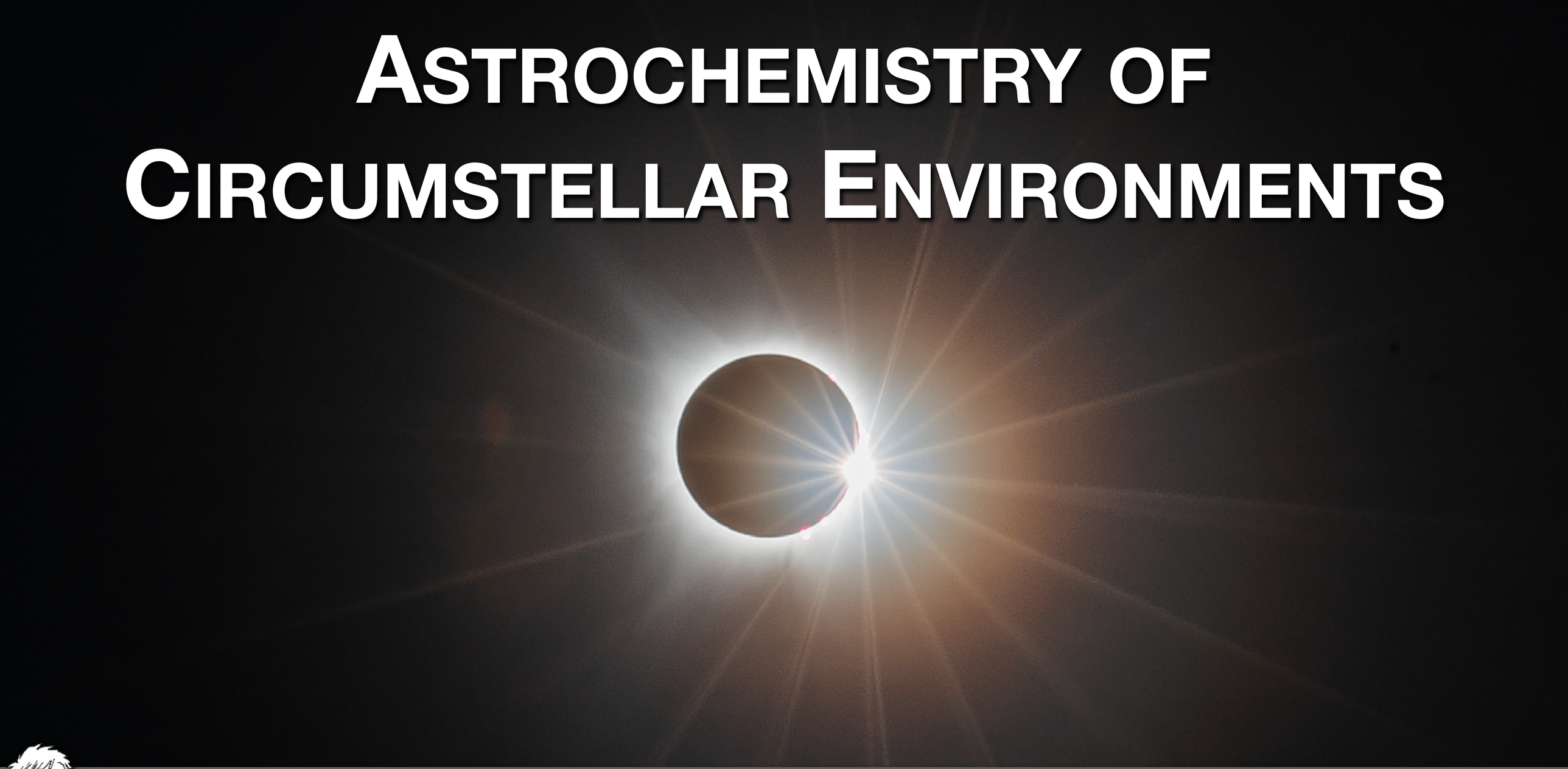
Astrochemistry of Circumstellar Environments



Brett A. McGuire
Department of Chemistry Massachusetts Institute of Technology

ASTROCHEMISTRY

Astrochemistry *astrōkeməstrē* (n) The study of molecules in space: where they are how they got there and what they are doing.


