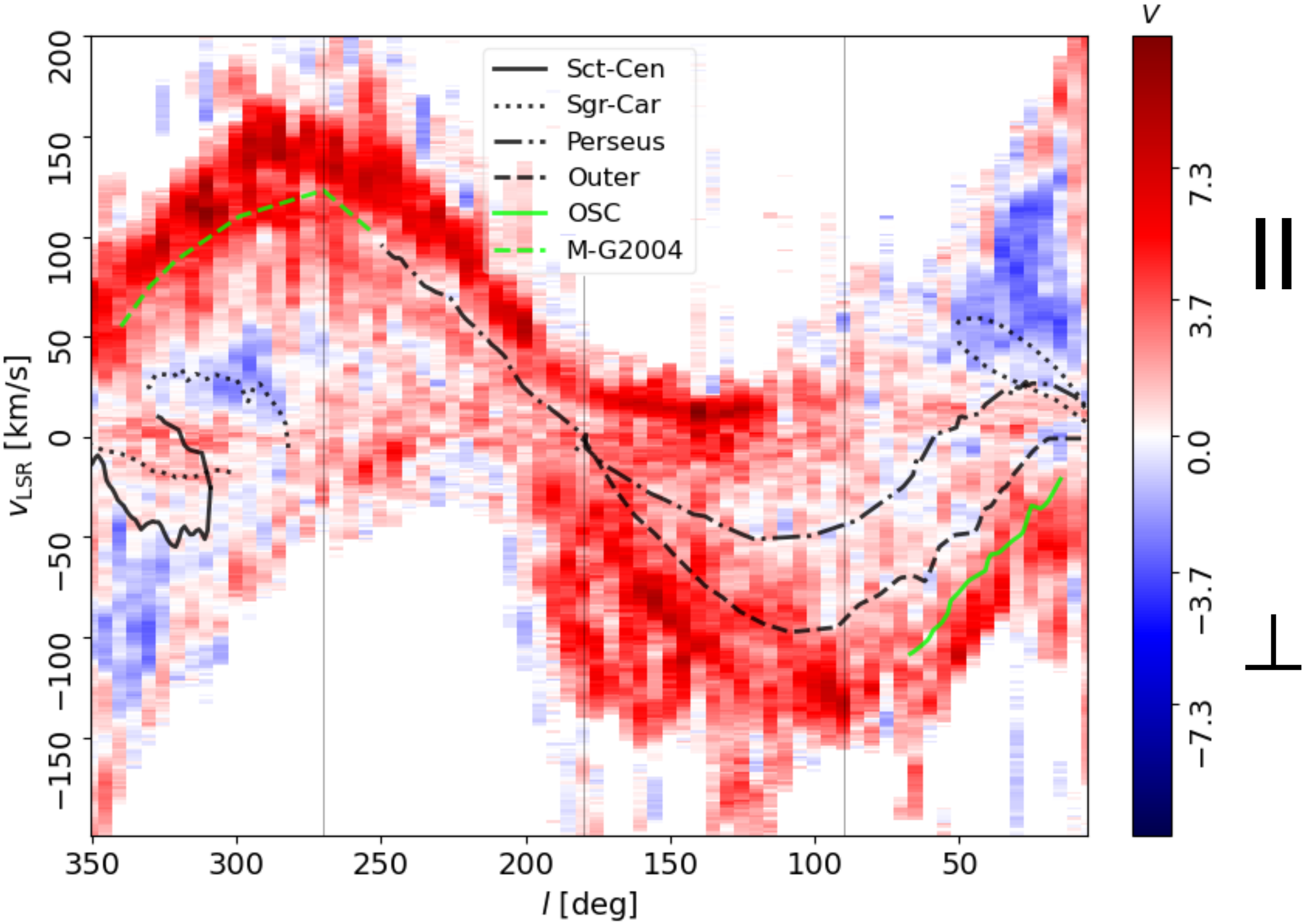
Orientation of atomic filaments

Soler, J.D. et al. 2022.



