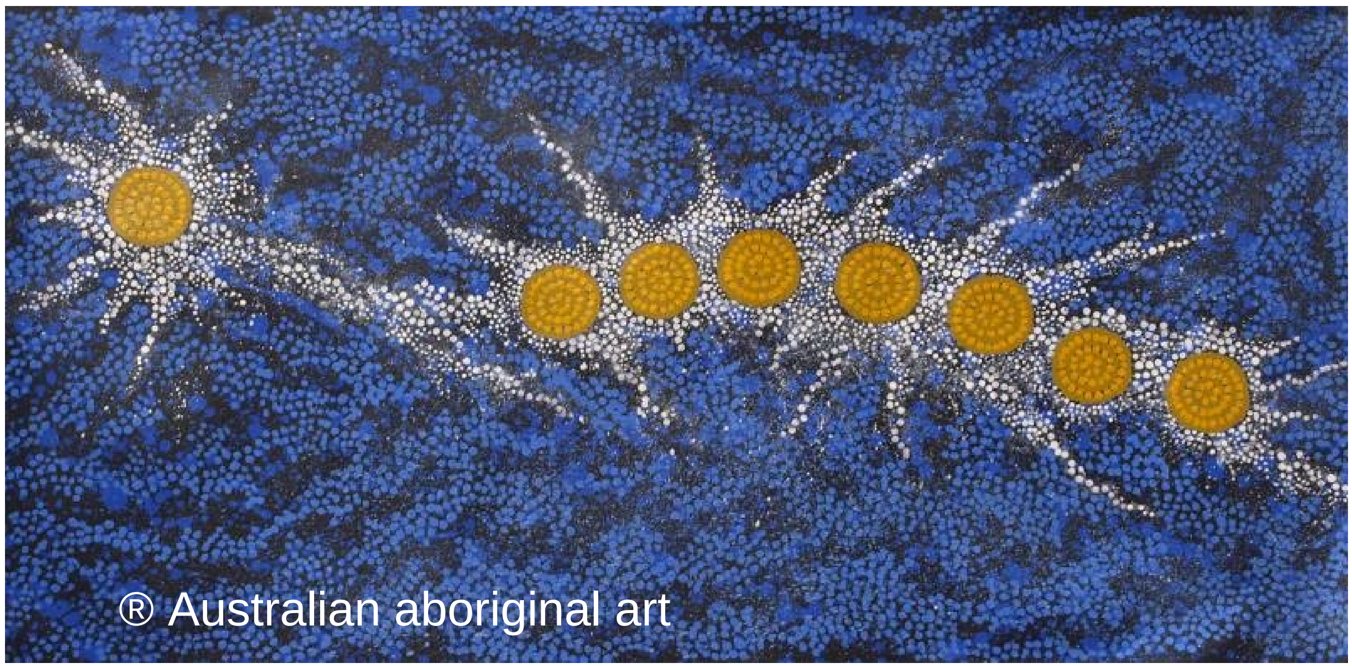
Dense core formation by fragmentation of velocity-coherent filaments in L1517



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Formation and Early Evolution of Very Low Mass Stars and Brown Dwarfs
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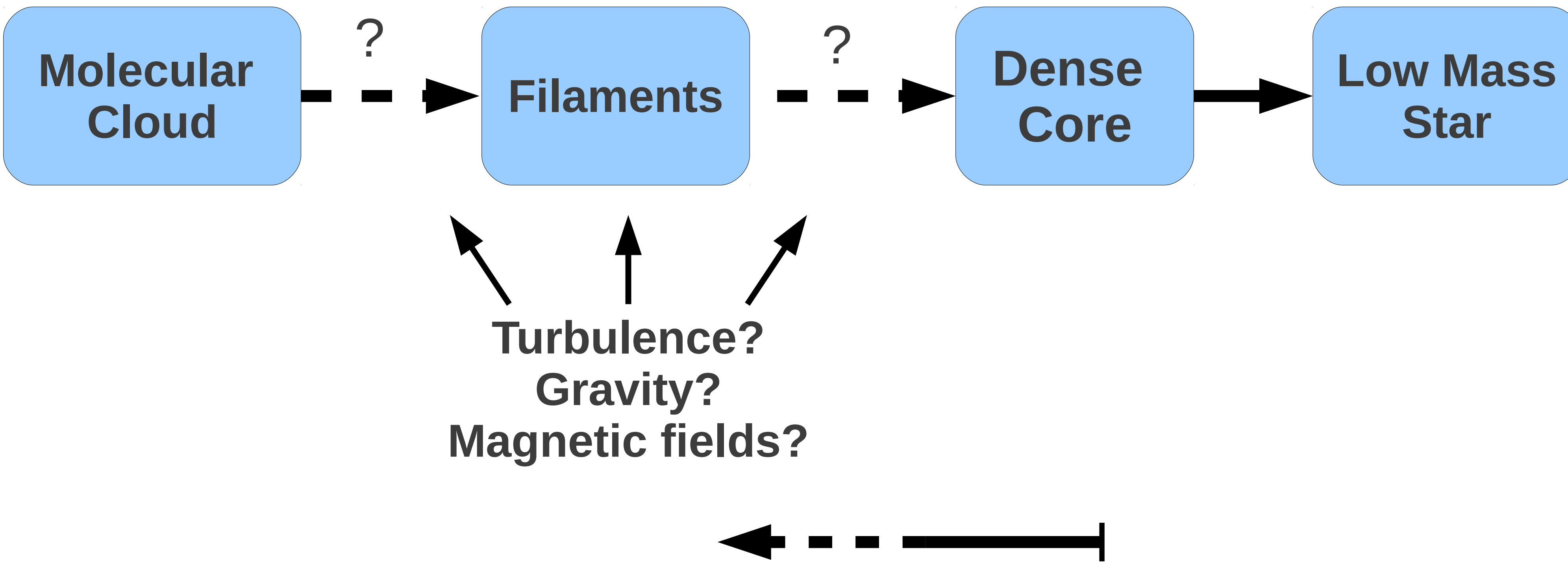
MINISTERIO DE FOMENTO

