ALMA 2010

Novice User Workshop

Program - November 20 Sat.

Time	Topic	Speaker
9:30-9:40	Opening remark	
9:40-10:30	Introduction to ALMA	Sheng-Yuan Liu (ASIAA)
10:40-11:30	Radio astronomy and single-dish telescopes	Yi-Nan Chin (TKU)
11:40-12:30	Introduction to interferometry	Chin-Fei Lee (ASIAA)
14:10-15:00	Galactic sources and the Solar System	Yi-Jehng Kuan (NTNU)
15:10-16:00	Extragalactic astronomy	Chorng-Yuan Huang (NCU)
16:10-17:00	Tools for ALMA	Shigehisa Takakuwa (ASIAA)

Organized by National Taiwan Normal Univ. / ASIAA Sponsored by National Science Council

主辦單位：國立台灣師範大學地球科學系 / 中研院天文所 協辦單位：行政院國家科學委員會

http://www.es.ntnu.edu.tw/tuCASA/novice-wksp.

ALMA Science: Galactic and Solar System Astronomy

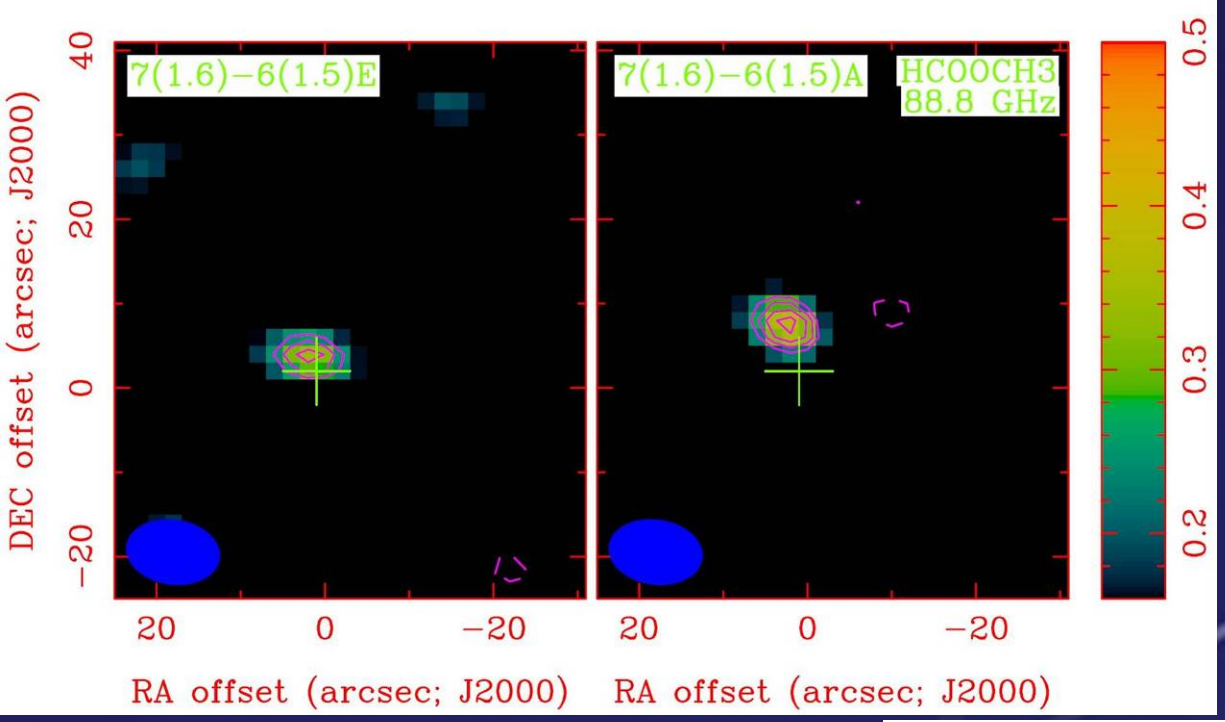
Yi-Jehng Kuan (管一政)
Dept of Earth Sciences, Nat'l Taiwan Normal University

ALMA Novice-User Workshop 2010
(NTNU, November 20, 2010)

What have been observed (and studied) with existing (sub)millimeter arrays?

Some examples:

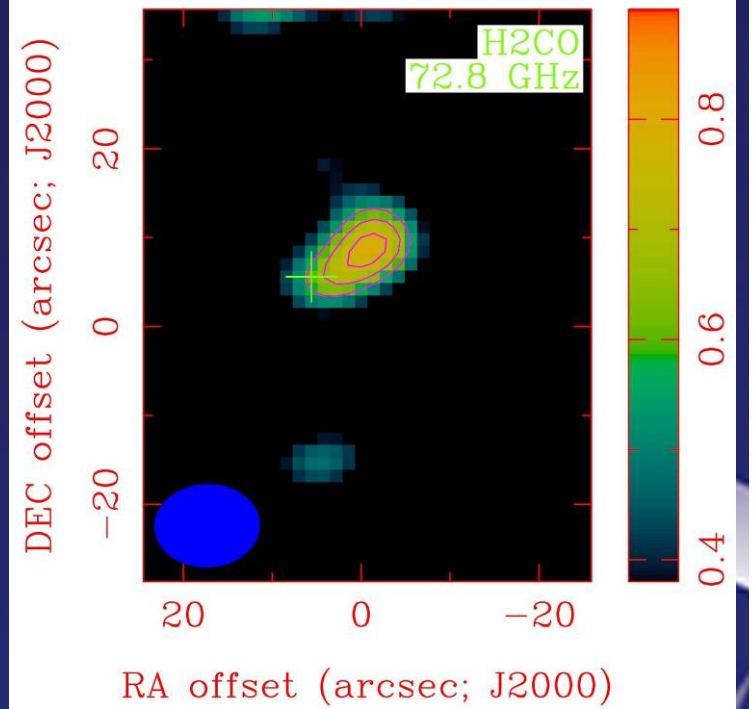
- Solar System
  - Comets: Hale-Bopp and C/2002 T7 (LINEAR)

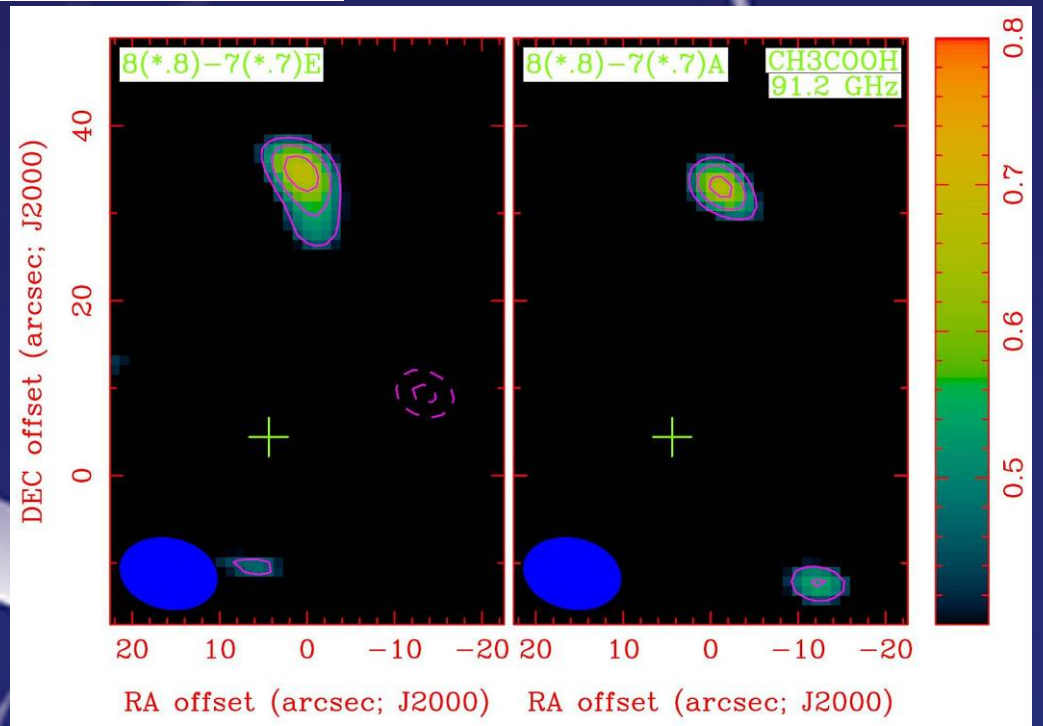


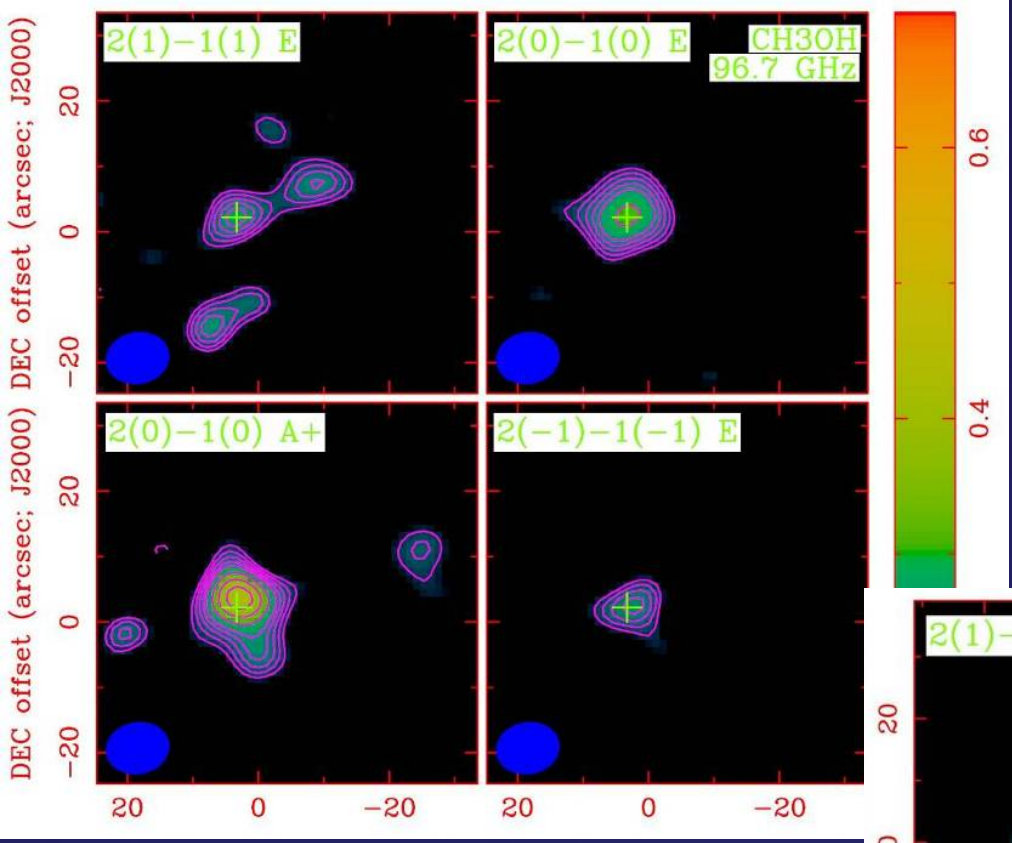
Hale-Bopp

BIMA observations;
1997 April 01

(ALMA band 3)



