A search for biomolecules in Sgr B2, and the massive star-forming region NGC 3576

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Biomolecules project

- A wide range of complex organic molecules, including amino acids, have been found in comets.
- These may have seeded the `pre-biotic soup' on Earth.
- A wide range of organic molecules have been detected in molecular clouds, but no amino acids.
- We are searching for the simplest amino acid, glycine, NH_2CH_2COOH.

- Biological molecules are chiral, but the origin of this chirality is a mystery. One possibility is circularly polarised light in the ISM (Jeremy Bailey) leading to a chiral excess in the seeded cometary material.
- No chiral molecules have been detected in molecular clouds.
- We are searching for a simple one, propylene oxide, C_3H_6O.

- Precise frequencies for 3-mm transitions of glycine and propylene oxide have been measured in the laboratory by the Monash University group - Peter Godfrey, Dinah Cragg
- We have looked at 2 positions

* Sgr B2 (N) LMH = Large Molecule Heimat, which is where the largest number of large, complex molecules have been detected, a dense, dusty region
* IRAS 16562-3959 = G345.5+1.5 - a region found to be rich in simpler molecules, comparable to Orion KL, from Mopra and SEST observations.

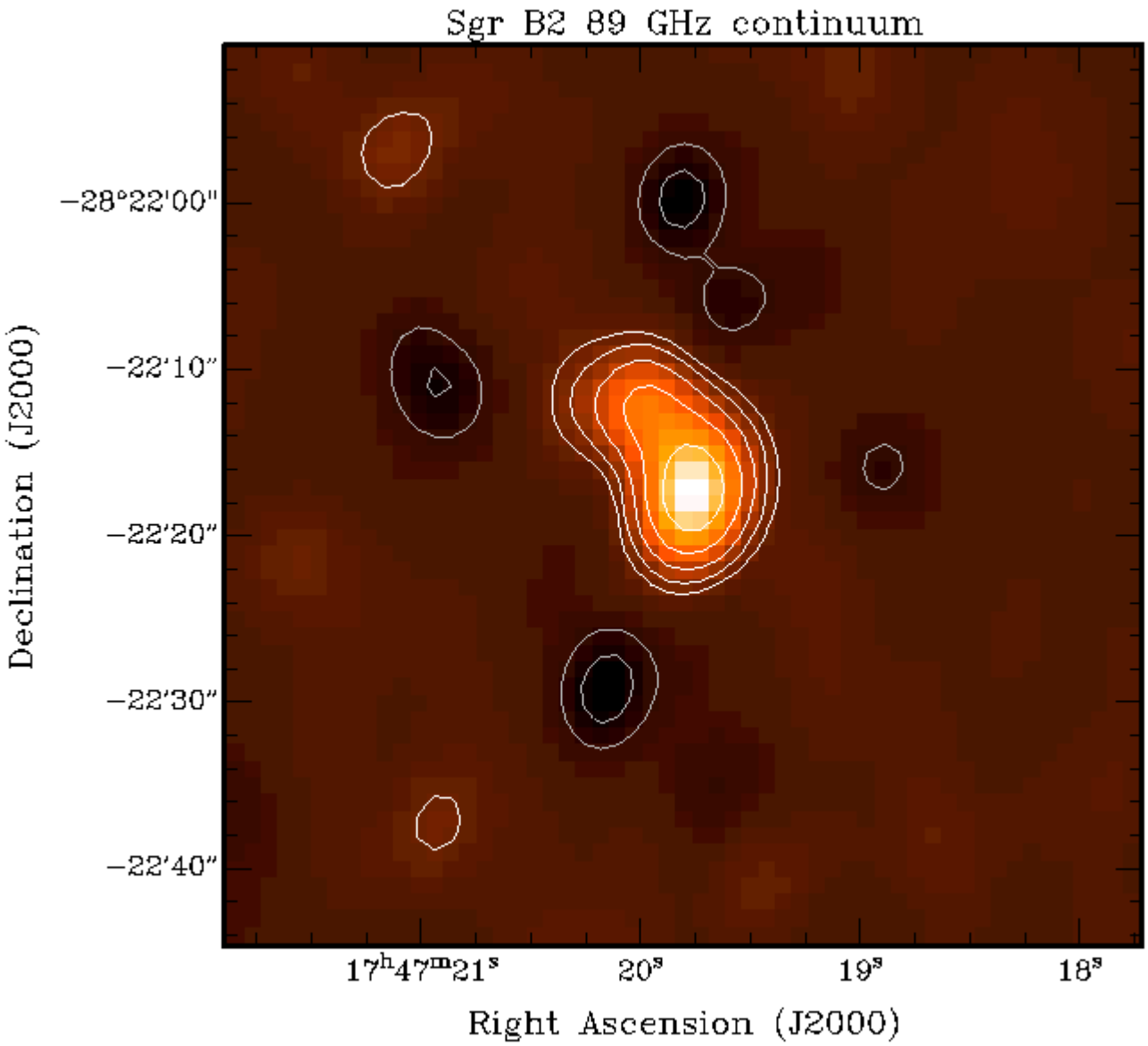
- If the molecules are confined to the densest regions (shielded from UV, formed in dense regions) then the angular size may be only a few arcsec, and the best way to detect then would be with high resolution and an interferometer eg ATCA at 3 mm. This has the advantage that the `forest' of confusing spectral lines is resolved out.
- On the other hand, if the molecules are distributed more widely, then the interferometer will resolve the emission out (no zero spacings) and a single dish observation eg Mopra, is needed.
- We are using both the ATCA (C1077) and Mopra (UNSW key project).