DIRECCIÓN GENERAL DEL INSTITUTO GEOGRÁFICO NACIONAL

OBSERVATORIO ASTRONÓMICO NACIONAL (OAN)

Introduction

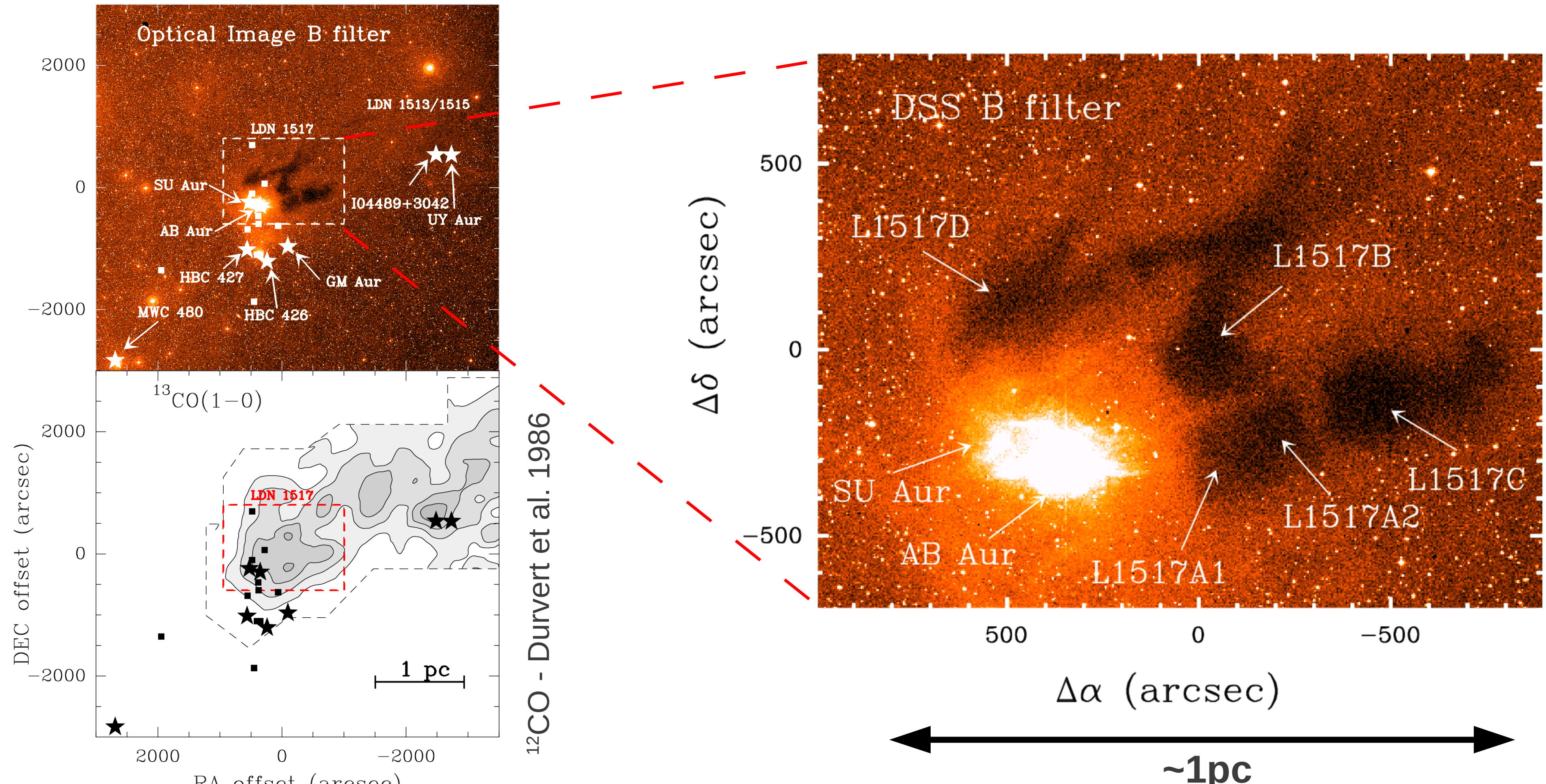
Low Mass star-formation process



