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

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Abstract

The formation of dense cores in dark clouds is still a poorly understood process, with some models proposing that it is driven by supersonic collisions of gas flows while others defending a more quiescent mode of fragmentation. To shed new light on core formation, we have studied the kinematics of the gas in dense cores and the gas in the surrounding cloud using the L1517 region as a laboratory of core formation. Our observations show that the gas surrounding the cores is structured in 0.5 pc-long filaments whose velocity is subsonic and presents at most weak large-scale oscillatory gradients. The cores embedded inside the filaments share the large scale motions of the surrounding gas. This velocity coherence of the core-forming gas rules out core-formation models by supersonic gas collisions, and supports a quiescent mode of fragmentation. In addition, it shows that dissipation of turbulence precedes core formation, and that it gives rise to filamentary structures that later fragment into cores. (Work published in Hacar & Tafalla 2011, A&A, 533, A34.)

1.- The L1517 dark cloud in Taurus

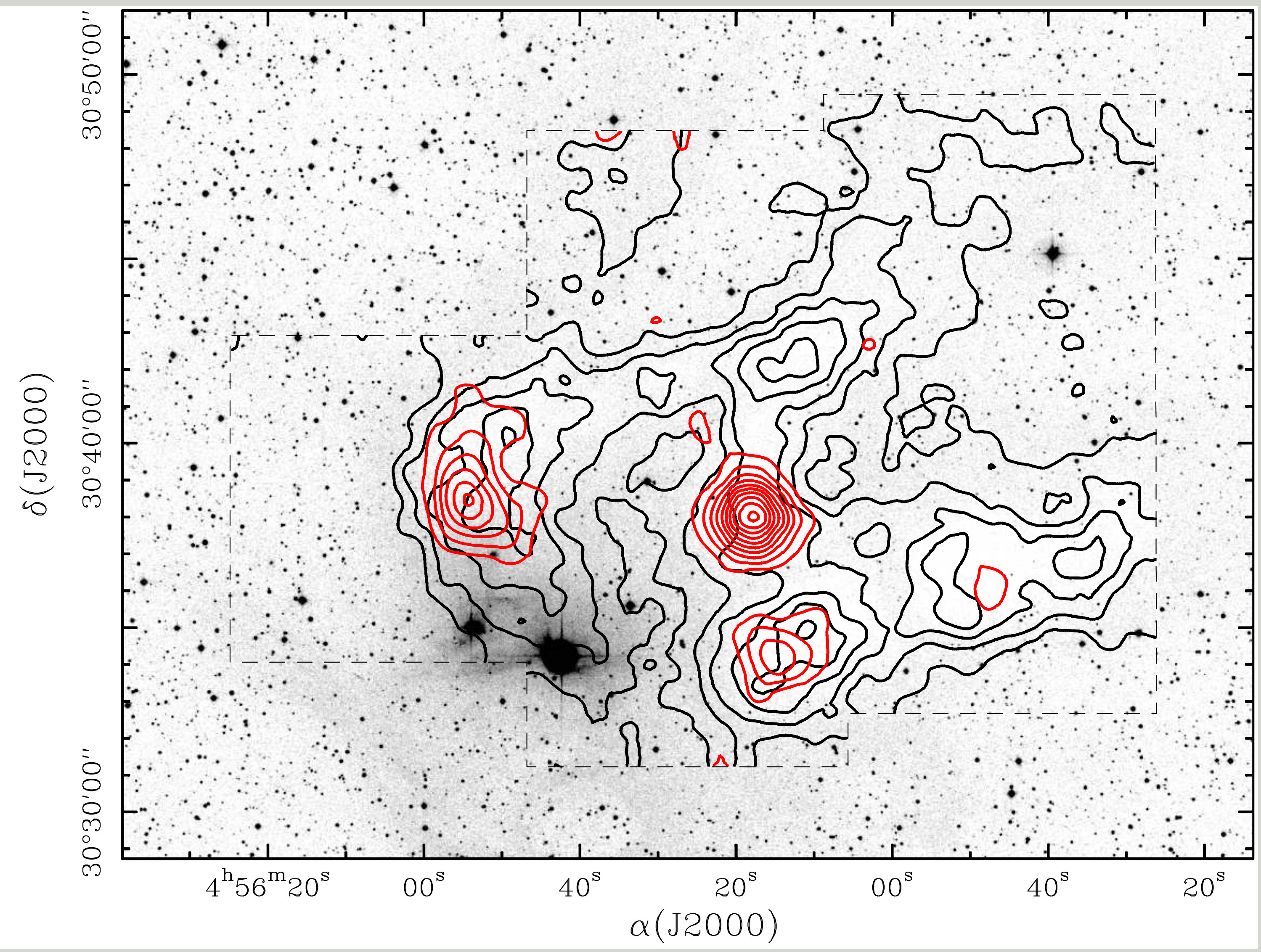

Fig.1: C^{18}O (black contours) and N$_2$H$^+$ (red contours) integrated emission over the Optical image in the L1517 region.