ATCA results at 3 mm (C1077)

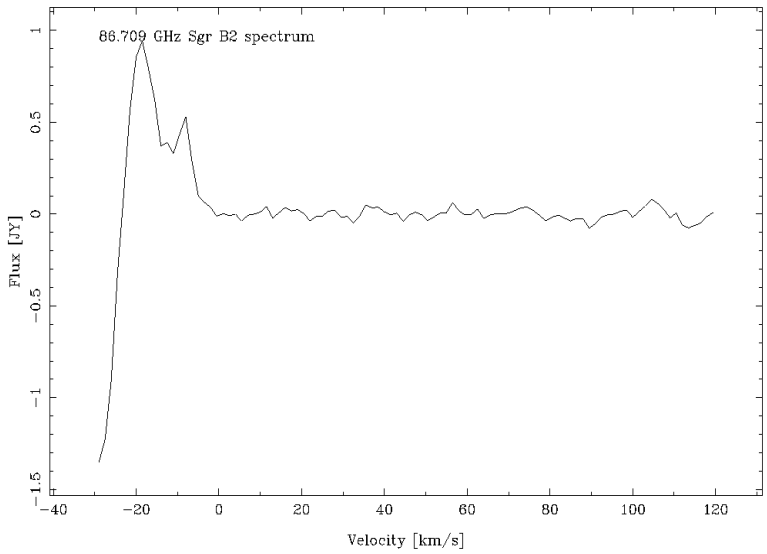
- June 2002, 2 days, Sgr B2 and G345.5+1.5, EW 352 = 3 EW baselines
- August 2002, 2 days, Sgr B2,
  H75 = 3 NS baselines
- Data cubes and spectra show RMS around 30 mJy/beam in line free channels (as expected)

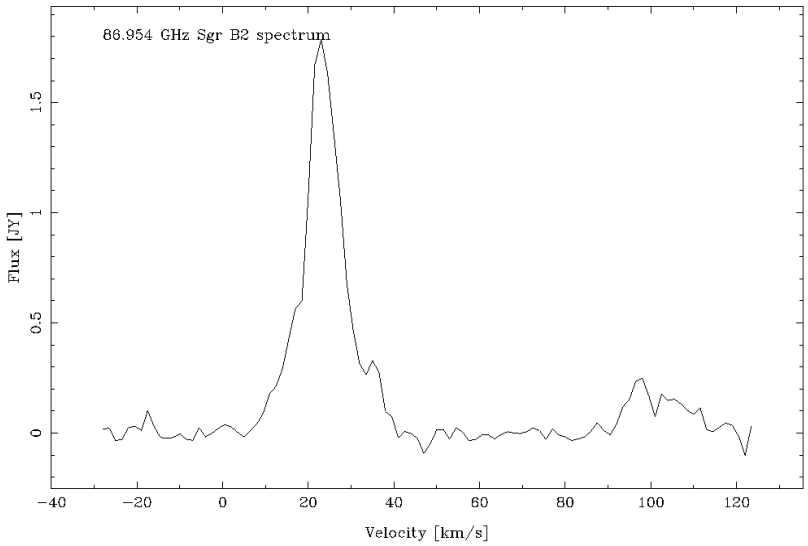
Sgr B2

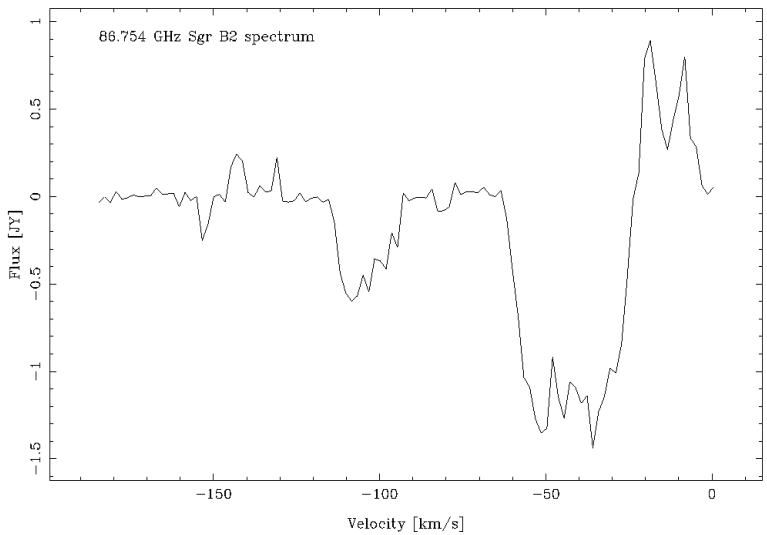
- Sgr B2 3 mm continuum (EW352 + H75) shows extended 2.5 Jy source, and background RMS = 35 mJy/beam (dynamic range limited)
- Self-calibration used.

