THE FIRST SPECTRAL SURVEY OF BETELGEUSE 1 AND 3 MM

Alizée Duthu

Laboratoire d'Astrophysique de Bordeaux

F.Herpin (LAB, France)

Table 1: Parameters for Emission Lines in Betelgeuse in 3 mm

ν_{obs} Mhz	ν_{lab} Mhz	Molecule	Transition	$E_{u/k}$ K	v_{LSR} $km.s^{-1}$	ΔV_{FHWM} $km.s^{-1}$	$\int T_A \cdot dV$ $Kkm.s^{-1}$
81450		U	U	U	U	12	0.3
84559		U	U	U	U	3.5	0.03
85847		U	U	U	U	2	0.02
86242.17	86243	SiO	2 - 1	6.25	6.89	5.3	0.17
88635	88631.42	HCN	1 - 0	4.25	5.85	26.6	0.53
89809		U	U	U	U	13	0.08
93862		U	U	U	U	5	0.28
110201.31	110201.35	^{13}CO	1 - 0	5.29	4.12	33	1.75
111946		U	U	U	U	22	0.35
115721.34	115271.20	CO	1 - 0	5.53	3.63	17	4.59

Table 2: Parameters for Emission Lines in Betelgeuse in 1 mm

ν_{obs} Mhz	ν_{lab} Mhz	Molecule	Transition	$E_{u/k}$ K	v_{LSR} $km.s^{-1}$	ΔV_{FHWM} $km.s^{-1}$	$\int T_A \cdot dV$ $Kkm.s^{-1}$
205922	U	U	U	U	U	2.726	0.055
208562	230538.00	CO	2 - 1	16.60	4.20	25	1.05
208661	U	U	U	U	U	25.5	0.97
215580	U	U	U	U	U	7	0.35
217103.74	217104.92	SiO	5 - 4	31.3	5.63	16	0.59
219948	219949.44	SO	5 - 4	34.99	4.8197	3	0.05
220398.74	220398.68	^{13}CO	2 - 1	15.9	3.9249	28	6.16
226281.63	226287.41	CN	2 -1	16.31	11.66	6	0.07
226341.17	226341.93	CN	2 - 1	16.31	5.00	14	0.18
226617.41	226616.55	CN	2 - 1	16.31	2.8618	2	0.03
226893.93	226892.13	CN	2 - 1	16.34	1.6225	8	0.14
230538.33	230538	CO	2 - 1	16.6	3.5709	31	49.6
232020	U	U	U	U	U	29	1.16
235153.48	235151.71	SO_2	4 - 3	19.03	1.75	2	0.04
235161.15	235159.59	SO_2	88 - 89	4564.96	3.25	2	0.04
252970	230538.00	CO	2 - 1	16.60	3.98	29	0.87
253064	U	U	U	U	U	31	0.68
255950	255958	SO_2	3 - 2	27.62	13.15	4	0.07
260516.88	260518.02	SiO	6 - 5	43.76	5.3162	22	1.32
265886.49	265886.19	HCN	3 - 2	25.52	3.6587	28	2.52