Hacar & Tafalla 2011, A&A, 533, A34

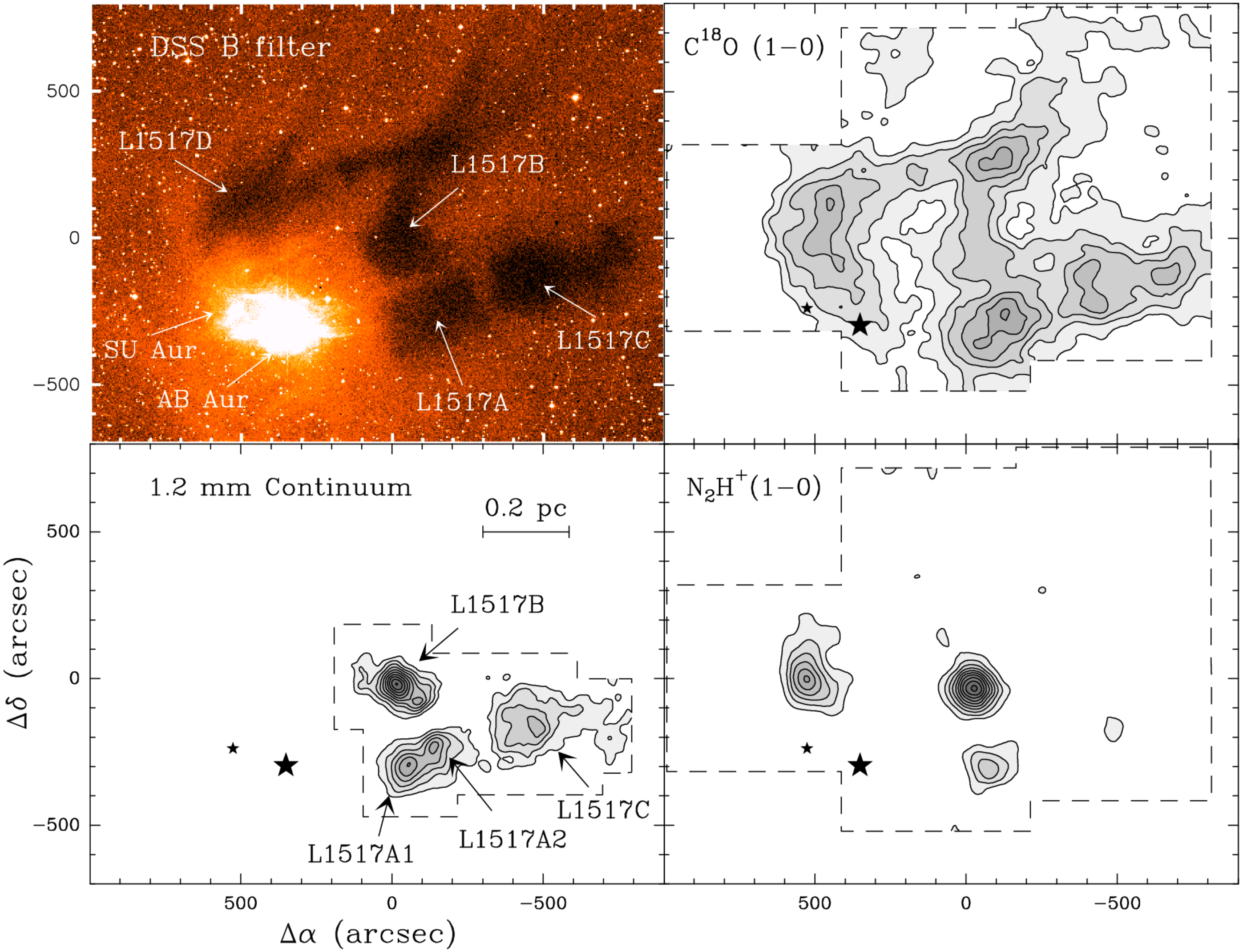
• Our goal: Understanding the cloud-to-core transition from the study of their internal gas kinematics of the gas surrounding the cores