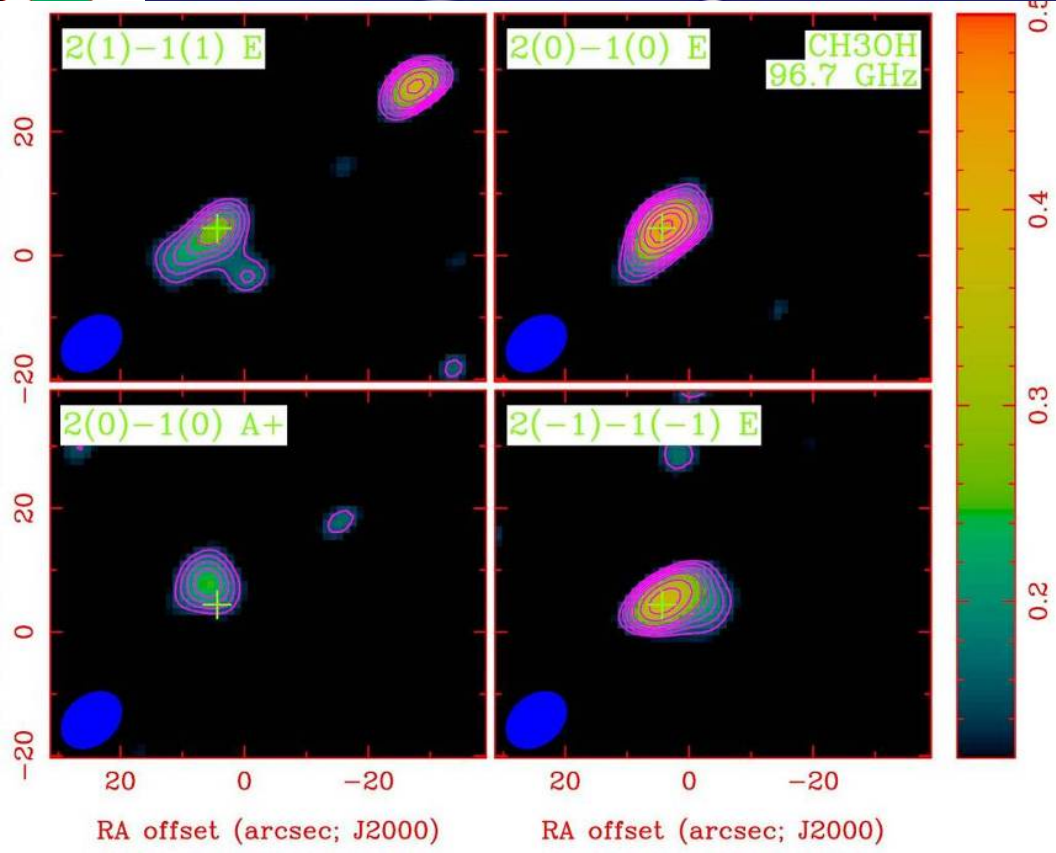


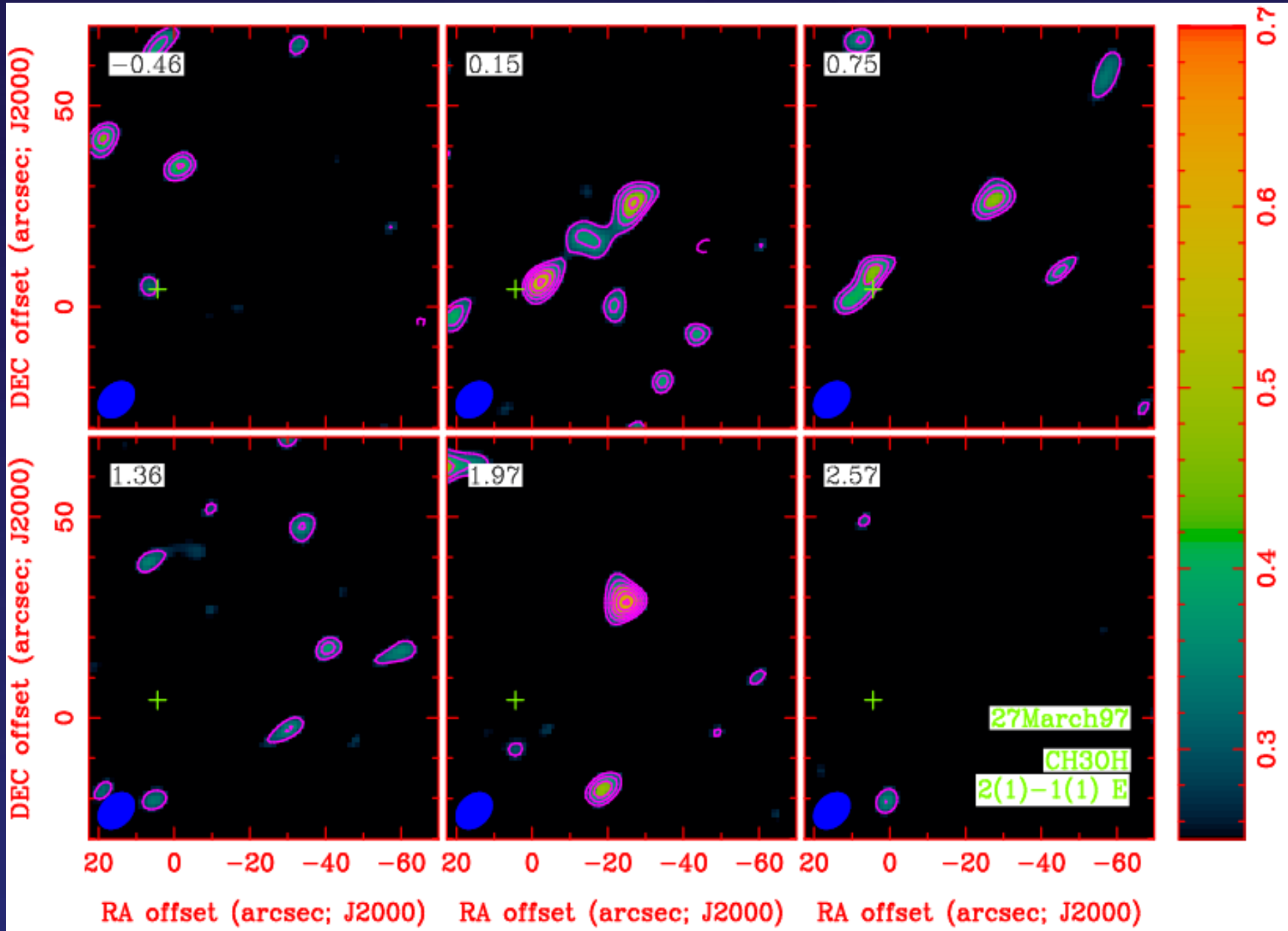


Comet Hale-Bopp,

1997 Mar 31

(ALMA band 3)

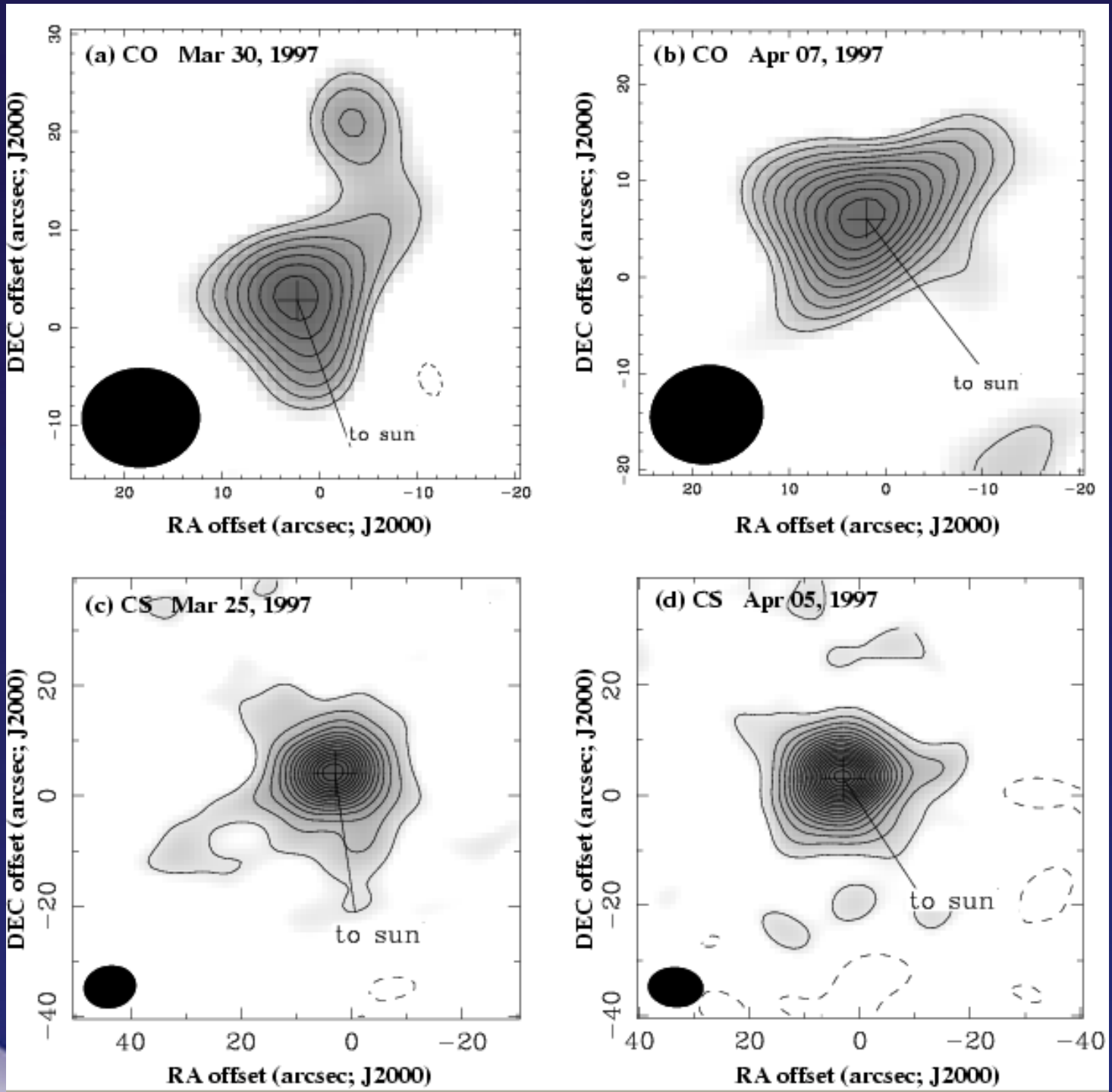



−0.46
0.15
0.75
1.36
1.97
2.57
27March97
CH3OH
2(1)−1(1) E
DEC offset (arcsec; J2000)
RA offset (arcsec; J2000)
50
0
20
−20
−40
−60
0.3
0.4
0.5
0.6
0.7

Comet Hale-Bopp,

1997 March

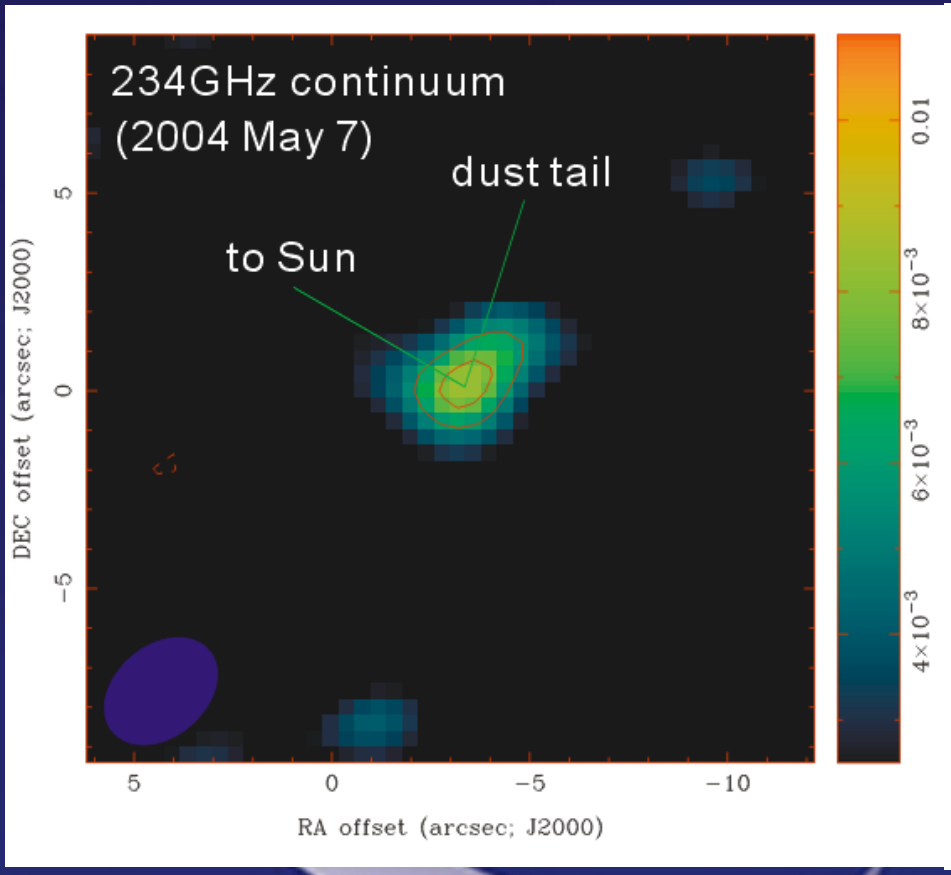
(ALMA band 3)

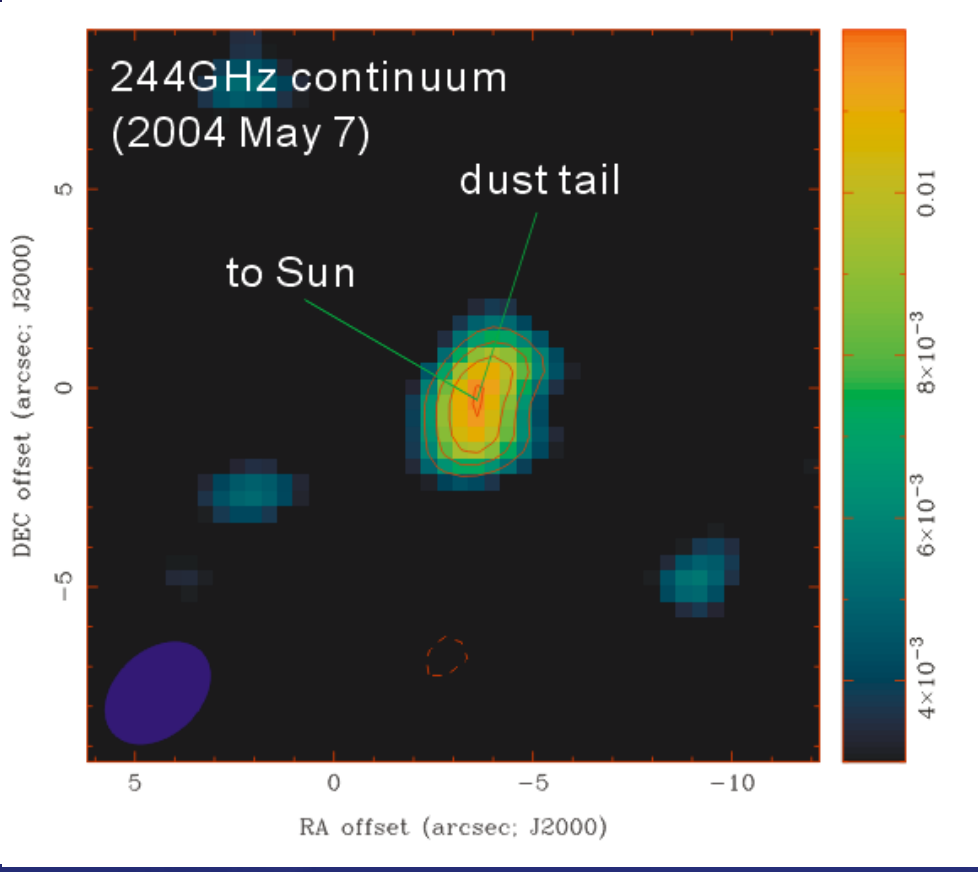


Comet C/2002 T7 (LINEAR)

SMA: 1.3-mm continuum

(ALMA band 6)





Science with ALMA (DRSP 2.2)