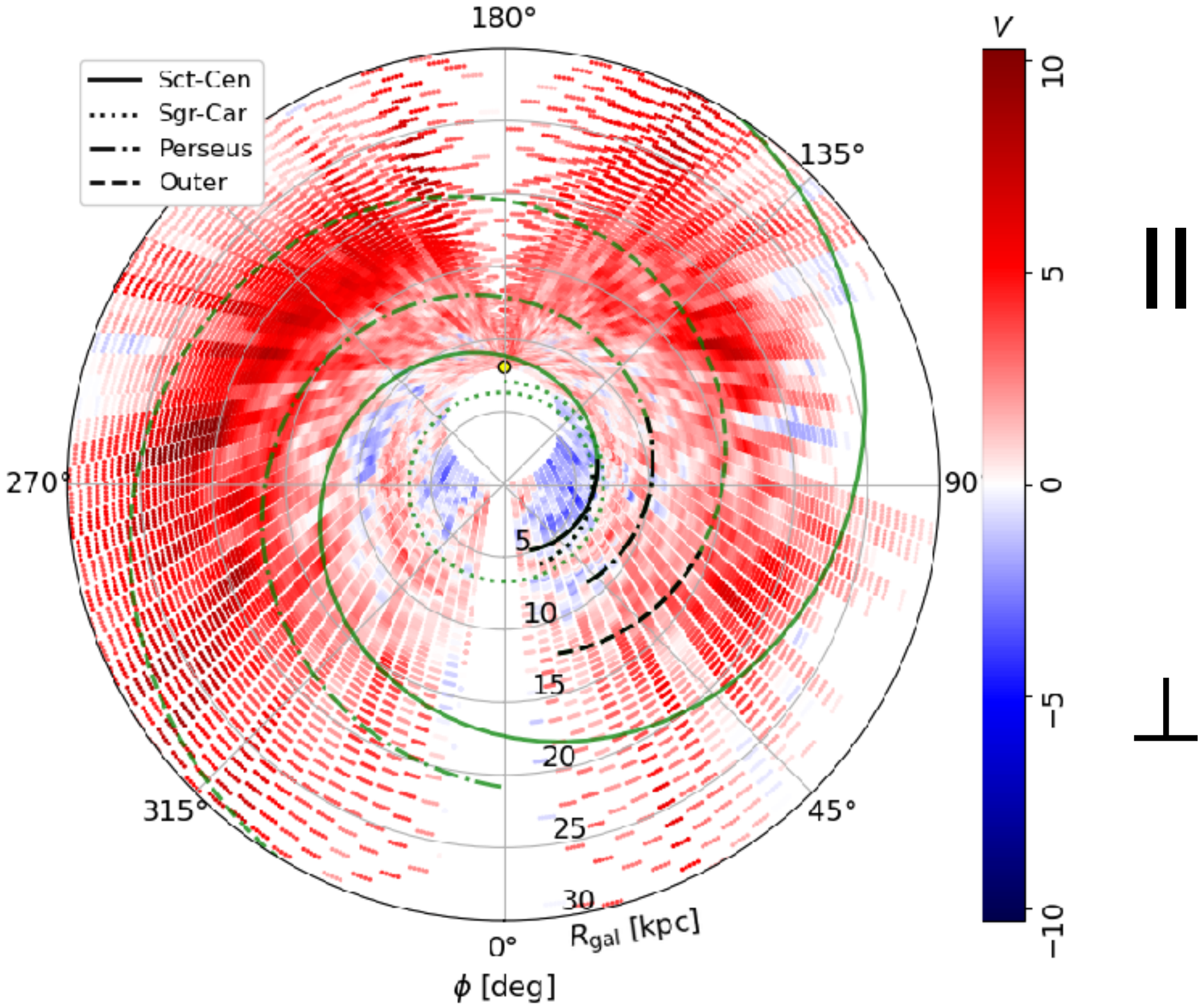
Orientation of atomic filaments

Soler, J.D. et al. 2022.



