A Salty Torus around IRC+10216 ?

G. Quintana-Lacaci

ESO, Garching, 17th April 2015

Metals in IRC+10216: Single dish

Astron. Astrophys. 183, L10–L12 (1987)

Letter to the Editor

ASTRONOMY AND ASTROPHYSICS

Metals in IRC+10216: detection of NaCl, AlCl, and KCl, and tentative detection of AlF

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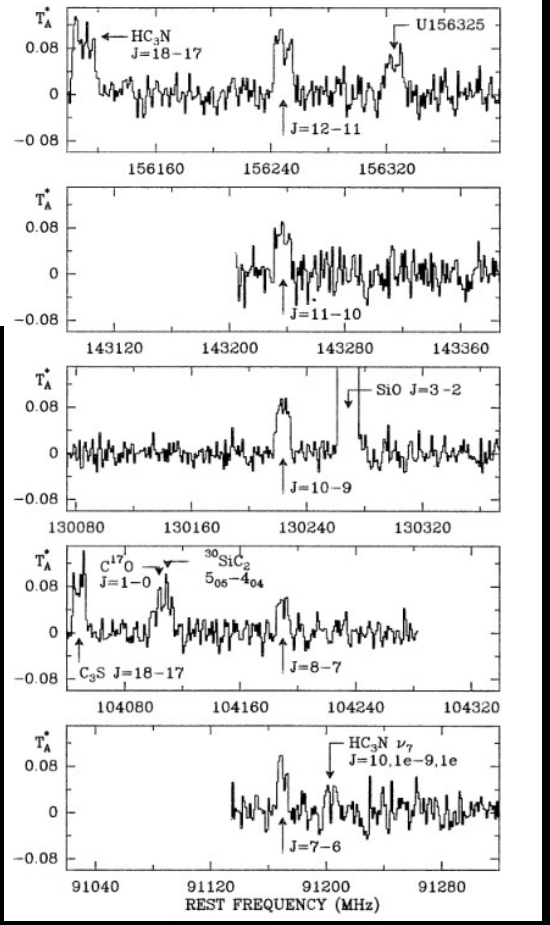
Received June 25, accepted July 7, 1987



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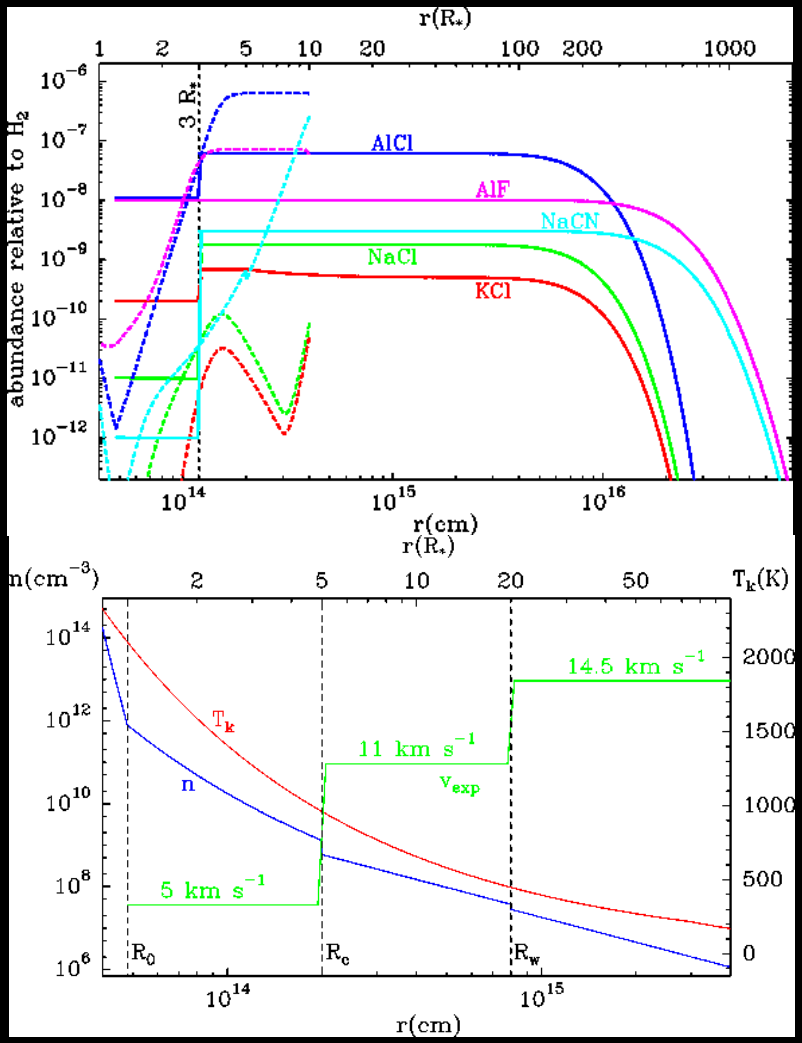

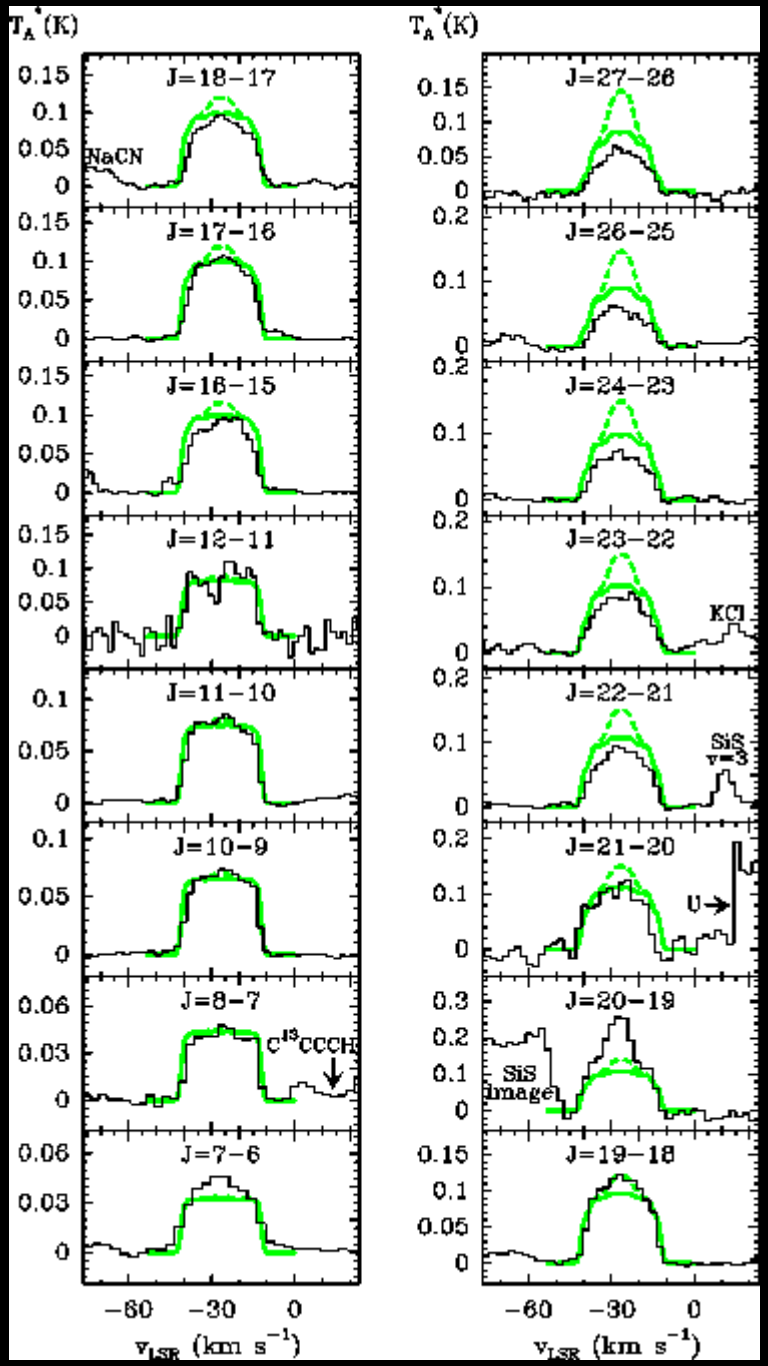

Agúndez et al. 2012

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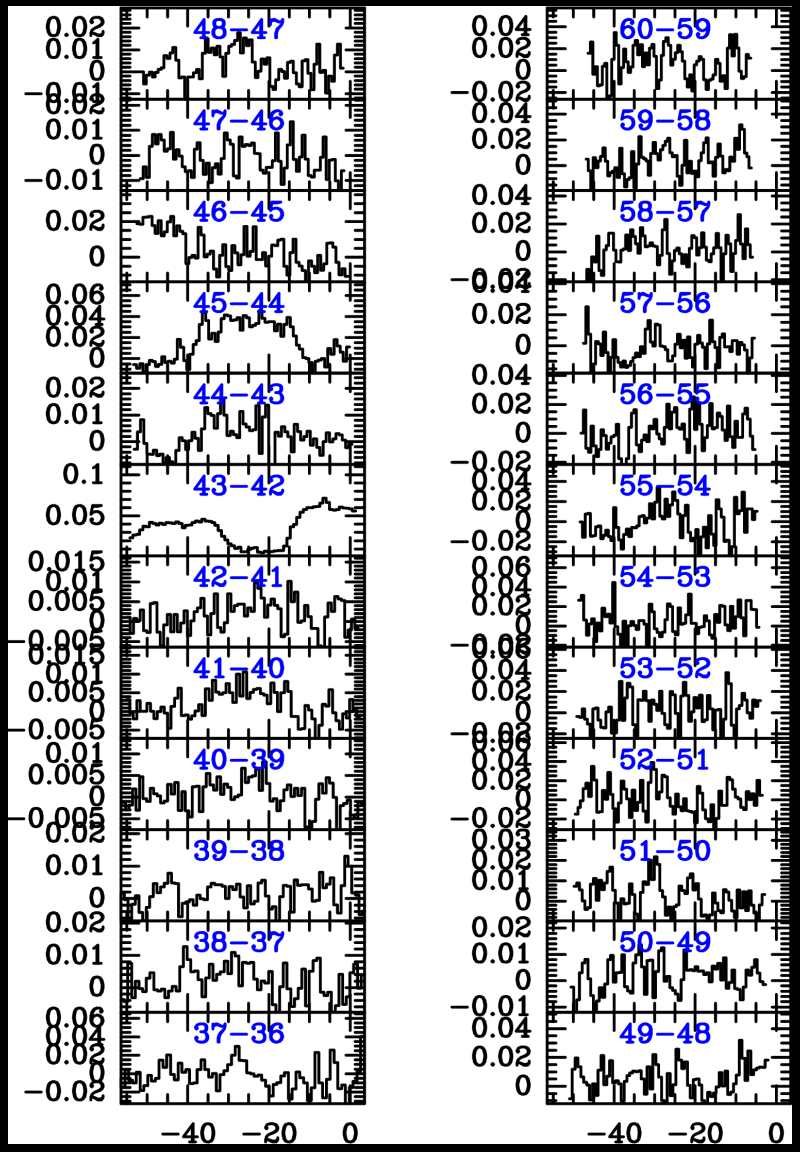


HIFI – Cernicharo et al. (in preparation)