Comets

A complete picture of an Earth-grazing short-period comet	D. Bockelee-Morvan	168 hrs
A TOO observation of an Oort cloud comet	D. Bockelee-Morvan	168 hrs
Observations of the great comet of the decade	D. Bockelee-Morvan	200 hrs
Characterization of the Jupiter-family comet population	D. Bockelee-Morva	200 hrs
is Hale-Bopp still alive?	D. Bockelee-Morvan	12 hrs
Chiron distant activity	D. Bockelee-Morvan	5 hr
CO nucleus outgassing of 29P/Schwassmann-Wachmann 1	D. Bockelee-Morvan	
CO nucleus outgassing of 29P/Schwassmann-Wachmann 1	D. Bockelee-Morvan	40 hrs
D/H in cometary water	D. Bockel□e-Morvan	10 hrs per year

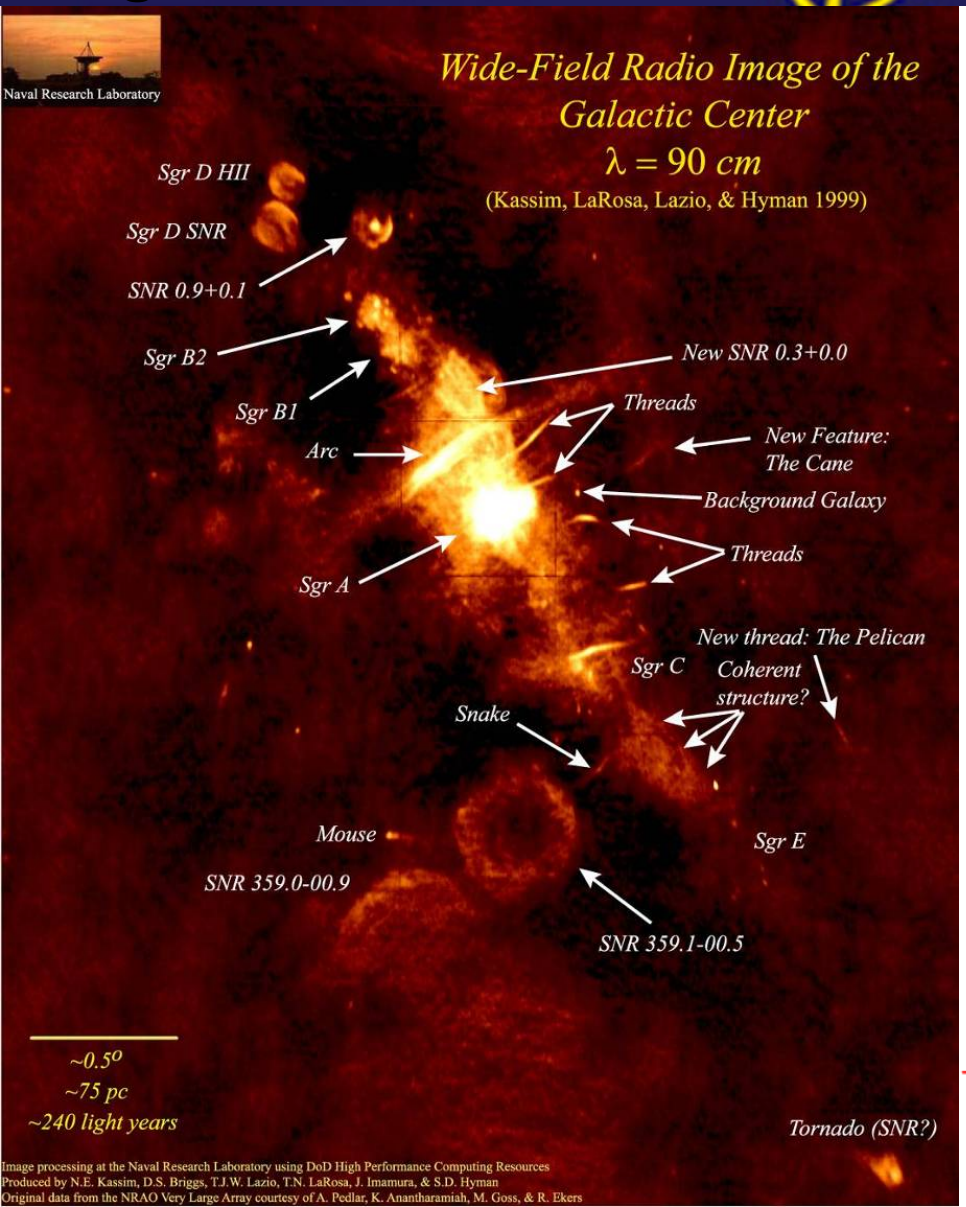
What have been observed (and studied) with existing (sub)millimeter arrays?

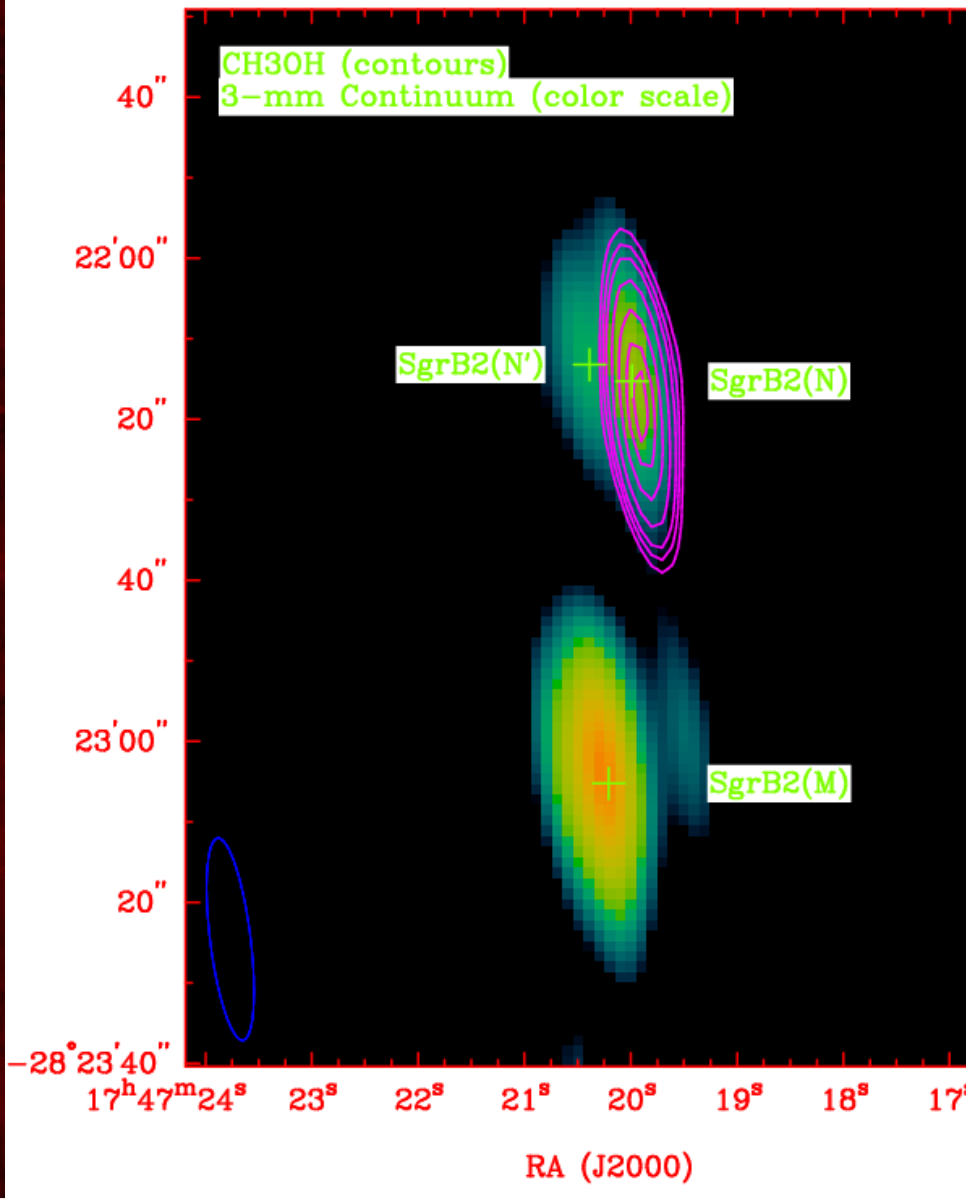
Some examples:

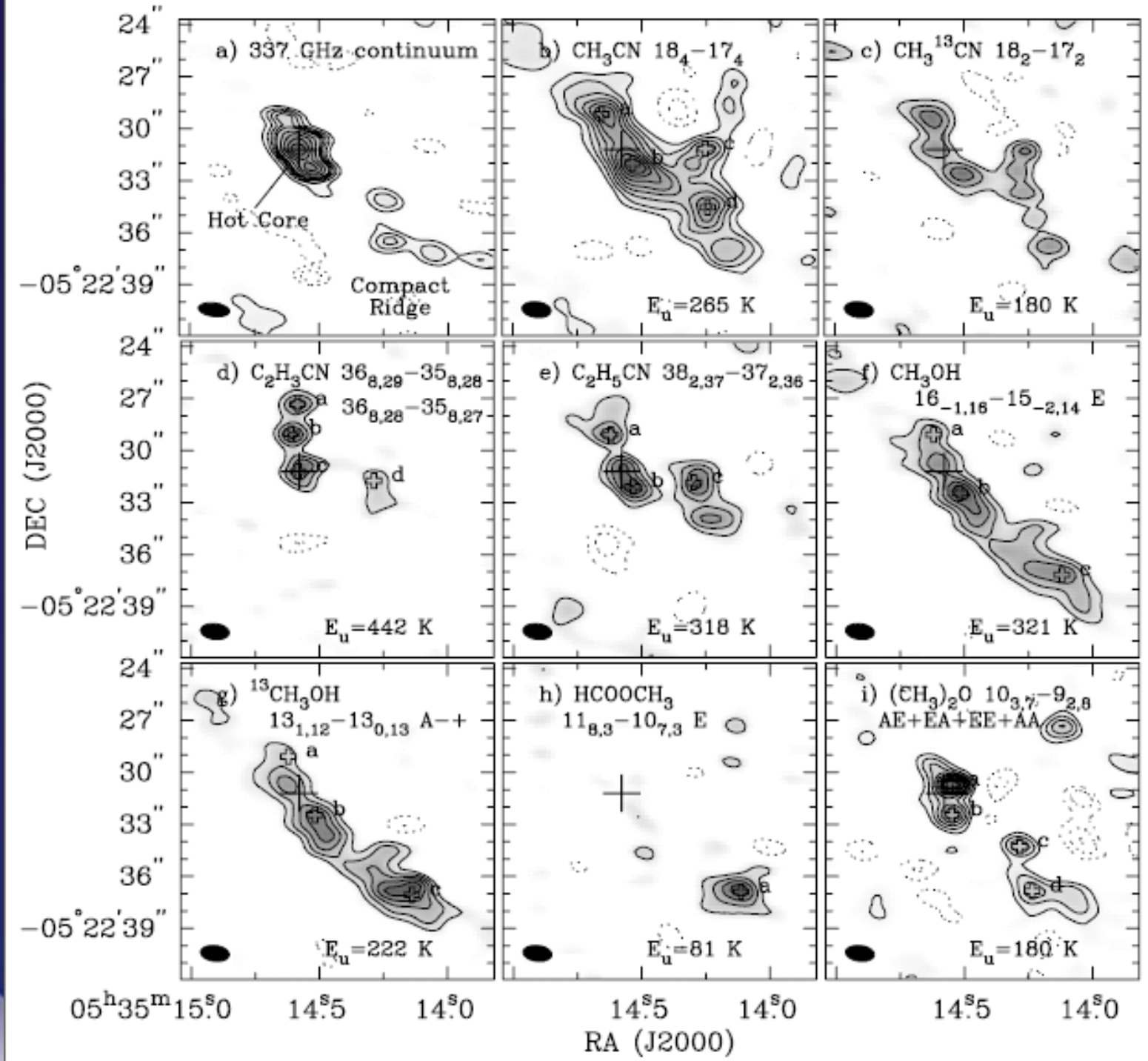
- Solar System
  - Comets: Hale-Bopp and C/2002 T7 (LINEAR)
- Galactic sources
  - Hot molecular cores/massive star forming regions: Sgr B2 and Orion KL

Galactic Center: Sgr A*

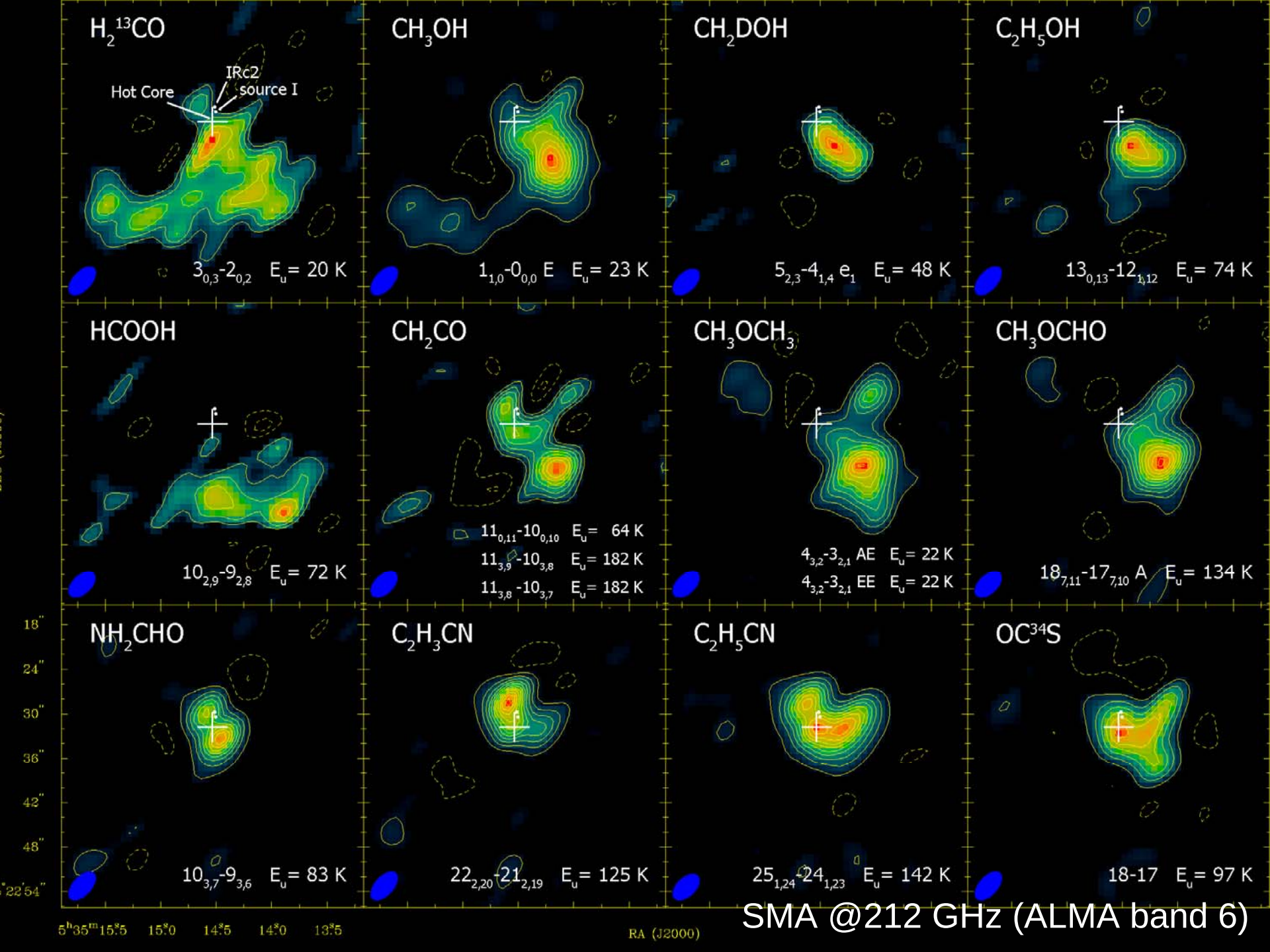
HMCs: Sgr B2(N) & (M)