- The cloud contains a group of 5 dense starless cores (Myers et al. 1983).
- We have observed the cores and the surrounding cloud with FCRAO in C^{18}O, N$_2$H$^+$, and SO, complemented with IRAM30m Continuum observations.

2.- The cloud as a network of filaments

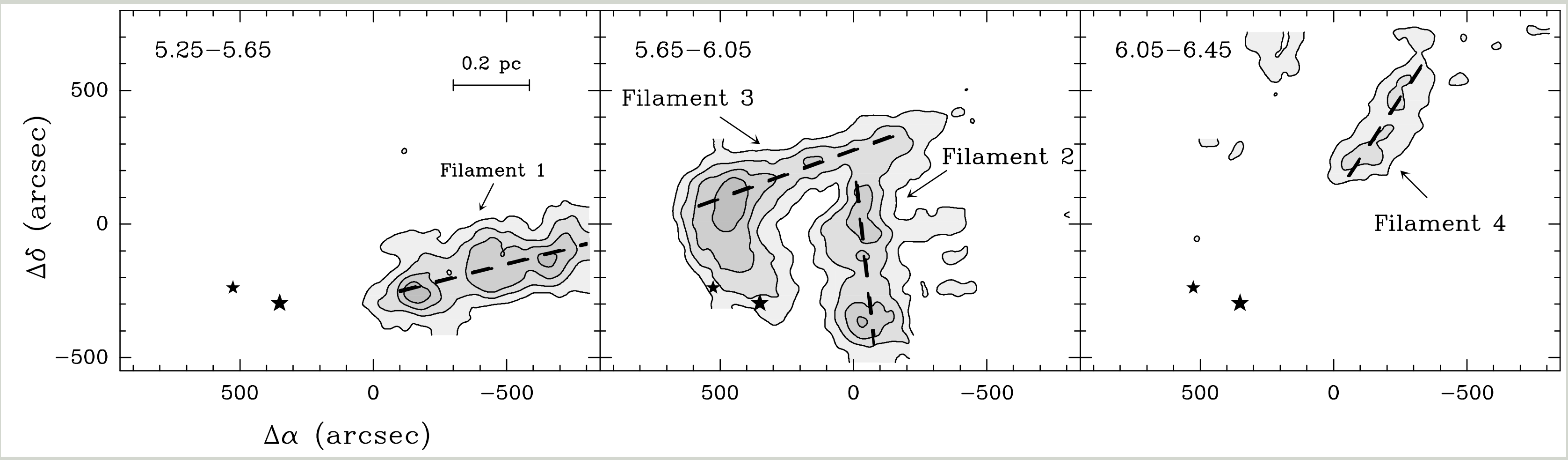

Fig.2: C^{18}O channel maps in L1517. Velocity ranges (in km s^{-1}) are identified in the upper left corner in each case. Filaments are identified in the plot. Dashed lines indicate the main axis of each filament.

- The C^{18}O velocity maps show the cloud consists of 4 distinct filamentary structures.
- The filaments have typically lengths of ∼ 0.5 pc and masses of ∼ 10 $M_\odot$.
- All the cores are embedded in the filaments.

