Properties of filaments in IC 5146 as revealed by Herschel

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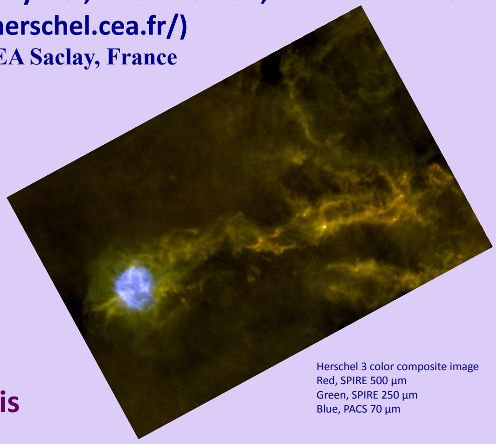
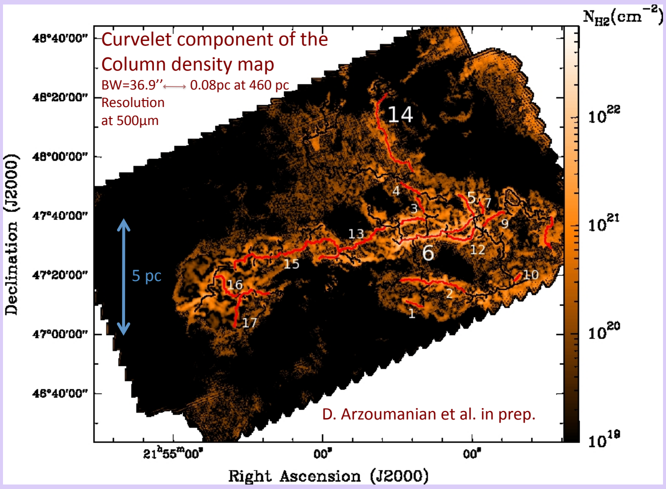


Herschel 3 color composite image
Red, SPIRE 500 µm
Green, SPIRE 250 µm
Blue, PACS 70 µm

Summary

We present the first results of the analysis of filamentary structures in IC5146 observed as part of the **Herschel Gould Belt survey** (André & Saraceno 2005, André et al. 2010).
IC5146 is a star forming region in Cygnus at 460 pc (Herbig & Reipurth 2008), consisting of a young massive star open cluster surrounded by an HII region, the Cocoon Nebula.
The Herschel images of IC5146, taken in parallel mode with SPIRE and PACS (70-500 µm) and the derived column density maps derived from the Herschel data (as explained by Könyves et al. 2010), reveal a whole network of filaments. We discuss here some of their properties. Our main result is that all filaments seem to share the same characteristic width of 0.10 ± 0.05 pc.



Filament analysis

The Ridges of the filaments were determined by applying the skeleton algorithm (Sousbie et al. 2008) on the column density map.

The **radial column density profiles of the filaments were averaged along their ridges**. The FWHM width of the filaments were estimated from simple Gaussian fits to the radial profiles and were deconvolved from the resolution of the column density maps (36.9" at 500 µm).
The observed column density profiles were also fitted with model profiles of the following (Plummer) form:

$$\Sigma_\eta(r) = \frac{\rho_c R_{flat}}{\left(1+\frac{r^2}{R_{flat}^2}\right)^{\frac{\eta-1}{2}}} A_\eta$$