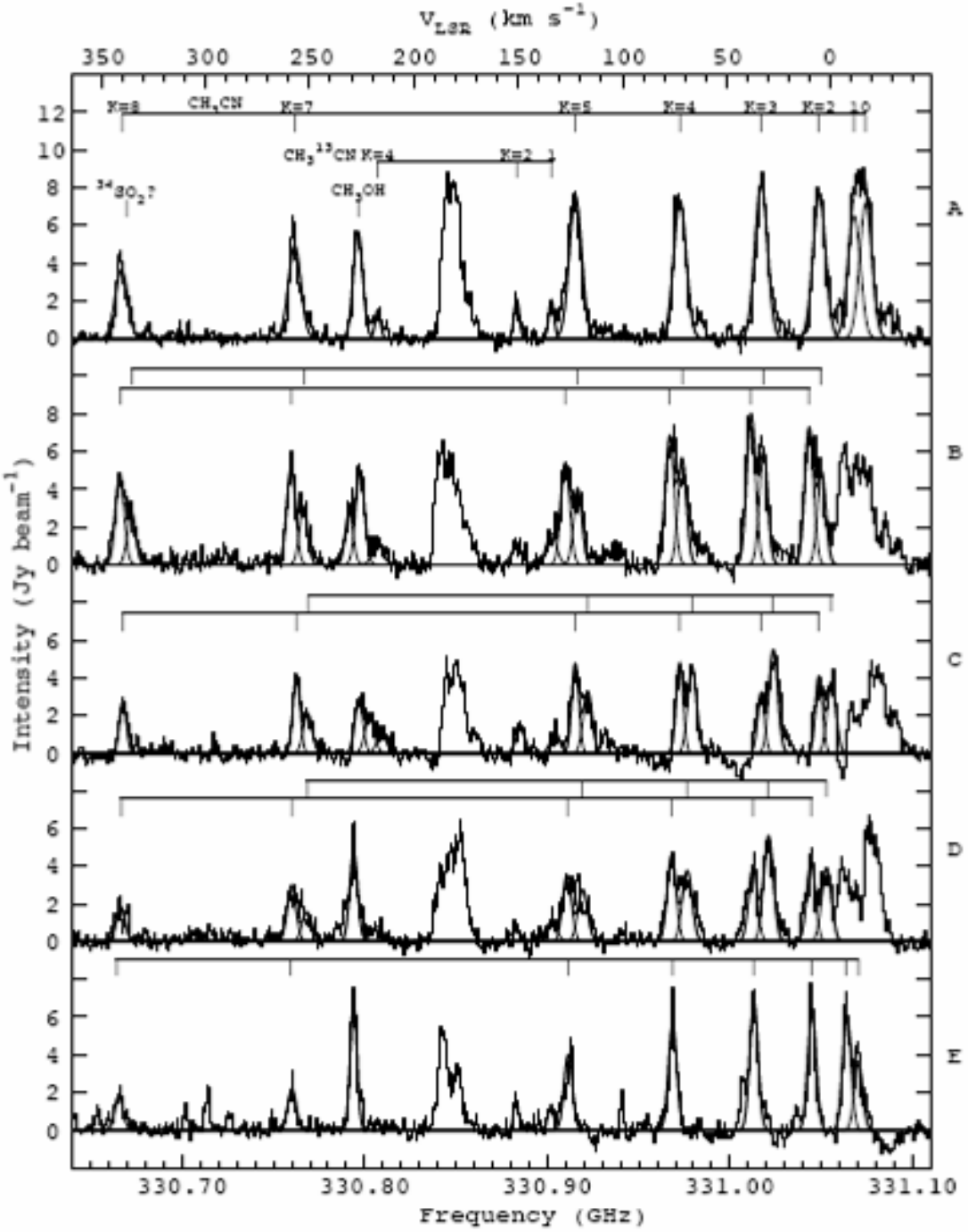


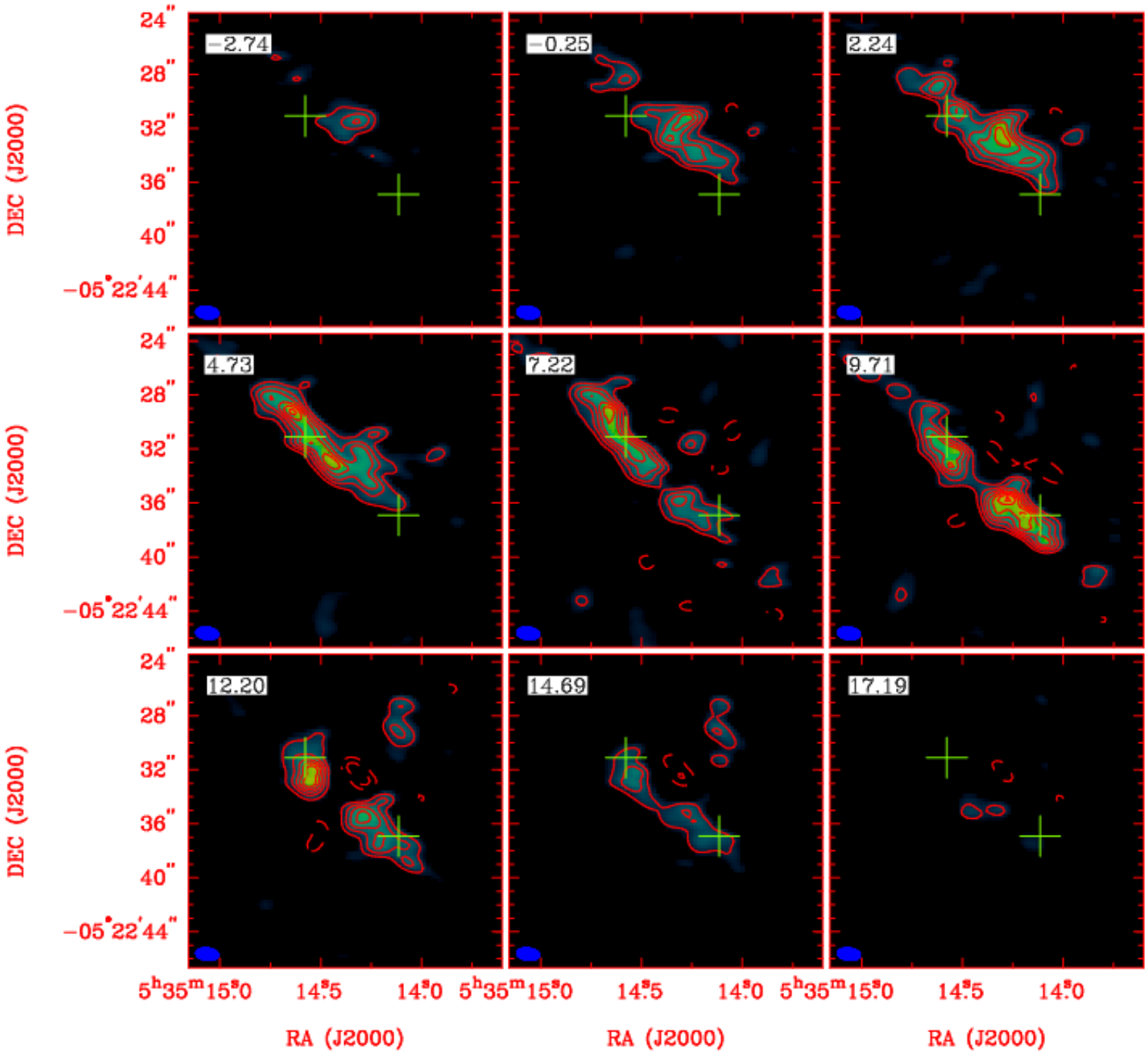




SMA
@342 GHz
ALMA
band 7


H2 13CO
Hot Core
IRc2
source I
3 0,3 -2 0,2 Eu= 20 K
CH3OH
1 1,0 -0 0,0 E Eu= 23 K
CH2DOH
5 2,3 -4 1,4 e1 Eu= 48 K
C2H5OH
13 0,13 -12 1,12 Eu= 74 K
HCOOH
10 2,9 -9 2,8 Eu= 72 K
CH2CO
11 0,11 -10 0,10 Eu= 64 K
11 3,9 -10 3,8 Eu= 182 K
11 3,8 -10 3,7 Eu= 182 K
CH3OCH3
4 3,2 -3 2,1 AE Eu= 22 K
4 3,2 -3 2,1 EE Eu= 22 K
CH3OCHO
18 7,11 -17 7,10 A Eu= 134 K
NH2CHO
10 3,7 -9 3,6 Eu= 83 K
C2H3CN
22 2,20 -21 2,19 Eu= 125 K
C2H5CN
25 1,24 -24 1,23 Eu= 142 K
OC34S
18-17 Eu= 97 K
18"
24"
30"
36"
42"
48"
22'54"
5h35m15.5 15.0 14.5 14.0 13.5
RA (J2000)
SMA @212 GHz (ALMA band 6)


V_{LSR} (km s^{-1})
350
300
250
200
150
100
50
0
CH_3CN
$CH_3{}^{13}CN$
CH_3OH
$^{34}SO_2$?
Intensity (Jy beam^{-1})
A
B
C
D
E
330.70
330.80
330.90
331.00
331.10
Frequency (GHz)



CH_3CN
$J = 18_3\text{-}17_3$
at 331.014
GHz (ALMA
band 7)

Science with ALMA (DRSP 2.2)

Chemistry of Star-Forming Regions

Chemical survey of hot cores and inner warm envelopes around YSOs	E. van Dishoeck	650 hrs
Chemical fractionation in Low-mass Cores	Y. Aikawa	358 hrs
Chemical differentiation in star-forming regions	M. Wright	134 hrs
Unbiased line surveys of high mass star forming regions	P. Schilke	612 hrs
Low Frequency Spectral Survey aimed at Complex Organics	B. E. Turner	35 hrs
Surveys of interstellar HCO+ absorption	R. Lucas	80 hrs
Surveys of interstellar molecular absorption	R. Lucas	57 hrs
Chemical Enhancements in Outflows	R. Plume	16 hrs
Tracing the photoprocesses shaping the Horsehead nebula	J. Pety	103 hrs

What have been observed (and studied) with existing (sub)millimeter arrays?