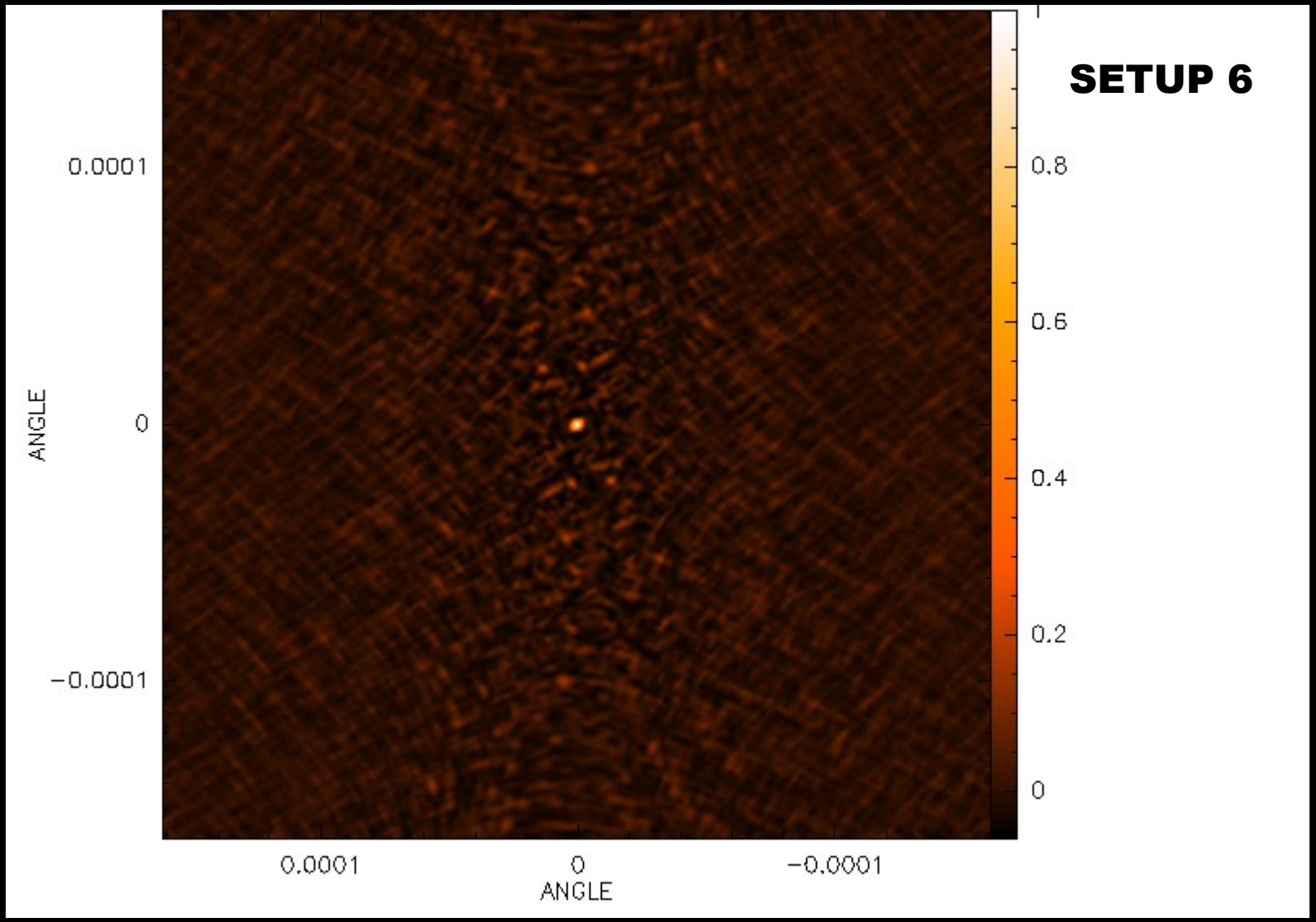
Metals as seen by ALMA

Molecule	Trans.	Freq (MHz)	Beam	Setup
NaCl	20–19	260223.113	$0.''867 \times 0.''563$	5
NaCl	21–20	273202.100	$0.''704 \times 0.''516$	3
NaCl v=1	20–19	258287.756	$0.''758 \times 0.''606$	6
NaCl v=1	21-20	271170.047	$0.''711 \times 0.''514$	3
$Na^{37}Cl$	21–20	267365.814	$0.''709 \times 0.''551$	4
KCl	34–33	260916.468	$0.''866 \times 0.''561$	5
KCl	35–34	268558.984	$0.''705 \times 0.''549$	4
$K^{37}Cl$	35–34	260939.948	$0.''865 \times 0.''561$	5
$K^{37}Cl$	36–35	268363.909	$0.''706 \times 0.''549$	4
AlCl	18–17	262219.282	$0.''863 \times 0.''559$	5
$Al^{37}Cl$	18–17	256063.773	$0.''764 \times 0.''611$	6
$Al^{37}Cl$	19–18	270269.445	$0.''714 \times 0.''515$	3
AlF	8–7	263749.390	$0.''858 \times 0.''557$	5

Cycle 0 - BAND 6 Observations

Metals as seen by ALMA

Cleaning issues



Metals as seen by ALMA

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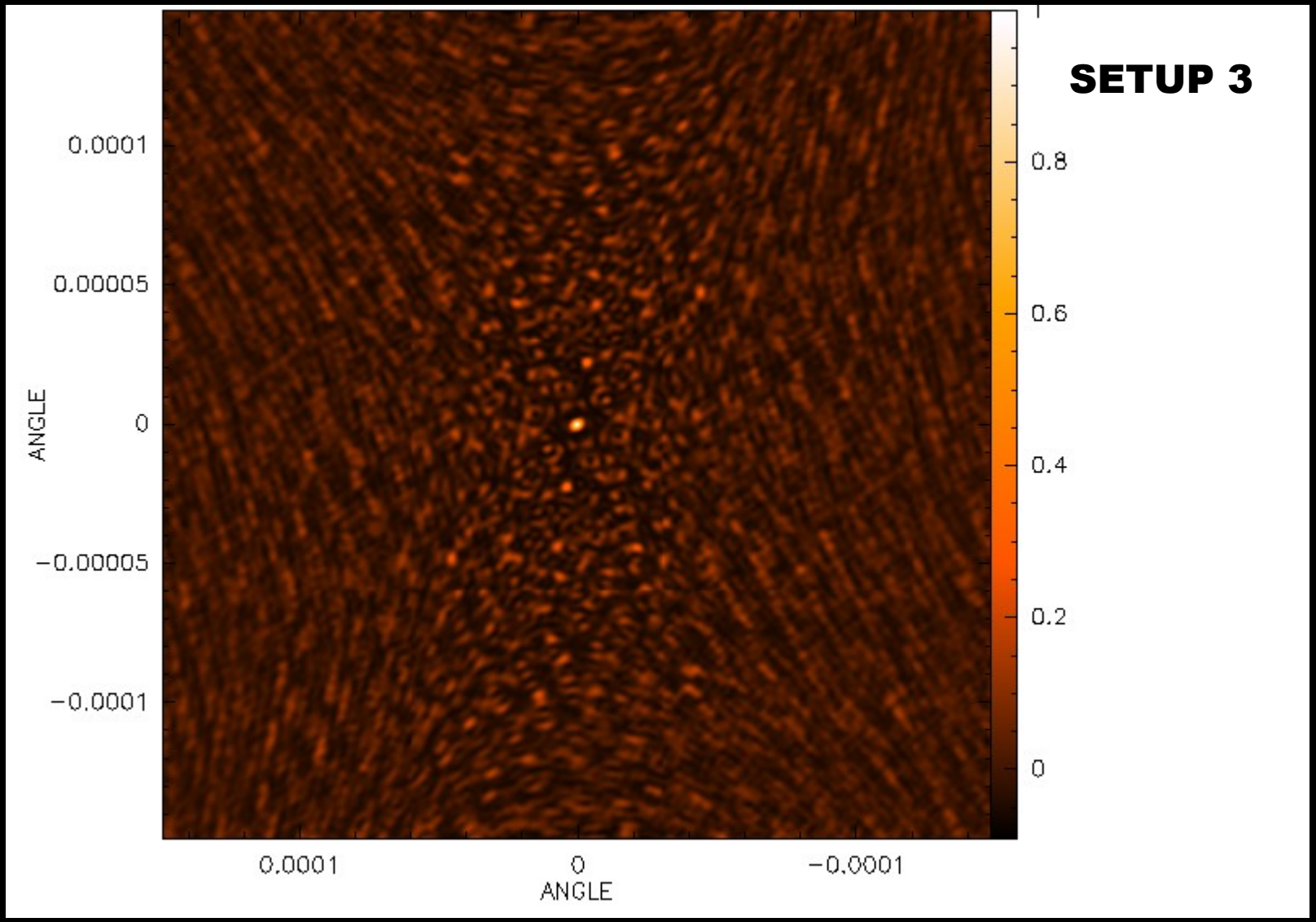

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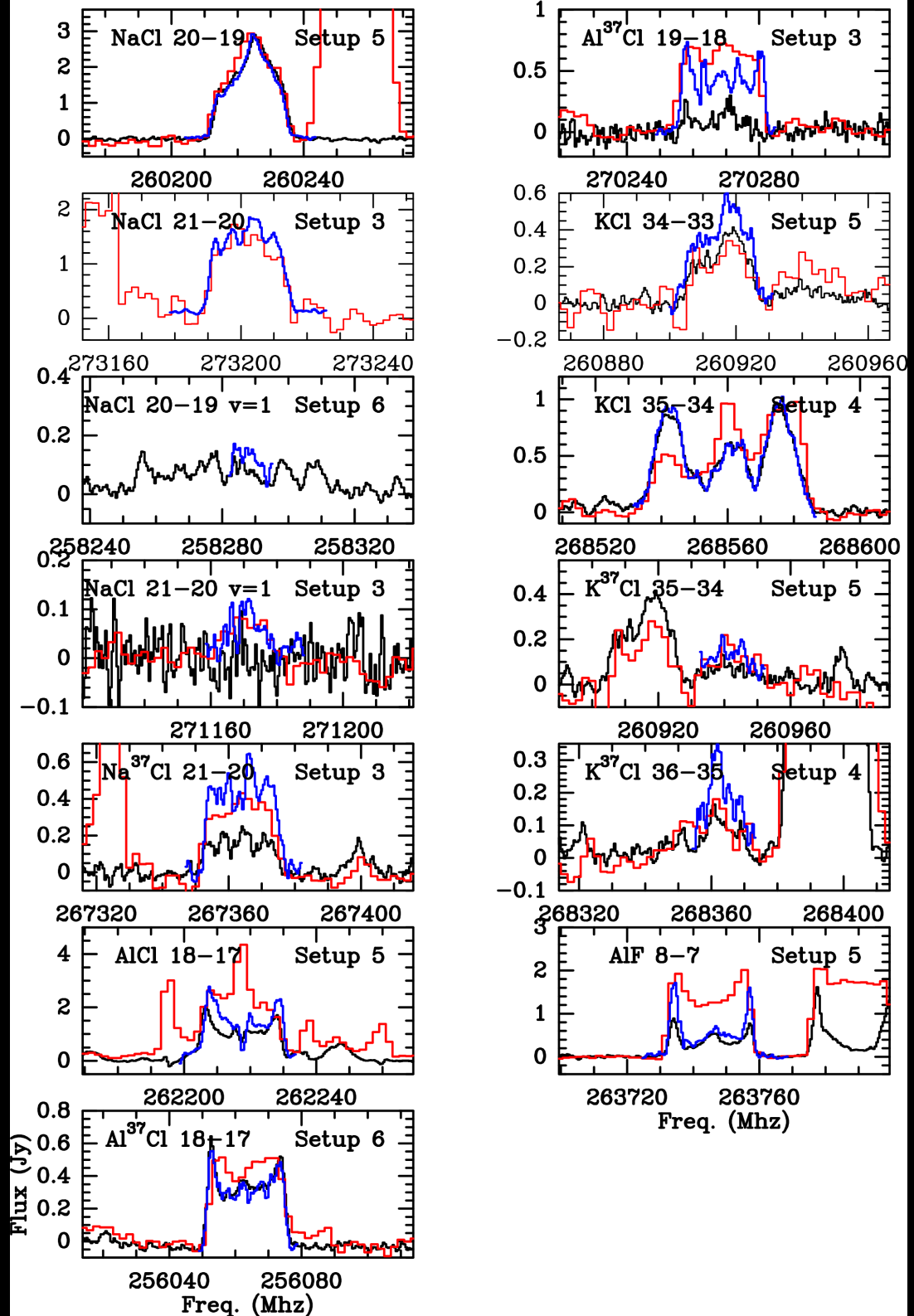

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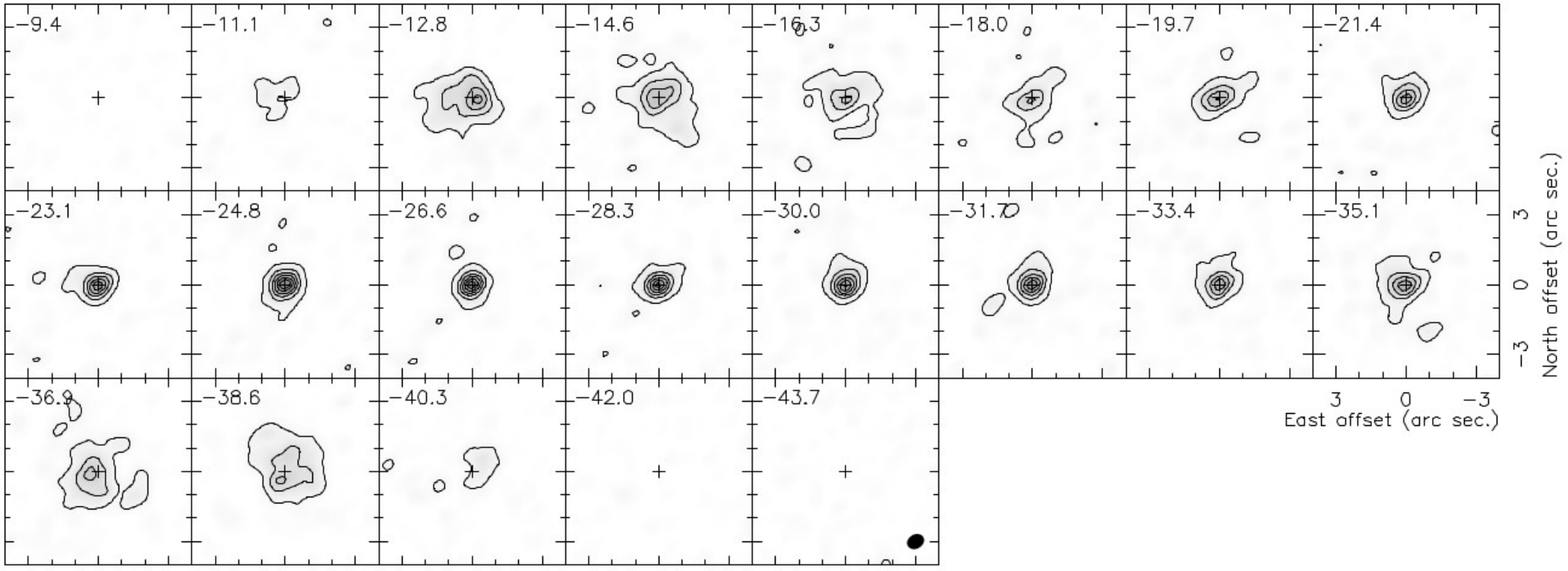
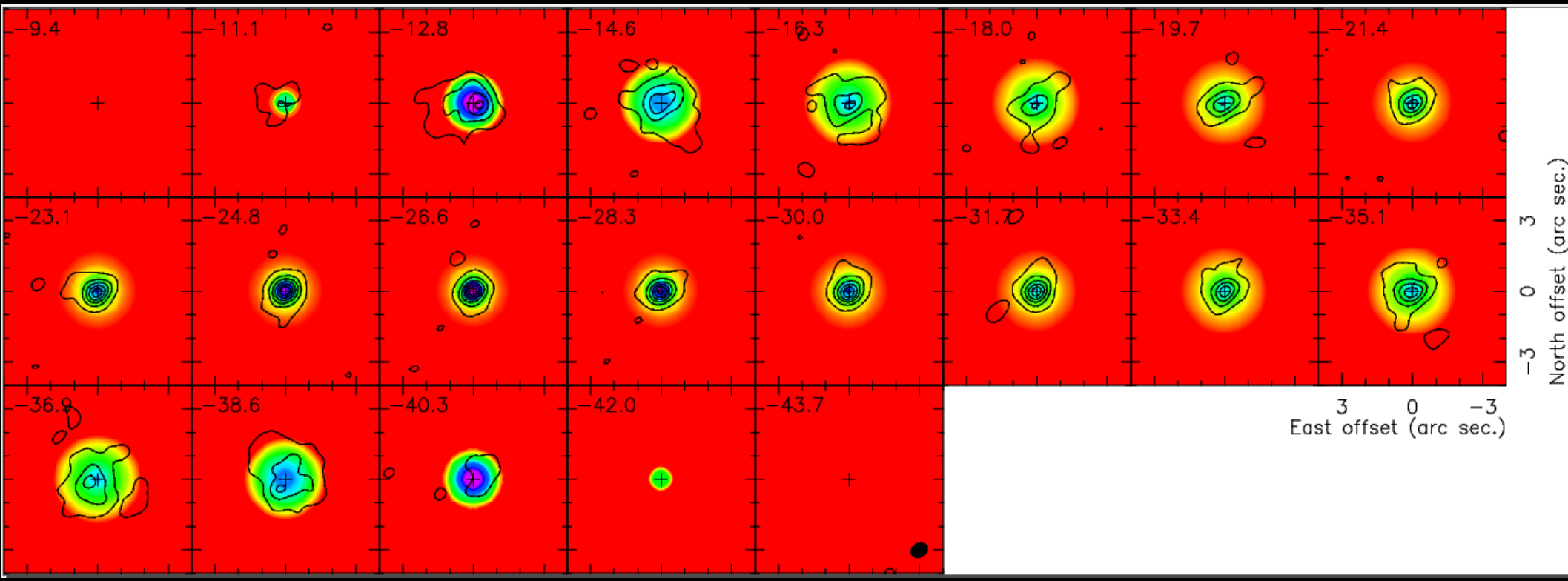