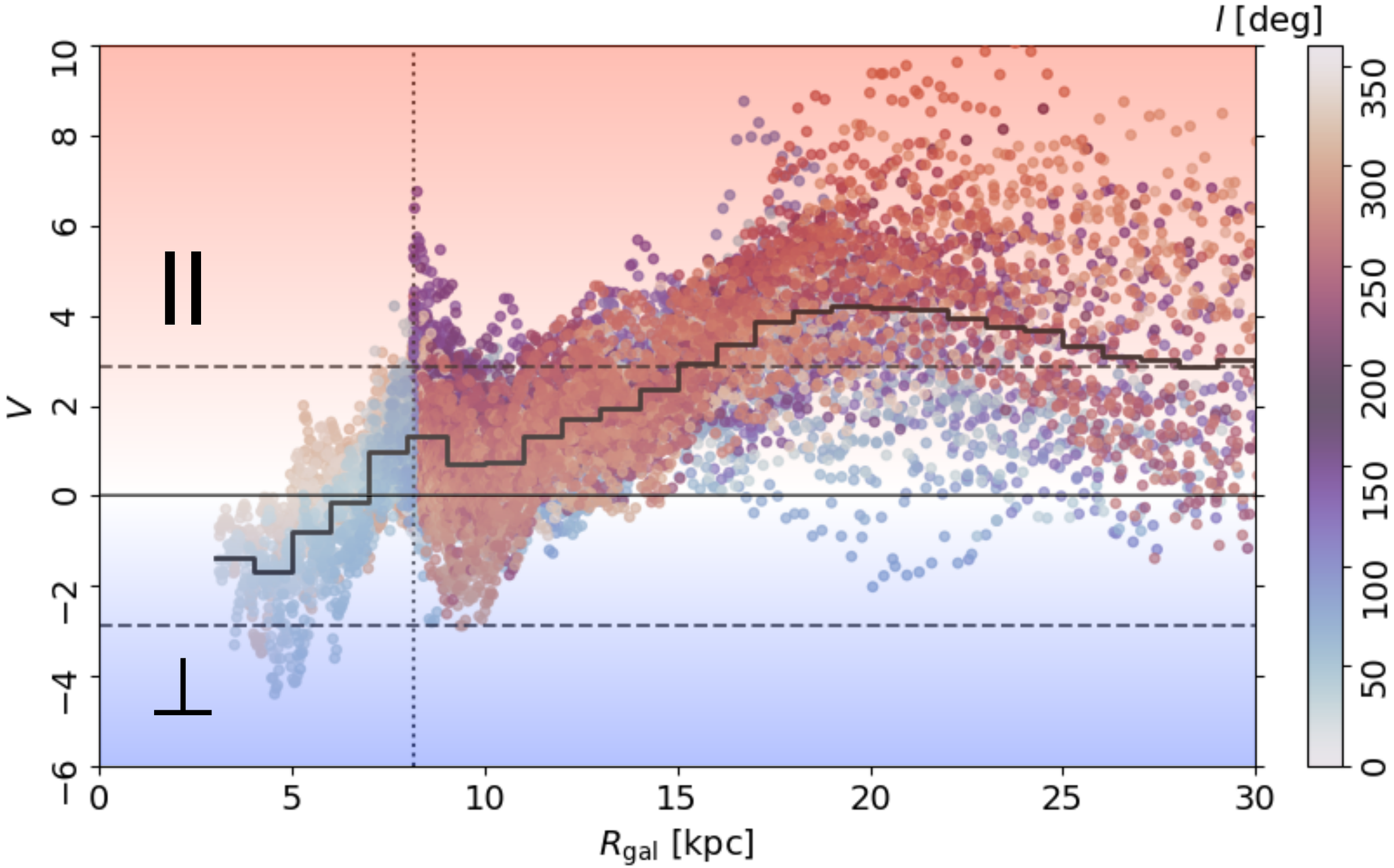
Orientation of atomic filaments

Soler, J.D. et al. 2022. A&A in press.



