Herschel CHESS view of the intermediate-mass protocluster OMC-2 FIR 4

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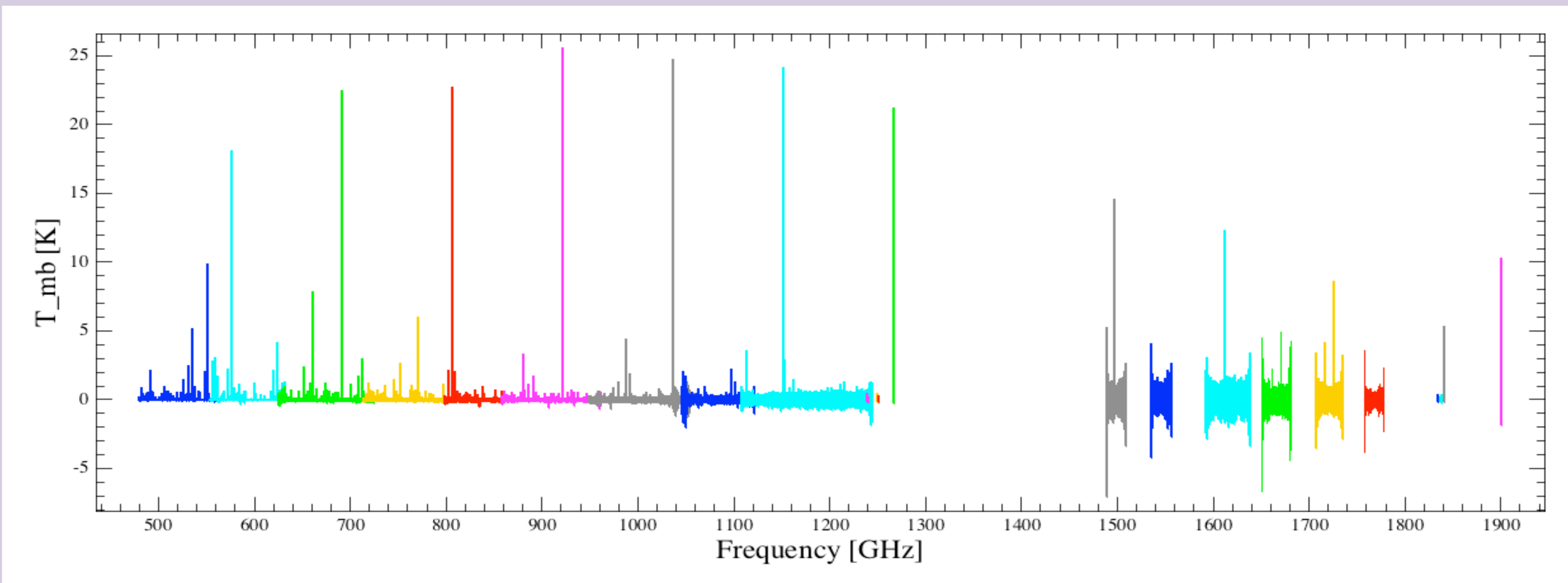
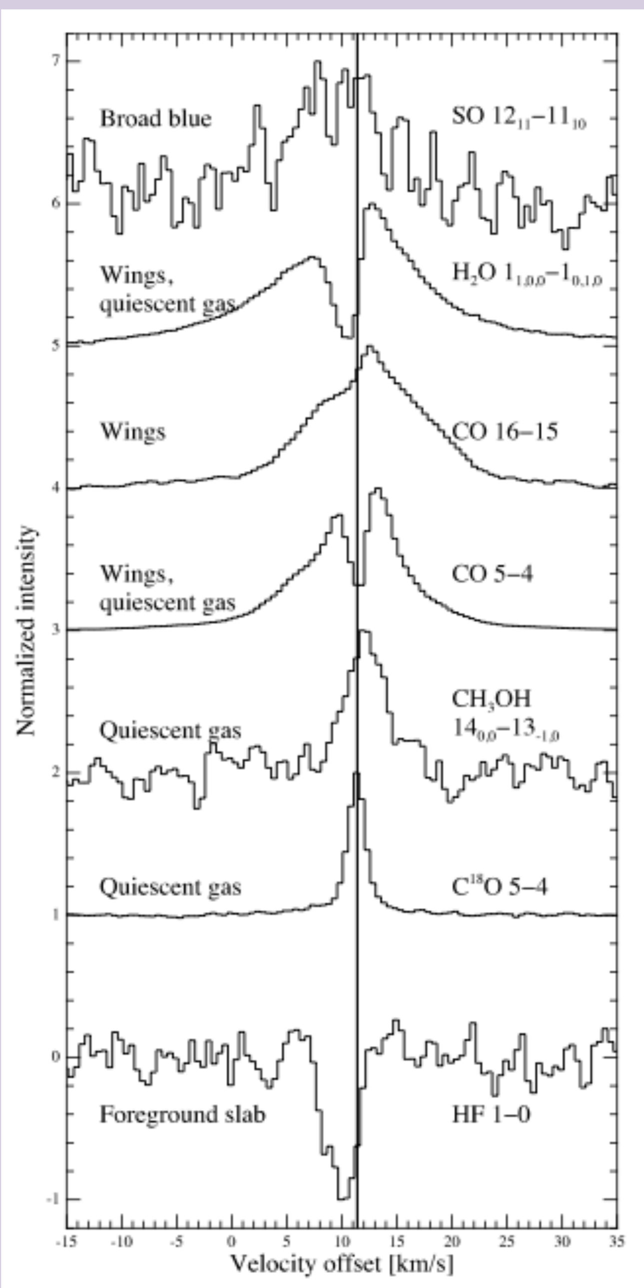
Context and observations