In the beginning the Universe was created …
This had made many people very angry and has been widely regarded as a bad move.
-Douglas Adams The Restaurant at the End of the Universe


1
H
1.00794
Hydrogen
HI
2
He
4.002602
Helium
3
Li
6.941
Lithium
4
Be

KNOWN INTERSTELLAR MOLECULES

Created with **ASTROMOL** v2021.8.0
bmcguir2.github.io/astromol
McGuire 2022 *ApJS* 259 30

2 Atoms

CH, CN, CH^+, OH, CO, H_2, SiO, CS, SO, SiS, NS, C_2, NO, HCl, NaCl, AlCl, KCl, AlF, PN, SiC, CP, NH, SiN, SO^+, CO^+, HF, N_2, CF^+, PO, O_2, AlO, CN^-, OH^+, SH^+, HCl^+, SH, TiO, ArH^+, NS^+, HeH^+, VO, PO^+, SiP, FeC

3 Atoms

H_2O, HCO^+, HCN, OCS, HNC, H_2S, N_2H^+, C_2H, SO_2, HCO, HNO, HCS^+, HOC^+, SiC_2, C_2S, C_3, CO_2, CH_2, C_2O, MgNC, NH_2, NaCN, N_2O, MgCN, H_3^+, SiCN, AlNC, SiNC, HCP, CCP, AlOH, H_2O^+, H_2Cl^+, KCN, FeCN, HO_2, TiO_2, CCN, SiCSi, S_2H, HCS, HSC, NCO, CaNC, NCS, MgC_2, HSO

4 Atoms

NH_3, H_2CO, HNCO, H_2CS, C_2H_2, C_3N, HNCS, $HOCO^+$, C_3O, *l*-C_3H, $HCNH^+$, H_3O^+, C_3S, *c*-C_3H, HC_2N, H_2CN, SiC_3, CH_3, C_3N^-, PH_3, HCNO, HOCN, HSCN, HOOH, *l*-C_3H^+, HMgNC, HCCO, CNCN, HONO, MgCCH, HCCS, HNCN, H_2NC, $HCCS^+$, CH_3^+

5 Atoms

HC_3N, HCOOH, CH_2NH, NH_2CN, H_2CCO, C_4H, SiH_4, *c*-C_3H_2, CH_2CN, C_5, SiC_4, H_2CCC, CH_4, HCCNC, HNCCC, H_2COH^+, C_4H^-, CNCHO, HNCNH, CH_3O, NH_3D^+, H_2NCO^+, $NCCNH^+$, CH_3Cl, MgC_3N, HC_3O^+, NH_2OH, HC_3S^+, H_2CCS, C_4S, CHOSH, HCSCN, HC_3O, NaCCCN, MgC_3N^+

6 Atoms

CH_3OH, CH_3CN, NH_2CHO, CH_3SH, C_2H_4, C_5H, CH_3NC, HC_2CHO, H_2C_4, C_5S, HC_3NH^+, C_5N, HC_4H, HC_4N, *c*-H_2C_3O, CH_2CNH, C_5N^-, HNCHCN, SiH_3CN, MgC_4H, CH_3CO^+, H_2CCCS, CH_2CCH, HCSCCH, C_5O, $HCCNCH^+$, C_5H^+, *c*-C_5H, HC_4S, HMgCCCN, MgC_4H^+, $H_2C_3H^+$, HOCOOH, H_2C_3N

7 Atoms

CH_3CHO, CH_3CCH, CH_3NH_2, CH_2CHCN, HC_5N, C_6H, *c*-C_2H_4O, CH_2CHOH, C_6H^-, CH_3NCO, HC_5O, $HOCH_2CN$, HC_4NC, HC_3HNH, *c*-C_3HCCH, MgC_5N, CH_2C_3N, *l*-H_2C_5, NC_4NH^+, MgC_5N^+