L1517: Laboratory of star formation



- **L1517: Prototypical low mass star forming region in Taurus**
- **Associated to a small stellar group (AB Aur, SU Aur, GM Aur...)**
- **Also contains 5 starless cores of 1-2 Msun (e.g. L1517B)**
- **Small, isolated and simple region**

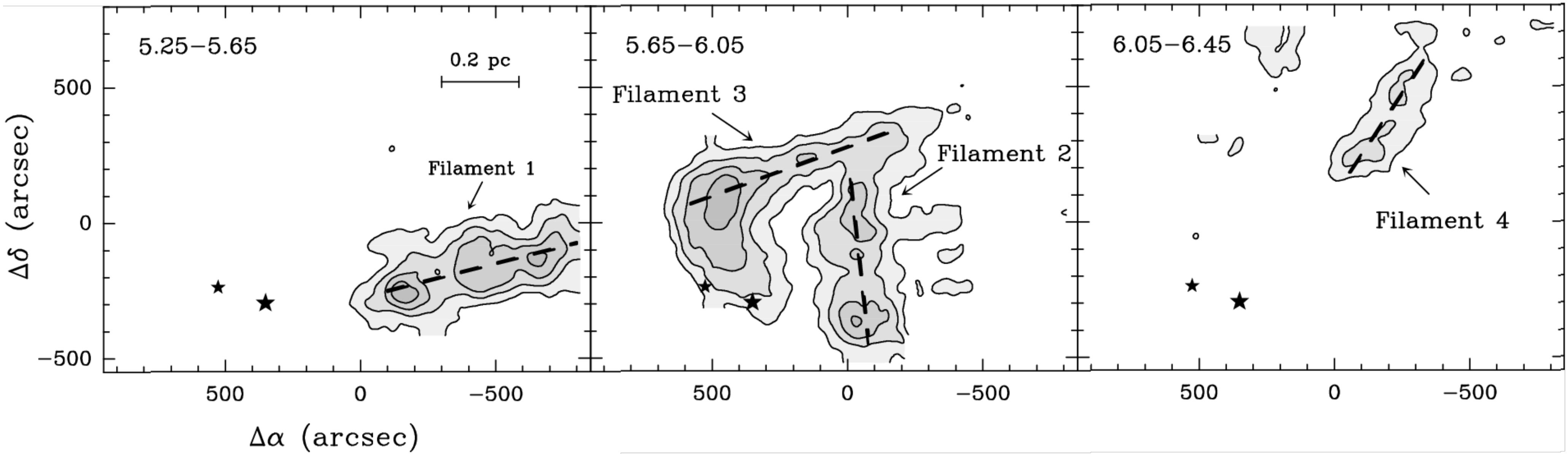
Observations: Dense vs. Diffuse gas



- **Because excitation+abundances+chemistry:**
  - **N_2H^+ = high-density tracer (>10^4 cm^{-3}) → dense cores**
  - **$C^{18}O$ = mid-density tracer (>$5x10^2$-10^4 cm^{-3}) → extended gas**