Broadband spectral surveys of star-forming regions offer a rich view of their physical, chemical and dynamical structure and evolution. As part of the *Herschel* guaranteed time key programme CHESS (Ceccarelli et al. 2010), we obtained a line-rich spectrum of the intermediate-mass protocluster OMC-2 FIR 4 with the **HIFI spectrograph** on-board the *Herschel* satellite, covering most of the frequencies between 480 and 1900 GHz.
We have also performed a complementary spectral survey at millimetre wavelengths with the **IRAM 30-m telescope** and mapped the region with the **Plateau de Bure Interferometer**.

Herschel - HIFI spectral survey



Full baseline-subtracted HIFI spectrum of OMC-2 FIR 4



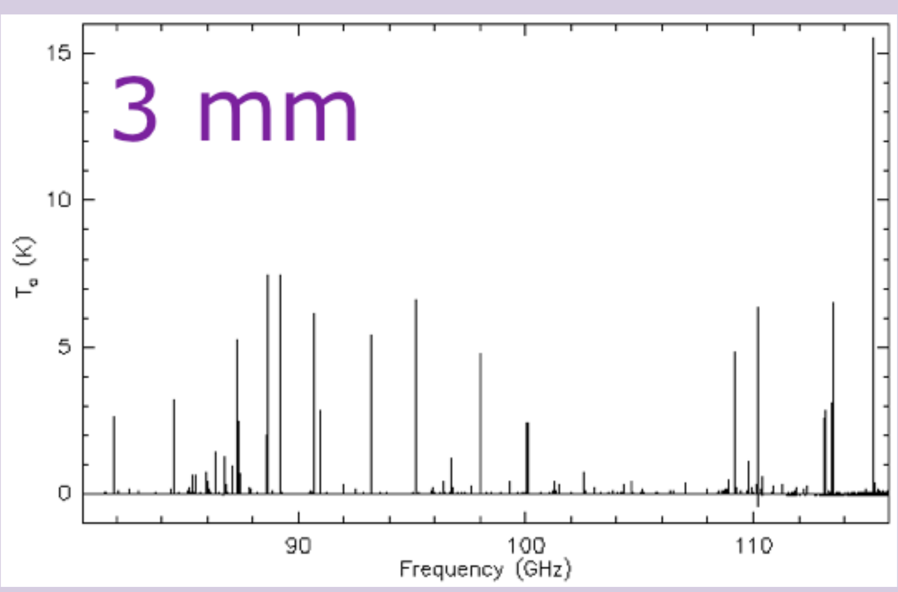
Species	#	E_u range K	$\overline{v_{lsr}}$ km/s	$\overline{FWHM}$ km/s	$\int T_{mb}dv$ K · km/s	Flux W · m^{-2}	Line components
CO^{s1}	11	83 … 752	11.8	12.3	2106.0	3.9(-14)	*Quiescent gas, wings, other.*
$^{13}CO^{s2}$	8	79 … 719	11.9	4.7	131.0	1.6(-15)	*Quiescent gas, wings.*
$C^{18}O^{s3}$	5	79 … 237	11.3	2.8	13.8	1.5(-16)	*Quiescent gas.*
$C^{17}O^{s4}$	3	81 … 151	10.8	3.2	4.0	1.4(-17)	*Quiescent gas.*
H_2O^{s5}	10	53 … 305	12.1	14.3	367.2	7.5(-15)	*Quiescent gas, wings, broad blue, other.*
$H_2^{18}O^{s6}$	1	61	13.7	19.2	1.1	1.0(-17)	*Wings.*
OH^{s7}	6	270	12.7	19.1	9.0	2.7(-16)	*Wings.*
OH^{+s8}	8	44 … 50	–	–	-5.4	-5.9(-17)	*Foreground slab.*
H_2O^{+s9}	1	54	8.4	2.5			*Foreground slab.*
CH_3OH^{s10}	431	33 … 659	12.2	4.7	520.5	6.2(-15)	*Quiescent gas, other.*
H_2CO^{s11}	74	97 … 732	11.9	4.7	96.9	9.56(-16)	*Quiescent gas, other.*
HCO^{+s12}	8	90 … 389	11.5	5.4	106.7	1.3(-15)	*Quiescent gas, other.*
$H^{13}CO^{+s12}$	2	87 … 117	11.4	2.2	0.7	6.2(-18)	*Quiescent gas.*
N_2H^{+s13}	7	94 … 349	11.7	3.0	26.3	3.1(-16)	*Quiescent gas, other.*