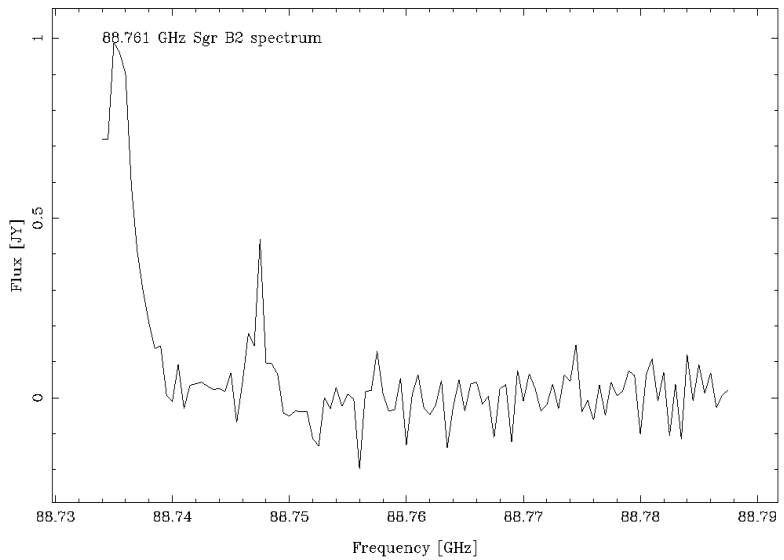

Sgr B2 89 GHz continuum
−28°22'00"
−22'10"
−22'20"
−22'30"
−22'40"
Declination (J2000)
17h47m21s
20s
19s
18s
Right Ascension (J2000)

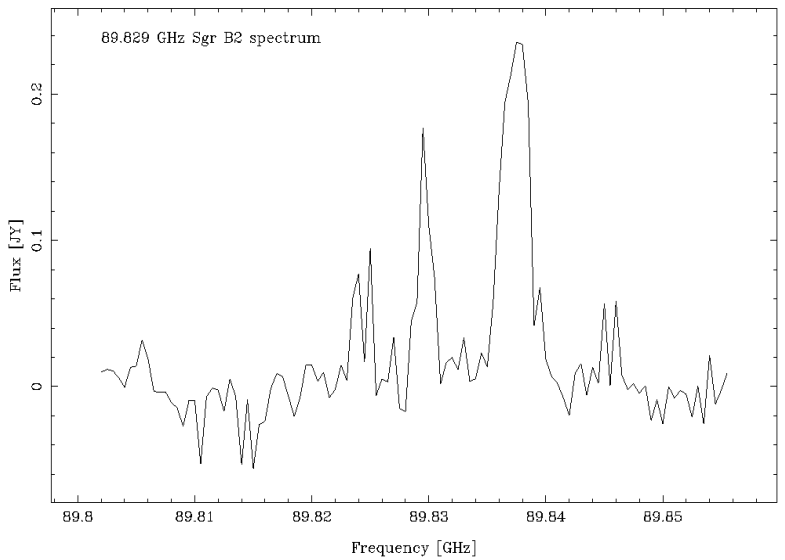
- Spectral lines in Sgr B2 all coincide with the LMH continuum source.
- Emission (ethyl cyanide and unknown line) and absorption ($H^{13}CO^{+}$) in 86.709 GHz data
- There are more unidentified lines in the other spectra of Sgr B2 LMH at 86.754, 86.954, 88.761, 90.451, 89.829 and 90.022 GHz