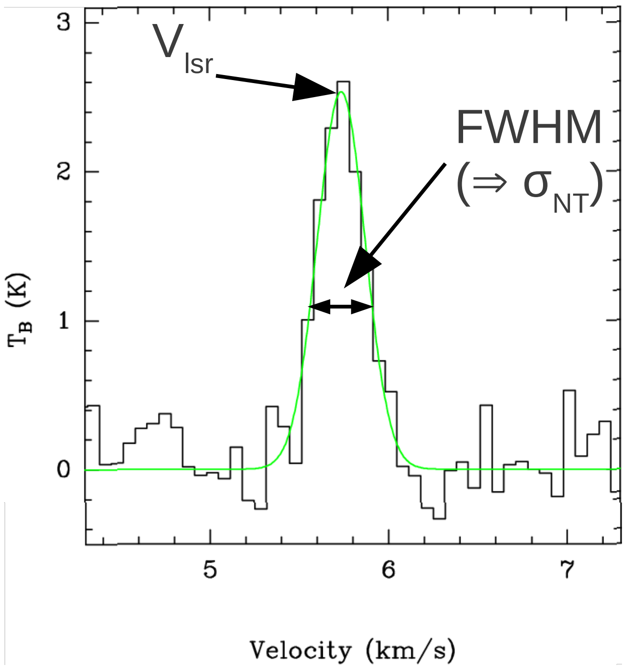
L1517 as a network of filaments

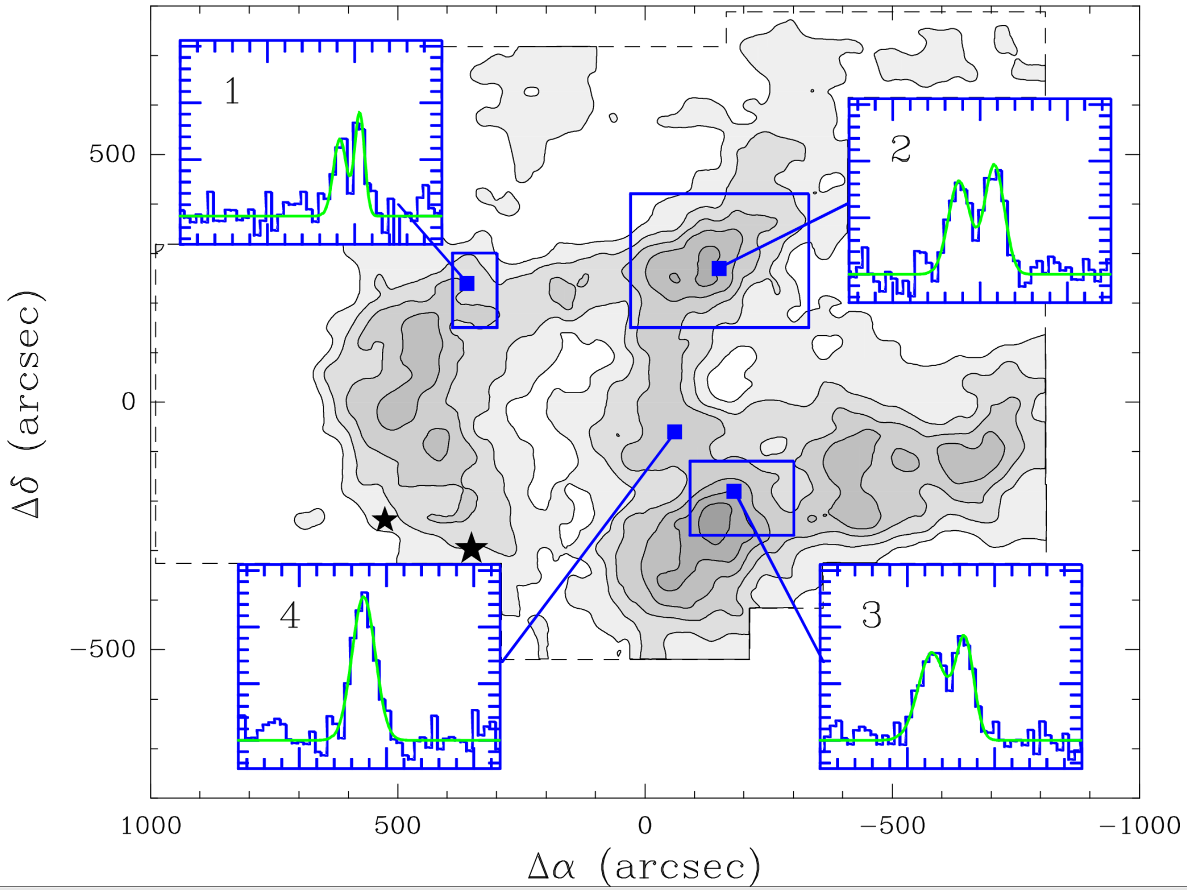
$C^{18}O$ (1-0) channel maps every 0.4 km s^{-1}



- $C^{18}O$ gas **highly structured** both spatially and in velocity
- We identify <u>4 Filaments</u> with typical masses of ~8-10 M_0 and lenghts of ~0.5 pc.
- All the cores are embeded in these filaments.
- These filaments connect the cores to the cloud
- We also define their main axis by straight lines (1st order)