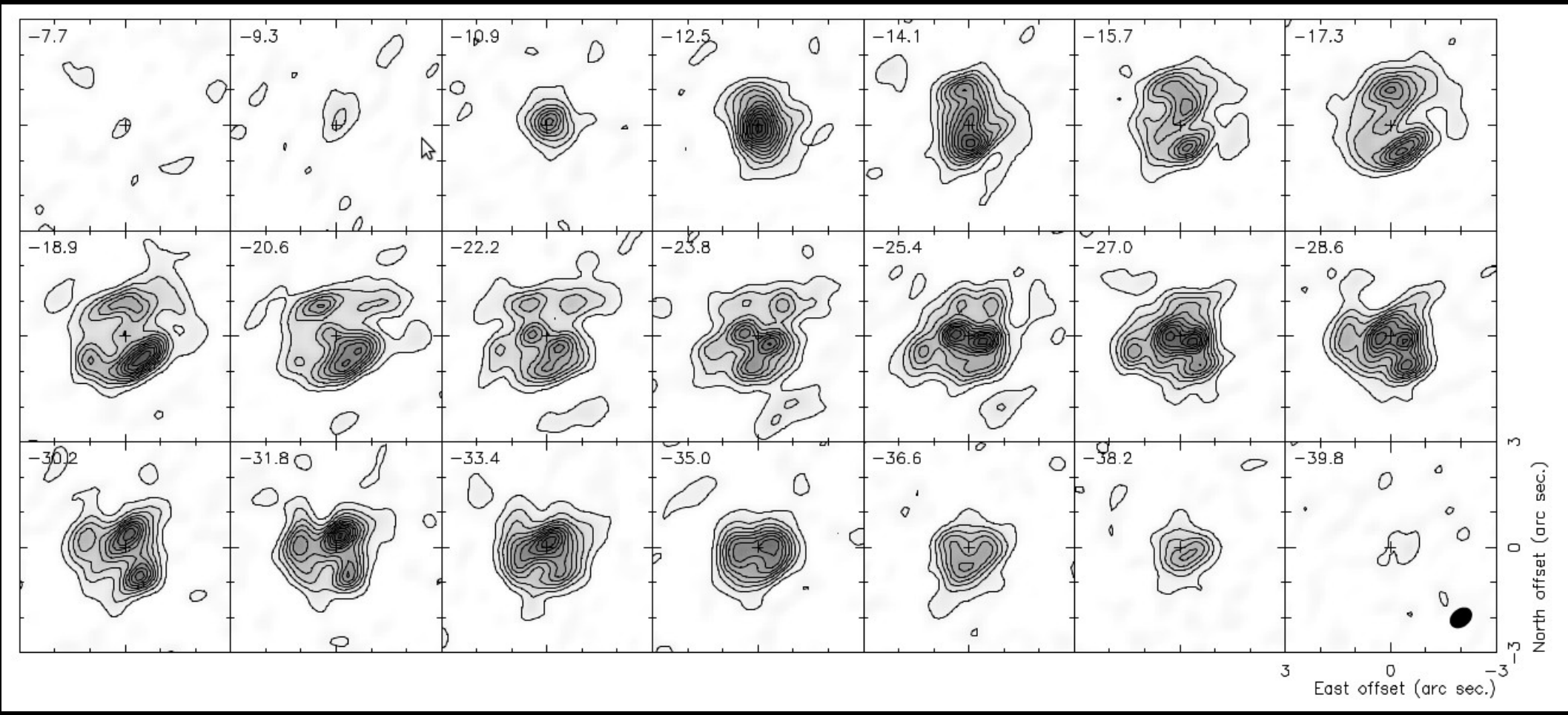
AIF 8-9

Metals as seen by ALMA



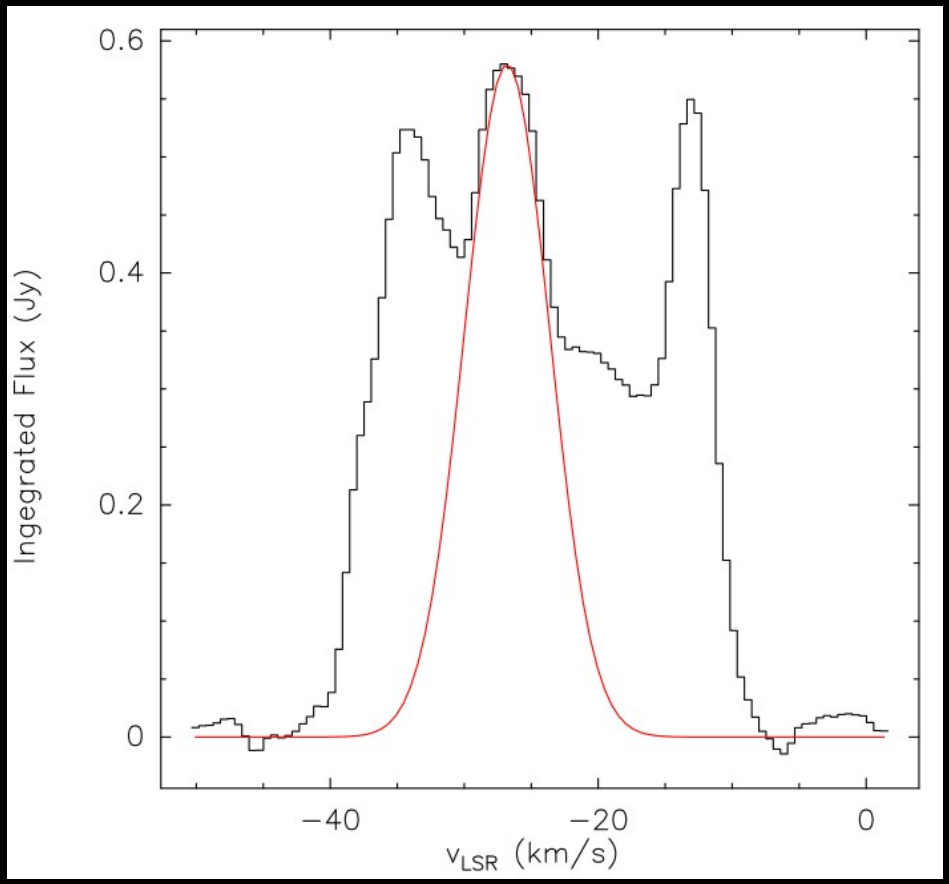
AIF 8-9

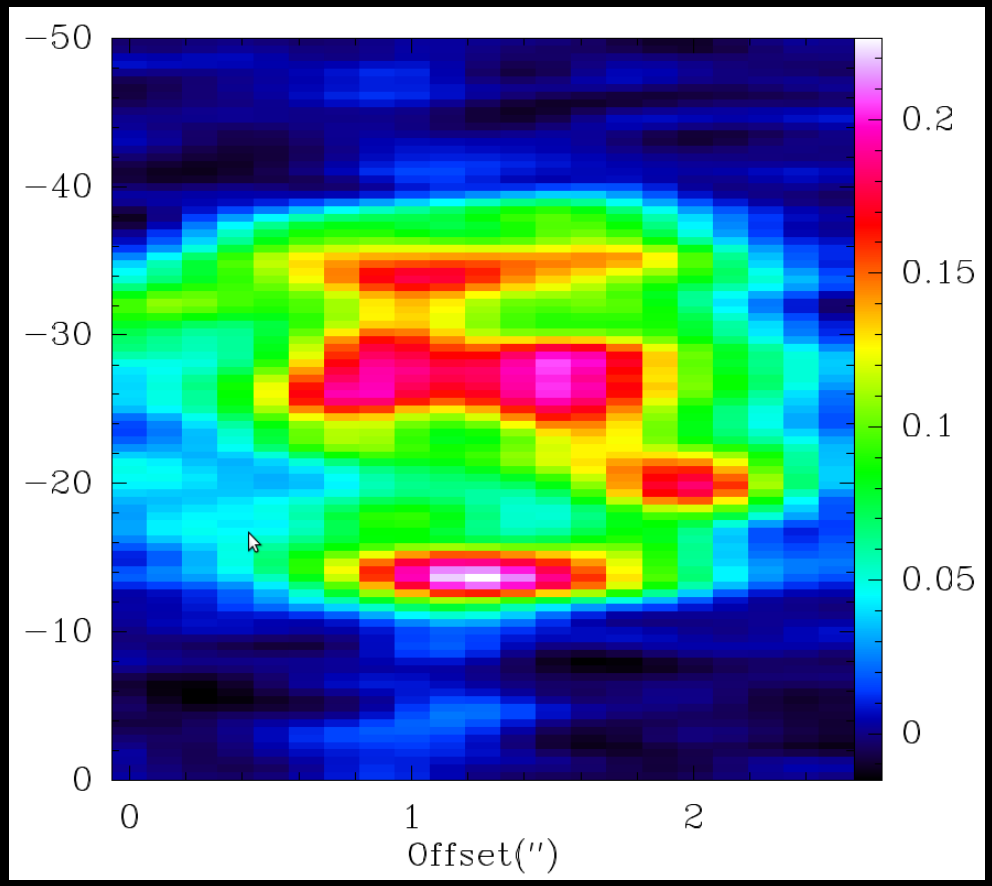
Metals as seen by ALMA



NaCl 21-20

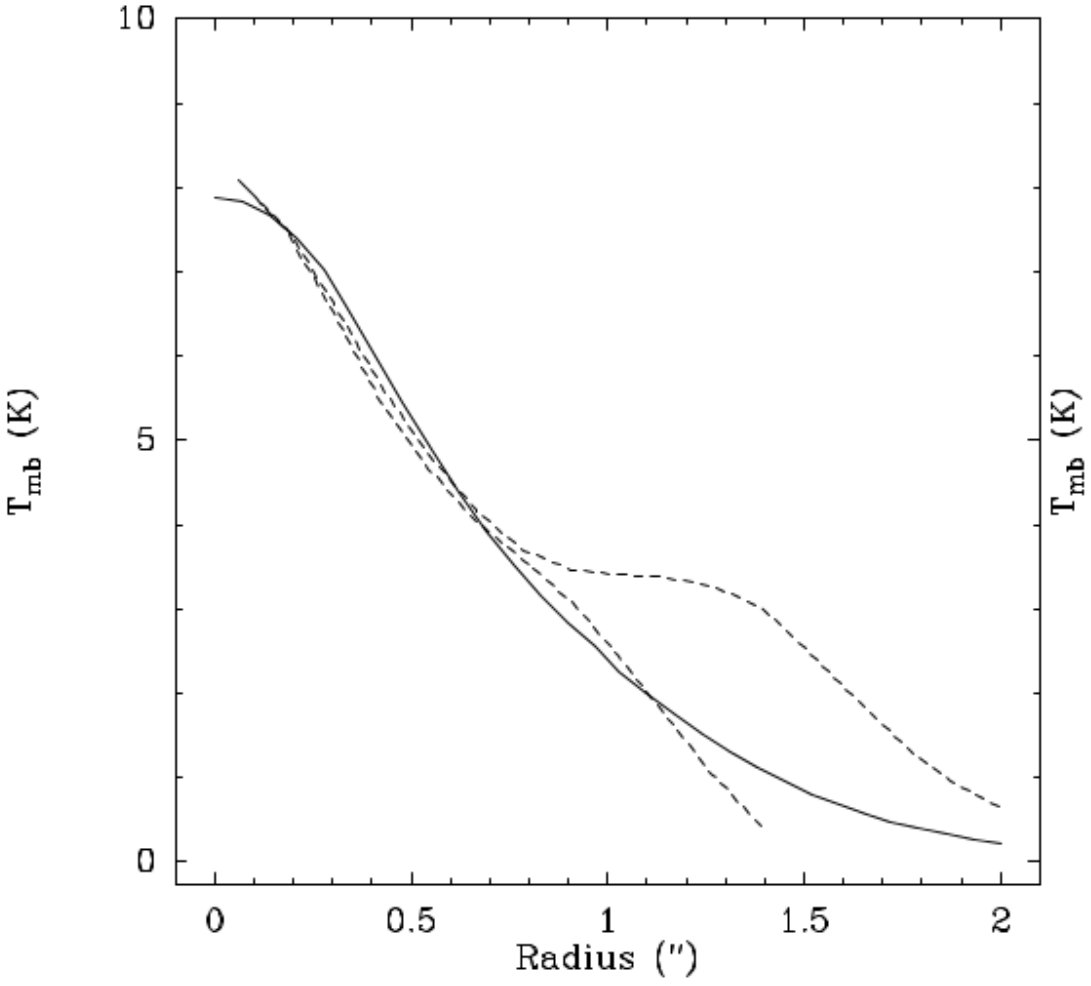
Metals as seen by ALMA

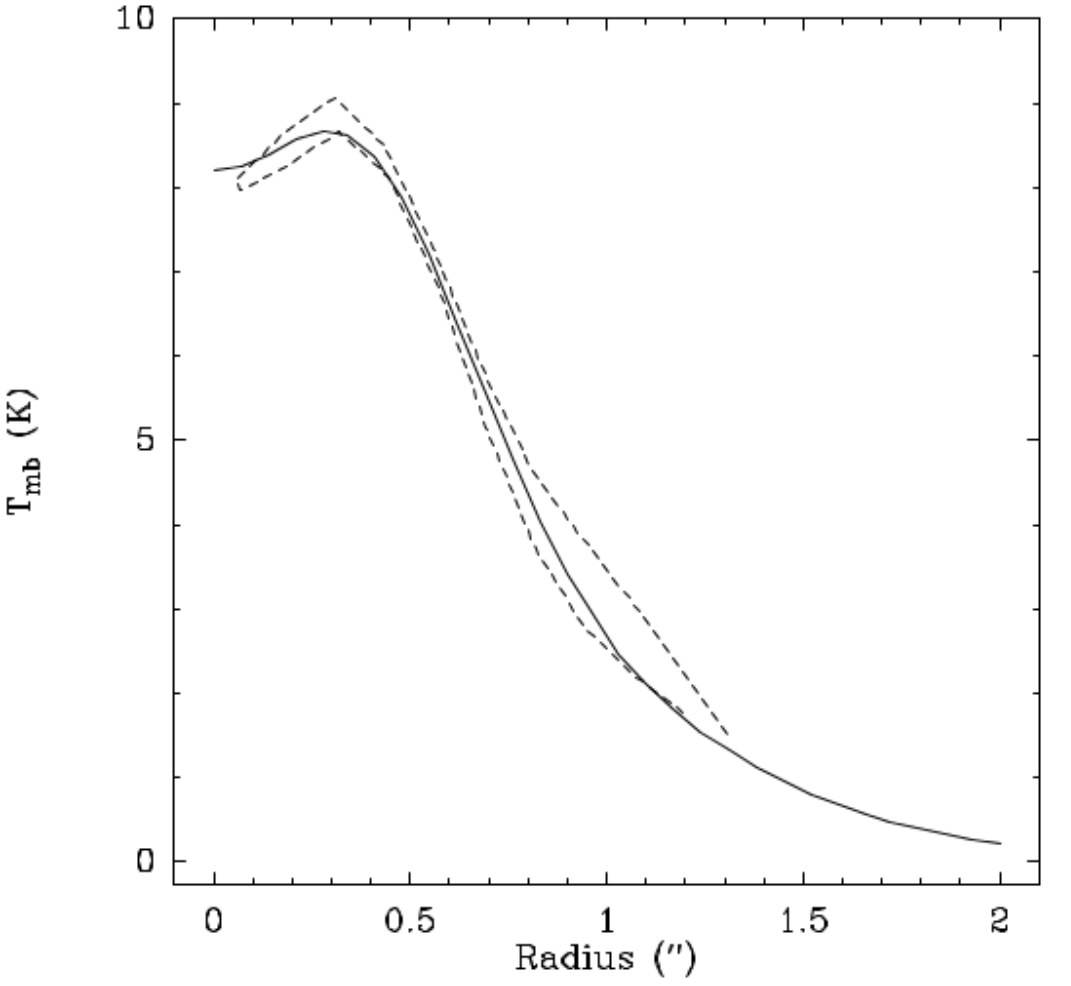