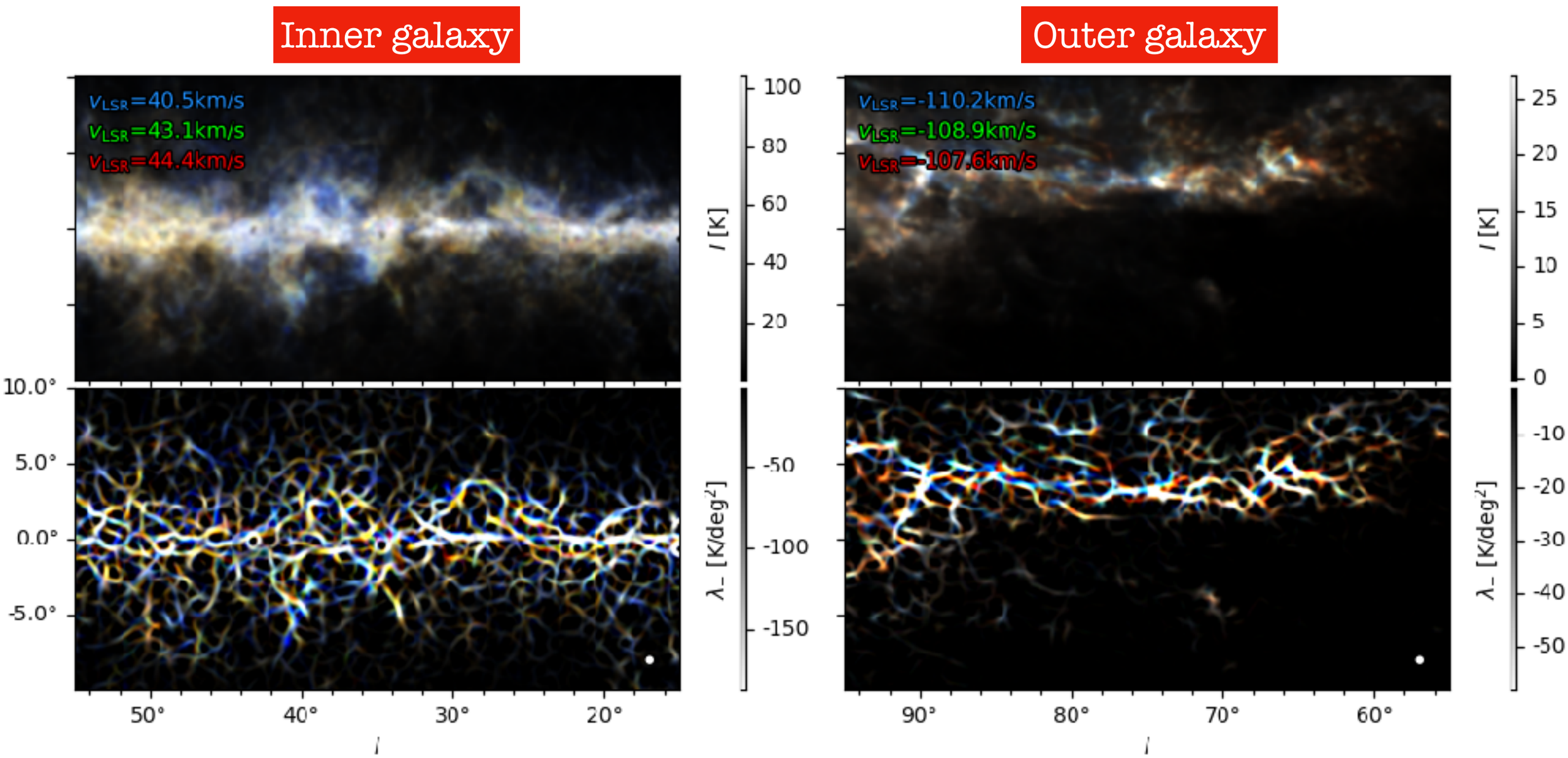
Atomic filament orientation

Soler, J.D. et al. 2022. A&A in press.



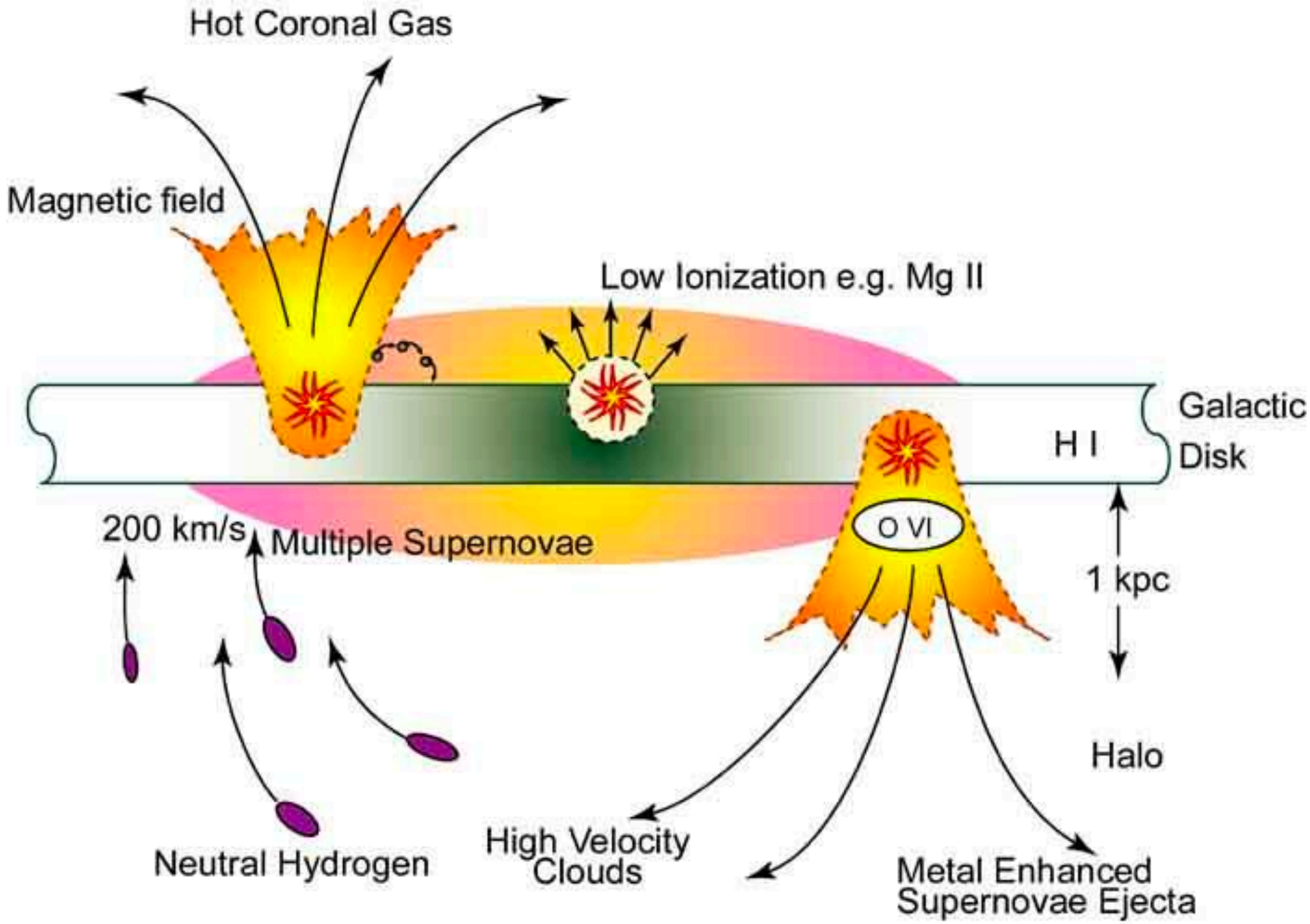
Atomic filament orientation

Soler, J.D. et al. 2022. A&A in press.