Some examples:

- Solar System
  - Comets: Hale-Bopp and C/2002 T7 (LINEAR)
- Galactic sources
  - Hot molecular cores/massive star forming regions: Sgr B2 and Orion KL
  - Young stellar objects and protoplanetary disks: IRAS 16293-2422, IRS 46, AA Tau, and HH 211

Sample spectral images of large organic molecules in Class 0 source IRAS 16293-2422

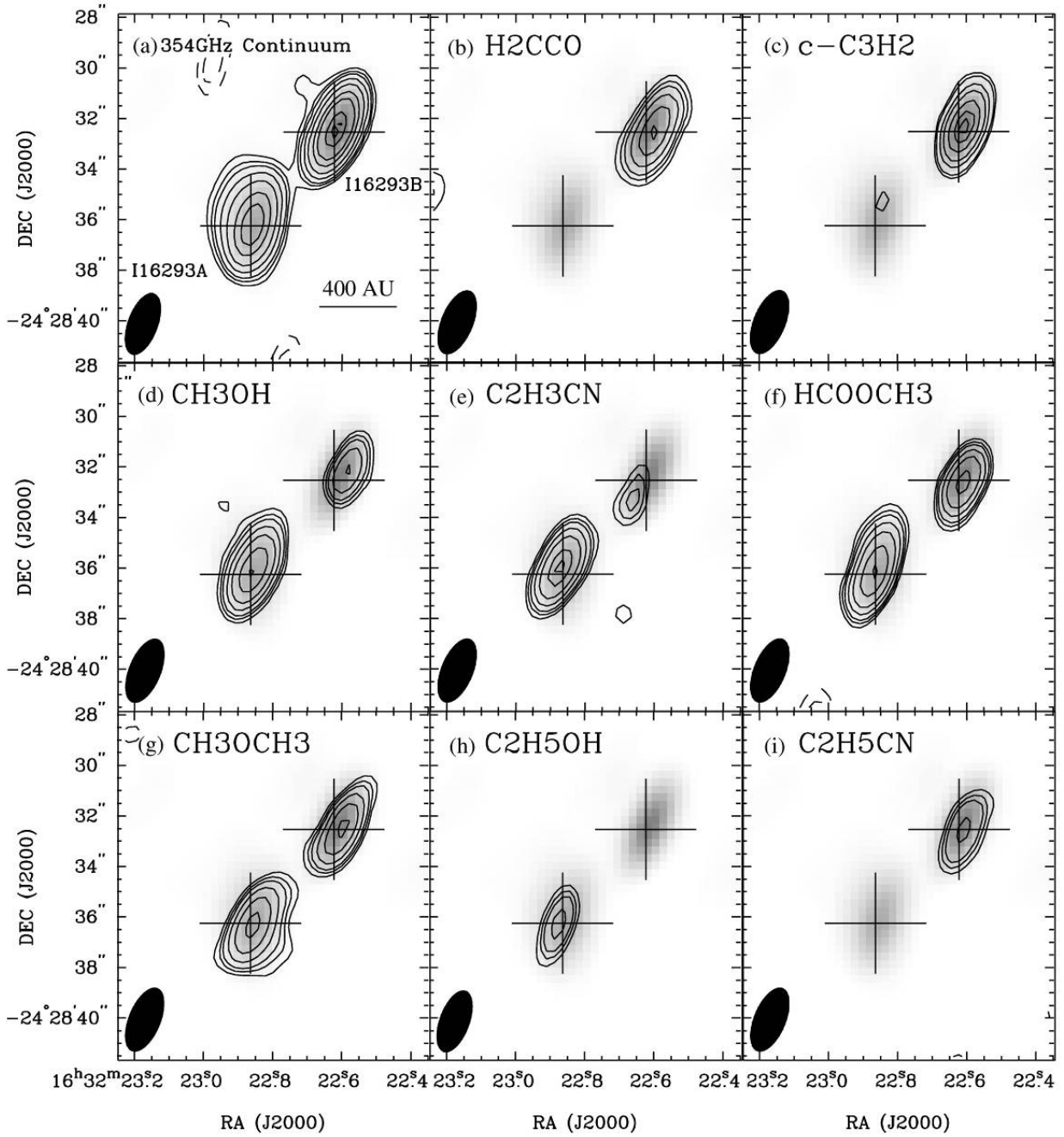


FIG. 1.— Spectral images of large organic molecules toward IRAS 16293-2422. Crosses mark the positions of I16293A and I16293B hot cores. The underlying grey scale denotes the 354 GHz continuum.

Crosses mark the positions of I16293A and I16293B, as denoted in the continuum image.

Sample Spectra of Large Organic Molecules in IRAS 16293-2422

354 GHz (830 μm)

- we provided the first observational evidence of the existence of large organic molecules in protostellar disk.

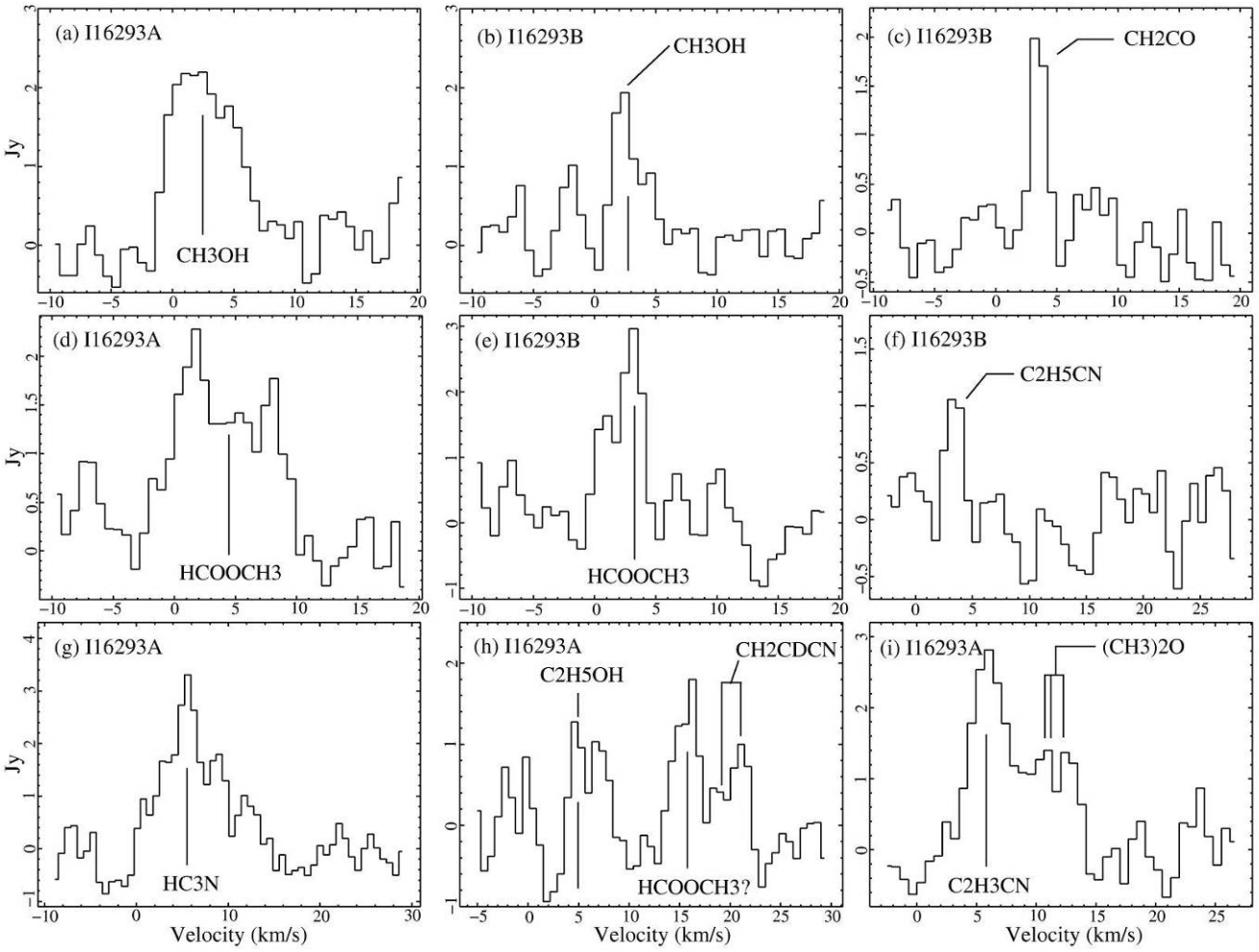
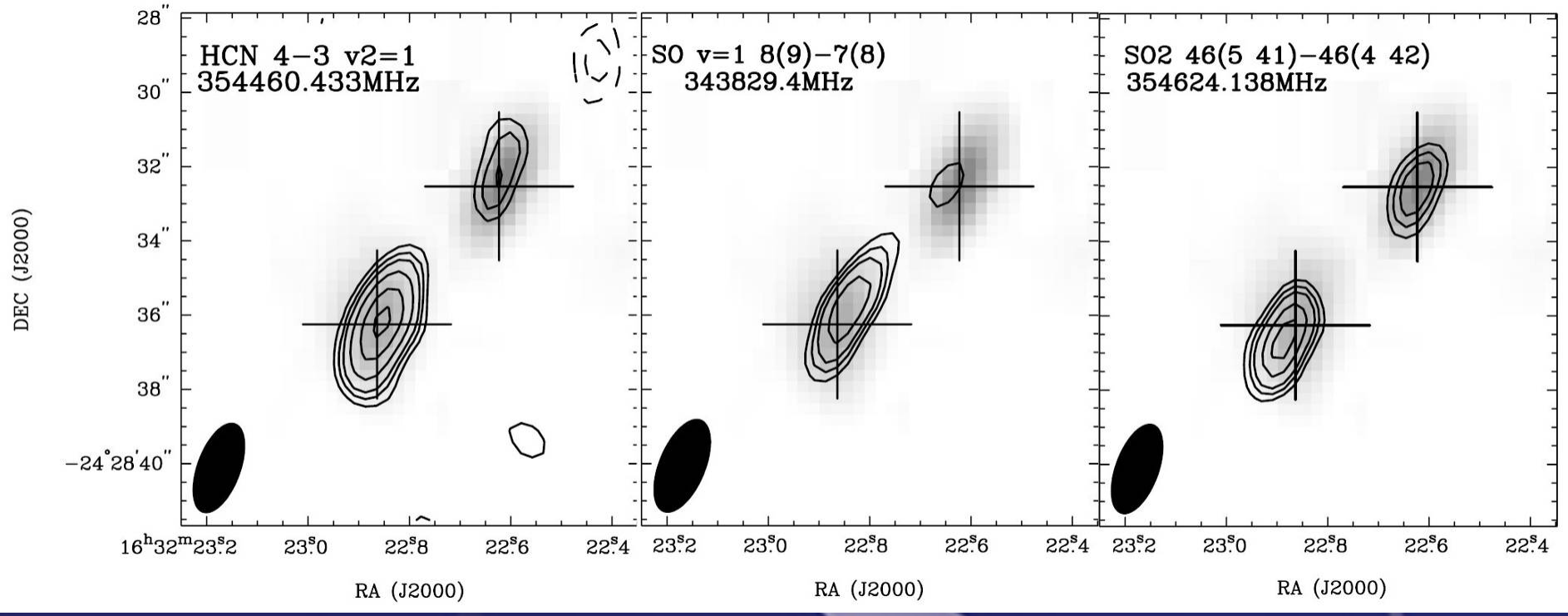


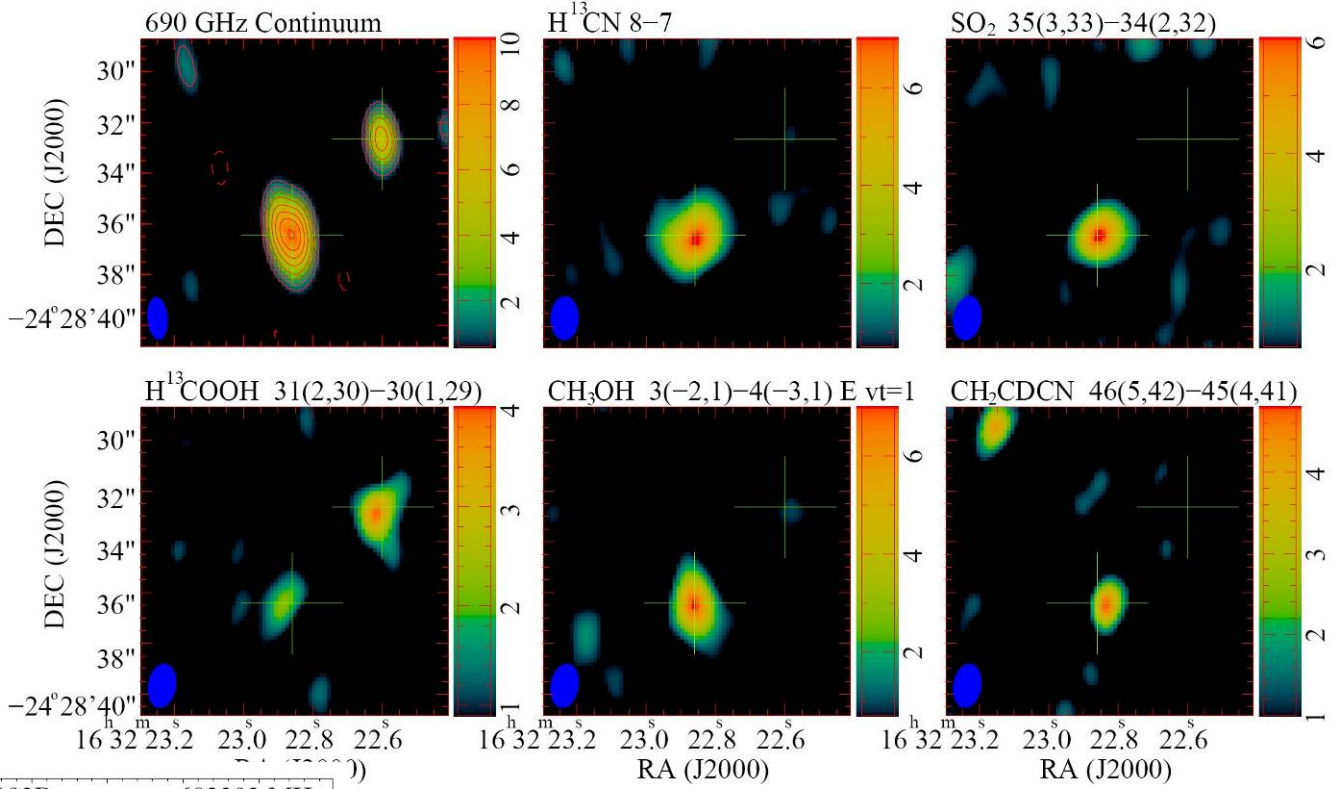
FIG. 2.— Sample spectra of large organic molecules toward IRAS 16293-2422. The 354742-MHz $12_{8,5}$-$11_{7,5}$ E transition of $HCOOCH_3$ shown in (h) is expected to be weak, hence, is less likely. Note that the weaker appearance of CH_2CDCN and $(CH_3)_2O$ spectral profiles shown in (h) and (i) is due to the fact that spectra (h) and (i) are taken at the peak emission positions of integrated C_2H_5OH and CH_2CHCN lines.