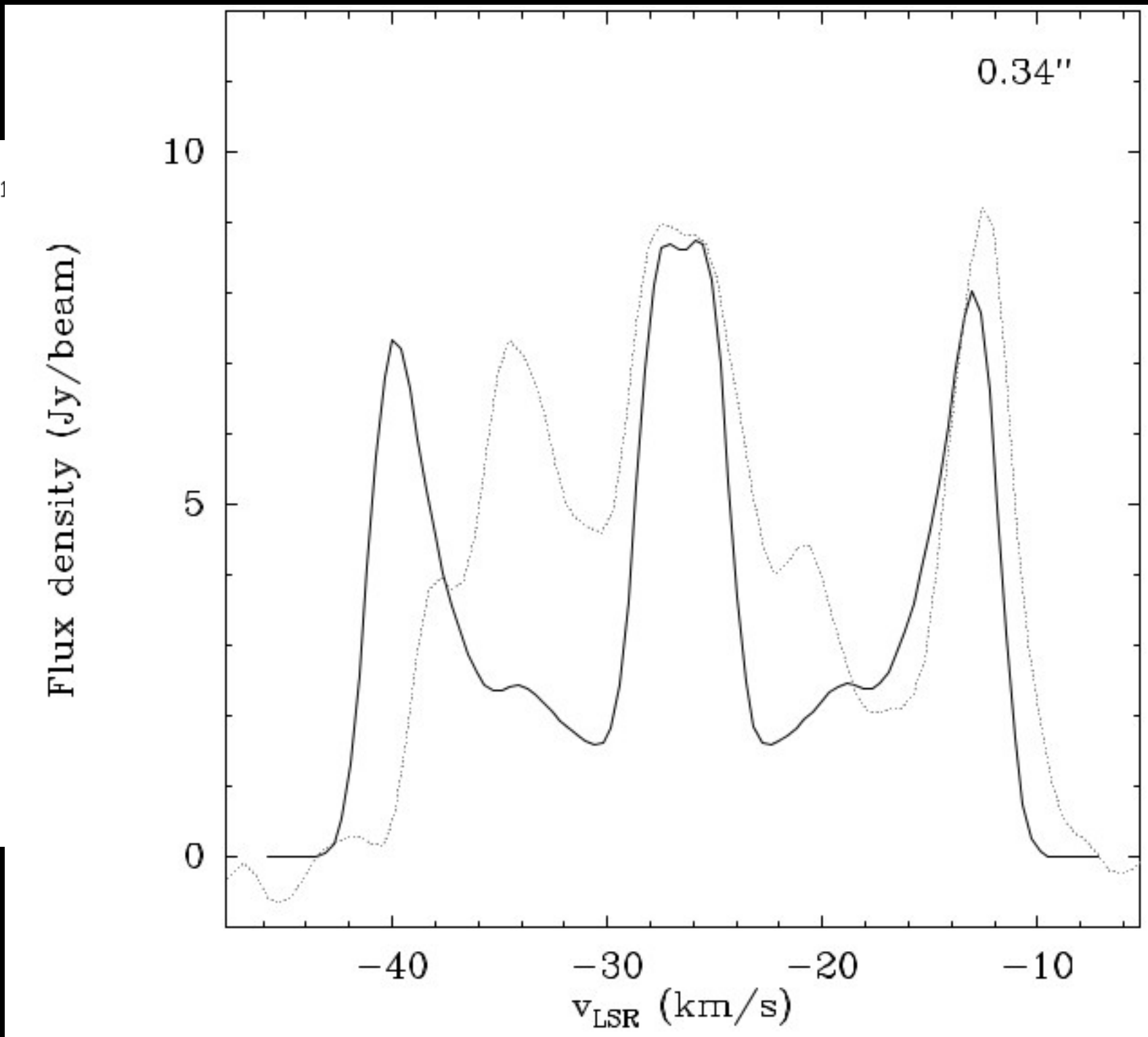


NaCl 21-20

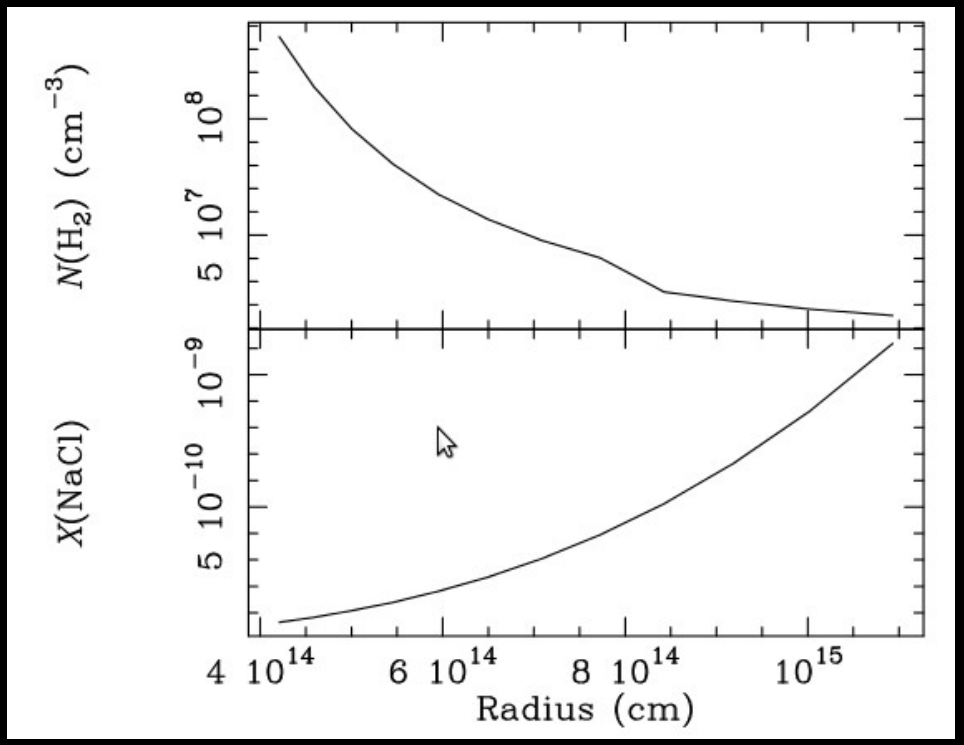
A Salty Torus?






0.34"
10
5
0
Flux density (Jy/beam)
−40
−30
−20
−10
v_{LSR} (km/s)

A Salty To



$$M_{\rm shell} = M_{\rm noTorus} + M_{\rm Torus} = 4\pi \int_{r_{\rm in}}^{r_{\rm out}} r^2\, n(r)\, {\rm d}r \qquad (1)$$