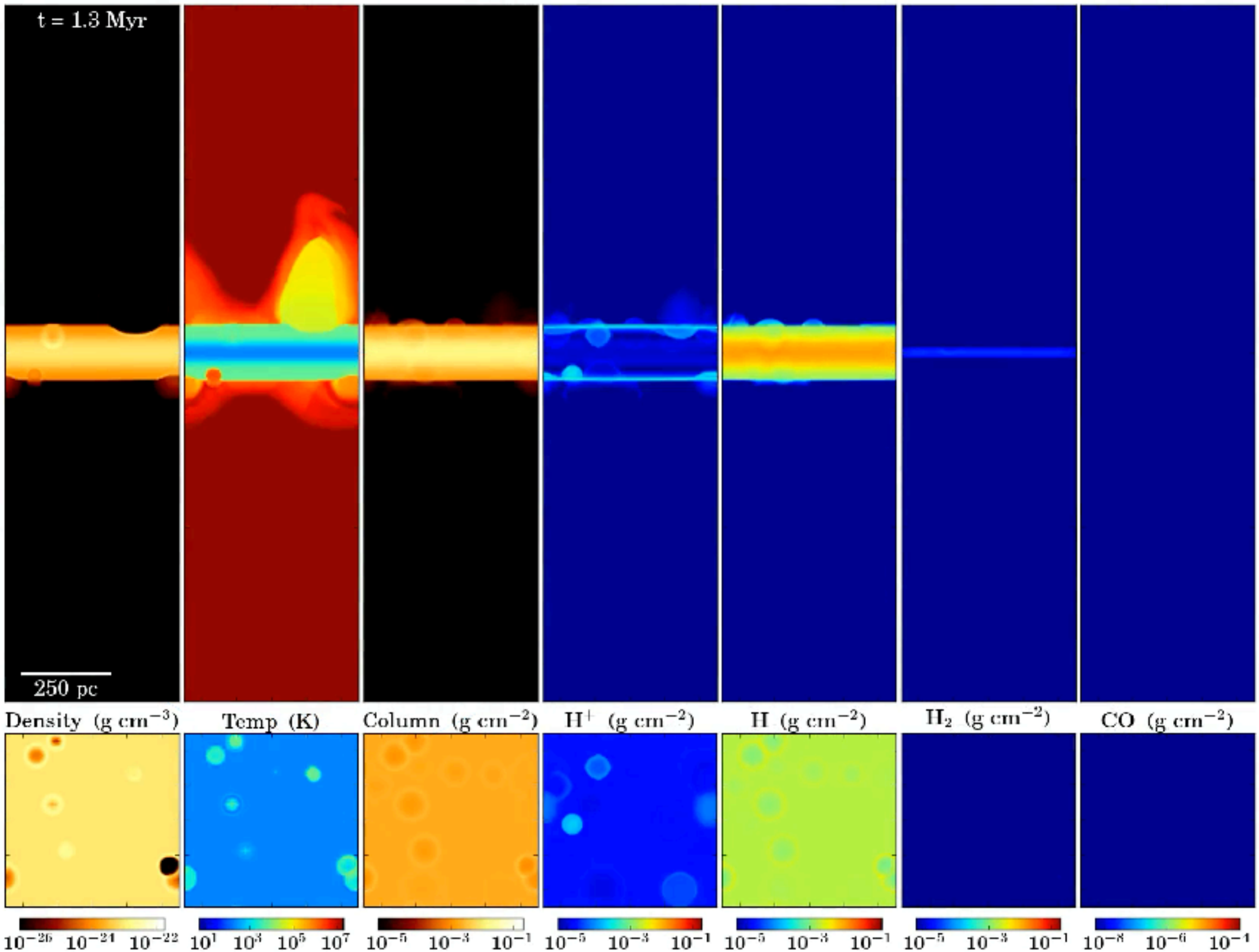
Atomic worms and chimneys

Heiles, 1994



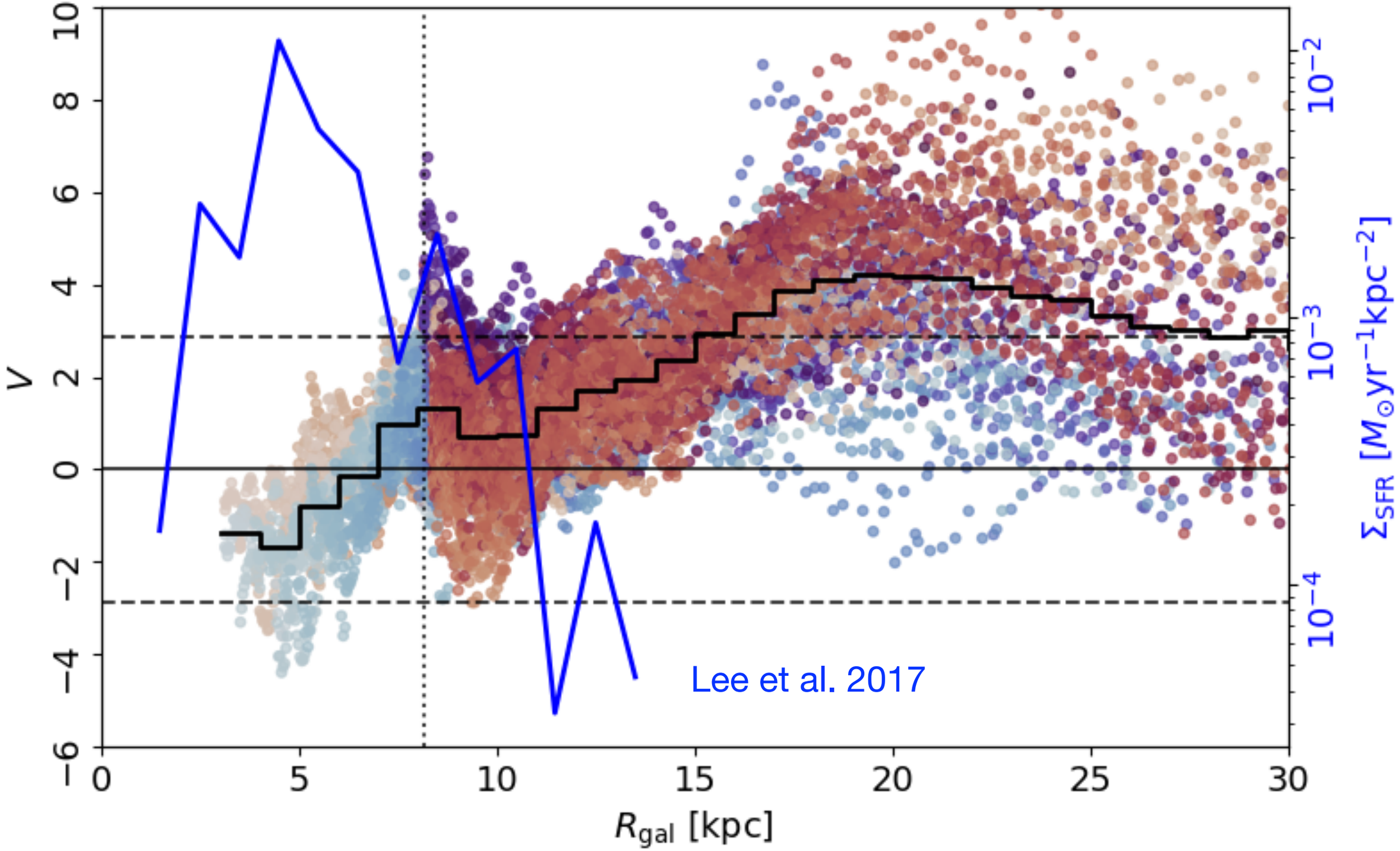
Atomic filament orientation and HI bubbles

Girichidis et al. MNRAS 2021. SILCC: Simulating the LifeCycle of molecular Clouds



Atomic filament orientation and star formation

Soler, J.D. et al. 2022. A&A in press.