CI^{s14}	2	24 … 63	11.9	1.8	9.9	1.0(-16)	*Quiescent gas, other.*
CII^{s15}	1	91	9.1	2.1	20.8	6.2(-16)	*Foreground slab.*
CH^{+s16}	1	40	9.8	6.0	-2.8	3.7(-17)	*Foreground slab.*
CH^{s17}	3	26	–	–	0.4	3.8(-18)	*Quiescent gas?*
CCH^{s18}	17	88 … 327	–	–	11.3	1.2(-16)	*Quiescent gas, broad blue.*
HCN^{s19}	9	89 … 447	12.3	12.1	110.1	1.3(-15)^a	*Quiescent gas, broad blue, wings.*
$H^{13}CN^{s20}$	2	87 … 116	12.7	10.0	1.7	1.4(-17)	*Quiescent gas, broad blue.*
HNC^{s21}	2	91 … 122	11.6	2.6	2.1	1.9(-17)	*Quiescent gas.*
CN^{s22}	20	82 … 196	12.5	8.1	15.1	1.5(-16)	*Quiescent gas, broad blue.*
NH^{s23}	5	47	–	–	–^{a}	–^{a}	*Foreground slab, Other, broad blue?*
NH_3^{s25}	7	28…286	13.2	5.1	29.8	3.8(-16)	*Quiescent gas, broad blue, other.*
$^{15}NH_3^{s26}$	1	28	11.3	5.8	0.2	1.3(-18)	*Quiescent gas.*
CS^{s27}	12	129 … 543	12.2	10.3	23.7	2.0(-16)	*Quiescent gas, broad blue.*
$C^{34}S^{s27}$	1	127	10.0	1.7	0.2	1.6(-18)	*Quiescent gas?*
H_2S^{s28}	6	55 … 103	11.6	5.0	13.9	1.8(-16)	*Quiescent gas, broad blue?*
SO^{s29}	12	166 … 321	9.4	9.3	5.7	5.0(-17)	*Wings, foreground slab?*
SO_2^{s30}	2	65 … 379	11.1	10.0	0.3	2.3(-18)	*Broad blue.*
SH^{+s31}	2	25	–	–	0.4		*Other.*
HCl^{s32}	10	30 … 90	11.4	–	2.9^b	2.7(-17)^b	*Quiescent gas, other.*
$H^{37}Cl^{s32}$	10	30 … 90	11.4	–	0.9^b	9.0(-18)^b	*Quiescent gas, other.*
H_2Cl^{+s33}	5	23 … 58	9.4	1.3			*Foreground slab.*
$H_2^{37}Cl^{+s33}$	1	58	9.4	1.3			*Foreground slab.*
HDO^{s6}	3	43 … 95	12.9	3.3	1.1	8.4(-18)	*Quiescent gas, other?*
DCN^{s34}	2	97 … 125	12.0	4.9	0.4	3.1(-18)	*Other, broad blue?*
ND^{s35}	1	25	–	–	0.3	2.3(-18)	*Other, broad blue?*
NH_2D^{s36}	2	24	11.3	2.6	0.6	4.9(-18)	*Quiescent gas, other?*
HF^{s32}	1	59	10.0	2.8	-0.8	-3.8(-17)	*Quiescent gas, Foreground slab.*
All^c	718	23 … 752	12.0	5.4	3522.1	6.2(-14)	