Gas kinematics & Gaussian fits

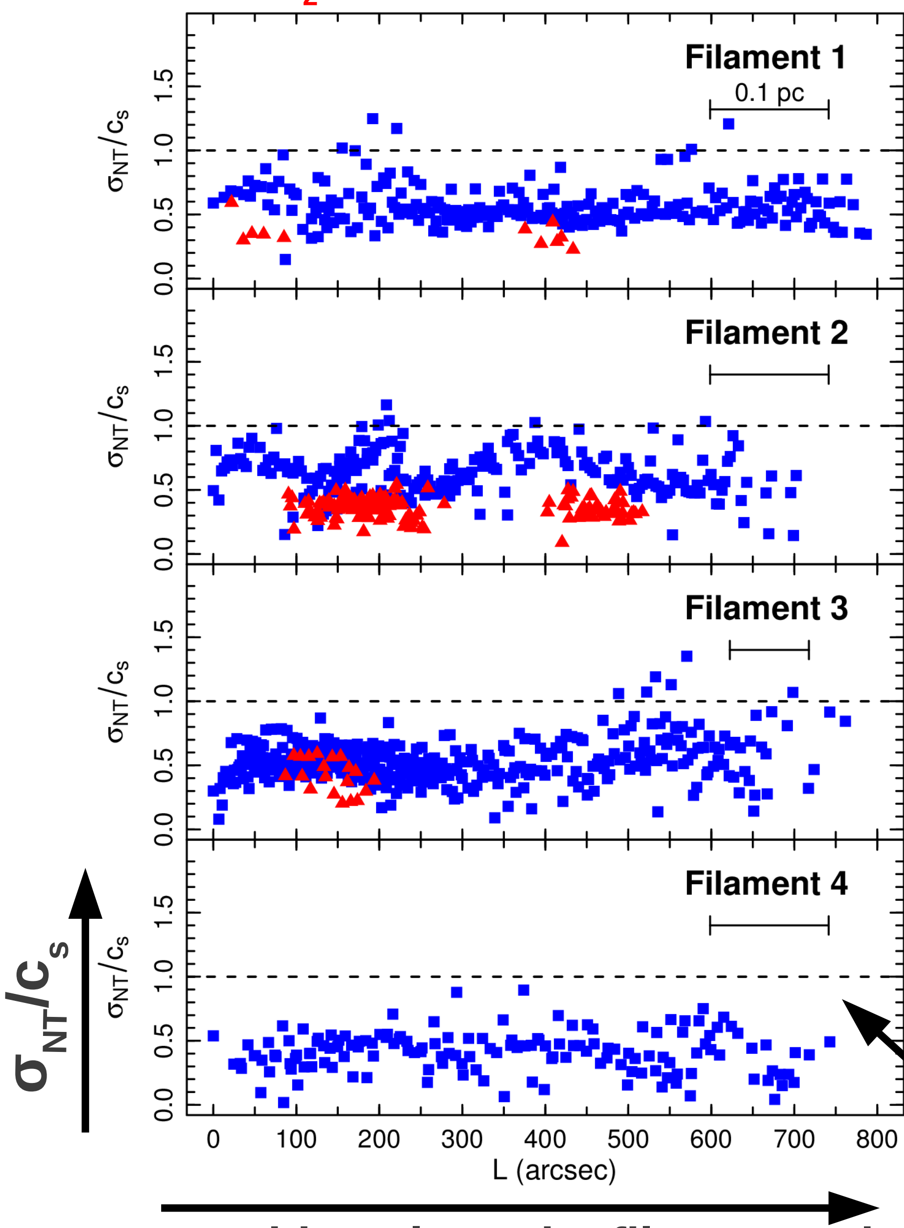




- In L1517, > 90% of the $C^{18}O$ spectra present 1 narrow component.
- Only ~10% are double peaked spectra, but easy to identify.
- N_2H^+ also shows only 1 vel. component (hyperfine components)
- Guassian fits provide a **full description** of the velocity field of the cloud in terms of σ_{NT} (Non-th vel. dispersion) and V_{lsr} (velocity centroid)

Subsonic filaments before the core formation

N_2H^+ (red) + $C^{18}O$ (blue)



