The Filamentary Diffuse ISM

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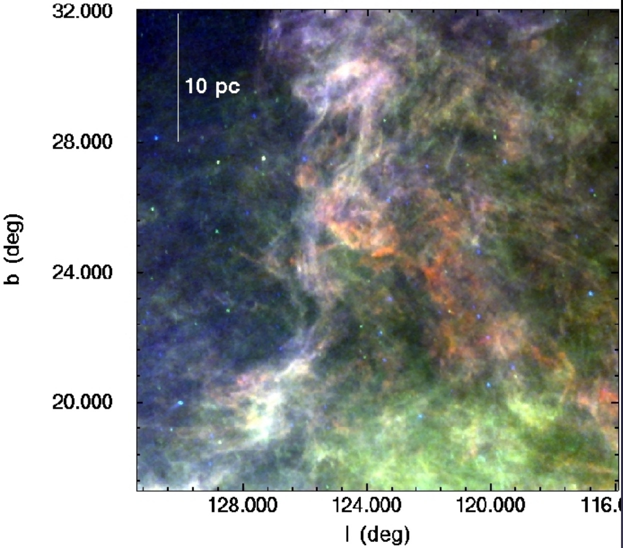
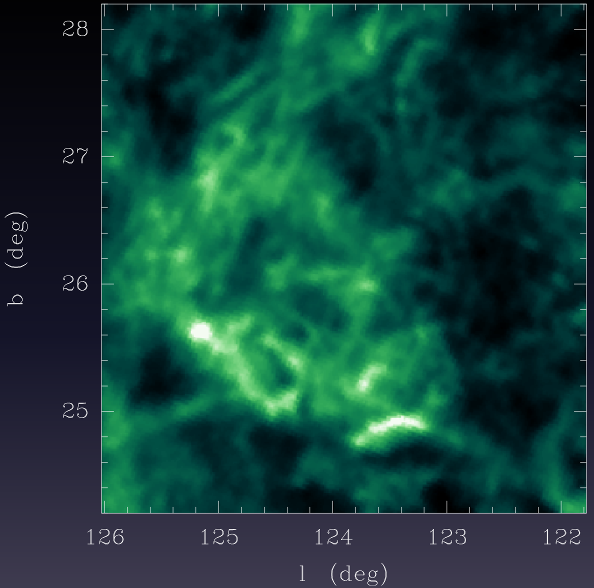
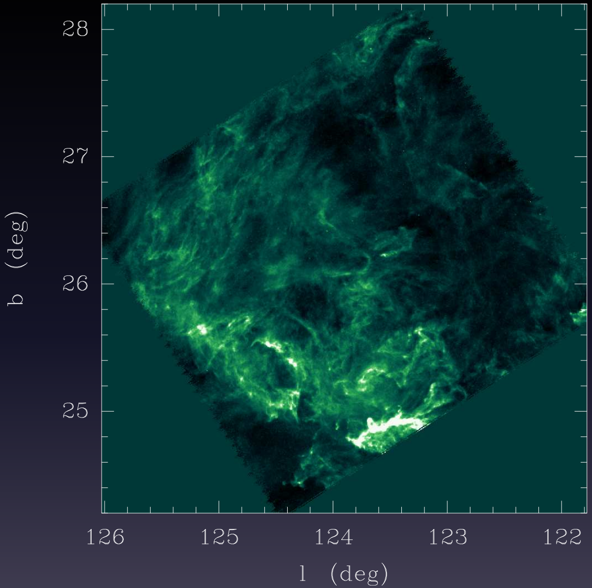


Polaris Flare, IRAS 100/60/25 $\mu\mathrm{m}$



Polaris Molecular Cloud MCLD123.5+24.9, IRAS 100μm



Herschel/SPIRE 250μm, (SDP data, Gould Belt survey, André et al 2010)

