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Observed properties of a filament system in the Orion B molecular cloud

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Abstract. Self-gravitating, thermally supercritical filaments seem to play an important role in the star formation process. Thus describing their properties and understanding their dynamical evolution may provide crucial insights on the initial conditions of star formation. We use *Herschel* dust continuum observations to describe the density structure of a filament system in the North of the Orion B molecular cloud, and IRAM 30m molecular line observations to access to its kinematics. The $N_2H^+(1-0)$ emission, tracing dense gas reveals a one-component ordered velocity pattern along the crest of the thermally supercritical filament of the system. These observations give us insights onto the dynamical properties of the star forming filament and its fragmentation into star forming cores.

1. Introduction

Herschel and *Planck* dust emission observations have revealed the highly filamentary structure of the interstellar medium (ISM). Moreover, *Herschel* images indicate that prestellar cores and protostars are observed preferentially along the densest of these filaments (André et al. 2010). Combining *Herschel* data with molecular line observations (Arzoumanian et al. 2013) we showed that interstellar filaments are divided into two families: 1) The low density unbound filaments, which are thermally subcritical with masses per unit length ($M_{\rm line}$) smaller than the critical value $M_{\rm line,crit} = 2\,c_{\rm s}^2/G \sim 16\,{\rm M}_\odot/{\rm pc}$ (Ostriker 1964), where $c_{\rm s} \sim 0.2\,{\rm km/s}$ is the sound speed for $T \sim 10\,{\rm K}$. 2) The dense self-gravitating, thermally supercritical filaments with $M_{\rm line} > M_{\rm line,crit}$, which are unstable to radial gravitational contraction and fragmentation into cores (Inutsuka & Miyama 1997).

2. IRAM 30m observations: Velocity pattern along a dense filament

Herschel images display the filamentary structures of this system (Fig. 1), where a thermally supercritical star forming filament is surrounded by lower column density filaments. In particular, a well defined thermally subcritical and quiescent filament connected to the supercritical filament from the side.These two filaments, have central column densities (and masses per unit length) that differ by more than one order of magnitude, yet they show the same inner width of about 0.1 pc. The observed velocity pattern derived from the optically thin $N_2H^+(1-0)$ dense gas tracer shows an ordered velocity structure along the supercritical fila-

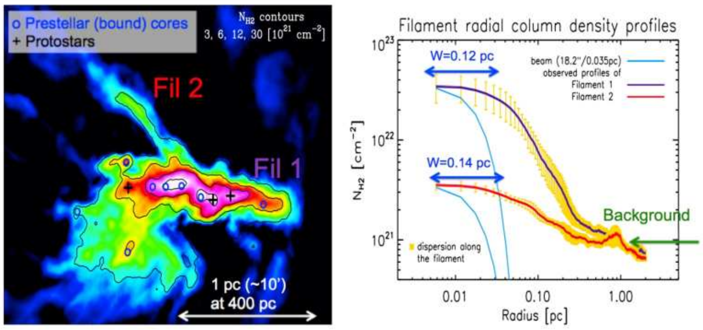

Fig. 1. *Left: Herschel* $N_{\mathrm{H_2}}$cutout map of a filament system in Orion B (Schneider et al. 2013, Könyves et al. in prep.). *Right:* The supercritical filament ($M_{\mathrm{line}} \sim 95\,\mathrm{M_{\odot}/pc}$) and the subcritical filament ($M_{\mathrm{line}} \sim 10\,\mathrm{M_{\odot}/pc}$) share the same central width of ~ 0.1 pc compatible with the statistical results derived from the analyses of *Herschel* Gould Belt observations in nearby clouds (cf. Arzoumanian et al. 2011; André et al. 2014, and references therein).

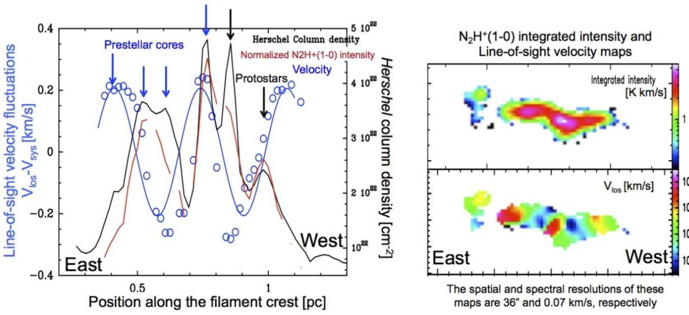

Fig. 2. *Left: Herschel* $N_{\mathrm{H_2}}$, normalized $\mathrm{N_2H^+}(1-0)$ intensity, and line-of-sight velocity ($\mathrm{V_{los}}$) fluctuations along the crest of Filament 1. The sinusoidal function (blue solid line) shows the best fit oscillatory mode of the observed velocity structure (circles), with an amplitude of 0.2 km/s, a wavelength of 0.3 pc and a large scale gradient (removed in this plot) of 0.4 km/s/pc. *Right:* Integrated intensity and $\mathrm{V_{los}}$ map of Filament 1 derived from the $\mathrm{N_2H^+}(1-0)$ data. The data points with signal to noise ratio larger than 3 are shown.

ment that may result from its fragmentation process (Fig. 2). Such velocity oscillations are also seen along star forming filaments in observations, e.g., in the Taurus molecular cloud (Hacar & Tafalla 2011) and also in numerical simulations of massive filament formation (e.g., Inoue et al., 2017, sub.).

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