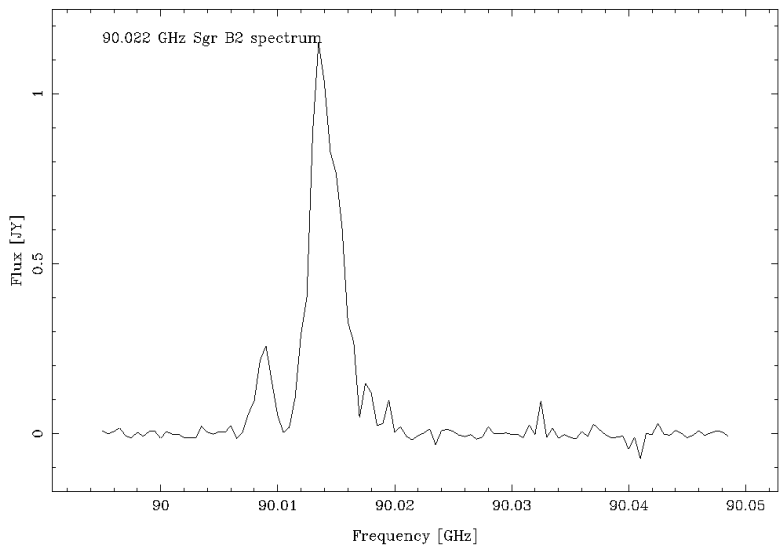

86.709 GHz Sgr B2 spectrum
Flux [JY]
Velocity [km/s]
1
0.5
0
−0.5
−1
−1.5
−40
−20
0
20
40
60
80
100
120

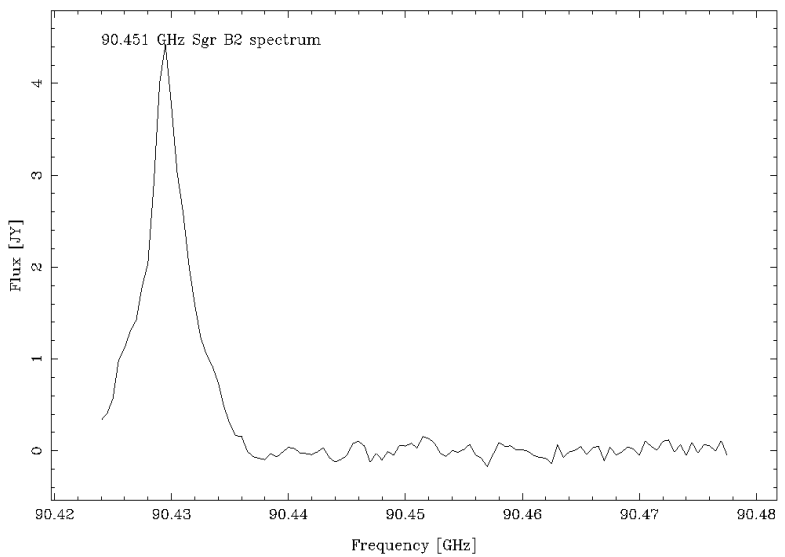

86.954 GHz Sgr B2 spectrum
Flux [JY]
Velocity [km/s]
1.5
1
0.5
0
−40
−20
0
20
40
60
80
100
120


86.754 GHz Sgr B2 spectrum
Flux [JY]
Velocity [km/s]
1
0.5
0
−0.5
−1
−1.5
−150
−100
−50
0


88.761 GHz Sgr B2 spectrum
Flux [JY]
Frequency [GHz]
88.73
88.74
88.75
88.76
88.77
88.78
88.79
0
0.5
1


89.829 GHz Sgr B2 spectrum
Flux [JY]
Frequency [GHz]
89.8
89.81
89.82
89.83
89.84
89.85
0
0.1
0.2


90.022 GHz Sgr B2 spectrum
Flux [JY]
Frequency [GHz]
90
90.01
90.02
90.03
90.04
90.05
0
0.5
1


90.451 GHz Sgr B2 spectrum
Flux [JY]
Frequency [GHz]
90.42
90.43
90.44
90.45
90.46
90.47
90.48
0
1
2
3
4

G345.5+1.5

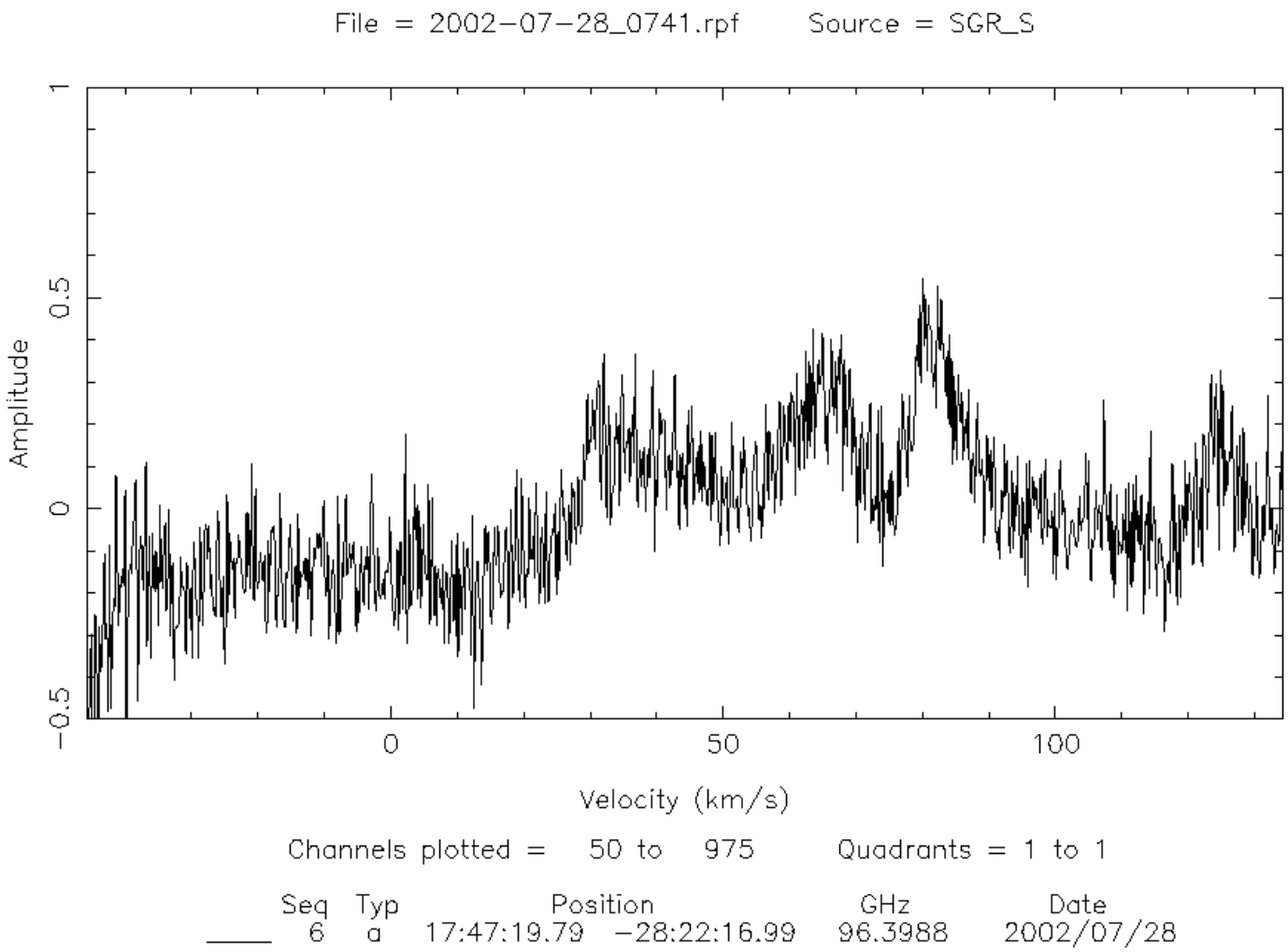
- The continuum image shows no detectable continuum, and has RMS = 4 mJy/beam
- The spectra show $H^{13}CO^{+}$, but not other unidentified lines (not as rich as Sgr B2 LMH)