- Filaments are ubiquitous (Schneider & Elmegreen 1979, Onishi et al 1996, Mizuno et al 1999, ...)
- IRAS: Cold phase is filamentary
    - $N_{\rm H}$ down to $\sim$ few $10^{21}~{\rm cm}^{-2}$
    - Transverse size down to $\sim$ 0.1 pc
- SPIRE: Extends to low column density, small-scale, filaments
    - $N_{\rm H} \sim 10^{20}~{\rm cm}^{-2}$ (André et al 2010)
    - Transverse size down to $\sim$ 0.02 pc
- no “cloud surface”
- Link between filaments and star formation (Larson 1985, Tachihara 1996, Hartmann 2002, ...)

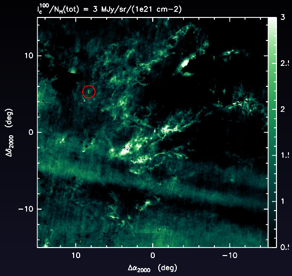
Categories of filaments

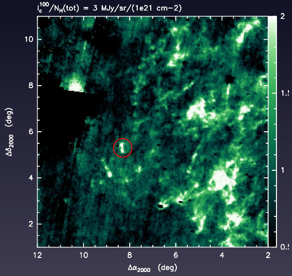
Star forming, massive filaments

Dense filaments ($N_{21} \sim$ few)

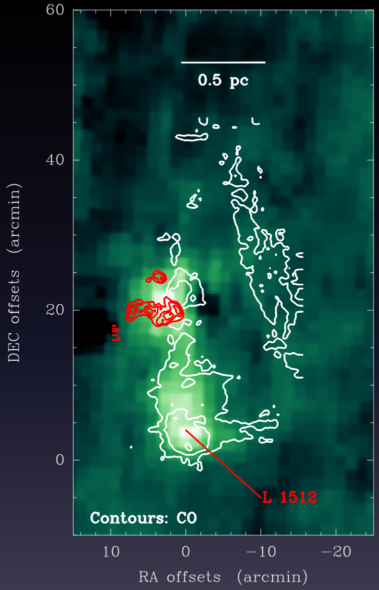
Tenuous filaments ($N_{21} \sim$ few 0.1)

Dense Filaments



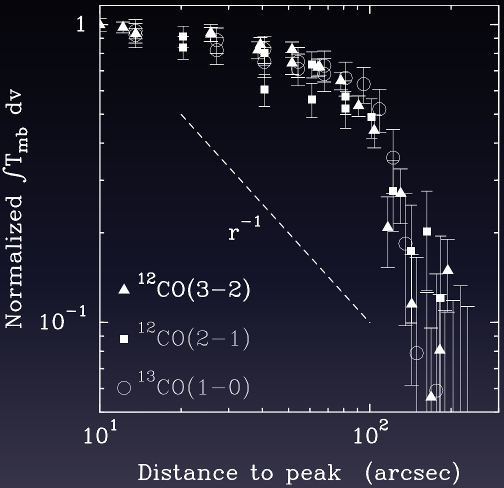


Taurus, N_{21}



CO(2-1) mapped @ CSO

Falgarone, Pety, Phillips 2001; Hily-Blant, Falgarone, & Phillips in prep



1
10^{-1}
Normalized $\int T_{mb}$ dv
r^{-1}
$^{12}CO(3-2)$
$^{12}CO(2-1)$
$^{13}CO(1-0)$
10^1
10^2
Distance to peak (arcsec)

- CO(2-1) traces the dense and also a much fainter filaments
- Radial profile
  - Radial Cut: CO(4-3), (3-2), (2-1) (CSO), $\mathrm{C^{18}O}$(1-0) (IRAM)
  - Photodissocation: no role
  - Sharp profile:

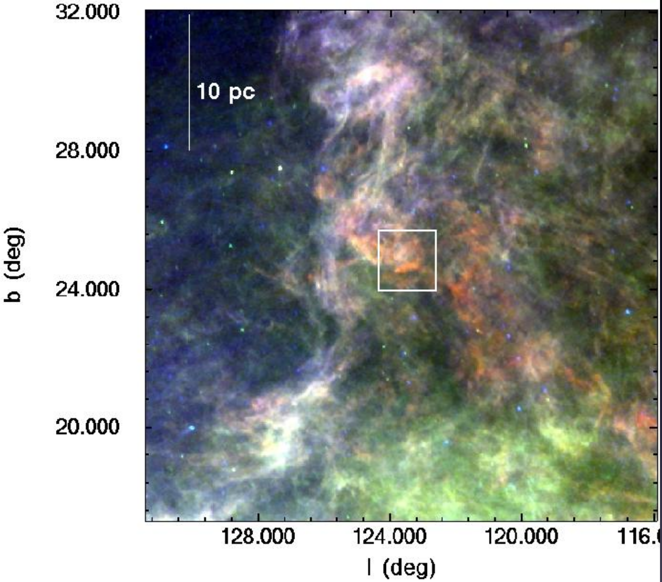
$$\boxed{n(r) \propto r^{-\alpha},\, \alpha \geq 3}$$

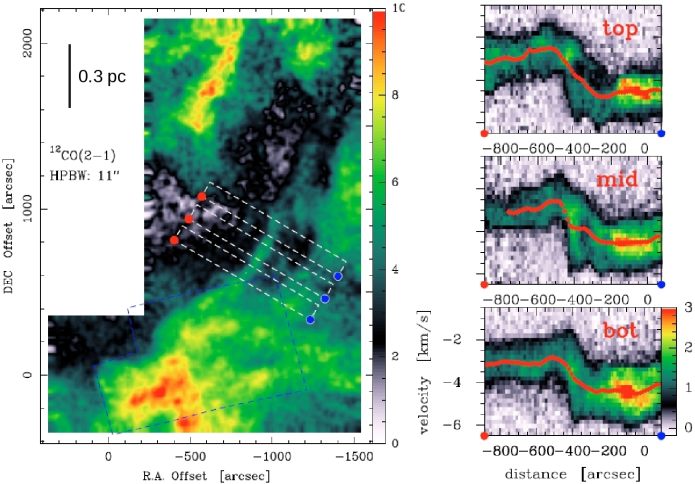
  - $\alpha = 1 - 4$ (Stodolkiewicz 1963, Fiege & Pudritz 2001)
- Non self-gravitating: $\mu \approx 5\ \mathrm{M_\odot\,pc^{-1}} \ll \mu_{\mathrm{vir}} = 84\ \mathrm{M_\odot\,pc^{-1}}$
- Central density $1.5(4)\ \mathrm{cm^{-3}}$, temperature ≈ 10 K,

$$\boxed{P/k = 1.5(5)\,\mathrm{K\,cm^{-3}} \gg P_{\mathrm{CNM}}/k = 3(4)\,\mathrm{K\,cm^{-3}}}$$

- Confinement: magnetic hoop ?

Tenuous Filaments


32.000
10 pc
28.000
b (deg)
24.000
20.000
128.000
124.000
120.000
116.
l (deg)



$^{12}CO(2-1)$, IRAM-30m/HERA (Hily-Blant & Falgarone 2009)

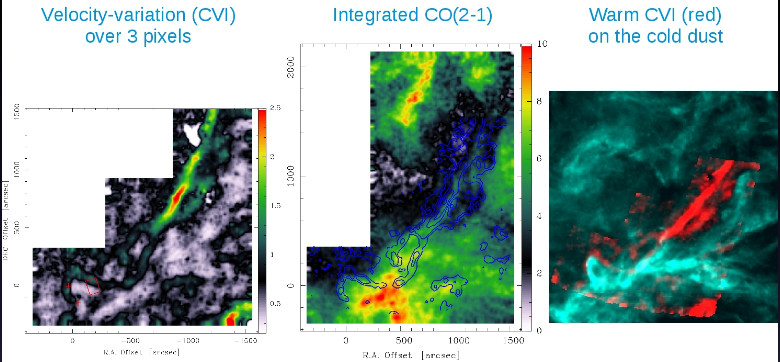
Parsec-scale shear-filament: $\delta v = 3\ \mathrm{km\,s^{-1}}$, $\delta l = 0.075$ pc