8 Atoms

$HCOOCH_3$, CH_3C_3N, C_7H, CH_3COOH, H_2C_6, CH_2OHCHO, HC_6H, CH_2CHCHO, CH_2CCHCN, NH_2CH_2CN, CH_3CHNH, CH_3SiH_3, NH_2CONH_2, $HCCCH_2CN$, CH_2CHCCH, MgC_6H, $C_2H_3NH_2$, HOCHCHOH, HCCCHCCC, C_7N^-, CH_3CHCO, MgC_6H^+

9 Atoms

CH_3OCH_3, CH_3CH_2OH, CH_3CH_2CN, HC_7N, CH_3C_4H, C_8H, CH_3CONH_2, C_8H^-, CH_2CHCH_3, CH_3CH_2SH, HC_7O, CH_3NHCHO, $H_2CCCHCCH$, HCCCHCHCN, H_2CCHC_3N

10 Atoms

CH_3COCH_3, $HOCH_2CH_2OH$, CH_3CH_2CHO, CH_3C_5N, CH_3CHCH_2O, CH_3OCH_2OH, H_2CCCHC_3N, C_6H_4, C_2H_5NCO, HC_7NH^+, $CH_3CHCHCN$, CH_2CCH_3CN, CH_2CHCH_2CN, NH_2COCH_2OH

11 Atoms

HC_9N, CH_3C_6H, C_2H_5OCHO, CH_3COOCH_3, CH_3COCH_2OH, C_5H_6, $NH_2CH_2CH_2OH$, CH_2CCHC_4H, $C_{10}H^-$, C_4H_5CN

12 Atoms

C_6H_6, *n*-C_3H_7CN, *i*-C_3H_7CN, $C_2H_5OCH_3$, 1-C_5H_5CN, 2-C_5H_5CN, *n*-$CH_3CH_2CH_2OH$, *i*-$CH_3CH_2CH_2OH$, 1-C_5H_4CCH, 2-C_5H_4CCH

13+ Atoms

C_6H_5CN, $HC_{11}N$, *c*-$C_5H_4CCH_2$, *c*-C_6H_5CCH, 1-$C_{10}H_7CN$, 2-$C_{10}H_7CN$, C_9H_8, 2-C_9H_7CN, C_{60}, C_{60}^+, C_{70}

298 Molecules

Last Updated: 2 Jan 2024

Massachusetts Institute of Technology

KNOWN INTERSTELLAR MOLECULES

Created with **ASTROMOL** v2021.8.0
bmcguir2.github.io/astromol
McGuire 2022 *ApJS* 259 30

2 Atoms

CH, CN, CH^+, OH, CO, H_2, SiO, **CS**, SO, **SiS**, NS, C_2, NO, HCl, **NaCl**, **AlCl**, **KCl**, **AlF**, PN, **SiC**, **CP**, NH, **SiN**, SO^+, CO^+, HF, N_2, CF^+, **PO**, O_2, **AlO**, **CN^-**, OH^+, SH^+, HCl^+, SH, **TiO**, ArH^+, NS^+, HeH^+, **VO**, PO^+, **SiP**, **FeC**

3 Atoms

H_2O, HCO^+, HCN, OCS, HNC, H_2S, N_2H^+, C_2H, SO_2, HCO, HNO, HCS^+, HOC^+, **SiC_2**, **C_2S**, **C_3**, CO_2, CH_2, C_2O, **MgNC**, NH_2, **NaCN**, N_2O, **MgCN**, H_3^+, **SiCN**, **AlNC**, **SiNC**, **HCP**, **CCP**, **AlOH**, H_2O^+, H_2Cl^+, **KCN**, **FeCN**, HO_2, **TiO_2**, **CCN**, **SiCSi**, S_2H, HCS, HSC, NCO, **CaNC**, NCS, **MgC_2**, HSO

