Star Forming Structures in Giant Molecular Clouds: Core Networks, Bubbles, and Filaments in the Vela Molecular Ridge

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Open issues in star formation

Low star formation efficiency in giant molecular clouds ---> TURBULENCE

Young stars often in clusters and associations ----> GAS FRAGMENTATION

Turbulence, gravity, magnetic fields shape the interstellar medium at all scales
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Observational tools

High resolution, large scale mm and sub-mm observations needed to follow turbulence and fragmentation down to small (< 1 pc) scale

Large array of sensitive mm/sub-mm detectors (BOLOMETER ARRAYS) available for several years (SCUBA, SIMBA, MAMBO, SCUBA2, SABOCA, LABOCA …) Allow obtaining large scale maps (tens of pc) with better than 0.1 pc resolution

Continuum dust emission OPTICALLY THIN at sub-mm wavelength → MASS MASS needs DUST TEMPERATURE (Far-Infrared)

HERSCHEL (70 to 500 micron) yielded large scale maps with reasonable Resolution ---> wavelength range optimal for temperature determination of cold dust

Knowledge of molecular cloud structure now good. But kinematics still needed
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VELA MOLECULAR RIDGE - OVERVIEW

13CO(1-0), NANTEN, beam 2.7 arcmin (Yamaguchi et al. 1999)

Vela Molecular Ridge: clouds A, C, D at 700 pc

BLAST
250 micron (BLUE)
350 micron (GREEN)
500 micron (RED)
(Netterfield et al. 2009)
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First higher-resolution, large scale mm observations (VELA D)

Vela D
SIMBA 1.3 mm
beam 24 arcsec
0.08 pc at 700 pc
Sensitivity 0.02 mJy/beam
(Massi et al. 2007)

12CO(1-0) -2 to 20 km/sec
SEST beam 44 arcsec
0.15 pc at 700 pc
(Elia et al. 2007)

24 micron (MIPS, BLUE)
70 micron (MIPS, GREEN)
250 micron (BLAST, RED)
(Olmi et al. 2009)
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Filaments and bubbles in Vela D

Vela D - $^{12}$CO(1-0)
(Elia et al. 2007)
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Filaments in Vela C

Vela C HOBYS (Hill et al. 2011)

HERSCHEL
70 micron (BLUE)
160 micron (GREEN)
250 micron (RED)
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LABOCA map of Vela C (dust continuum 870 micron)

LABOCA at APEX
870 micron
Beam 18.5 arcsec
0.06 pc at 700 pc
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Vela C and Vela D - dust emission

Vela C - LABOCA/APEX (0.87 mm)
(Massi et al. in prep.)

Vela D
SIMPMA/SEST (1.3 mm)
(Massi et al. 2007)
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CORE MASS FUNCTION in VELA

\[ \frac{dN}{dM} = kM^{-2.0} \]

Vela C – 0.87 mm

Vela C – FIR

(Velvino et al. 2012)

Vela D – FIR+1.3mm

(2009)

Vela D \(^{12}\)CO(2-1)

(Elia et al. 2007)

Vela D – FIR

(Netterfield et al. 2009)

Vela Molecular Ridge

FIR

(Netterfield et al. 2009)
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CORE PROPERTIES in Vela C
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Tentative evolutionary scenario for GMCs

<table>
<thead>
<tr>
<th>TIME</th>
<th>dust temperature</th>
<th>structure</th>
<th>Stars</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold (&lt; 15 K)</td>
<td>Nest of filaments</td>
<td>Low-mass</td>
<td></td>
</tr>
<tr>
<td>Cold + warm</td>
<td>Ridges, shells</td>
<td>Clusters</td>
<td></td>
</tr>
<tr>
<td>Warm (&gt; 15 K)</td>
<td>Shells</td>
<td>Small clusters (&lt; 100 stars)</td>
<td></td>
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