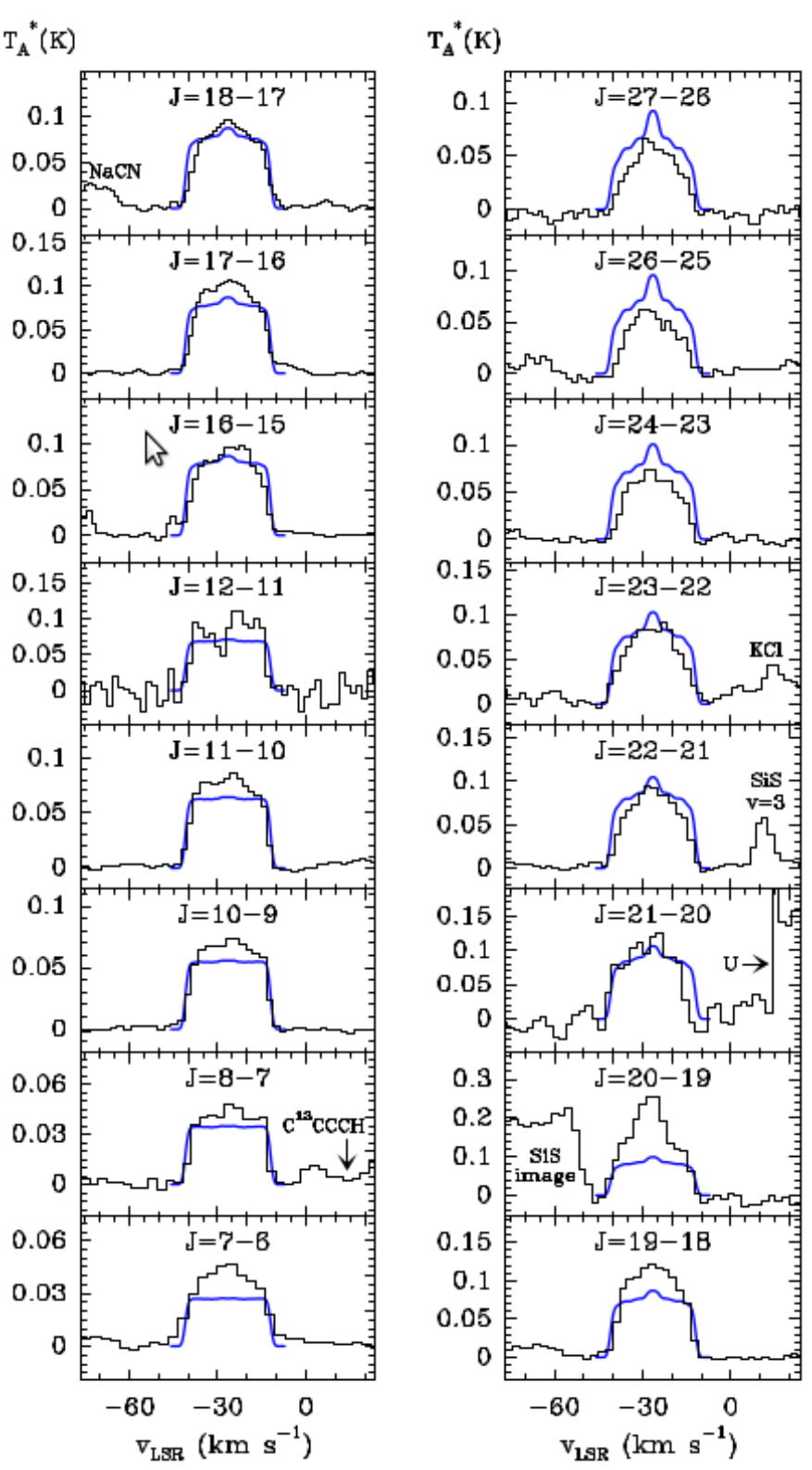
where $n(r) = 0.65\, n_{\rm noTorus}(r) + 0.35\, n_{\rm Torus}(r)$. Therefore, we can estimate the total mass of the torus as:

$$M_{\rm Torus} = 4\pi \times 0.35 \times \int_{r_{\rm in}}^{r_{\rm out}} r^2\, n_{\rm Torus}(r)\, {\rm d}r \qquad (2)$$

Mass = 1.1 10^{-4} M_O = 36 M_{earth}

Rin= 27 au

Rout= 73 au



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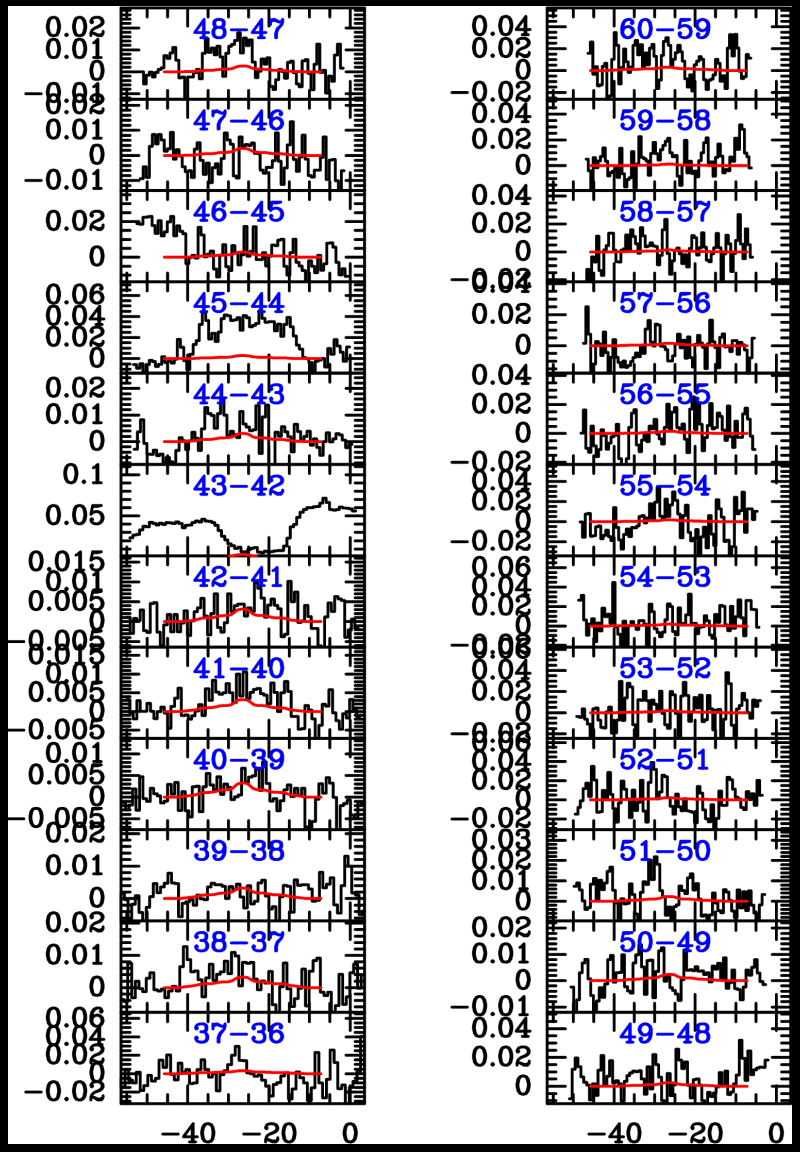
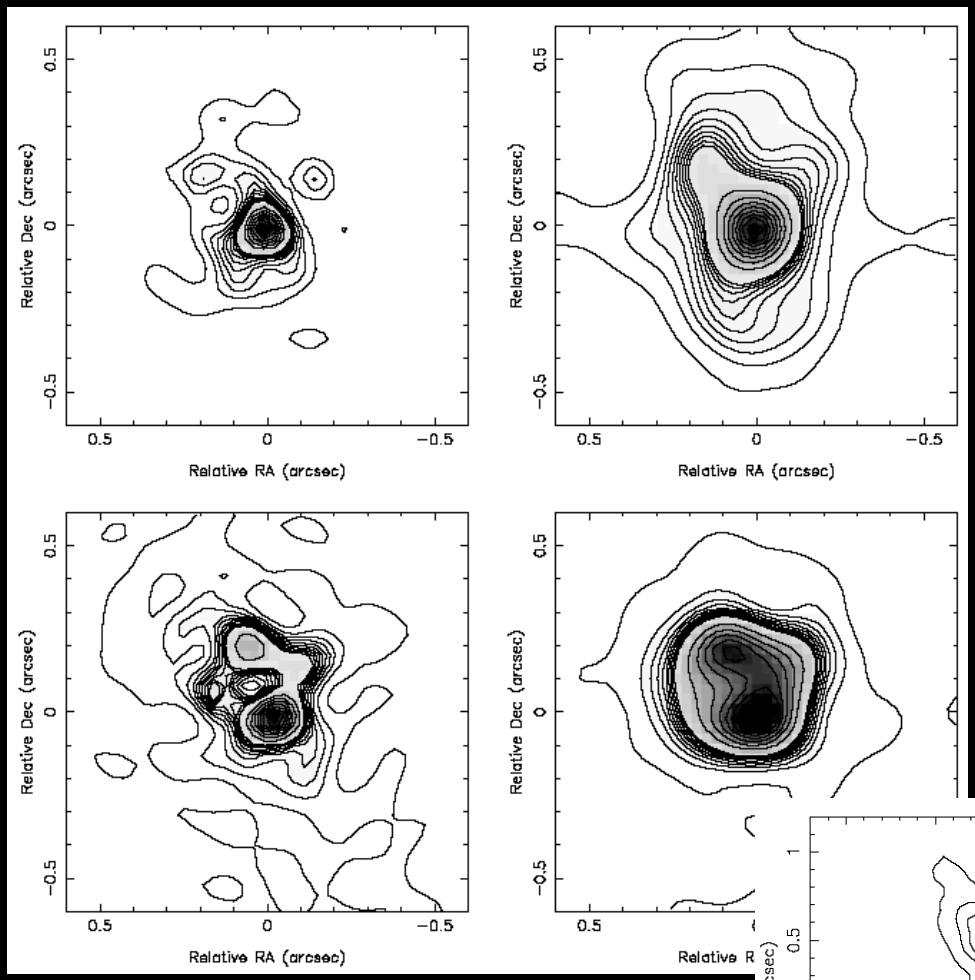
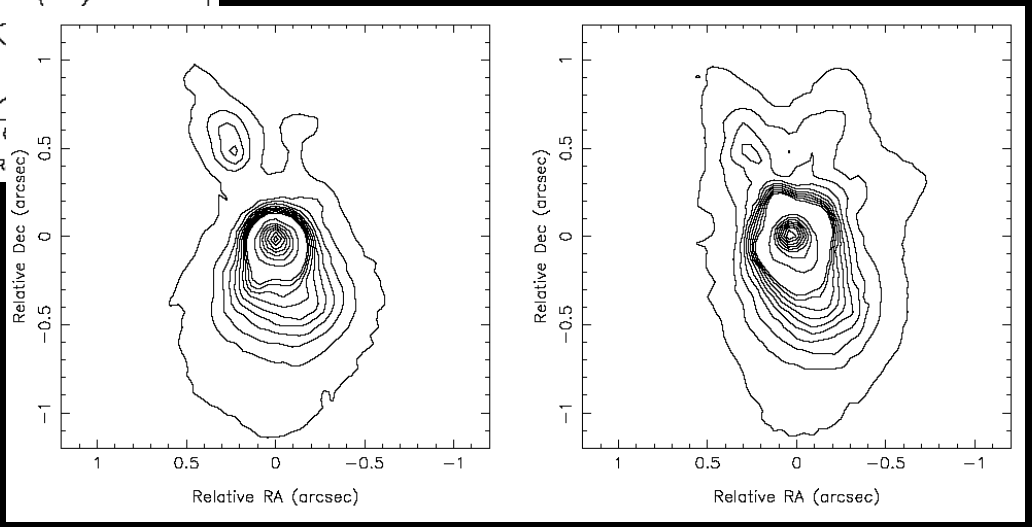


HIFI – Cernicharo et al. (in preparation)