ATCA

- As yet, no significant detection of glycine or propylene oxide, but ATCA limits comparable to BIMA/ OVRO searches.

Mopra results

- Data are not yet fully reduced, but also show unidentified lines in Sgr B2, none (yet ?) identified with glycine or propylene oxide



Sgr B2 Mopra spectrum

Other searches

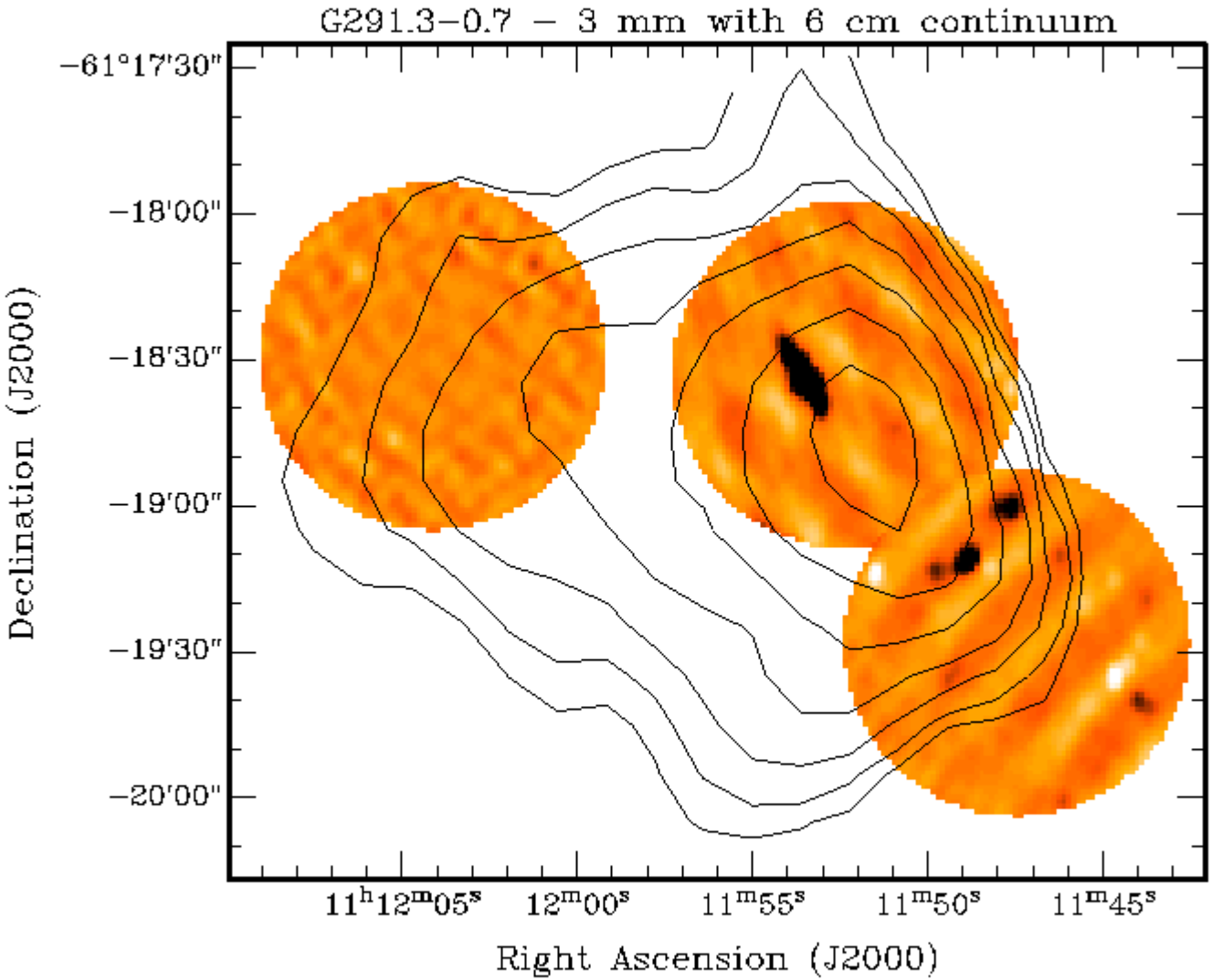
- Poster paper at Bioastronomy 2002, Hamiltion Island, Y.-J. Kuan et al., and associated New Scientist article, report a tentative (?) detection of glycine in NRAO 12-m observations (including Sgr B2 LMH) from multiple higher transitions. Nothing yet on astro-ph or published.