3.- The cores have not formed by direct collisions of gas flows

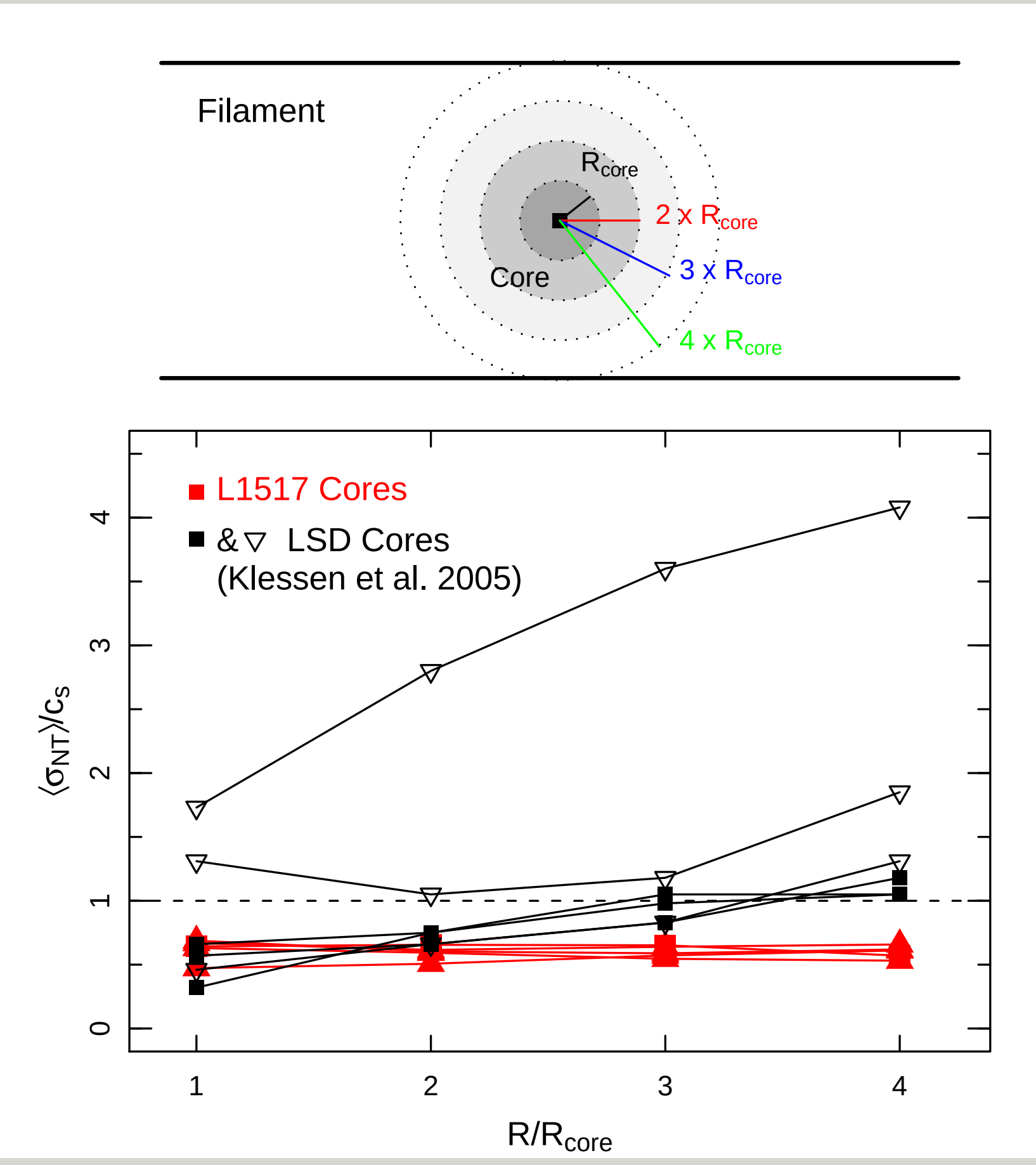

Fig.3: Non-thermal velocity dispersion (in c_s units) around the L1517 cores compared to the turbulent models of Klessen et al. 2005.

- We have determined the non-thermal gas motions as a function of distance to each core center using C^{18}O (red triangles).
- We have compared the observed motions with the predictions from a model of core formation by direct collision of gas flows (Klessen et al. 2005).
- In contrast to the predictions of even the most quiescent models the gas motions around the L1517 cores remain constant and subsonic up to distances of at least 4 core radii.

References

Gehman, C. S., Adams, F. C., Fatuzzo, M., & Watkins, R. 1996, ApJ, 457, 718
Goodman, A. A., Barranco, J. A., Wilner, D. J., & Heyer, M. H. 1998, ApJ, 504, 223
Hacar A. & Tafalla M., 2011, A&A, 533, A34
Klessen, R. S., Ballesteros-Paredes, J., Vázquez-Semadeni, E., & Durán-Rojas, C. 2005, ApJ, 620, 786
Myers, P. C. & Benson, P. J. 1983, ApJ, 266, 309