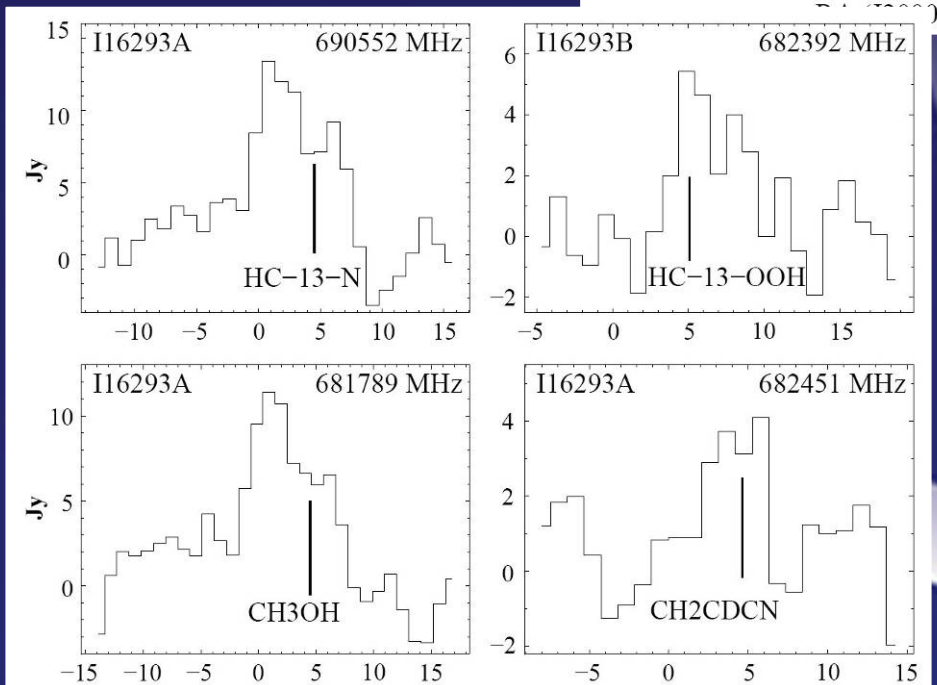
Highly-Excited Vibrational Transitions



- The detection of highly excited transitions of HCN, SO and SO_2 with their respective lower energy levels occurring 1050 K, 1660 K and 1800 K above the ground, clearly demonstrates that the inner-most regions of the two protostellar cores are *very hot*.

690 GHz (430 μm)

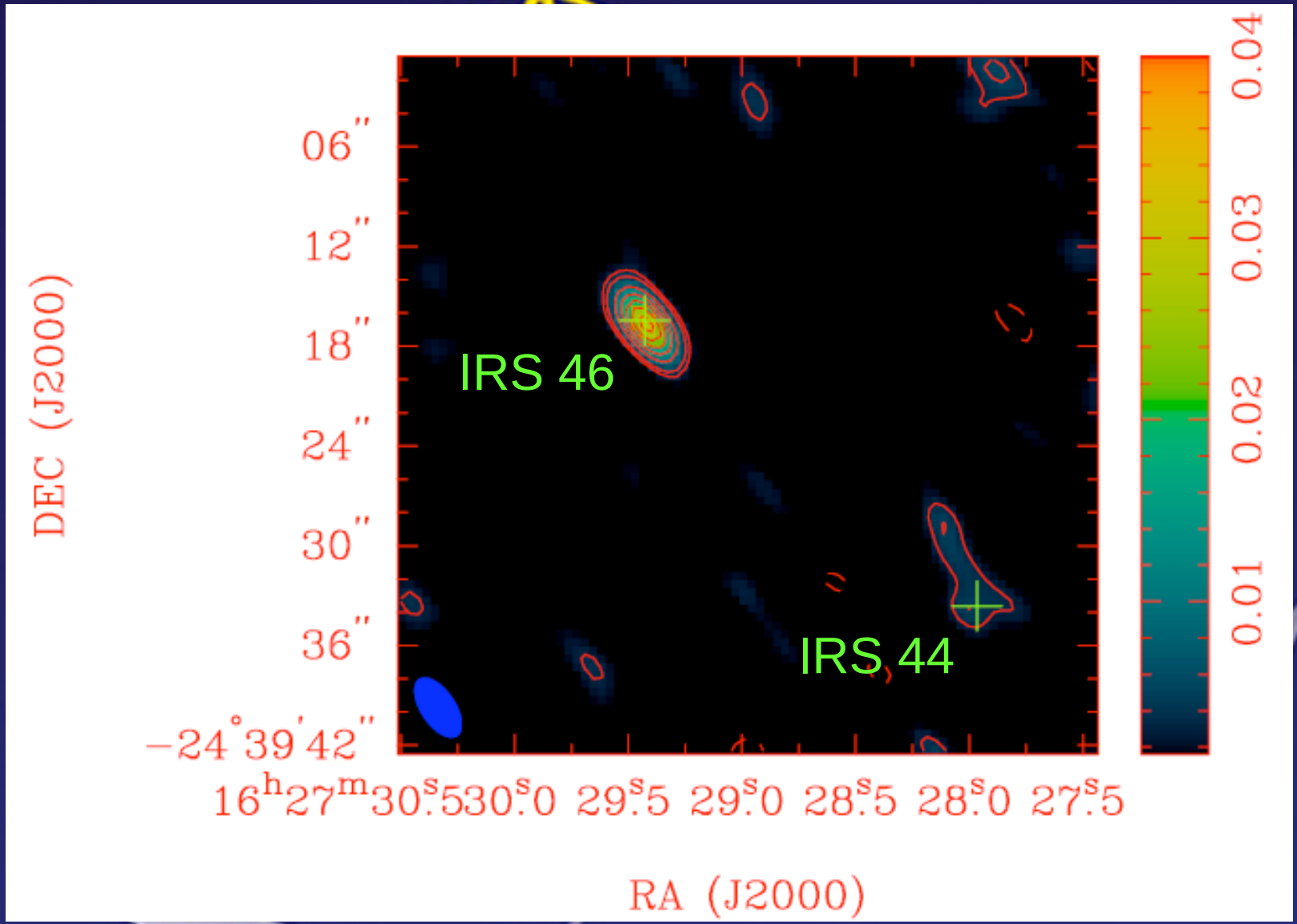




SMA 690-GHz (ALMA band 9)

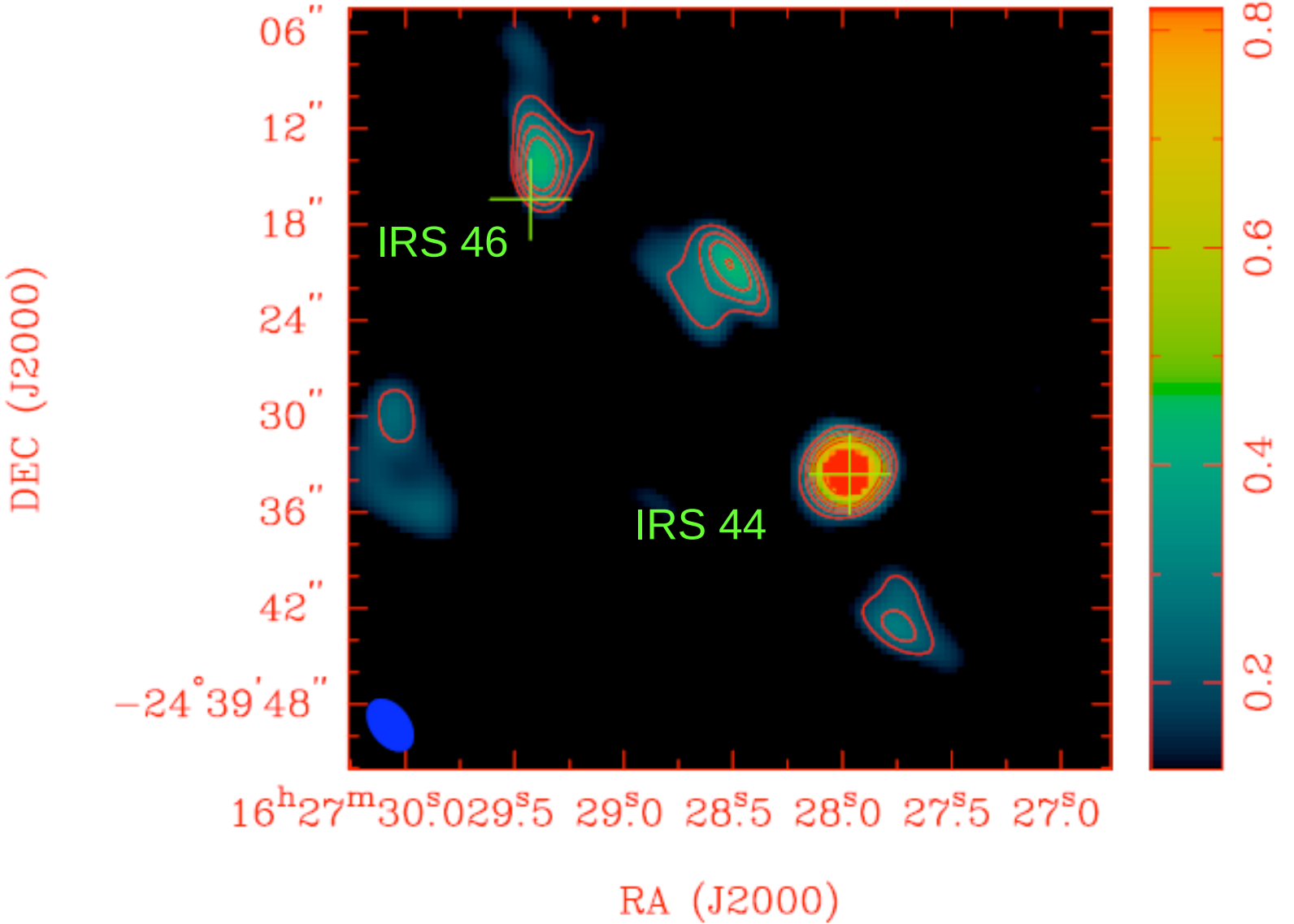
Class I source: IRS 46

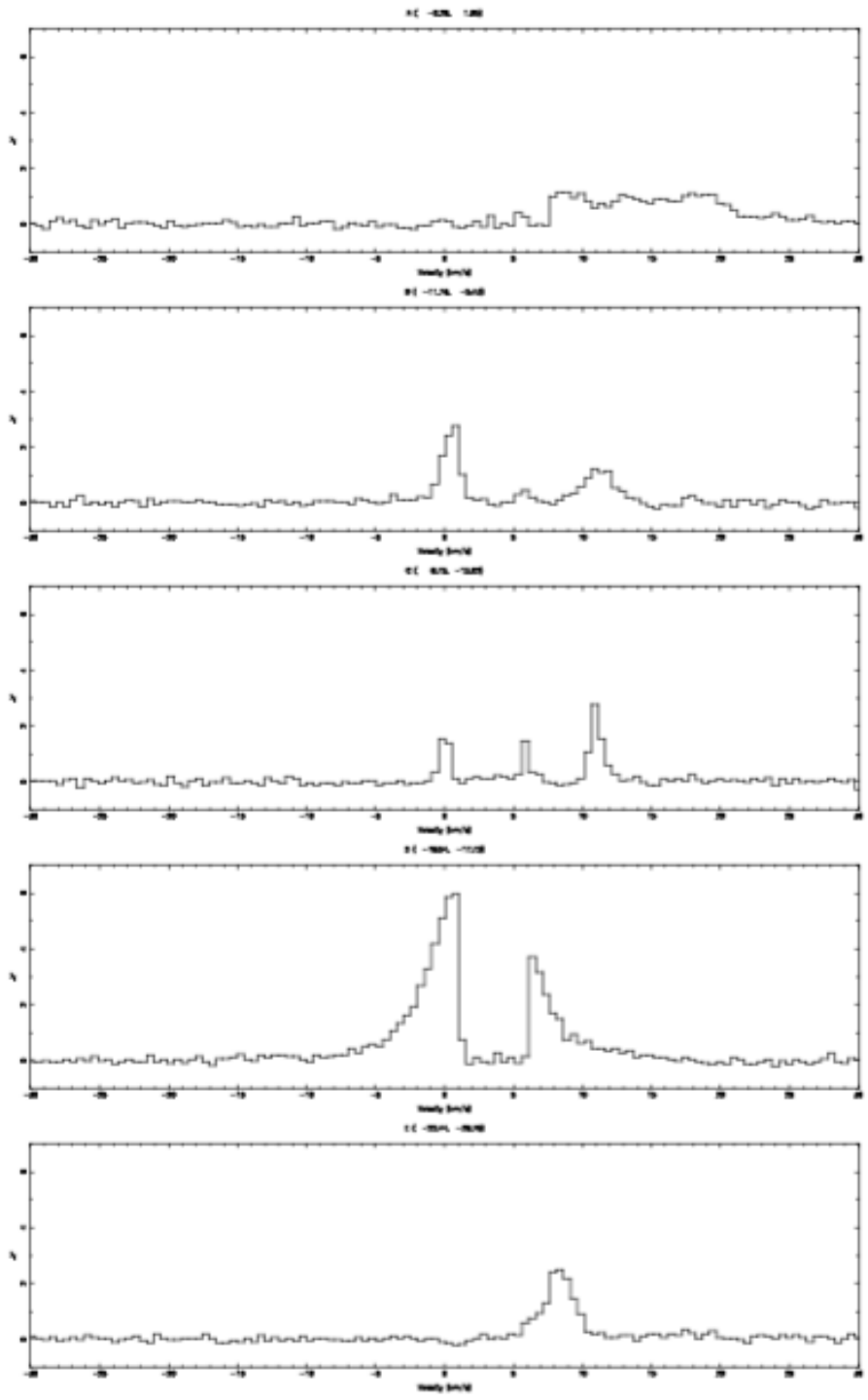
SMA 226-GHz continuum (ALMA band 6)