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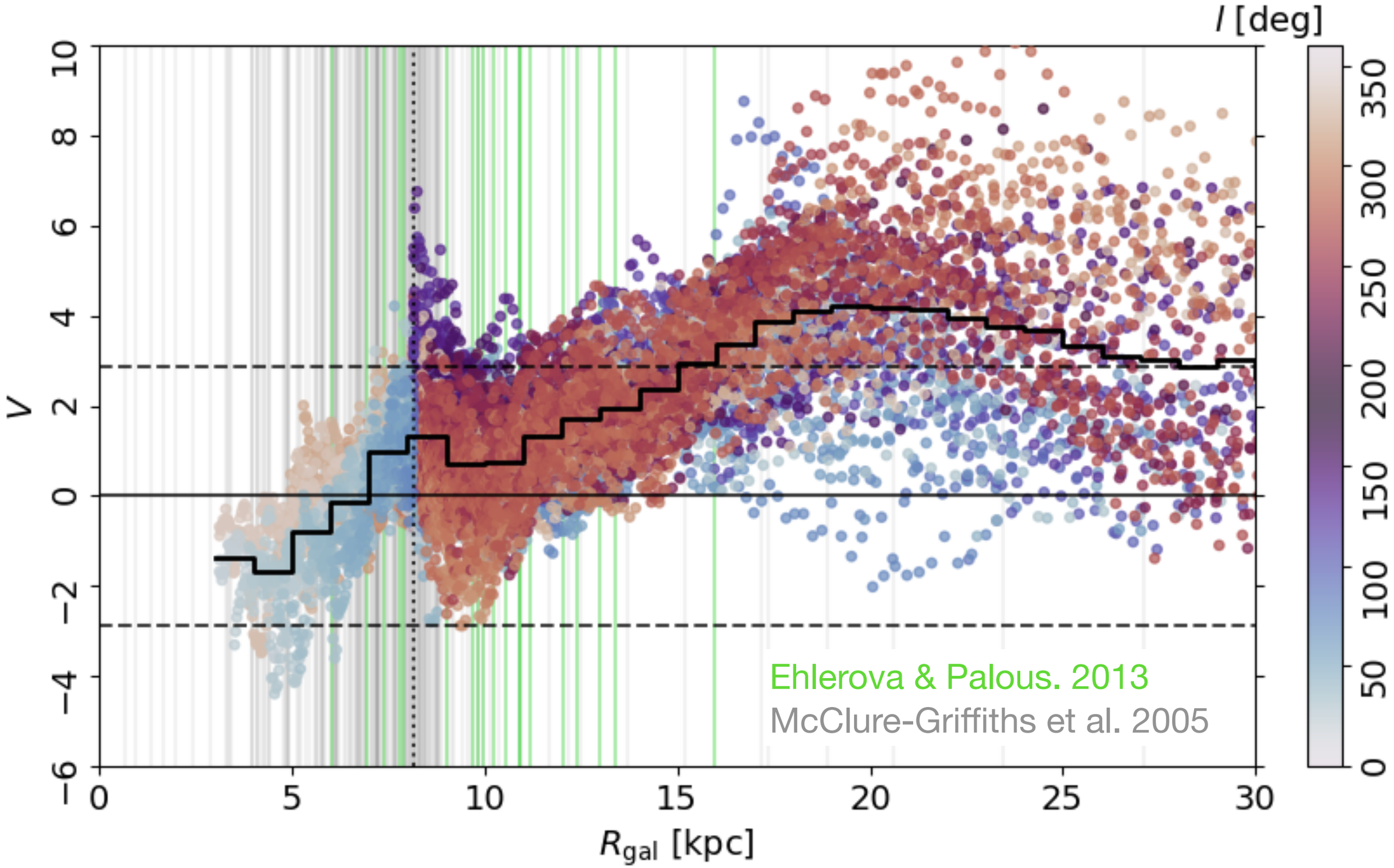
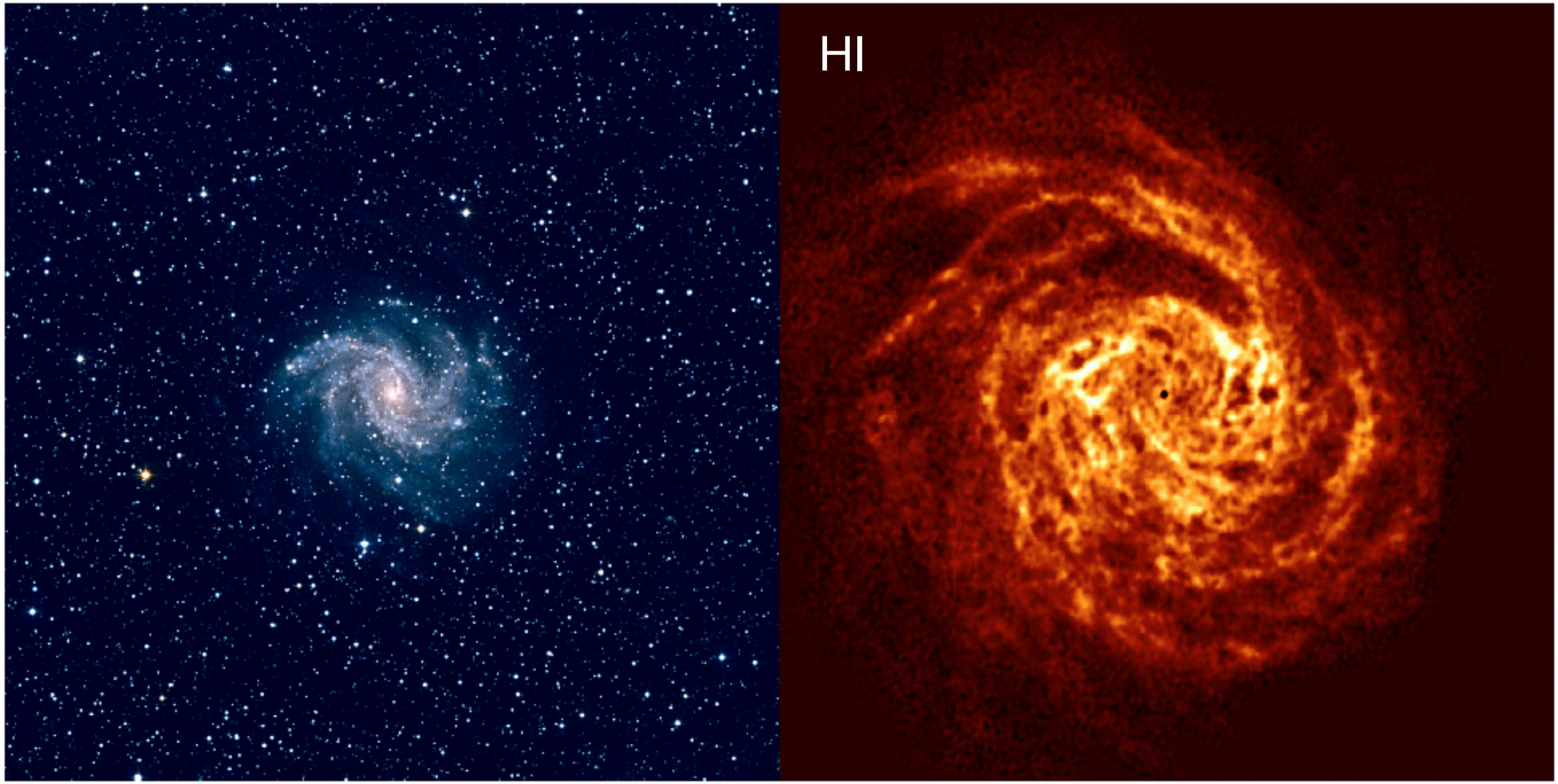