4.- The L1517 filaments are velocity-coherent

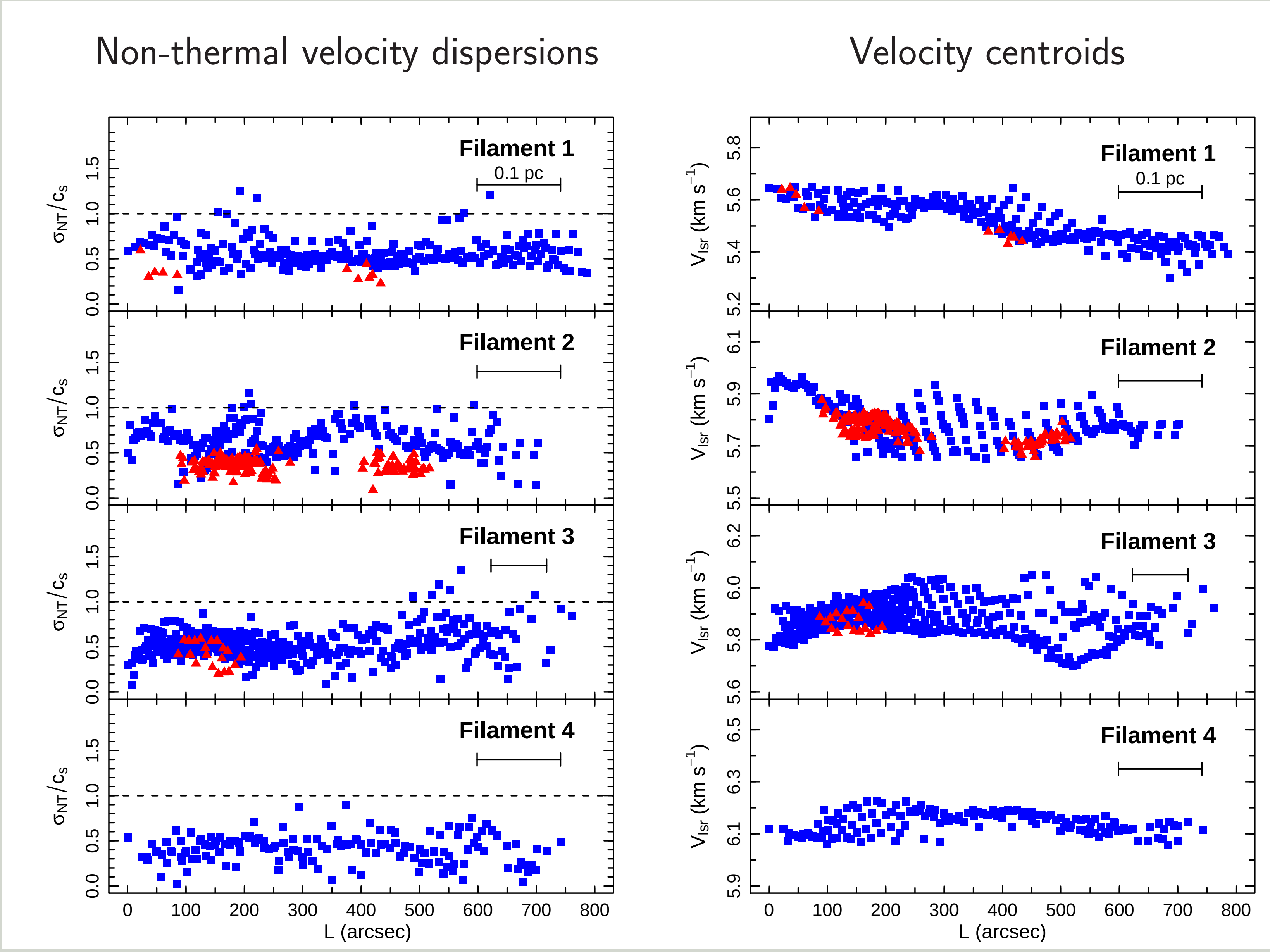

Fig.4: C^{18}O (blue squares) and N$_2$H$^+$ (red triangles) non-thermal velocity dispersions (left) and velocity centroids (right) of all spectra with S/N ≥ 3 along the main axis of each filament in L1517.

- Non-thermal velocity dispersions (left panels) are subsonic and constant over the whole filament length (∼ 0.5 pc).
- Velocity centroids (right panels) are continuous and present at most subsonic large-scale oscillations.
- We define this behavior as **velocity-coherence**, following Goodman et al. 1983.
- The internal velocity gradients in the dense cores follow the large-scale velocity gradients of the filaments.
- Dense core formation seems to have involved little change in the gas kinematics. Turbulence dissipation preceeds core formation.

5.- Kinematical evidence of streaming motions along the filaments?