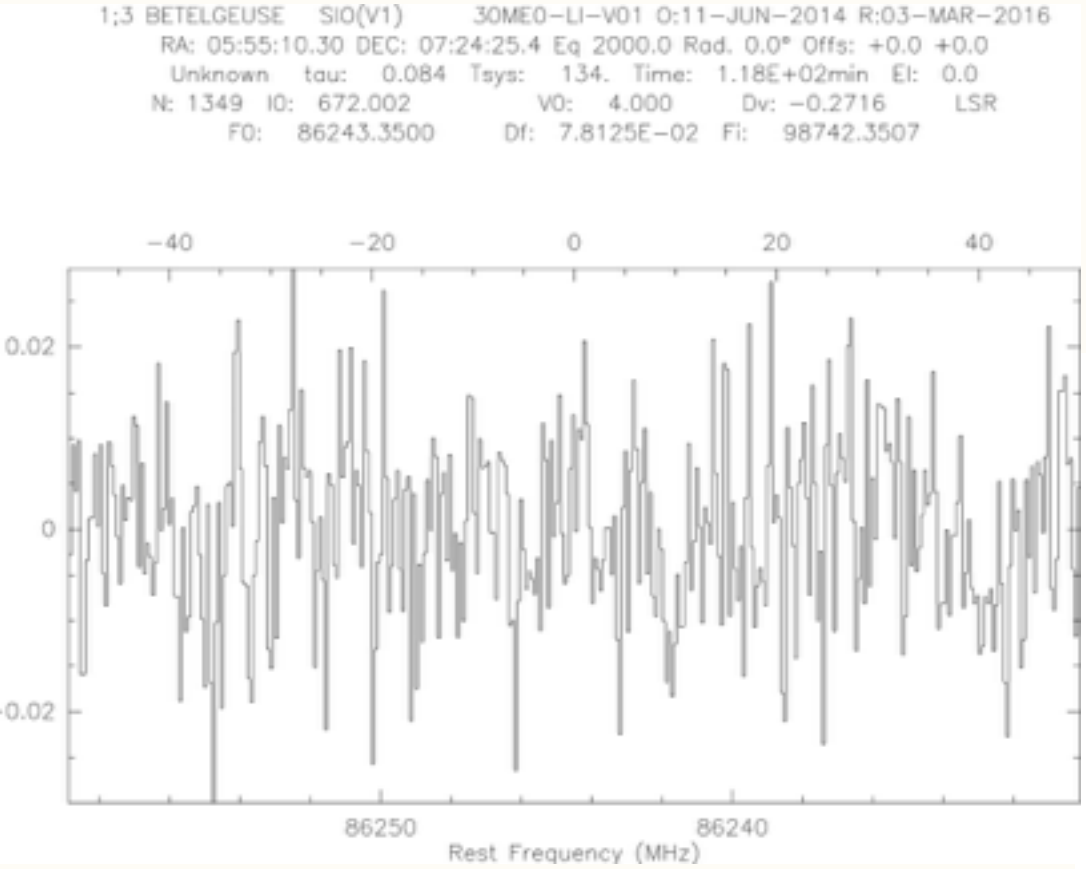
DETECTED MOLECULES AT 1.3 AND 3 MM

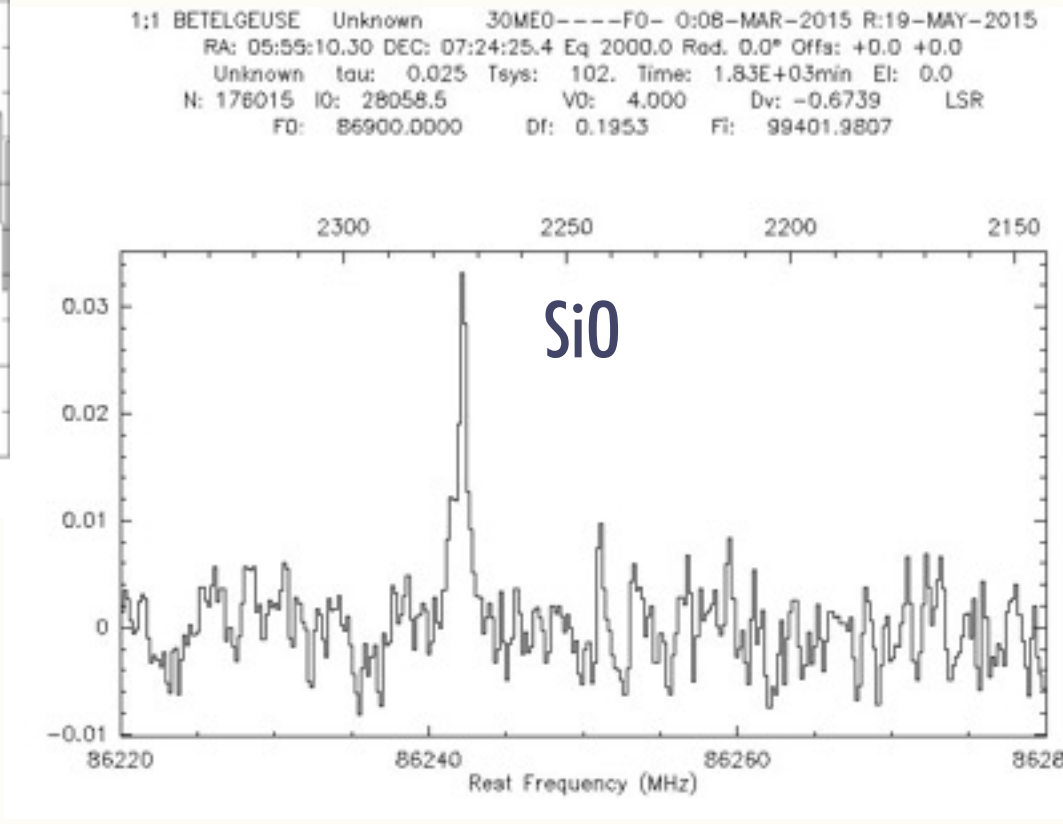
observations : IRAM 30M, EMIR/FTS200

30 lines detected :
⇒ 7 different molecules determined
⇒ 11 lines not identified
⇒ 1 molecule sensitive to magnetic field CN