$\delta v / \delta l \approx 40\ \mathrm{km\,s^{-1}\,pc^{-1}} \gg 1\ \mathrm{km\,s^{-1}\,pc^{-1}}$ (typical for MCs)

Nature of the filamentary shear ?

- Parsec-scale filamentary shear
- Comparison with dust 250$\mu\mathrm{m}$ emission: Not associated with significant increase of density
- Unfruitful search for SiO emission

$\Rightarrow$ unlikely a strong shock
$\Rightarrow$ low velocity ($2 - 10\ \mathrm{km\,s^{-1}}$) shock ?



Hily-Blant & Falgarone 2007, 2009

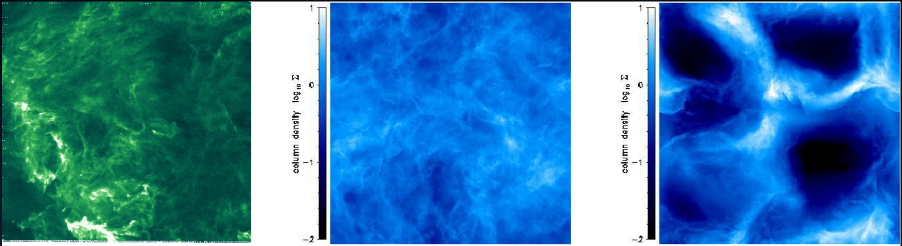
- Non-self gravitating filamentary:

$$\mu < 0.1\ \mathrm{M}_\odot\ \mathrm{pc}^{-1} \sim 0.01\mu_{\mathrm{vir}}$$

- Correlated with warm and tenuous gas:

$$T \approx 25\ \mathrm{K}, n \approx \mathrm{few}100\ \mathrm{cm}^{-3}$$

Origin of the tenuous filaments ?



Polaris Flare　　Solenoidal forcing　　Compressive forcing

Consistent with turbulence and rotational forcing rather than compressive (Hily-Blant et al 2008, Federrath et al 2010)

Conclusions and Perspectives

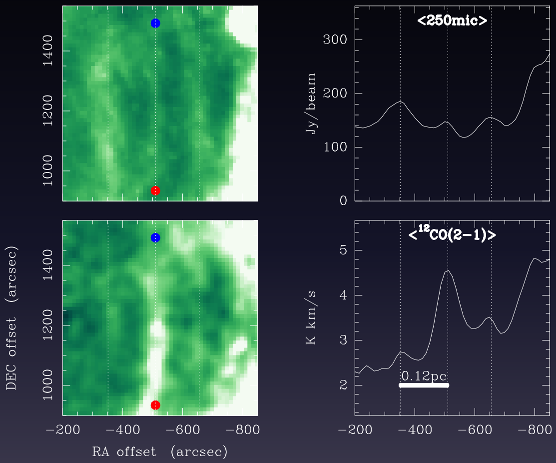
Conclusions

- Diffuse gas is filamentary from 10 to 0.005 pc scales
- CO traces both dense and tenous filaments
- Tenuous filaments appear ubiquitous
- Most tenuous filaments are not due to strong shocks
- Large shears are observed at scales from 1 to 0.001 pc

Perspectives

- Statistics (more filaments, more maps)
- Velocity field (*e.g.* rotation)
- Explore low velocity shocks properties and signatures
- Comparisons with numerical simulations

Nature of the filamentary shears ?



- Large shear not associated with sharp increase of density
- Unfruitful search for SiO
- Large filamentary shear unlikely a (strong) shock