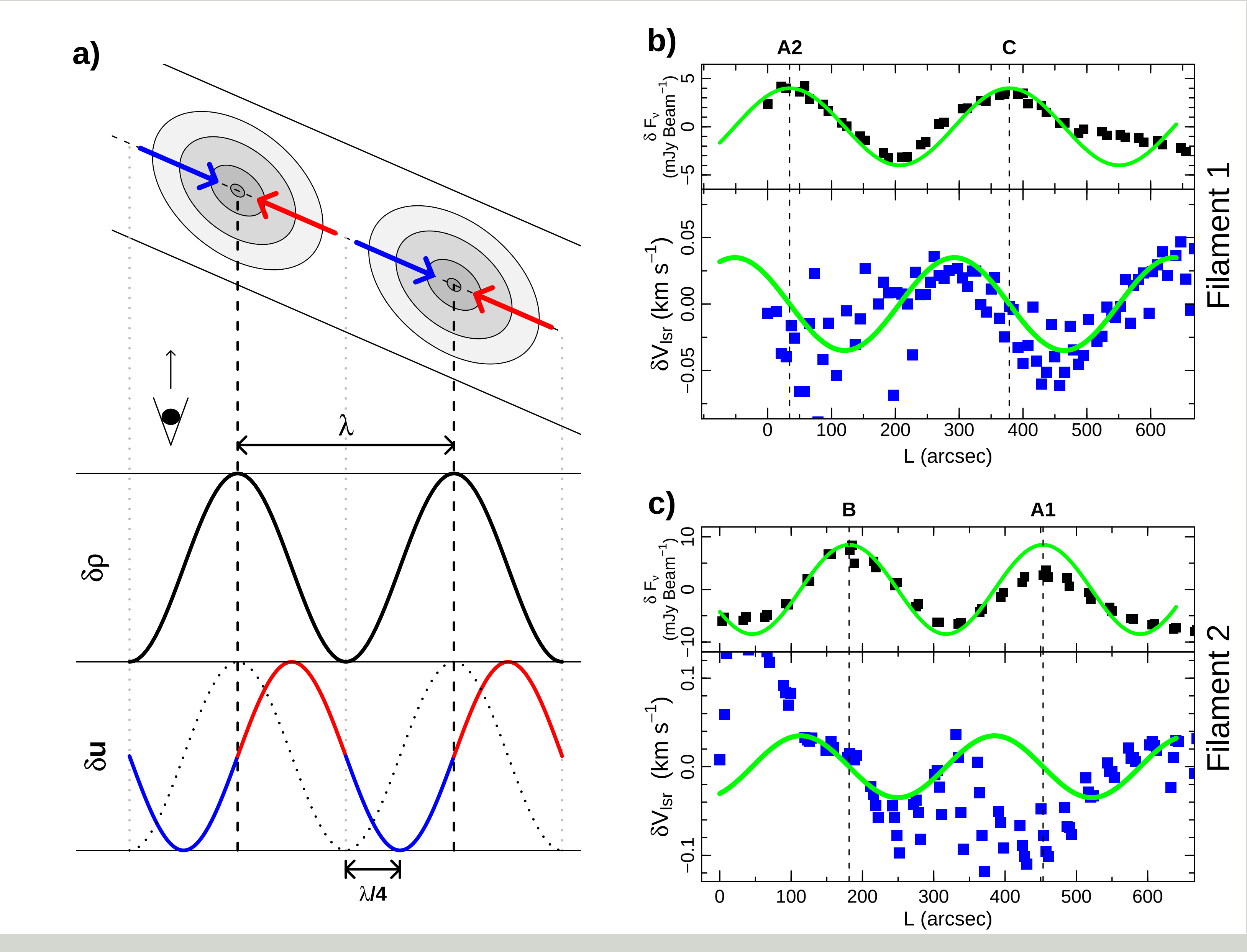

Fig.5: a) Schematic view of the density and velocity fields expected for a filament perturbed by unstable core-forming modes. b), c) Comparison of these predictions (green sinusoids) with the columnd density (upper) and velocity structure (lower) observed in filaments 1 and 2.

- Core formation by streaming motions in a filament implies a correlation between density and velocity structures.
- If the density pattern is sinusoidal, the velocity pattern should also be sinusoidal shifted by $\boldsymbol{\lambda/4}$ (left panel) (Gehman et al. 1996).
- We have fitted the density profile of filaments 1 and 2 with sinusoids and compared the observed the velocities with the above predictions (right panels).
- Filament 1 seems to follow the expected pattern, while the case of filament 2 is less clear.