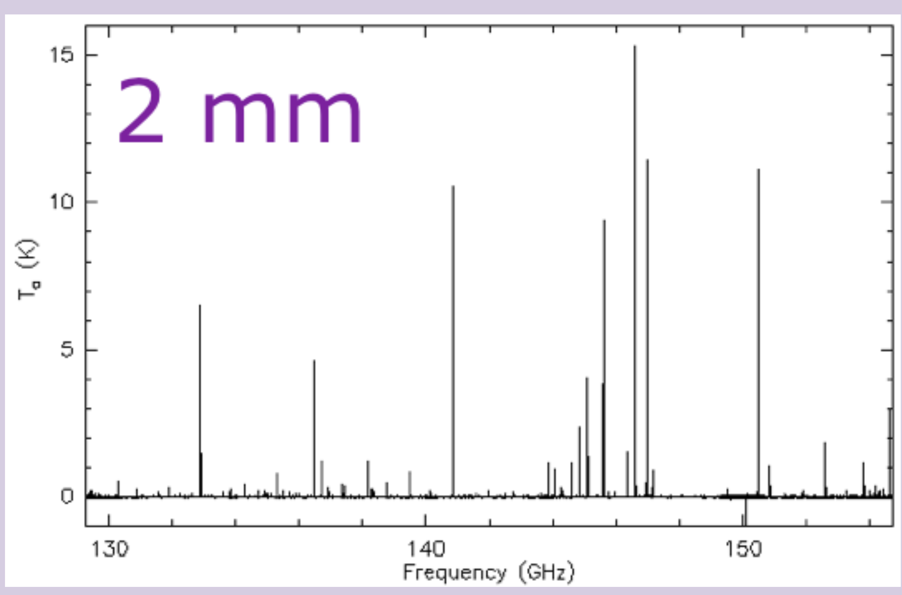
Variety of line profiles: several kinematical components

Line inventory:
- 718 lines identified
- 26 species (and 14 secondary isotopologues)
- 58% lines from CH_3OH; 10% from H_2CO
- E_{up} = 24 – 752 K

Kama et al. (submitted to A&A)

IRAM 30-m spectral survey





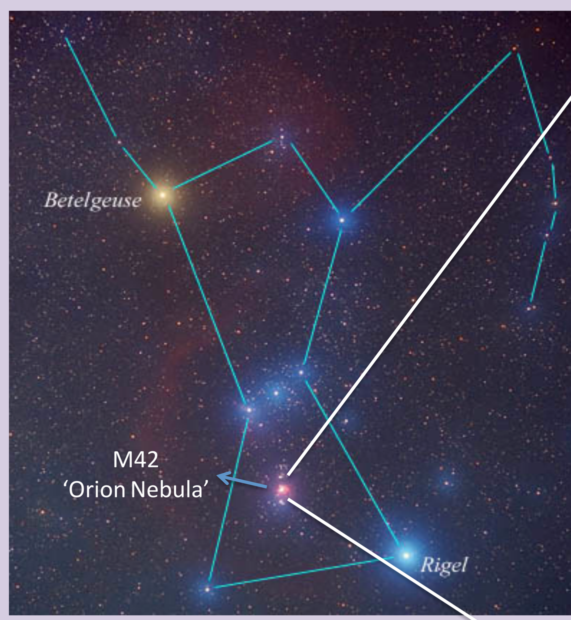
- **2 mm spectra**: data reduced
- **1 and 3 mm spectra**: to be reduced