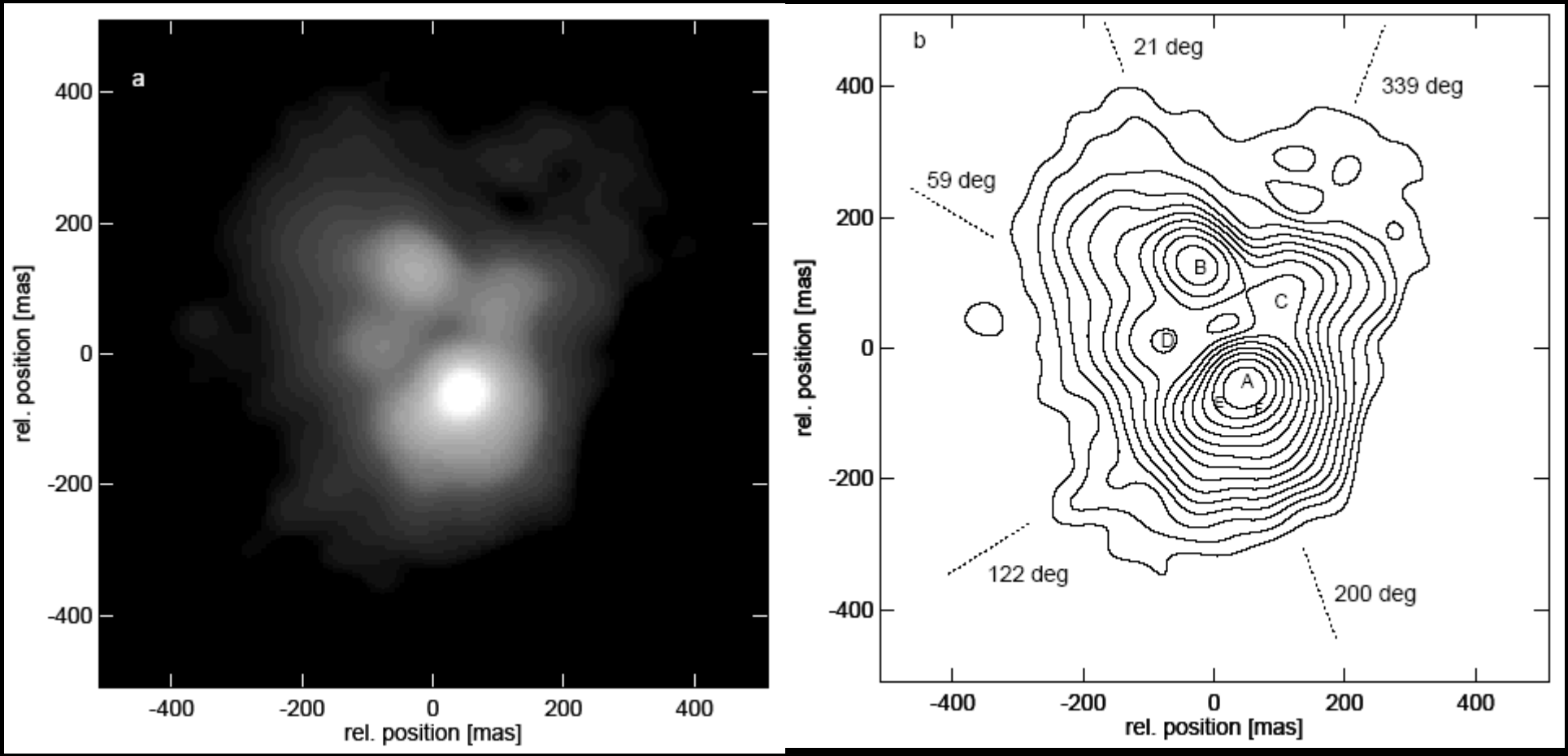
Other Structures: Outflow





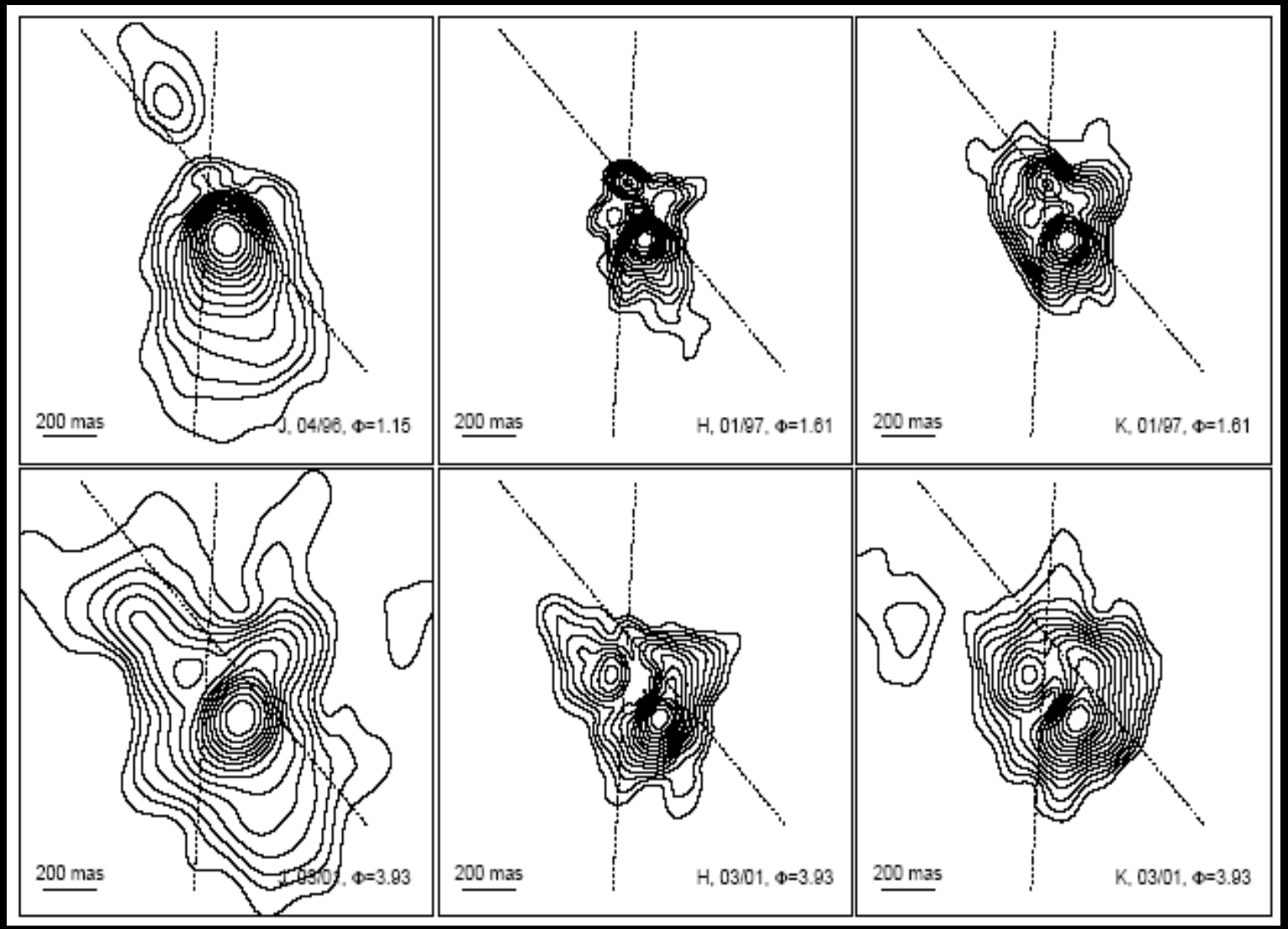
Haniff & Buscher, 1998
NIR (K: 2.2um and L:3.4um)

Other Structures: Outflow



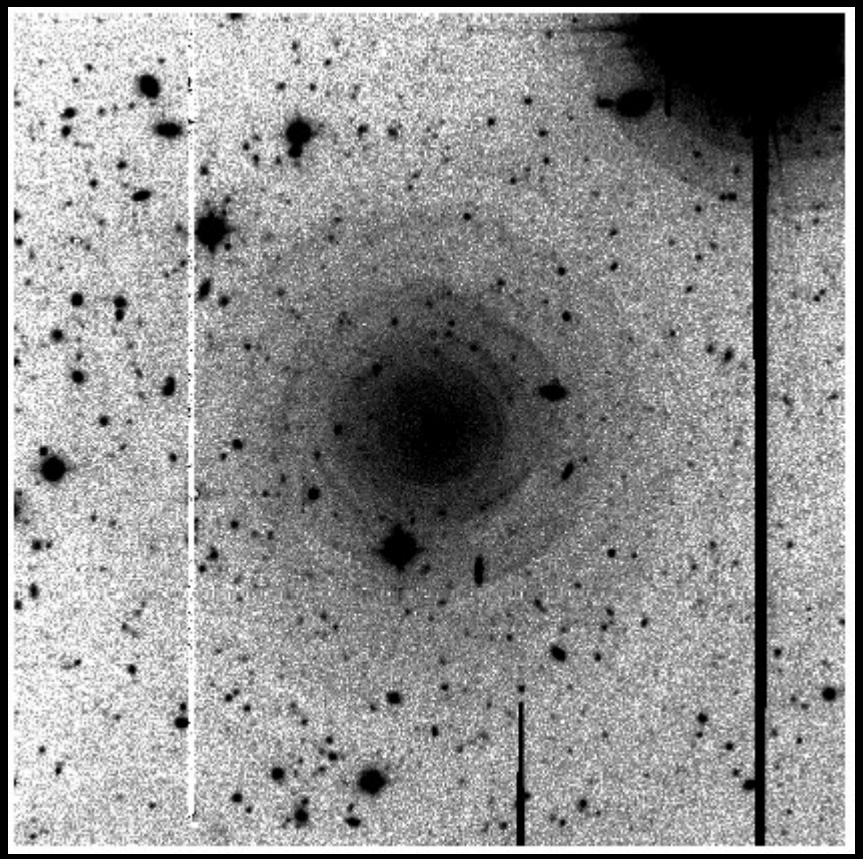
Weigelt et al.,1998
K' band (2.17um)

Other Structures: Outflow



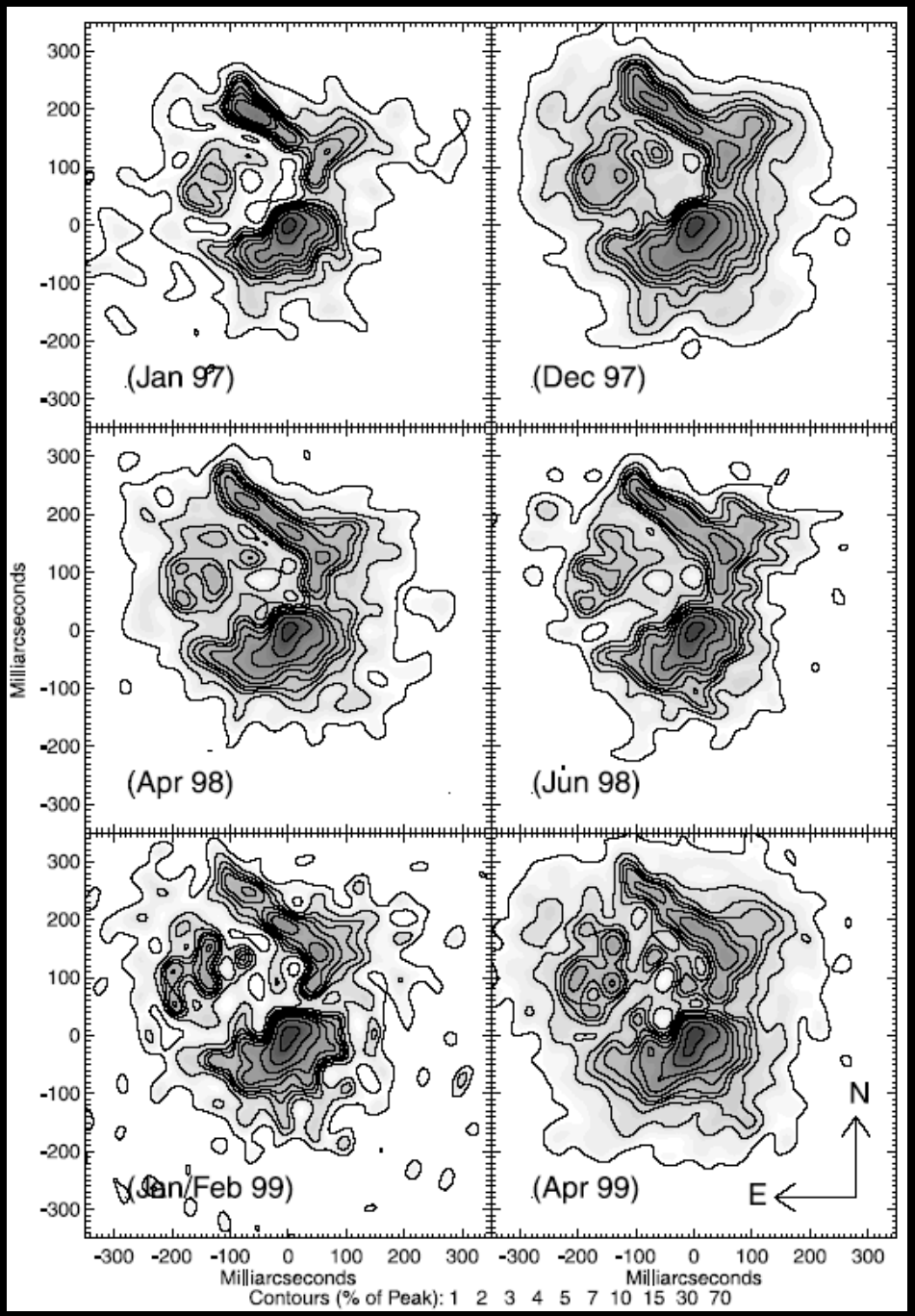
Weigelt et al., 2002
NIR (JHK)