The massive star-forming region G291.3-0.7 (alias NGC 3576 or RCW 57A)

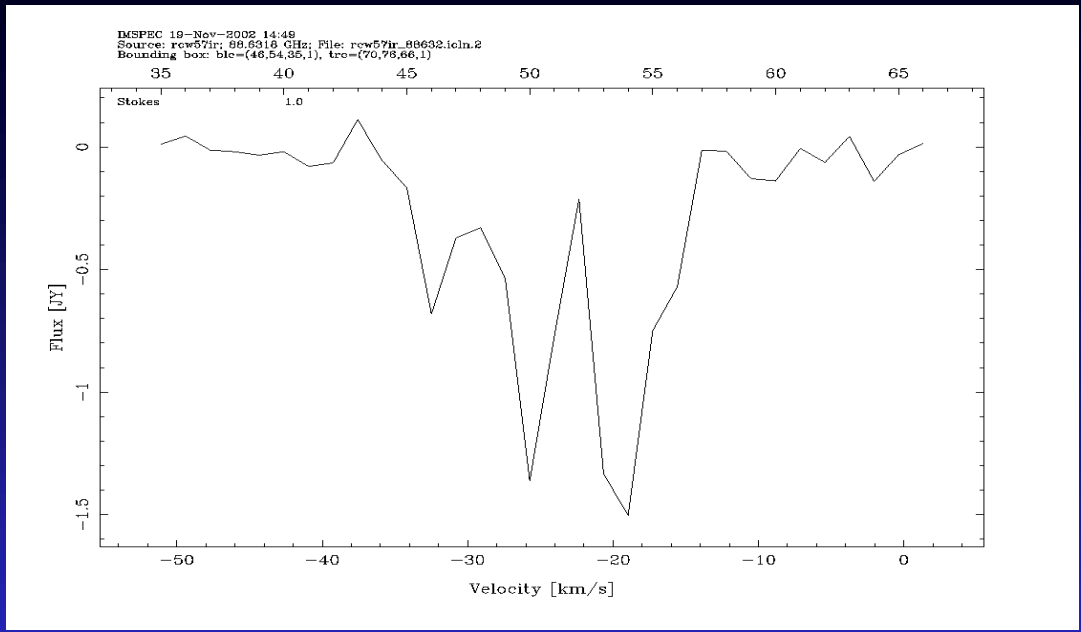
- 3 mm HCN and HCO^+ (C1079, Sept 2002, EW 352) and 6 cm formaldehyde (H_2CO) absorption (C1080)
- We observed 3 pointing centres at 3 mm,

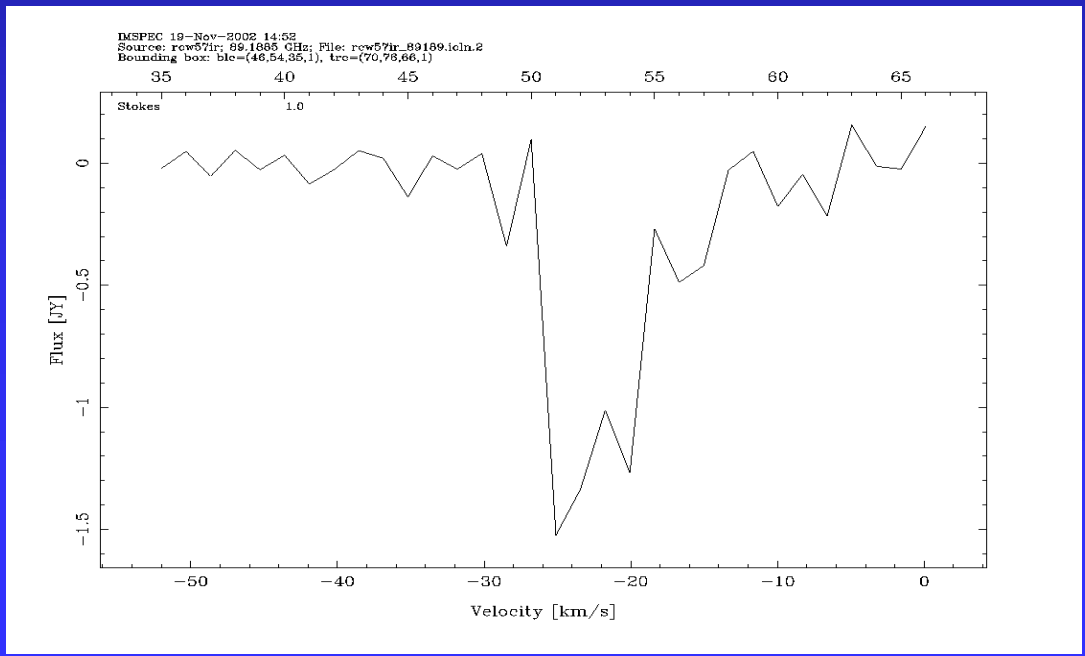
  1) IR peak, near the centre of the radio H II region, where massive stars have formed, but still with dense dust

  2) E cloud, and 3) W cloud which have different velocities and may be colliding.