Position along the filament axis

$\sigma_{NT} = c_s$

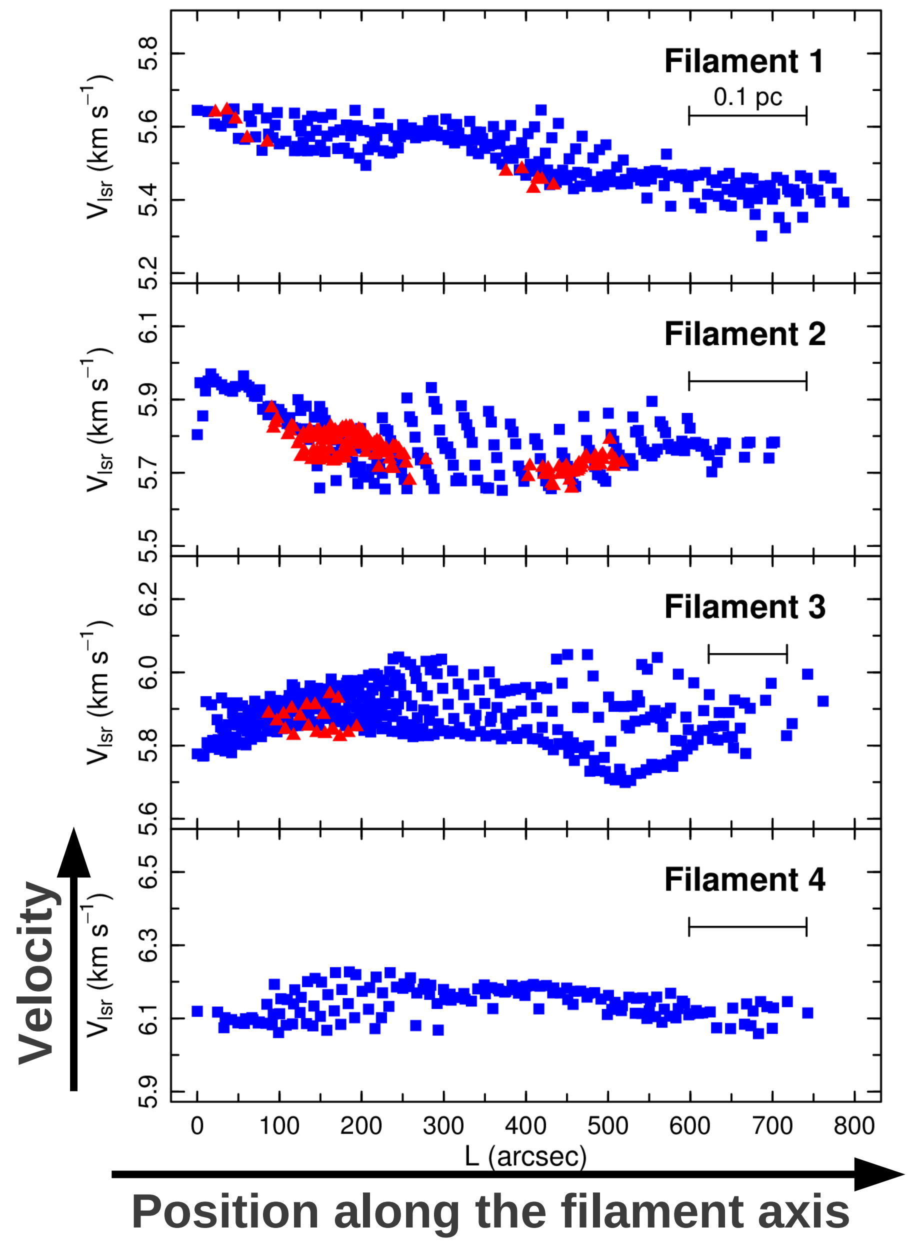
- All cores present $\sigma_{NT}(N_2H^+) < c_s$
- Goodman et al 1998:
  σ_{NT} const. and $< c_s$ = <u>Coherence</u>
  (see also Pineda et al 2009, 2011)
- But in L1517 also 92% of $C^{18}O$ points are also subsonic!!
- Therefore the coherent scale is not restricted to the cores, but extends up to ~0.5 pc.
- **Filaments are coherent (in σ_{NT}) before the formation of the cores (→ no internal shocks)**

Velocity-coherent filaments

- Filaments present an smooth and continuous velocity structure in V_{lsr}
- Following Goodman, we define this behavior as **Velocity-coherence**

