Massive star formation

with

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Trifid Nebula (SPITZER/IRAC+MIPS)
Massive star formation

Introduction

Motivation

• **M20** (Trifid Nebula) is an active site of star formation in a turbulent, filamentary molecular cloud.

• What sort of star formation is going on in a young HII region?

![M20 Trifid Nebula (Hα)](image)

**RA:** $18^h\ 02^m\ 23.55^s$, **DEC:** $-23^\circ\ 01'\ 51''$

**Distance:** 1.65 kpc

**Diameter:** ~15'

(Lefloch et al. 2003)
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Introduction

Scientific background

- M20 is ionized by an O7 type star (HD 164492).
- This region was studied by SPITZER in the range 3.5 - 24 μm (IRAC, MIPS).

Rho et al. (2006) detected 32 protostellar candidates, and 120 Class II sources in the nebula.

Trifid Nebula (SPITZER/IRAC+MIPS)
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Preparations

Time estimator

• Bertrand's introduction into the field
• “Brainstorming”
• Time estimator:
  Input:
  • Receiver and backend parameters
  • Sources
  • Atmospheric conditions
  • Observing mode
  • Observing parameters

RESULTS S-L On-The-Fly (8arcsec)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>time for tuning</td>
<td>21 min</td>
</tr>
<tr>
<td>time for 1 pointing</td>
<td>0 h 6 min</td>
</tr>
<tr>
<td>time for 1 focus</td>
<td>0 h 6 min</td>
</tr>
<tr>
<td>time for calibrations</td>
<td>0 h 4 min</td>
</tr>
<tr>
<td>size of the mapped region</td>
<td>632.0 x 208.0''</td>
</tr>
<tr>
<td>nb of rows to cover field</td>
<td>1 x 3</td>
</tr>
<tr>
<td>row spacing</td>
<td>72''</td>
</tr>
<tr>
<td>nb of on subscan per off subscan</td>
<td>1</td>
</tr>
<tr>
<td>spectral resolution</td>
<td>307 kHz (0.4000 km/s)</td>
</tr>
<tr>
<td>system temperature</td>
<td>1354.1 K</td>
</tr>
<tr>
<td>receiver temperature</td>
<td>213.4 K</td>
</tr>
<tr>
<td>r.m.s. reached in each spectrum after one coverage</td>
<td>1288.7 mK</td>
</tr>
<tr>
<td>time for one coverage</td>
<td>0 h 9 min</td>
</tr>
<tr>
<td>nb of coverages to reach the desired r.m.s</td>
<td>4.0</td>
</tr>
<tr>
<td>r.m.s. reached in each spectrum after all coverages</td>
<td>644.4 mK</td>
</tr>
<tr>
<td>integration on the source</td>
<td>0 h 34 min</td>
</tr>
<tr>
<td>TOTAL TIME</td>
<td>1 h 12 min</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Line Freq. in GHz</th>
<th>r.m.s. in mK of T_a</th>
<th>Backend</th>
<th>Spectral Resol. (km/s, if smoothing)</th>
</tr>
</thead>
<tbody>
<tr>
<td>230</td>
<td>700</td>
<td>VESPA 800kHz</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Sources:

Average Elevation for the sources in degrees

Atmospheric conditions (amount of precipitable water vapor):

3 mm (Average summer condition)
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Observation

Configuration

- **Lines:** $^{12}\text{CO}(2-1)$ @ 230.538 GHz and $^{18}\text{O}(1-0)$ @ 109.282 GHz
- **Receiver:** EMIR E230 / E090 (HERA could not be used, as we planned)
  Undersampled @ 1 mm, ~ Nyquist sampled @ 3 mm
- **Backends:** VESPA (80 kHz res., 80 MHz bandwidth), WILMA (2 MHz, 4 GHz)
- **Mode:** OTF map
- **Map size:** 600” x 276”
- **Duration of observations:** 1$^{h}$ 44$^{m}$
- **Sampling:** 12” between OTF lines, 3.8” between dumps
- **Calibration source:** 1757-240 W28A2 (~8 Jy @ 1mm)
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Data Reduction

Reduction with GILDAS

Averaged 12CO(2-1) spectrum

Averaged, spike/baseline removed, reference position added 12CO(2-1) spectrum
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Results - Conclusions

- We discussed the geometry and the large-scale structure of the region.
- Dust lines in absorption => access to the velocity field on the front side.
- Then, we reconstructed the velocity field...

What we had (Lefloch et al. 2003).

Low density expanding material:
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Results - Conclusions

A C18O core

• We detected one, “probably” high mass condensation.

• Channel maps showed us more positive velocities than we expected. => The drawing could explain the geometry.
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Results - Conclusions

Maps

Source: M20  Line: 12CO(2−1)  Freq: 230.53799 GHz  Beam: 11.25 x 11.25 PA 0°
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Hα + 12CO contours

M20 Trifid Nebula $^{12}$CO 2–1 on Hα
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Results - Conclusions

It was not that easy to extract, but after all...

• We detected one, probably massive condensation in the center of the cloud.
• We found evidence of expansion of the low density material behind the filaments with ~0-2 km/s.
• There is no evidence of strong dynamical interaction on large scales. (Velocities along the filaments showed that material is infalling towards the O star.)
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Thank you Bertrand, Albrecht, and IRAM people!

The End