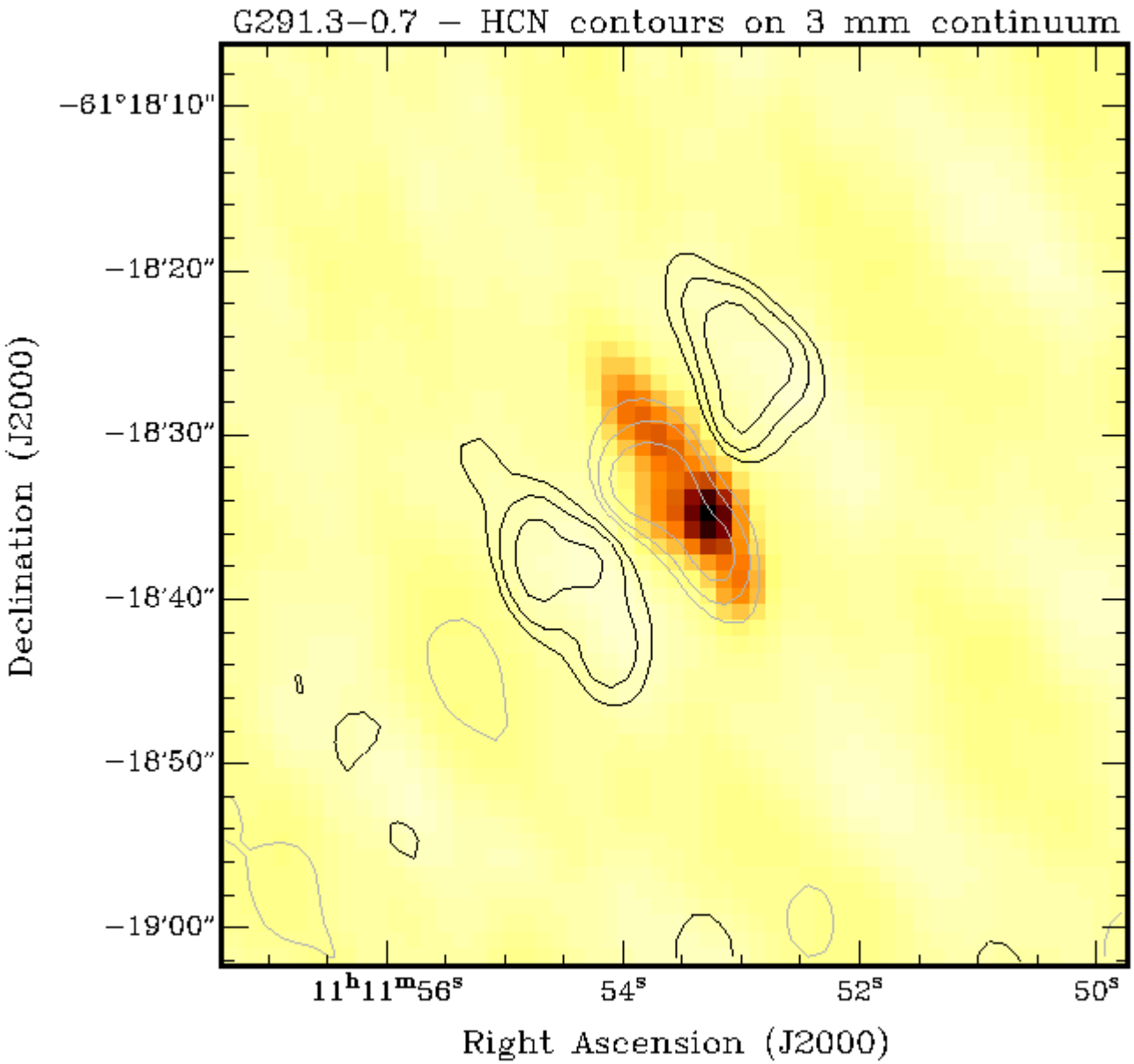

G291.3−0.7 − 3 mm with 6 cm continuum
−61°17'30"
−18'00"
−18'30"
−19'00"
−19'30"
−20'00"
Declination (J2000)
11h12m05s
12m00s
11m55s
11m50s
11m45s
Right Ascension (J2000)