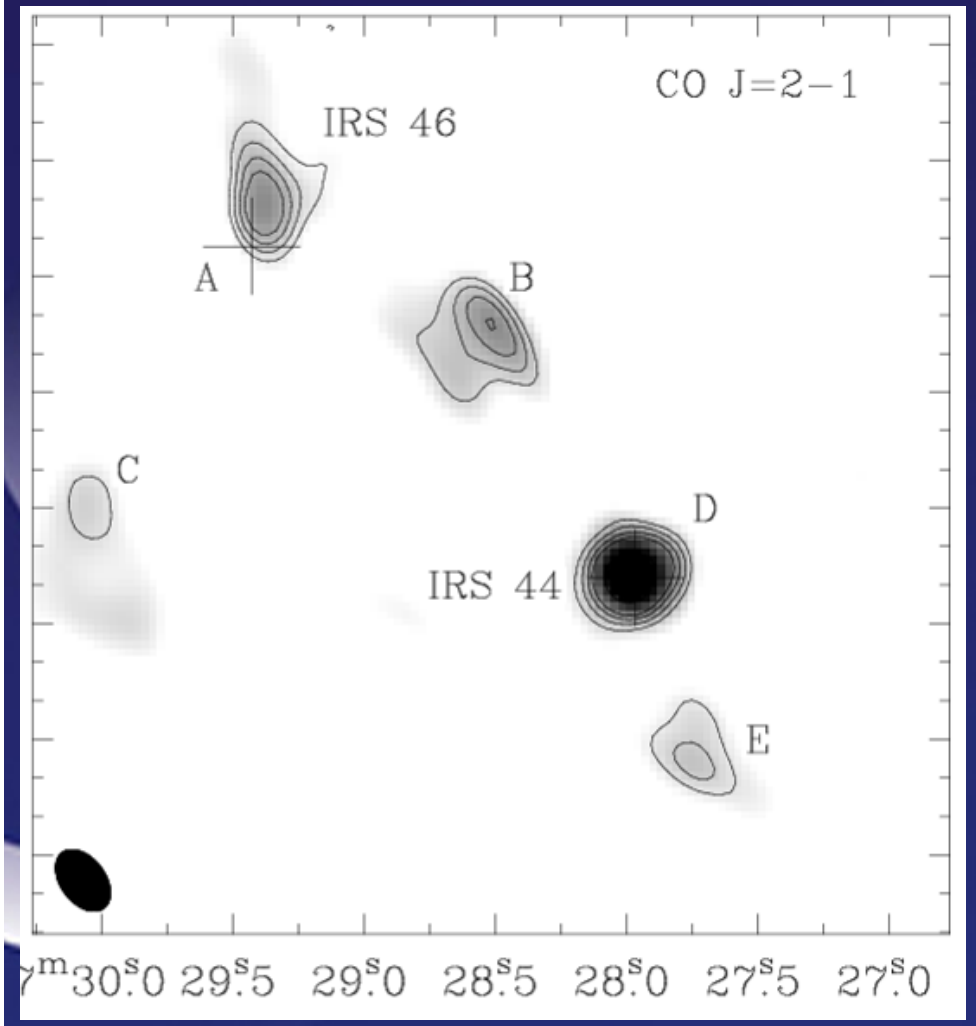


Class I source: IRS 46

SMA CO 2-1 (ALMA band 6)



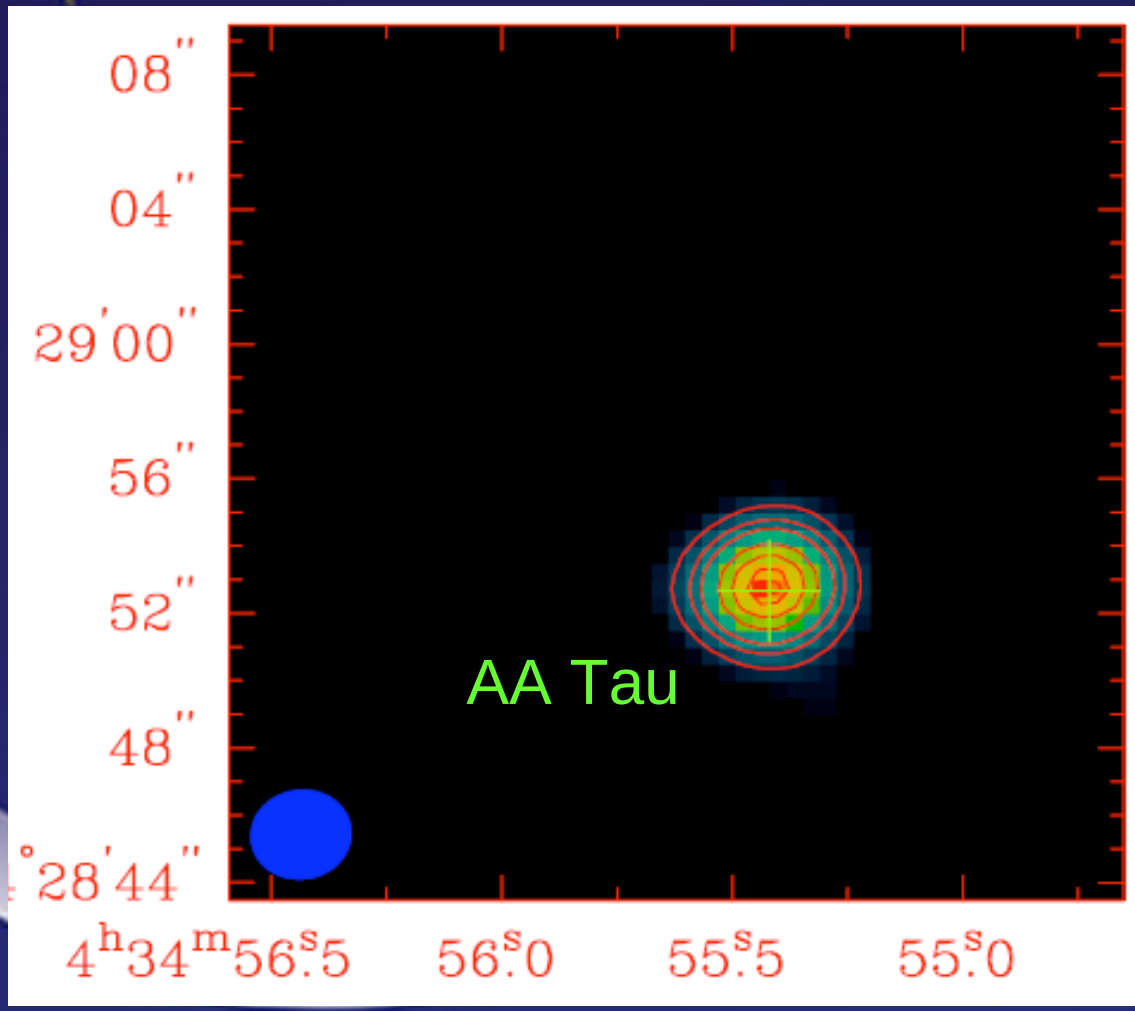



CO J=2−1
IRS 46
A
B
C
D
IRS 44
E
7m30.0 29.5 29.0 28.5 28.0 27.5 27.0

Class II CTT star: AA Tau

SMA 230-GHz continuum (ALMA band 6)

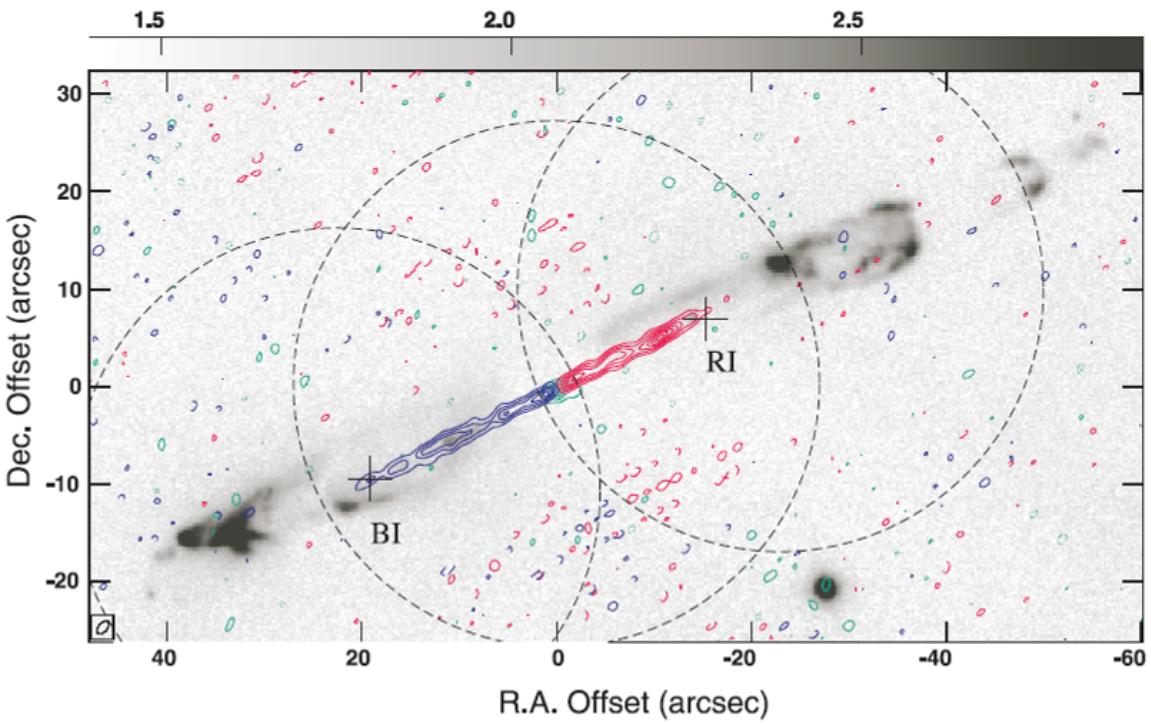
- AA Tauri disk



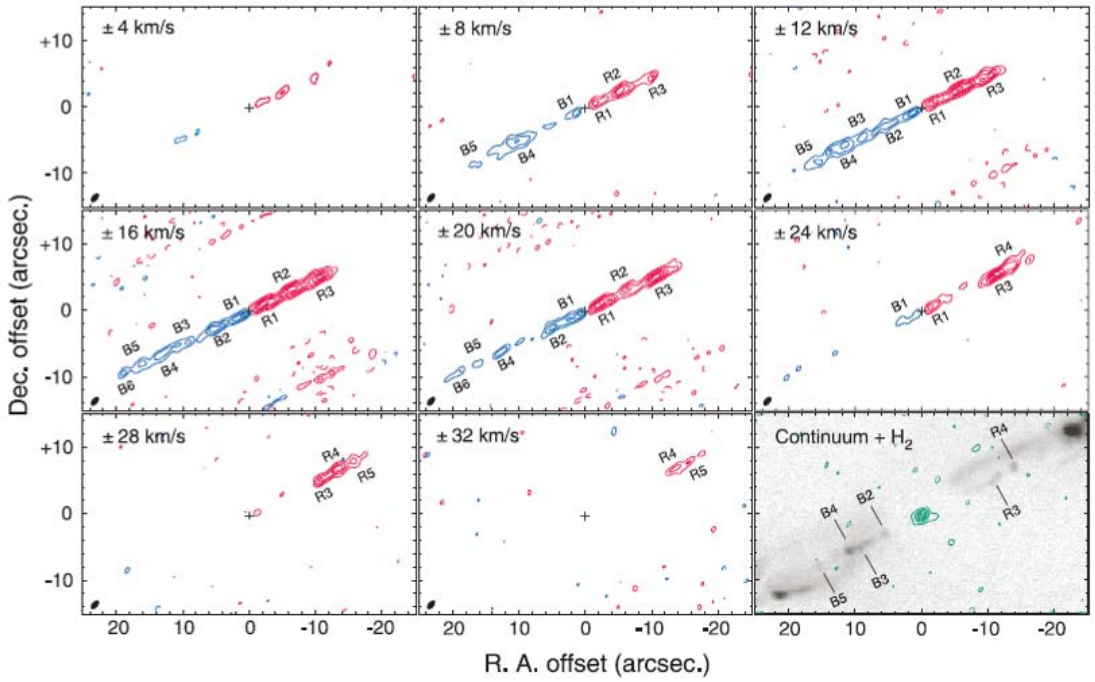
Science with ALMA (DRSP 2.2)

Protoplanetary Disks

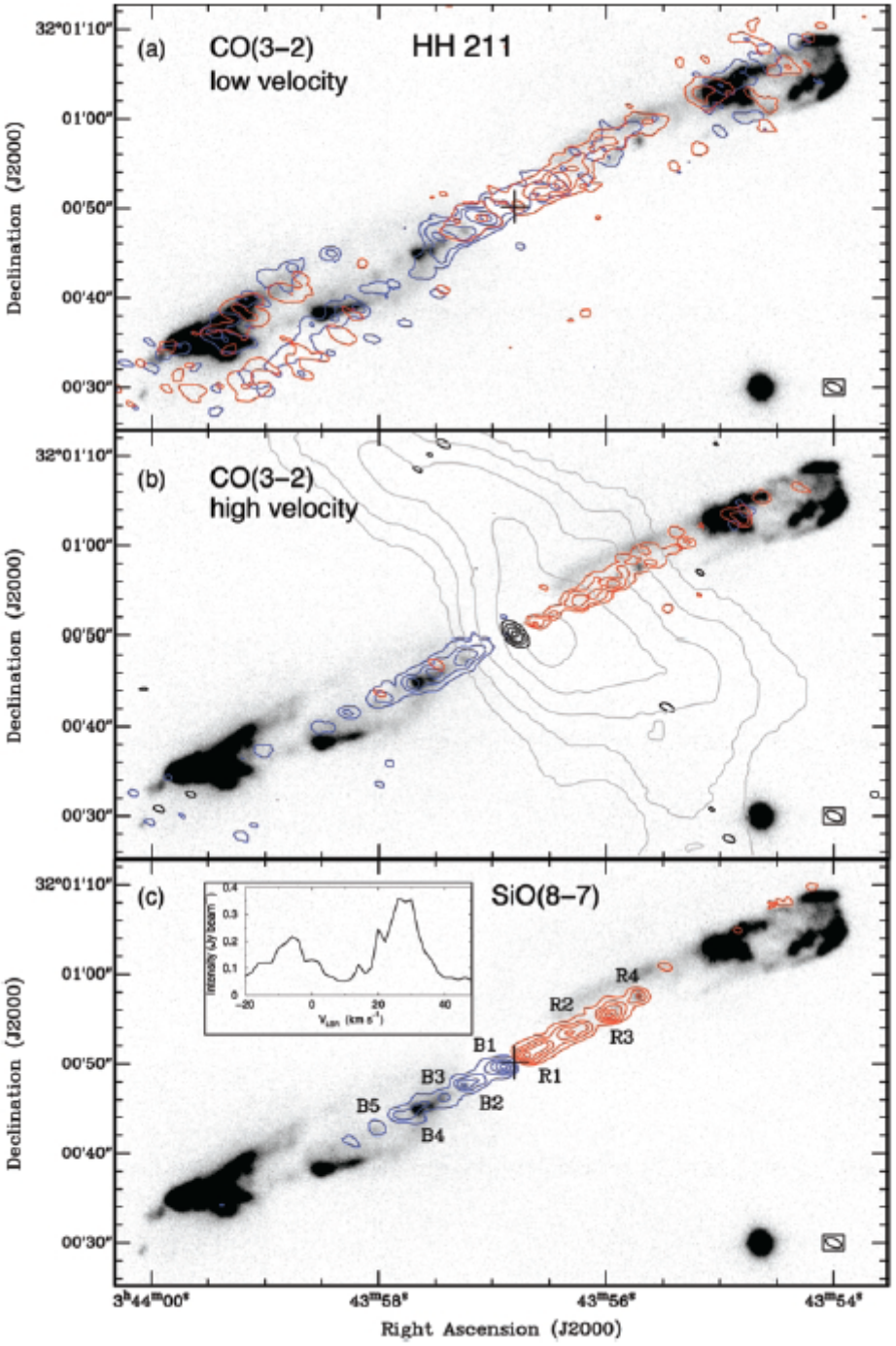
CO surveys of disks around stars from 0.3 to 3 msun	A. Dutrey	2760 hrs
Molecular surveys in 2-3 ``small'' samples from 0.5 to 3 msun	A. Dutrey	229 hrs
Continuum survey from 80 to 900 GHz	S.Guilloteau	260 hrs
Disks in the sub-stellar regime	L. Testi	54 hrs
Gaps in nearby protoplanetary disks	S.Guilloteau	13 hrs
Transitions disks around CTTs/WTTs & near ZAMS stars.	A.Bacmann	88 hrs
Structure of Debris disks & Vega-type objects.	A. Dutrey	690 hrs
Structure and properties of disks around high-mass (proto-)stars	L. Testi	190 hrs
Dust and Gas distribution in multiple-systems	A. Dutrey	120 hrs
Deuteration in Proto-Planetary Disks: DCO+ and HDO	A. Dutrey	25 hrs
Search for CI in circumstellar disks around young stars	A. Dutrey	0.33 hrs
Protoplanetary disks in Orion	J. Williams	90 hrs