with $\Sigma = \mu m_H N_{H_2}$ and $A_\eta = \int \frac{du}{(1+u^2)^{\eta/2}}$

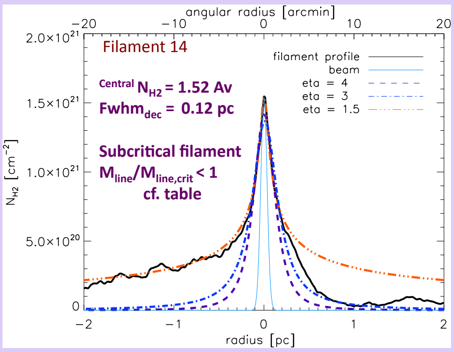
equivalent to a density profile

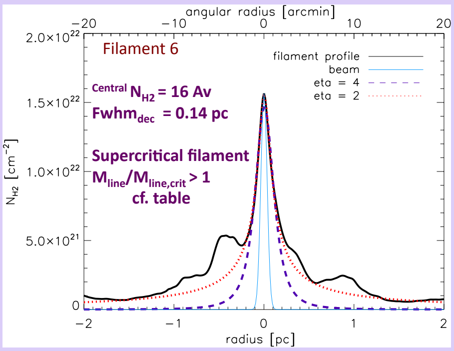
$$\rho_\eta(r) \sim \rho_c \left(\frac{r}{R_{flat}}\right)^{-\eta}$$ for r >> R_{flat}

Where ρ_c is the central density, R_{flat} the central radius, A_η is a constant of order unity. In the Ostriker (1964) model of hydrostatic equilibrium filaments η = 4, A_η = Π and R_{flat} corresponds to the Jeans length at the center of the filaments.

$$R_{flat} = \left(\frac{c_s^2}{G\Sigma_{r=0}}\right)$$ Ostriker model

Mean radial column density profiles perpendicular to the filaments





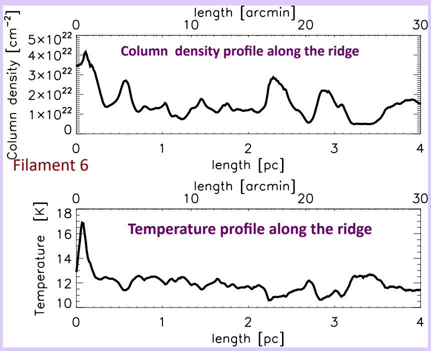
The light blue curve shows the beam size at the resolution of Herschel at 500µm.

Preliminary parameters of the filament sample

filament	central $N_{H_2} [cm^{-2}]$	$T_d[K]$	$FWHM_{dec}[pc]$	Jeans length [pc]	$\int N_{H_2}^{obs}/M_{crit}$
1	3.3×10^{21}	17	0.14	0.50	0.4
2	4.8×10^{22}	16	0.12	0.29	0.9
3	4.2×10^{21}	13	0.09	0.25	0.4
4	3.5×10^{21}	16	0.11	0.68	0.4
5	7.5×10^{21}	14	0.08	0.19	1.1
6	1.6×10^{22}	13	0.14	0.06	3.9
7	9.3×10^{22}	13	0.14	0.12	1.7
9	5.4×10^{21}	13	0.08	0.23	1.1
12	1.2×10^{22}	13	0.17	0.09	2.9
13	6.9×10^{22}	13	0.09	0.12	1.3
14	1.5×10^{21}	14	0.12	0.31	0.4
15	2.1×10^{22}	15	0.12	0.28	0.8
16	3.3×10^{21}	27	0.09	0.43	0.6
17	2.0×10^{22}	19	0.06	0.51	0.5

Mass per unit length along the filaments were calculated by integrating their column density profiles and expressed in the table in units of the critical thermal mass per unit length ($M_{line,crit} = 2c_s^2/G$).

Stability parameter (Inutsuka & Miyama 1997):
Gravitationally stable filaments if $M_{line} < M_{line,crit}$
Gravitationally unstable filaments if $M_{line} > M_{line,crit}$



Main results:

1. The **width** of the filaments is **uniform** in the whole network. It is independent from the local column density and not equal to the Jeans length. cf. the profiles of filaments 6 and 14: filaments with an order of magnitude difference but have similar FWHMs.
2. The filament profiles can not be described by an unmagnetized hydrostatic model with η = 4.
3. The filaments have shallower profiles with **1.5 < η < 3.**
4. These results suggest that the filaments are magnetized or they are not in equilibrium.

References:

André & Saraceno ESA SP-577, 2005, p. 179-184
André et al. 2010 A&A 518, id L102
Herbig & Reipurth, 2008, Handbook of Star Formating Regions Vol. I
Inutsuka & Miyama 1997, ApJ, 480, 681
Könyves et al. 2010 A&A 518, id L106
Ostriker J. 1964, ApJ, 140, 1056
Sousbie et al. 2008 MNRAS,383, 1655