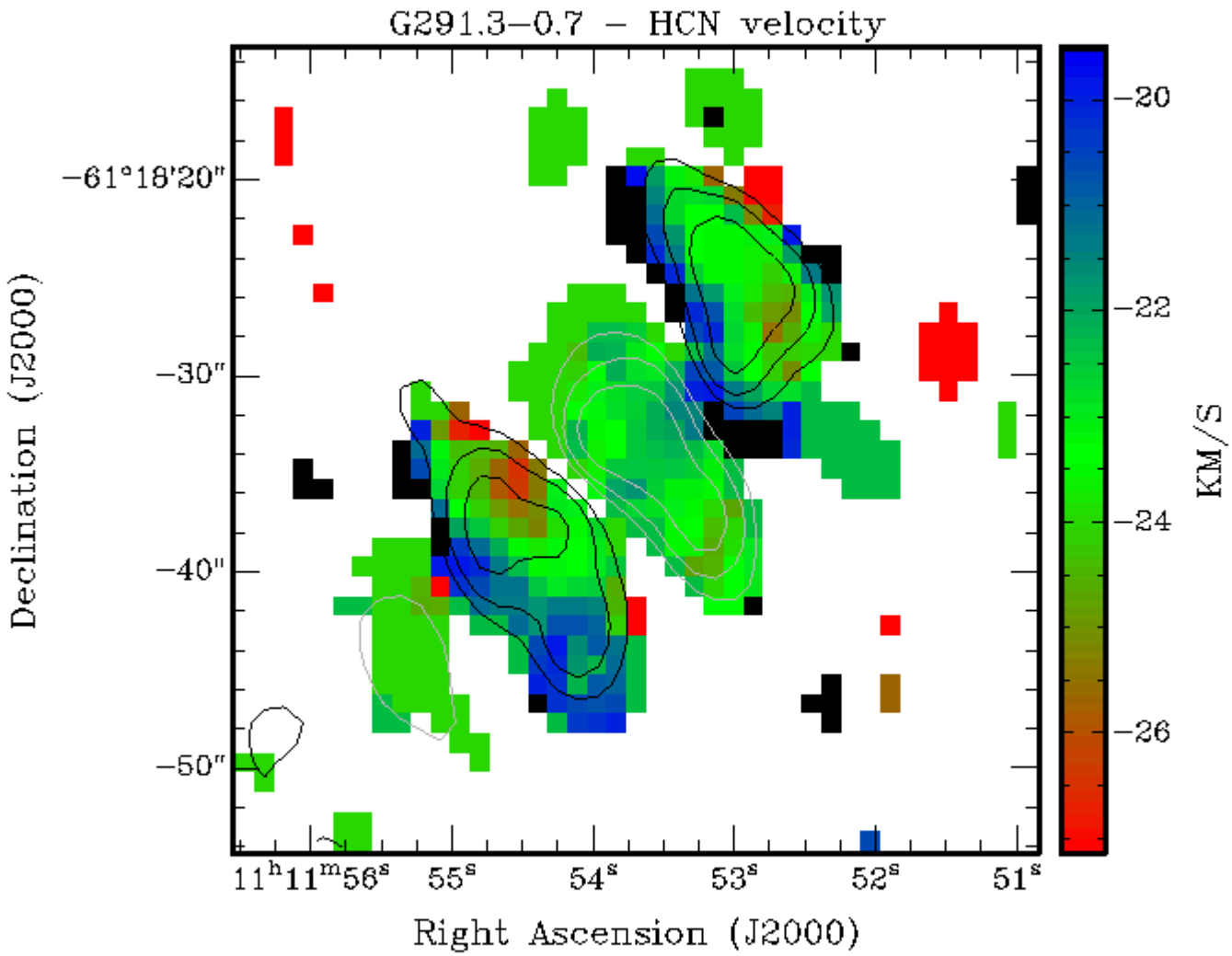
- We detect 3 mm continuum towards the IR and W positions, but the latter has complex extended structure, poorly sampled with only 3 baselines
- We detect HCN (86.829 GHz) and HCO^+ (89.189 GHz) in all 3 positions, but extended and weak in the E and W positions, and also poorly sampled with only 3 baselines


IMSPEC 19-Nov-2002 14:49
Source: rcw57ir; 88.6316 GHz; File: rcw57ir_88632.icln.2
Bounding box: blc=(46,54,35,1), trc=(70,78,66,1)
Stokes 1.0
Flux [JY]
Velocity [km/s]


IMSPEC 19-Nov-2002 14:52
Source: rcw57ir; 89.1885 GHz; File: rcw57ir_89189.icln.2
Bounding box: blc=(46,54,35,1), trc=(70,78,66,1)
Stokes 1.0
Flux [JY]
Velocity [km/s]

- The HCN and HCO^+ at the IR pointing centre has complex structure, around the 3-mm continuum peak, with absorption at the continuum position, and emission on either side, perpendicular to the elongated continuum peak.
- The velocity structure is complex, but is probably an outflow.


G291.3−0.7 − HCN contours on 3 mm continuum
−61°18′10″
−18′20″
−18′30″
−18′40″
−18′50″
−19′00″
Declination (J2000)
11h11m56s
54s
52s
50s
Right Ascension (J2000)


G291.3−0.7 − HCN velocity
−61°18'20"
−30"
−40"
−50"
Declination (J2000)
11h11m56s
55s
54s
53s
52s
51s
Right Ascension (J2000)
−20
−22
−24
−26
KM/S

Conclusion

- The ATCA at 3 mm is giving good results for dense cores (continuum and line), with the expected sensitivity,

  but complex structures are hard to image with only 3 baselines (!), so start with the simple ones (2003) and strong ones, as self-calibration helps in phase ‘shake-down’ problems.