HI holes in the spiral galaxy NGC6946

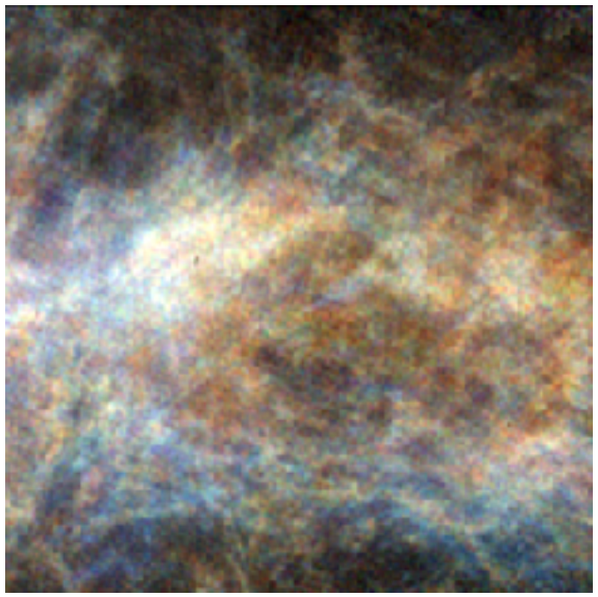
Boomsma et al. A&A 2008



Data-driven approach

Soler, J.D., et al. 2020. A&A
Soler, J.D., et al. 2021. A&A
Soler, J.D., et al. 2022. A&A

Observations



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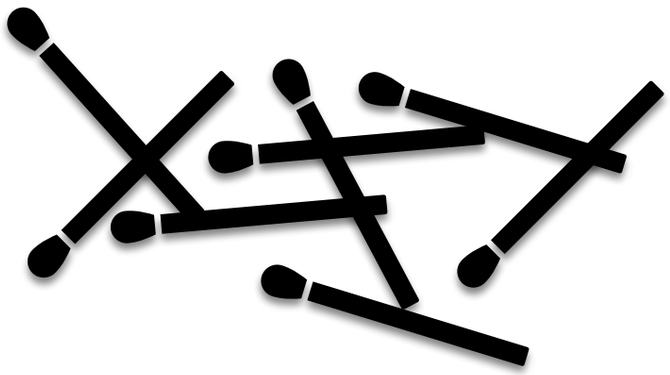
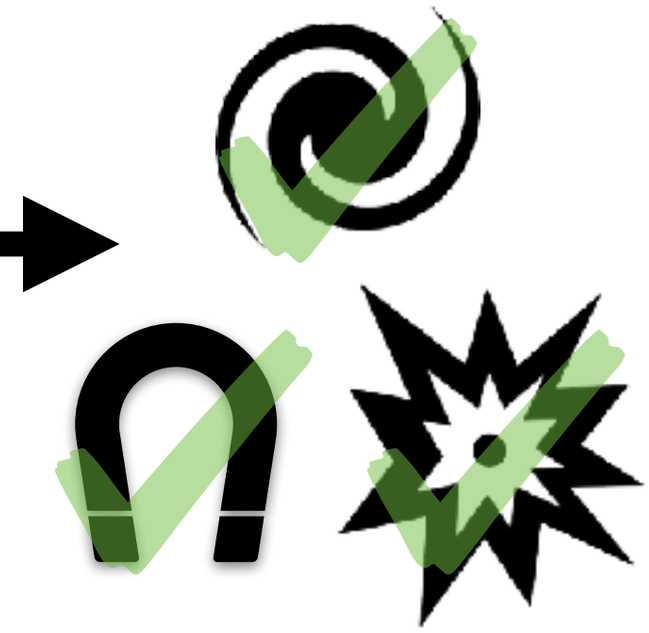


Knowledge



Epistemology tab

Soler & Nicoglou. Société d'histoire et d'épistémologie des sciences. 2022

How do the Sun and other stars form?

What is shaping the gas?

Epistemology tab

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How do the Sun and other stars form?

What is shaping the gas?

Juan D. Soler (IAPS, Rome)

The Galactic dynamics revealed by HI emission

We found that the **HI filament orientation** changes from no preferential orientation to mainly parallel to the Galactic plane with increasing distance from the Galactic center.

The change in the **HI filament orientation** is most likely due to the energy and moment input from **supernova feedback**.

In general, the **HI filament orientation** is **not inherited** by the **CO filaments**, which may be the result of stellar feedback and magnetic fields.

Soler, J.D. et al. 2020. A&A
Soler, J.D. et al. 2021. A&A
Soler, J.D. et al. 2022. A&A

juandiegosolerp@gmail.com