4 Atoms

NH_3, H_2CO, HNCO, H_2CS, **C_2H_2**, **C_3N**, HNCS, $HOCO^+$, C_3O, **l-C_3H**, $HCNH^+$, H_3O^+, **C_3S**, c-C_3H, **HC_2N**, H_2CN, **SiC_3**, CH_3, **C_3N^-**, **PH_3**, HCNO, HOCN, HSCN, HOOH, l-C_3H^+, **HMgNC**, HCCO, CNCN, HONO, **MgCCH**, HCCS, HNCN, H_2NC, $HCCS^+$, CH_3^+

5 Atoms

HC_3N, HCOOH, CH_2NH, NH_2CN, H_2CCO, **C_4H**, **SiH_4**, c-C_3H_2, CH_2CN, **C_5**, **SiC_4**, H_2CCC, CH_4, HCCNC, HNCCC, H_2COH^+, **C_4H^-**, CNCHO, HNCNH, CH_3O, NH_3D^+, H_2NCO^+, $NCCNH^+$, CH_3Cl, **MgC_3N**, HC_3O^+, NH_2OH, HC_3S^+, H_2CCS, C_4S, CHOSH, HCSCN, HC_3O, **NaCCCN**, **MgC_3N^+**

6 Atoms

CH_3OH, CH_3CN, NH_2CHO, CH_3SH, **C_2H_4**, **C_5H**, CH_3NC, HC_2CHO, **H_2C_4**, **C_5S**, HC_3NH^+, C_5N, **HC_4H**, **HC_4N**, c-H_2C_3O, CH_2CNH, **C_5N^-**, HNCHCN, **SiH_3CN**, **MgC_4H**, CH_3CO^+, H_2CCCS, CH_2CCH, HCSCCH, C_5O, $HCCNCH^+$, C_5H^+, c-C_5H, HC_4S, **HMgCCCN**, **MgC_4H^+**, $H_2C_3H^+$, HOCOOH, H_2C_3N

7 Atoms

CH_3CHO, CH_3CCH, CH_3NH_2, CH_2CHCN, HC_5N, C_6H, c-C_2H_4O, CH_2CHOH, **C_6H^-**, CH_3NCO, HC_5O, $HOCH_2CN$, HC_4NC, HC_3HNH, c-C_3HCCH, **MgC_5N**, CH_2C_3N, l-H_2C_5, NC_4NH^+, **MgC_5N^+**

8 Atoms

$HCOOCH_3$, CH_3C_3N, **C_7H**, CH_3COOH, H_2C_6, CH_2OHCHO, **HC_6H**, CH_2CHCHO, CH_2CCHCN, NH_2CH_2CN, CH_3CHNH, **CH_3SiH_3**, NH_2CONH_2, $HCCCH_2CN$, CH_2CHCCH, **MgC_6H**, $C_2H_3NH_2$, HOCHCHOH, HCCCHCCC, **C_7N^-**, CH_3CHCO, **MgC_6H^+**

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CH_3OCH_3, CH_3CH_2OH, CH_3CH_2CN, HC_7N, CH_3C_4H, **C_8H**, CH_3CONH_2, **C_8H^-**, CH_2CHCH_3, CH_3CH_2SH, HC_7O, CH_3NHCHO, $H_2CCCHCCH$, HCCCHCHCN, H_2CCHC_3N

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13+ Atoms

C_6H_5CN, $HC_{11}N$, c-$C_5H_4CCH_2$, c-C_6H_5CCH, 1-$C_{10}H_7CN$, 2-$C_{10}H_7CN$, C_9H_8, 2-C_9H_7CN, C_{60}, C_{60}^+, C_{70}