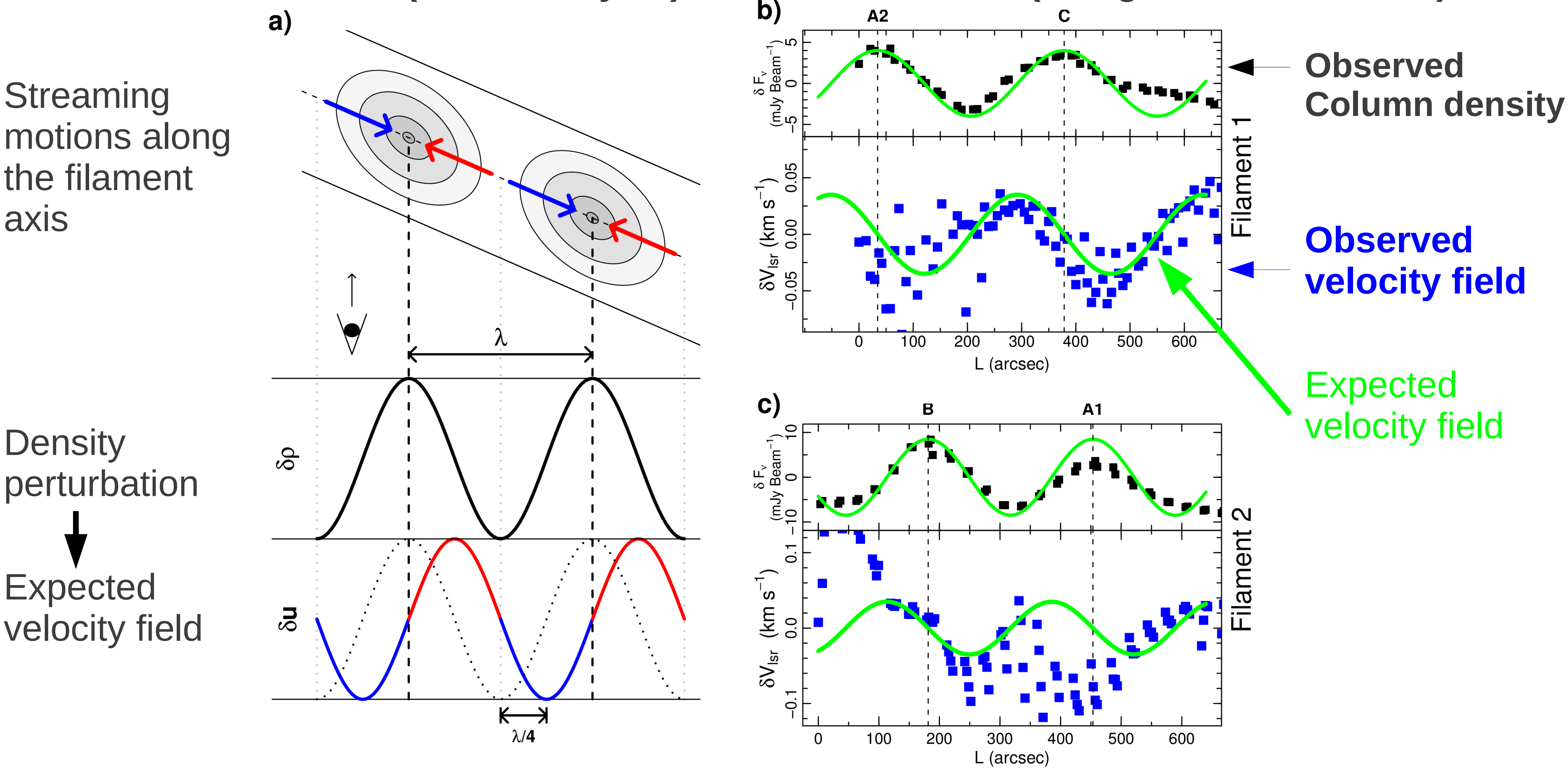
- Large-scale velocity oscillations
- Cores share these large scale motions
- Filament-to-core transition occurs without appreciable kinematic changes:
  - **Cores inherit all their kinematic properties from their parental filaments**
  - **It sugggests a quasi-static fragmentation (< 1 km s^{-1} pc^{-1})**

N_2H^+ (red) + $C^{18}O$ (blue)



Dense core formation by fragmentation of velocity-coherent filaments

1D Model (linear analysis): **Observations (along the filament axis):**



- **1D Linear analysis preditcs a shift of λ/4 between density and velocity perturbations**
- **Filament 1 seems to follow the expected pattern. Filament 2 is less clear.**
- **Streaming motions ≤ 0.05 km s^{-1} pc^{-1}**

Results

- The gas surrounding the cores is highly structured, both spatially and in velocity
- We identify 4 filaments typically with ~0.5 pc and ~10Msun.
- These filaments are characterized by an extremely quiescent kinematics, both in σ_{NT} and V_{lsr}
- We define this behavior as **Velocity-Coherence**
- At least Filament 1 presents large-scale velocity-oscillations consisten to streaming motions along its main axis.

- <u>CONCLUSION:</u> The core formation process occurs in 2 steps:
  - First, the subsonic, velocity-coherent filaments condense out of the more turbulent ambient cloud.
  - Then the cores fragment quasi-statically and inherit the kinematics of their parental filaments.

- See also Hacar & Tafalla 2011, A&A, 533, A34