2 types of line profil :
⇒ gaussian
⇒ simple and double horns

SIO DETECTION



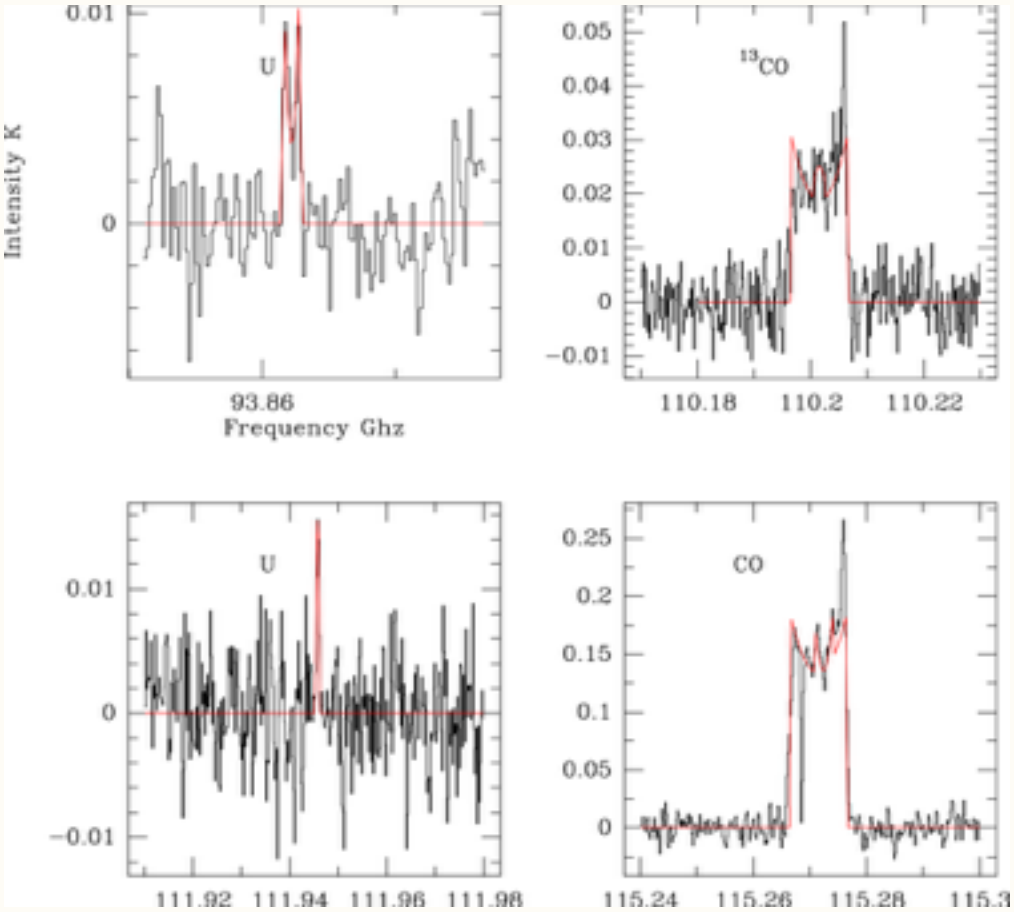


SiO detected (thermal or maser ?) but not in 2014⇒ Changing physical conditions in times

SIMPLE AND DOUBLE HORNS LINE PROFIL

horns line profile ⇒estimate of the expansion velocity for the molecular shell

double horns = 2 shells of same molecule with various velocity



3 mm

black =observation red = fit

Fit parameters for 3 mm simple horn

molecule	position	Vexp
U	93862.0	2.28
U	111945.74	1.37

Fit parameters for 3mm double horn

molecule	position Mhz	Vexp km.s^{-1}
^{13}CO	110201.5	17.25
	110201.5	3.45
CO	115271.5	17.25
	115271.5	5.71

RADEX MODEL

modelling parameters : density column $N(H_2)=7.10^{21}$ cm^{-2}, radial velocity v_{lsr} = 4.0 $km.s^{-1}$, temperature T_{ex} = 130 K

Species	N(Sp) cm^{-2}	abundance $/H_2$	FWHM $km.s^{-1}$	rms mK	abundance observed O-Rich Supergiant
CN	$6.0 \cdot 10^{14}$	$8.0 \cdot 10^{-9}$	3	3	$2.0 \cdot 10^{-8}$
CO	$5.5 \cdot 10^{16}$	$7.33 \cdot 10^{-6}$	14	5	$6.0 \cdot 10^{-5}$
^{13}CO	$9.5 \cdot 10^{15}$	$1.27 \cdot 10^{-6}$	15	5	
HCN	$4.0 \cdot 10^{13}$	$5.33 \cdot 10^{-9}$	16	5	$2.0 \cdot 10^{-6}$
SiO	$1.0 \cdot 10^{14}$	$1.33 \cdot 10^{-8}$	13	3	
^{29}SiO	$3.5 \cdot 10^{13}$	$4.67 \cdot 10^{-9}$	5	5	
SO	$1.5 \cdot 10^{13}$	$2.0 \cdot 10^{-8}$	2	3	
SO_2	$5.25 \cdot 10^{13}$	$7.0 \cdot 10^{-9}$	2	3	

CN : L.m Ziurys et al. 2009 (étoile VY CMa, model ETL)
CO et HCN : L.m Ziurys et al. 2009 (stars average NML Cyr et VY CMa, model ETL)

RATIO MOLECULE/ISOTOPE

molecules	ratio	ratio observed	mean value ration
12CO/13CO	5.77	2 to 100 Ramsted & Olosson (2014)	60 Royer et al. (2010, VYCMa)
28SiO/29SiO	2.85	9 to 29	
SO/SO2	2.85		

⇒ molecular abundances are lower than in other star

⇒ ratio molecule/ isotope not typical