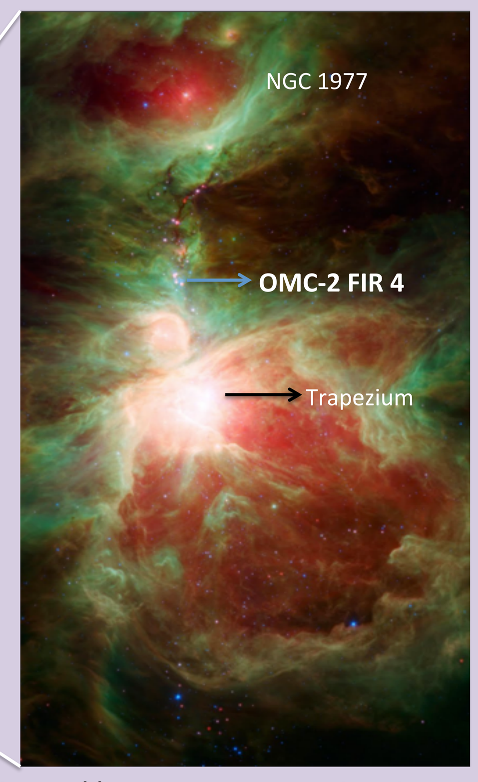
Several hundred lines from tens of species, including Complex Organic Molecules (WORK IN PROGRESS)

López-Sepulcre et al. (in prep.)