HH211 SMA 217 GHz (ALMA band 6)



HH211 SMA 345 GHz (ALMA band 7)



Science with ALMA (DRSP 2.2)

Young Stellar Objects

Mapping the turbulence in a molecular cloud	J. Richer	121 hrs
Magnetic field geometry in protostellar envelopes	J. Richer	112 hrs
Structure and collapse of protostellar envelopes	J. Richer	240 hrs
Infall toward protostars	A. Wootten	900 hrs
Magnetic field in molecular outflows	J. Richer	168 hrs
Energetics of the HH 80-81 molecular outflow	D. Shepherd	325 hrs
Survey of massive molecular outflows with ACA and TP only	D. Shepherd	180 hrs
Survey of the central fields in massive molecular outflow with the ALMA interferometer.	D. Shepherd	200 hrs
Deep integration on the massive jet source HH80-81: the disk-outflow connection	D. Shepherd	95 hrs
The internal structure of the BHR71 outlow	F.Gueth	65 hrs
Inner kinematics in pre-stellar cores with H2D+	A. Bacmann	360 hrs
Proving the existence of Keplerian rotation about a 20 solar masses young star	M. Beltran	55 hrs
Resolving the jet-disk interaction	H. Beuther	18 hrs
Probing the outflow launching mechanism through observations of the molecular outflow rotation	H. Arce	80 hrs
The energetics and temperature structure of protostellar outflows	H. G. Arce	840 hrs
Ionized Gas Accretion in Hypercompact HII Regions	S. Kurtz	6 hrs
The outflows in G5.89-0.39	Klaassen	8 hrs

Science with ALMA (DRSP 2.2)

The Sun		
Structure and Dynamics of the Chromosphere	A. O. Benz	10 hrs
Solar Radio Recombination Lines	A. O. Benz	10 hrs
Mm continuum from stars		
Evolution of Magnetic Activity in Main Sequence Stars	M. Guedel	30 hrs
Magnetic Energy Release and High-Energy Particles in Stellar Atmospheres	M. Guedel	14 hrs
Thermal Emission from Red Giant and Supergiant Stars	K.M. Menten	100 hrs
The photospheres and proper motions of normal stars	Black	200 hrs
Millimeter observations of nonthermal emission from active stars	R. A. Osten	36 hrs
Millimeter survey of stellar disk emission from late-type giants and supergiants	R. A. Osten	3.5 hrs
Flares from Young Stellar Objects: What we learned from 2003 January flare in GMR-A	R.S.Furuya	96 hrs
TOO Observations of Energetic Particles in Stellar Superflares	R. A. Osten	2 hrs
Using ALMA to probe active regions in Sun like stars	G. Hussain	60 hrs

Science with ALMA (DRSP 2.2)

Circumstellar envelopes		
Probing the Dust Formation Zone around Red Giant Stars	K. M. Menten	200 hrs
Line surveys in evolved stars	P. Cox	680 hrs
Resolving the Molspheres of M supergiants	G. Harper	18,4 hrs
Post-AGB sources		
Post-AGB Stars: proto-planetary and planetary nebulae	P. Cox	238 hrs
Molecular and atomic gas in planetary nebulae	P. Cox	73.2 hrs
The Heart of Eta Carinae	S. M. White	
Pulsar Wind Nebulae	V. Kaspi	10 hrs
Supernovae		
Structure of the Molecular Gas Shocked by Supernova Remnatns	K. Tatematsu	206 hrs
SNR-cloud interaction search in LMC	K. Tatematsu	86 hrs
The populations of relativistic particles and magnetic field structure in the Crab Nebula and other plerions	R. Bandiera	229 hrs
ToO Observing of Radio Supernovae -	S. Van Dyk	50 hrs per semester
Monitoring of Radio Supernovae	S. Van Dyk	30 hrs per semester

Science with ALMA (DRSP 2.2)

Planetary atmospheres

The dynamics of Mars' and Venus' middle atmopheres	E. Lellouch	120 hrs
The three-dimensional water cycle of Mars	E. Lellouch	320 hrs
Chemistry in the atmospheres of Venus and Mars	E. Lellouch	70 hrs
Composition and dynamics of giant planet stratospheres	E. Lellouch	160 hrs
Search for broad lines in the tropospheres of the giant planets	E. Lellouch	16 hrs
Chemical-dynamical couplings and meteorology in Titan's atmosphere	E. Lellouch	160 hrs
Io's volcanism	E. Lellouch	100 hrs
The atmospheres of Triton, Pluto and other transneptunians (TNO)	E. Lellouc	432 hrs

Planetary surfaces and dynamics

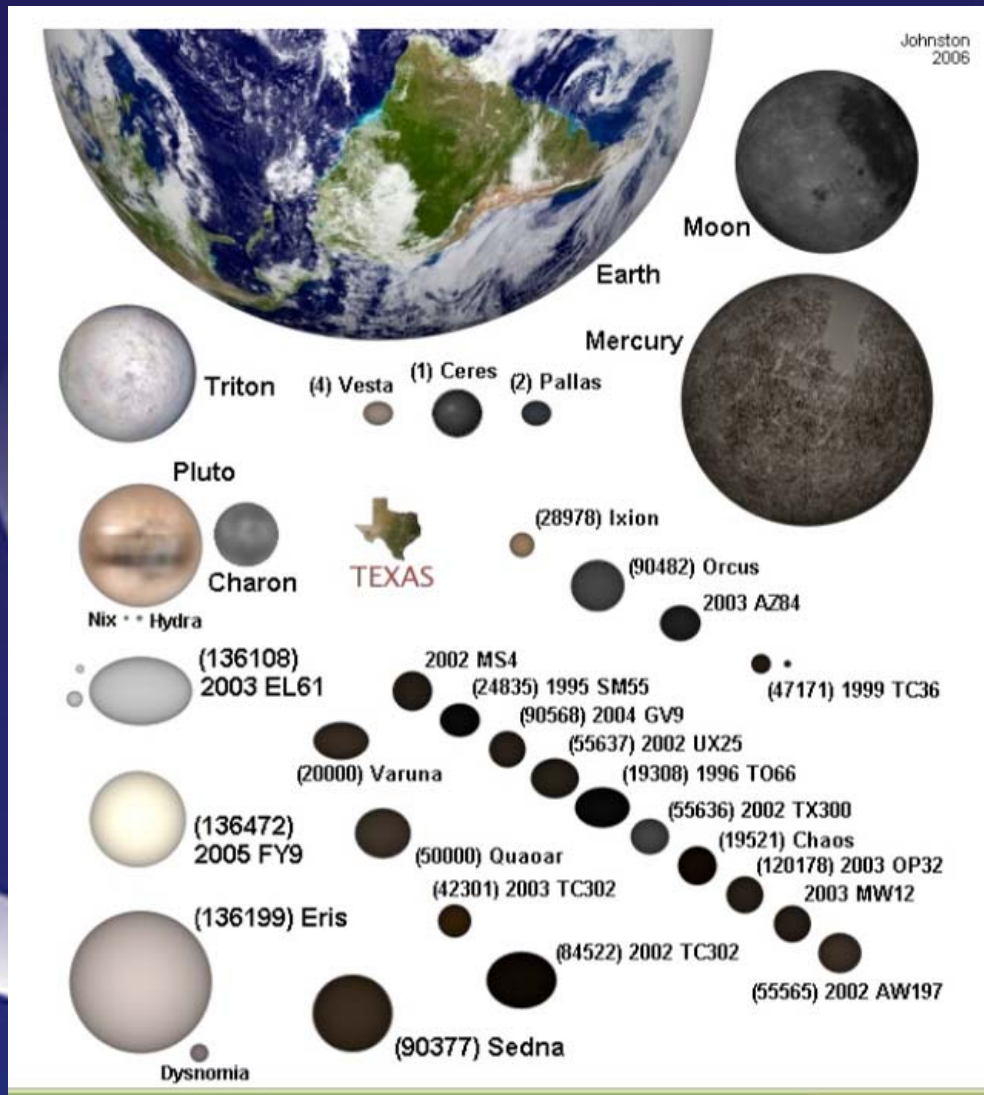
Albedos, sizes and surface properties of transneptunian objects	E. Lellouch	140 hrs
Mapping the surfaces of the Moon, Mercury and Mars	B. Butler	66 hrs
Mapping the surfaces of large icy bodies	B. Butler	104 hrs
Structure and composition of Saturn's rings	B. Butler	48 hrs
Mapping the surfaces of larger asteroids	B. Butler	105 hrs
Sizes and albedoes of NEAs	B. Butler	20 hrs
Astrometry of NEAs and TNOs	B. Butler	30 hrs
Radar observations of NEAs	B. Butler	12 hrs

Albedo & Surface Properties of a Trans-Neptunian Object (I)

- By measuring the variations in continuum thermal flux from a Kuiper-Belt object
  - to look for possible correlations in albedo, size, and color, so
  - to trace KBO's dynamical and collisional history
- For the largest of KBOs, mm lightcurves due to rotation can be obtained, providing additional information on the object surface properties.

Albedo & Surface Properties of a Trans-Neptunian Object (II)

- Angular resolution: 0.05“ (baseline ~ 4 km)
- Receivers: Band 7 (275 – 373 GHz)
- Spectral resolution: N/A w/ 16 GHz BW
- Continuum Sensitivity:
  - 0.1 K for a KBO with T_B ~ 1 K (beam diluted), at 40 AU, $T_{surface}$ ~ 40 K, and 1,000 km (~ 0.01“) in diameter
- Observing time: ~ 1 hr



Direct Detection of Jupiter Around a Nearby Solar-like Star

- A Jupiter at the distance of α Centauri, will have a 345 GHz flux density of 6 μ Jy
- moving on the same orbit around α Cen A as Jupiter does around the Sun (~5 AU)
  - a maximum elongation projected distance of 3.9" from α Cen A
- Angular resolution: 0.1"
- Receivers: Band 7 (345 GHz)
- Continuum Sensitivity: 2 μ Jy
- Observing Time: ~175 hrs (6 μ Jy)

References

- NRAO Public Wiki: "Preparing for ALMA" Activity
  https://safe.nrao.edu/wiki/bin/view/ALMA/Preparing4ALMA
- ALMA Design Reference Science Plan (DRSP 2.2)
  - http://www.eso.org/sci/facilities/alma/science/drsp/
- ALMA Primer: Observing with ALMA
  - http://almatelescope.ca/ALMAPrimer.pdf

Thank you!

ALMA 2010 Novice User Workshop

November 20 Program

Time	Topic	Speaker
9:30-9:40	Opening remark	
9:40-10:30	Introduction to ALMA	Sheng-Yuan Liu (ASIAA)
10:40-11:30	Radio astronomy and single-dish telescopes	Yi-Nan Chin (TKU)
11:40-12:30	Introduction to interferometry	Chin-Fei Lee (ASIAA)
14:10-15:00	Galactic sources and the Solar System	Yi-Jehng Kuan (NTNU)
15:10-16:00	Extragalactic astronomy	Chorng-Yuan Huang (NCU)
16:10-17:00	Tools for ALMA	Shigehisa Takakuwa (ASIAA)

組織委員會 / Organizing Committee

陳惠茹（國立清華大學）
Vivien Chen (NTHU)
黃崇源（國立中央大學）
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管一政（國立台灣師範大學）
Yi-Jehng Kuan (co-Chair, NTNU)
賴詩萍（國立清華大學）
Shih-Ping Lai (NTHU)
李景輝（中央研究院天文所）
Chin-Fei Lee (ASIAA)

date :
2010/11/20 Sat.

location :
RM S102 TEACHING & RESEARCH BLDG.
SHIDA SCIENCE CAMPUS
(師大分部 教學研究大樓 S102)

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http://www.es.ntnu.edu.tw/tuCASA/novice-wksp.