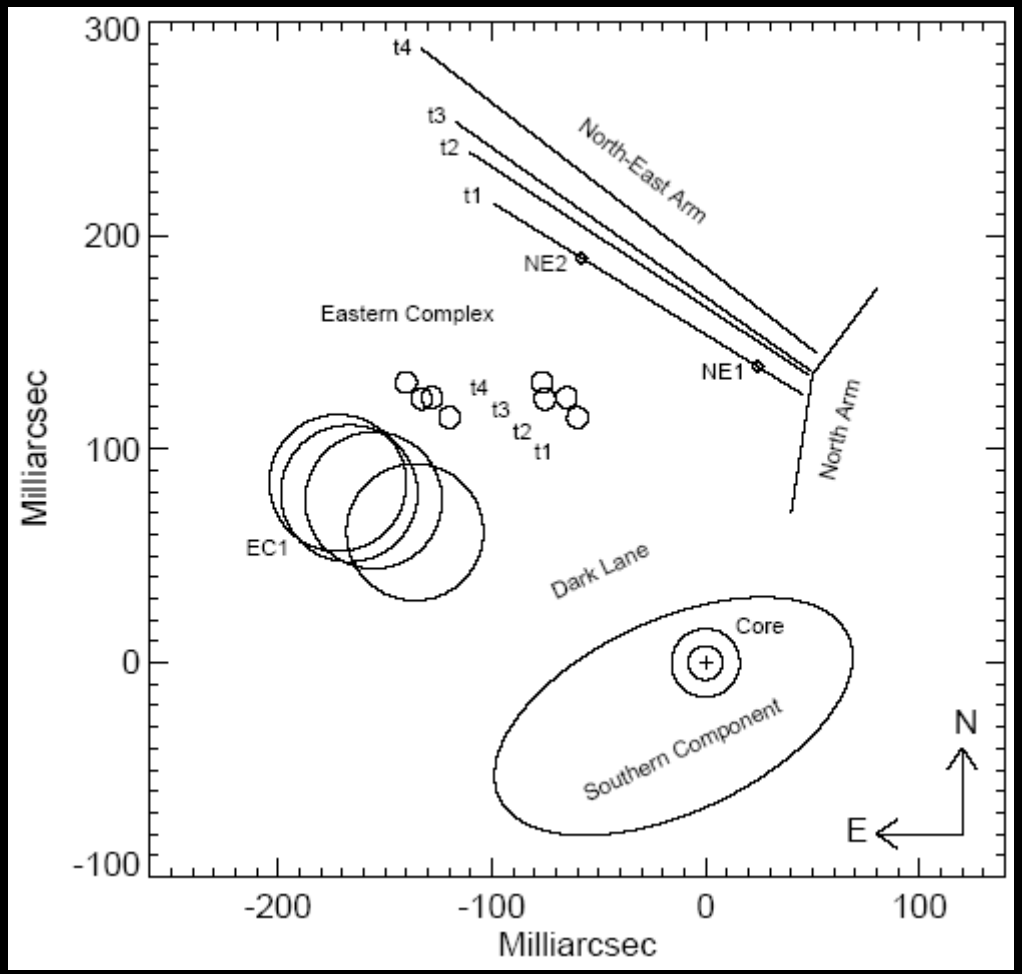
Other Structures: Shells



Mauron and Huggins, 1999
B and V Bands

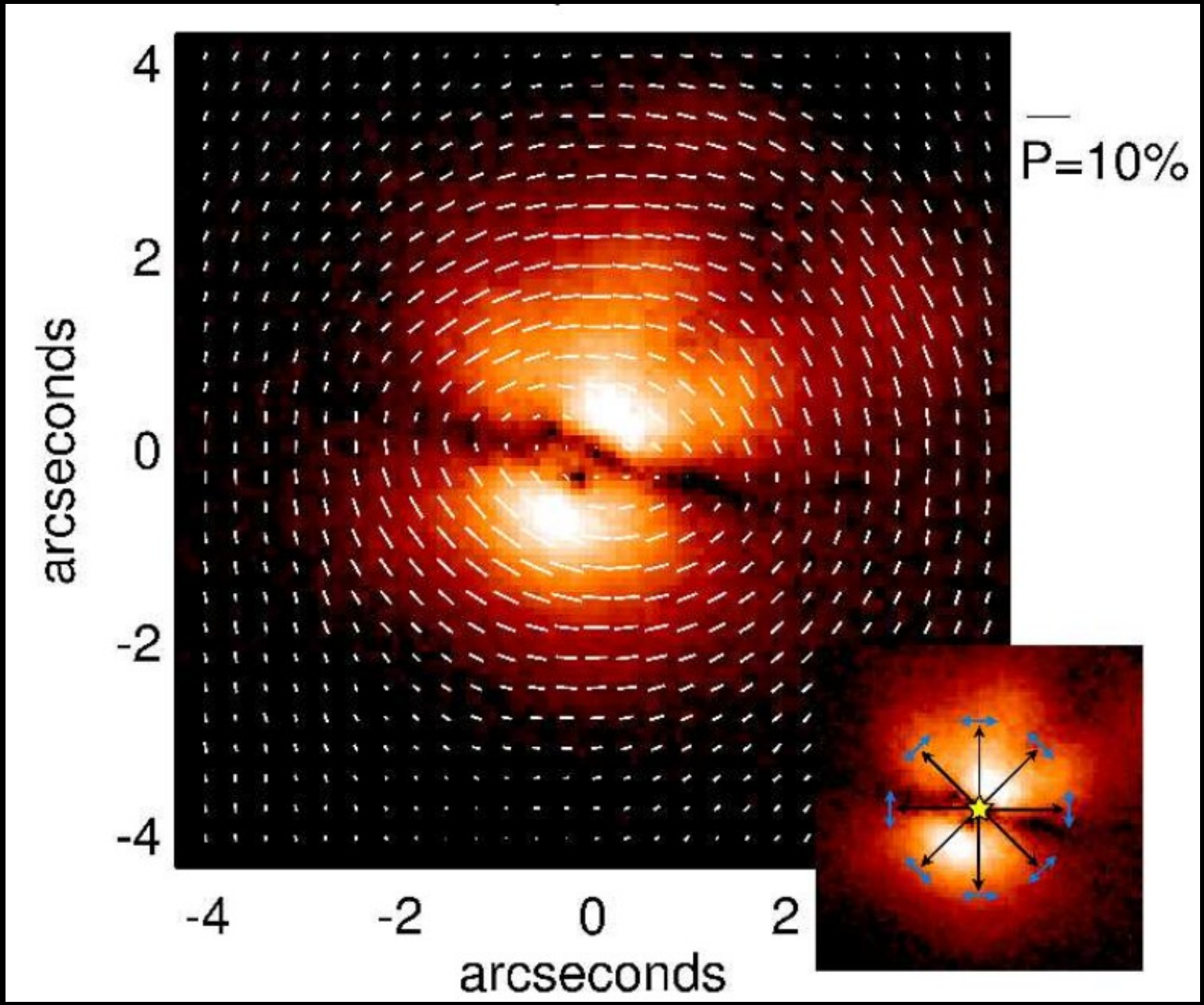
Other Structures: Dust Lane





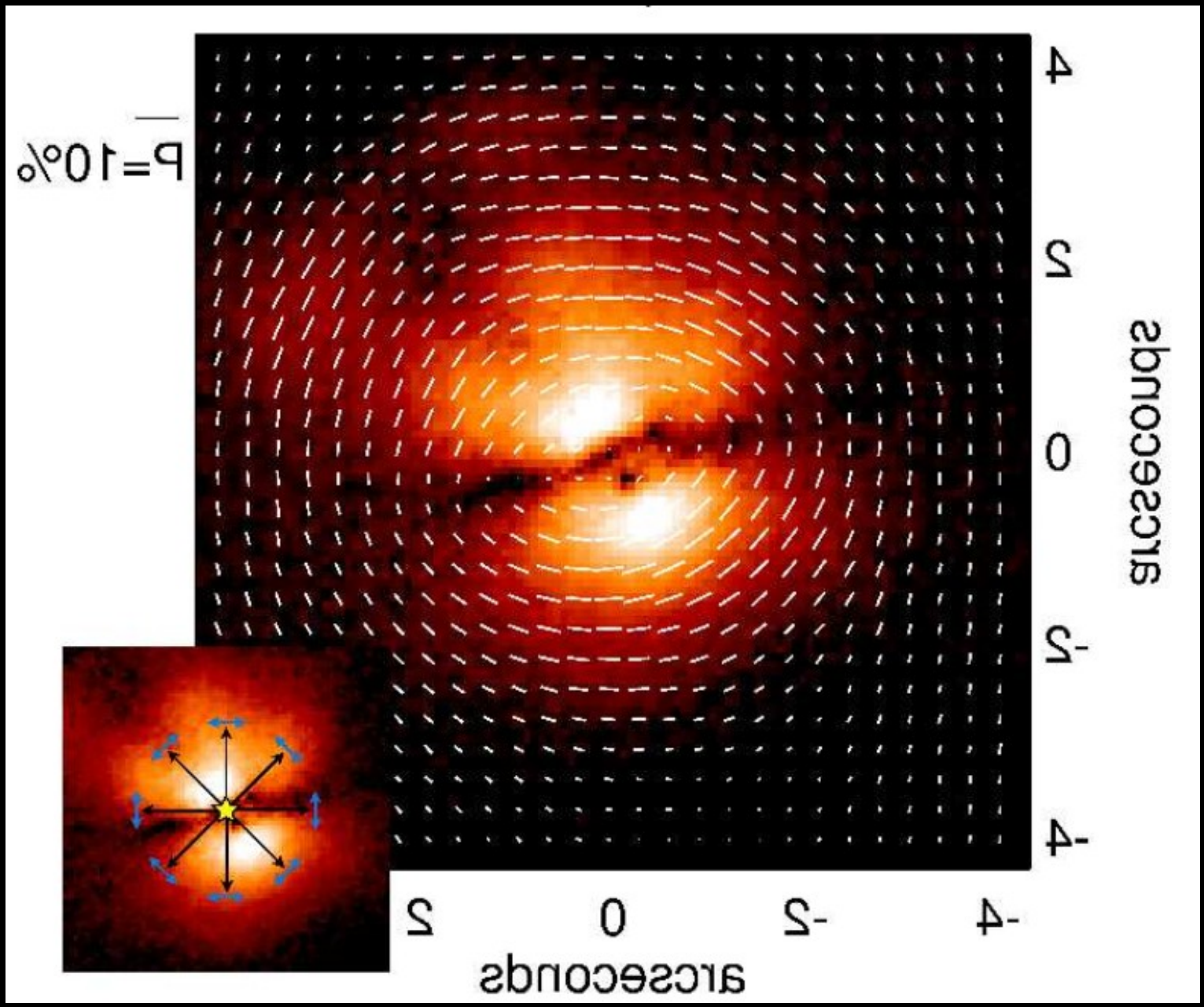
Tuthill et al., 2000
K Band

Other Structures: Dust Lane



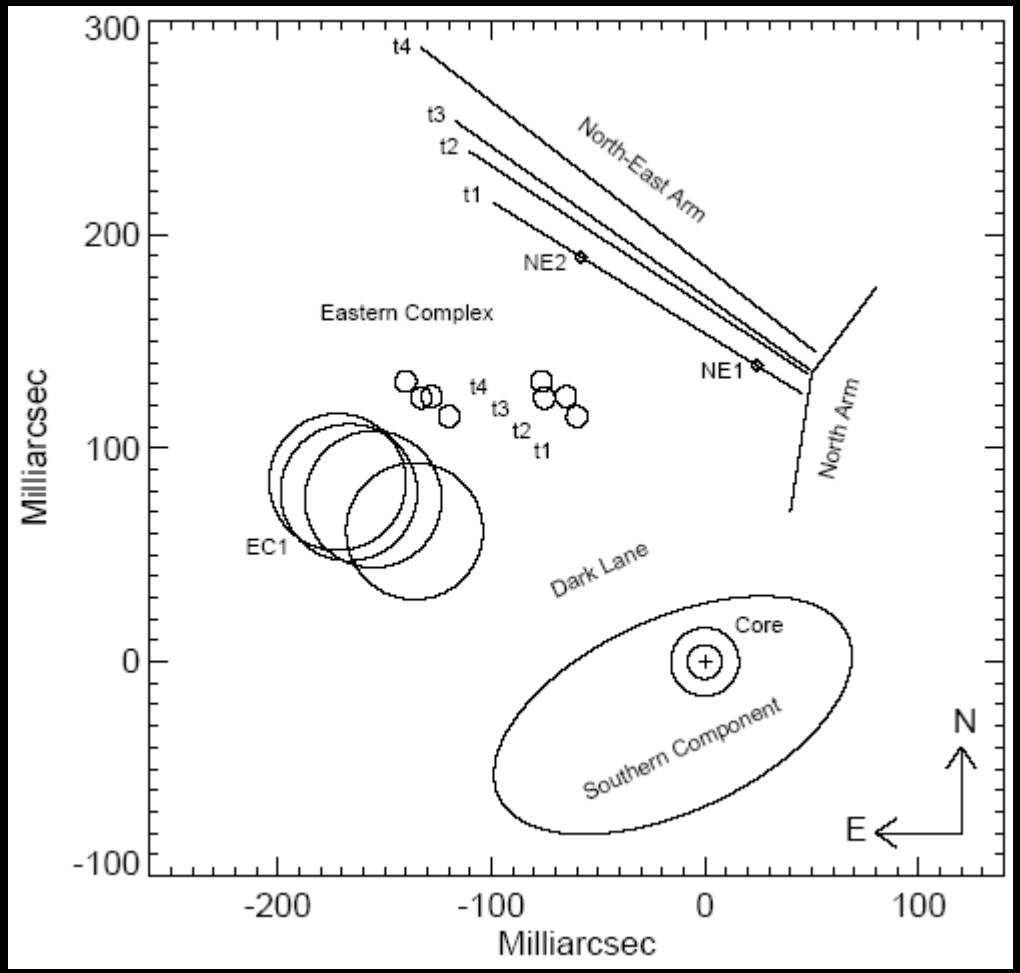
Jeffers et al. 2014

Other Structures: Dust Lane



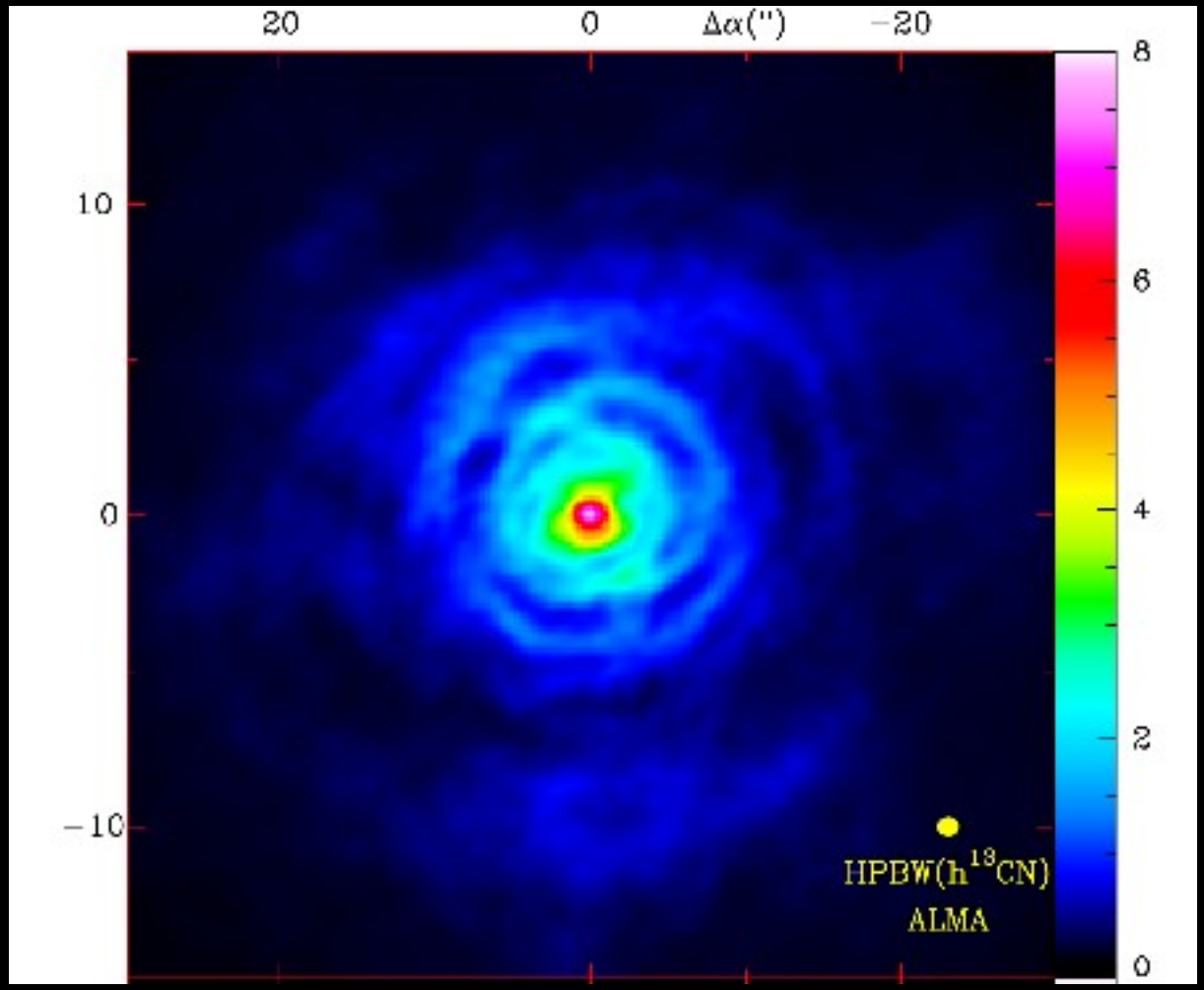
Jeffers et al. 2014

Kinematics: Constrains



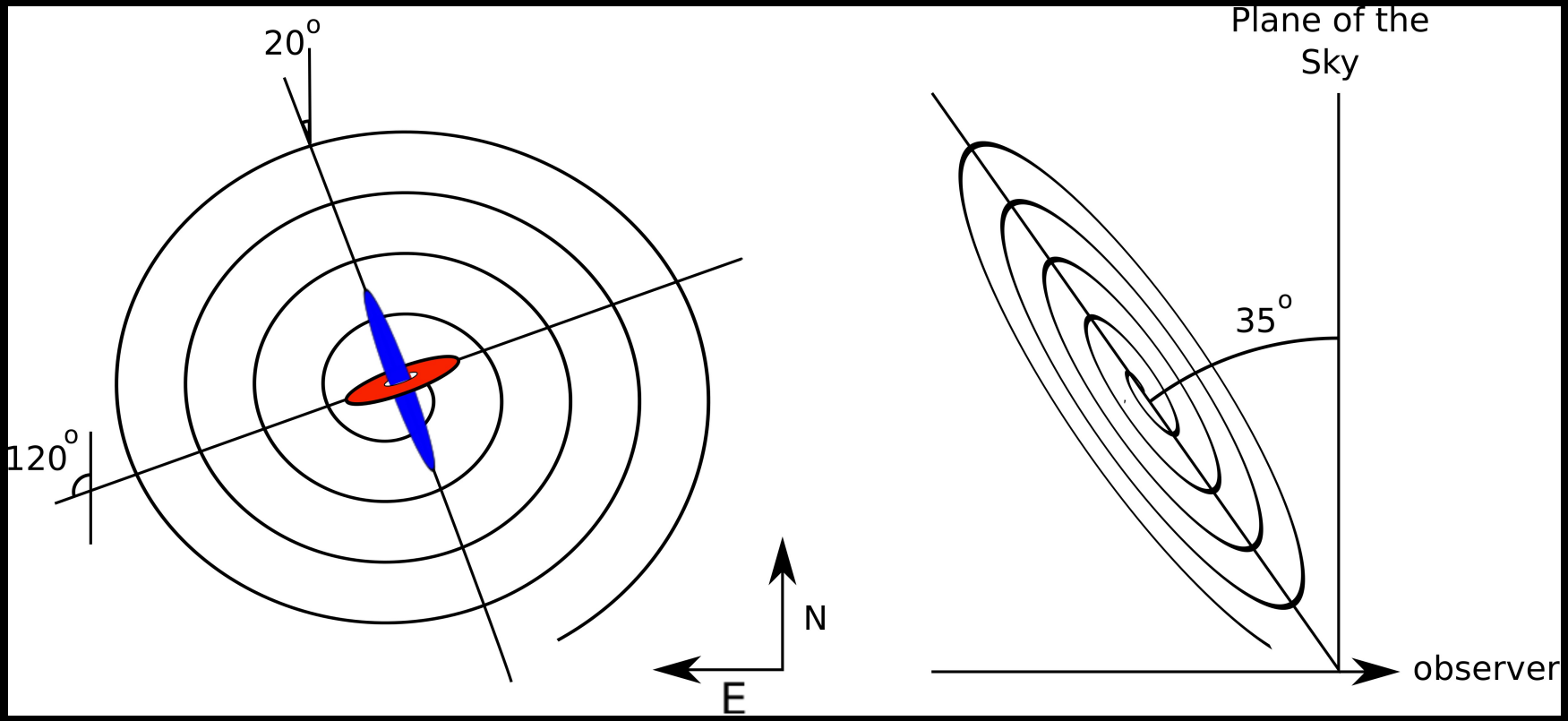
P.A. ~ 120º. Tuthill et al. 2000

Kinematics: Constrains

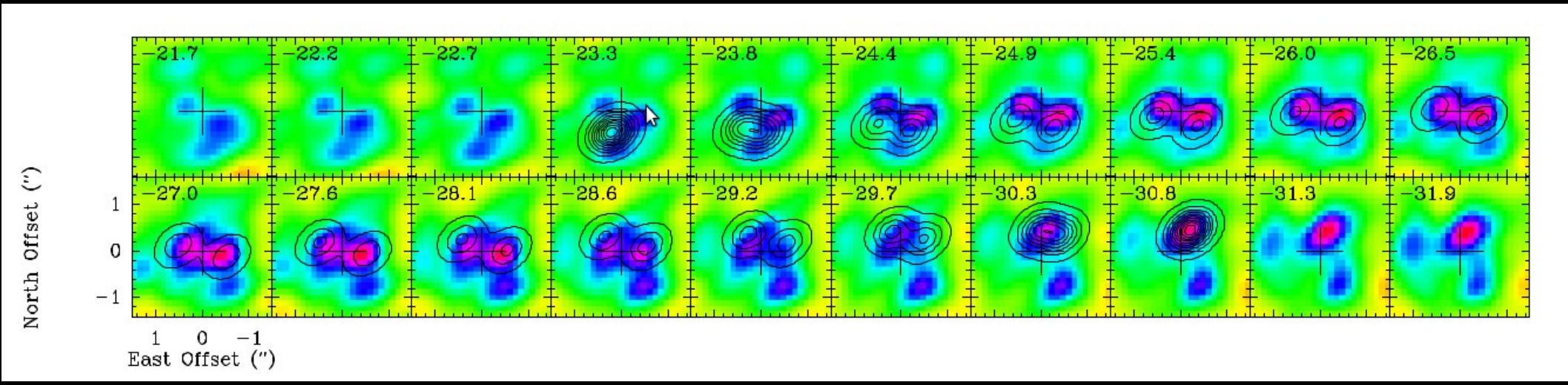


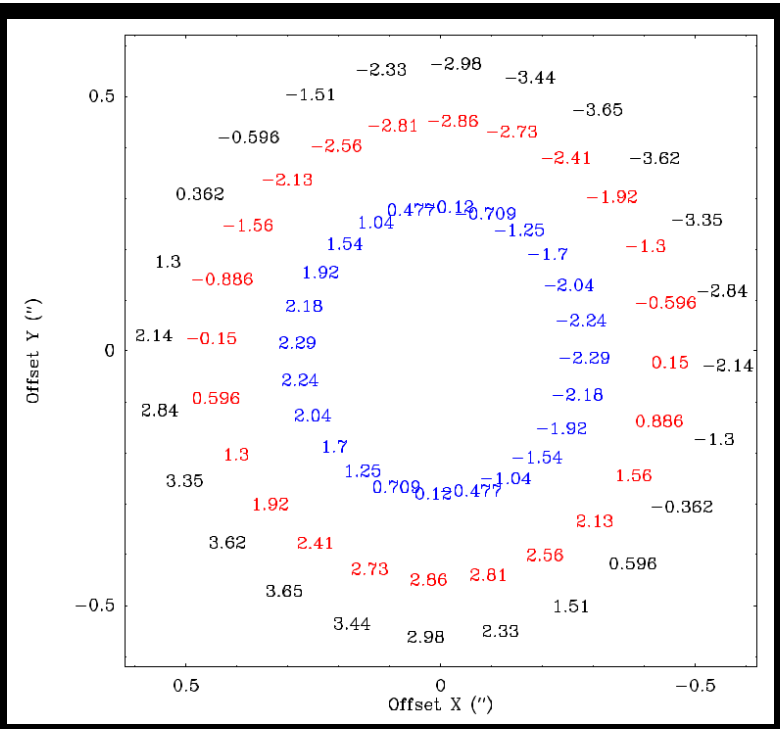
i ~ 35º. Cernicharo et al. In prep

Global structure



A Salty Rotating Torus





Why a Salt rich torus?

Volcanically emitted sodium chloride as a source for Io's neutral clouds and plasma torus

E. Lellouch*, G. Paubert†, J. I Moses‡, N. M. Schneider§ & D. F. Strobel||

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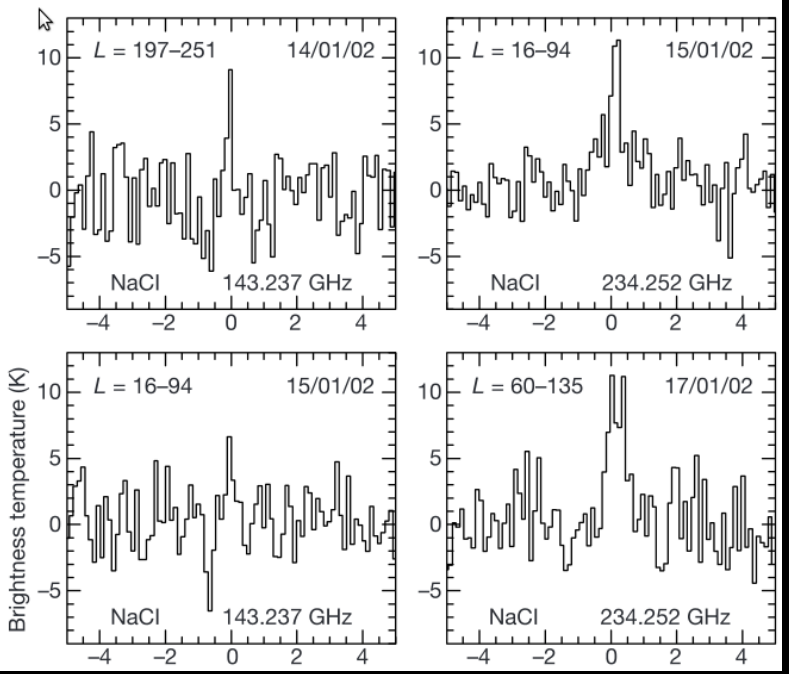
† *Institut de Radio-Astronomie Millimétrique, E-18012 Granada, Spain*
‡ *Lunar and Planetary Institute, Houston, Texas 77058-1113, USA*
§ *LASP, University of Colorado, Boulder, Colorado 80309-0392, USA*
|| *The Johns Hopkins University, Baltimore, Maryland 21218, USA*