The source: OMC-2 FIR 4

An intermediate-mass protocluster in Orion



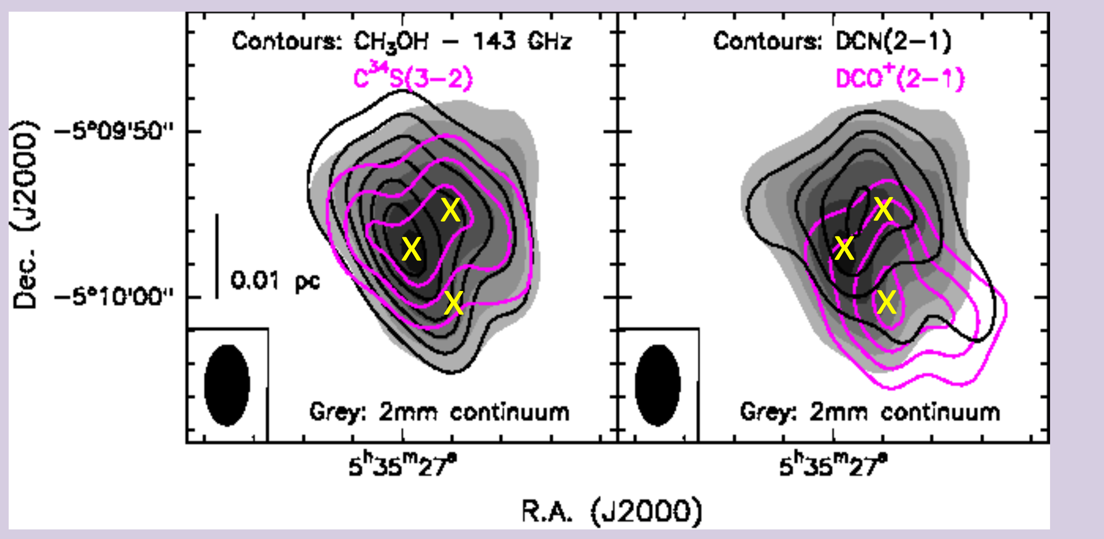


d = 420 pc
V_{LSR} = 11.4 km/s
L ~ 500 L_{sun}

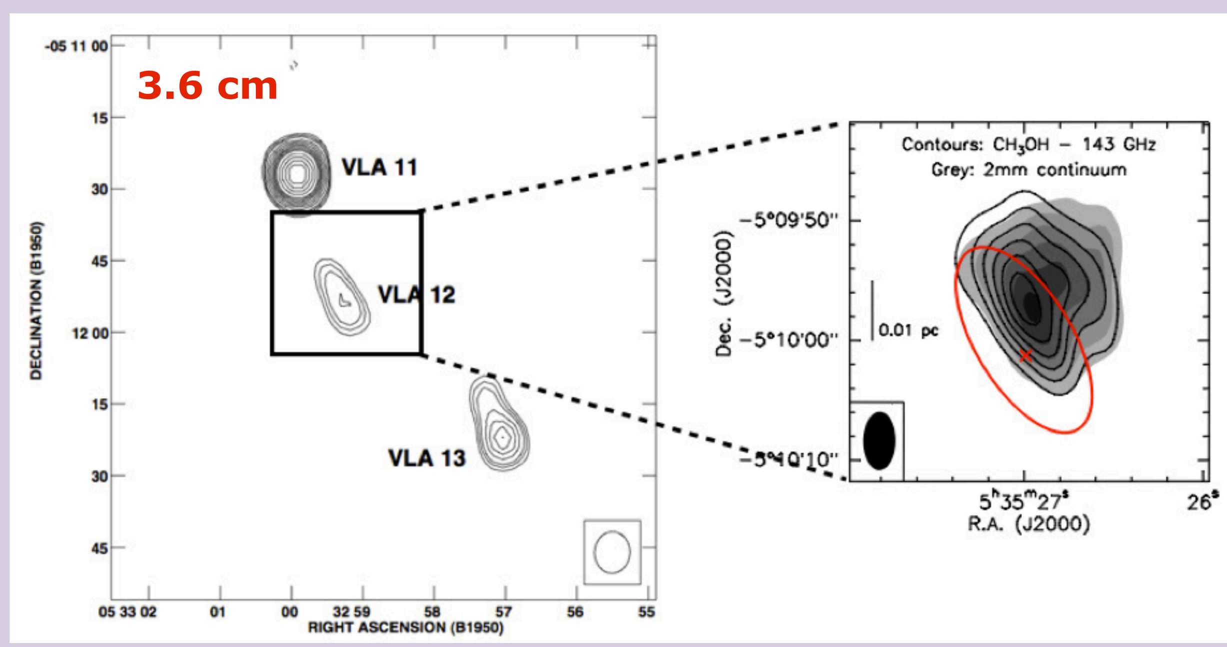
http://www.spitzer.caltech.edu

PdBI maps: The small scale structure of OMC-2 FIR 4

- High-angular resolution continuum and molecular line maps point towards **core multiplicity** in OMC-2 FIR 4.
- We distinguish 3 regions (marked with crosses), which are traced differently by each line, indicating **chemical differentiation** within OMC-2 FIR 4.
- Radio continuum emission detected with the VLA is compatible with an **HII region** driven by a **B4 young star**.



Velocity-integrated maps (contours) overlaid on the continuum image (grey).



Left: VLA continuum map at 3.6 cm (Reipurth et al. 1999). *Right*: OMC-2 FIR 4 as seen by our PdBI maps. The red ellipse represents the VLA cm emission.

Complexity in OMC-2 FIR 4: multiple cores, chemical differentiation, and ionised gas coexist within 10000 AU

López-Sepulcre et al. (submitted to A&A)

References

Ceccarelli et al. 2010, A&A 521, L22
López-Sepulcre et al. (submitted to A&A)
Kama et al. (submitted to A&A)
Reipurth et al. 1999, ApJ, 118, 983

Acknowledgements

A.L.S. and C.C. : CNES (Centre National d'Èdutes Spatiales) and from the Agence Nationale pour la Recherche (ANR), France (project FORCOMS, contracts ANR-08-BLAN-022)
M.K. : NWO grant, NOVA, Leids Kerkhoven-Bosscha Fonds and the COST Action on Astrochemistry