The atmosphere of Jupiter's satellite Io is extremely tenuous, time variable and spatially heterogeneous. Only a few molecules—SO_2, SO and S_2—have previously been identified as constituents of this atmosphere, and possible sources[1–4] include



Lellouch et al. 2003

Prerequisites for explosive cryovolcanism on dwarf planet-class Kuiper belt objects

M. Neveu [a,*], S.J. Desch [a], E.L. Shock [a,b], C.R. Glein [c]

[a] *School of Earth and Space Exploration, Arizona State University, Tempe, AZ 85287-1404, USA*
[b] *Department of Chemistry and Biochemistry, Arizona State University, Tempe, AZ 85287-1404, USA*
[c] *Geophysical Laboratory, Carnegie Institution of Washington, 5251 Broad Branch Rd. NW, Washington, DC 20015, USA*

Neveu et al. 2015

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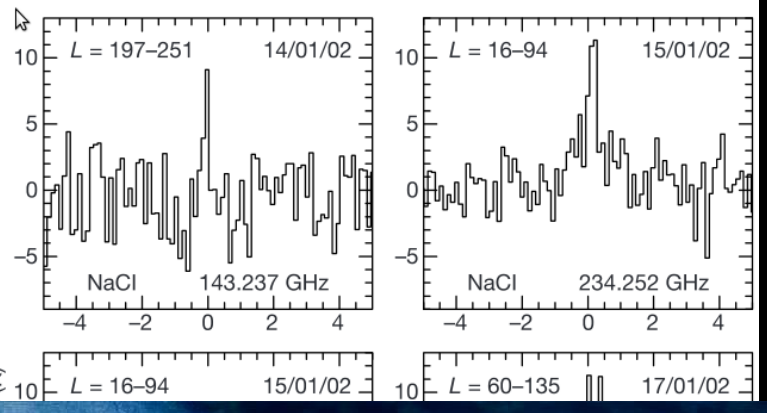

Lellouch et al. 2003

Neveu et al. 2015

Prerequisites for ex
planet-class Kuiper

M. Neveu [a,*], S.J. Desch [a],

[a] *School of Earth and Space Exploration, A*
[b] *Department of Chemistry and Biochemist*
[c] *Geophysical Laboratory, Carnegie Institut*

Conclusions

- We found an elongation with a P.A.~ 76º visible in NaCl and KCl

No direct relation with any observed structure!

- A rotating torus:
  - Conciliate the dark lane & the spiral tilted 35º
  - Correlate with the 20º outflow
  - Already Inferred from IR and visible observations

Cycle 3