298 Molecules

Last Updated: 2 Jan 2024

Massachusetts Institute of Technology


IRC+10216
VY Ca Maj

VY Canis Majoris

COMMISSION 27 OF THE I. A. U.
INFORMATION BULLETIN ON VARIABLE STARS

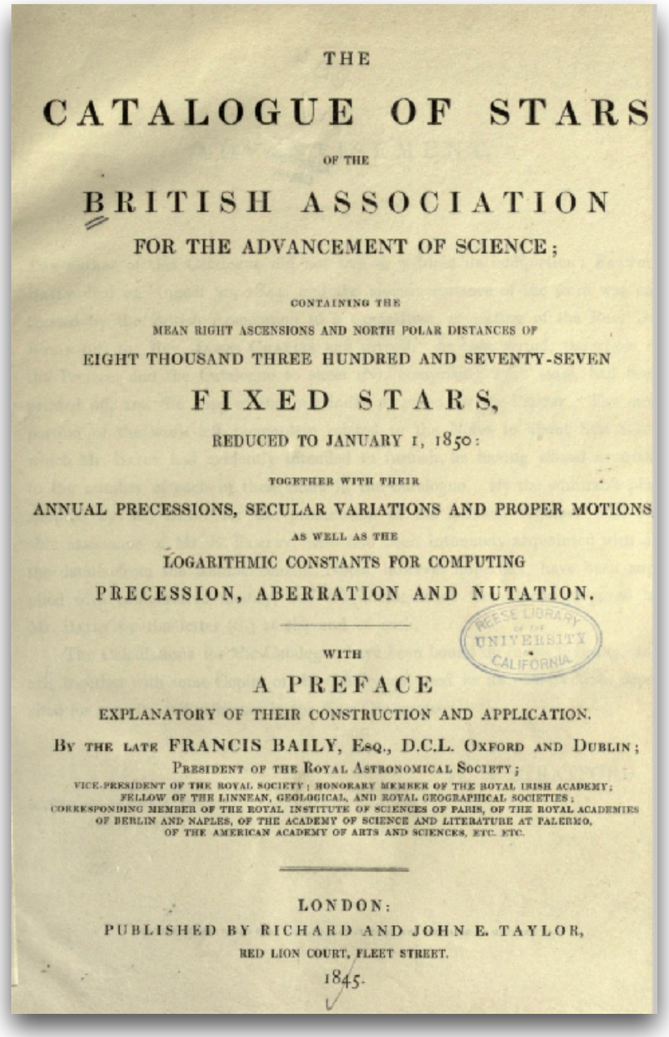
NUMBER 599

Konkoly Observatory
Budapest
1971 December 7

THREE SOMEWHAT OVERLOOKED FACETS OF VY CANIS MAJORIS

1. SECULAR CHANGES IN LIGHT?

The first record of VY Canis Majoris seems to be in the star catalogue of Lalande, which contains a measurement on March 7, 1801, of its position and an estimate of its magnitude as 7. My search of the literature has uncovered 24 additional magnitude estimates made during the following century. Though most were by meridian observers and were


THE
CATALOGUE OF STARS
OF THE
BRITISH ASSOCIATION
FOR THE ADVANCEMENT OF SCIENCE;
CONTAINING THE
MEAN RIGHT ASCENSIONS AND NORTH POLAR DISTANCES OF
EIGHT THOUSAND THREE HUNDRED AND SEVENTY-SEVEN
FIXED STARS,
REDUCED TO JANUARY 1, 1850:
TOGETHER WITH THEIR
ANNUAL PRECESSIONS, SECULAR VARIATIONS AND PROPER MOTIONS
AS WELL AS THE
LOGARITHMIC CONSTANTS FOR COMPUTING
PRECESSION, ABERRATION AND NUTATION.
WITH
A PREFACE
EXPLANATORY OF THEIR CONSTRUCTION AND APPLICATION.
By the late FRANCIS BAILY, Esq., D.C.L. Oxford and Dublin;
President of the Royal Astronomical Society;
VICE-PRESIDENT OF THE ROYAL SOCIETY; HONORARY MEMBER OF THE ROYAL IRISH ACADEMY;
FELLOW OF THE LINNEAN, GEOLOGICAL, AND ROYAL GEOGRAPHICAL SOCIETIES;
CORRESPONDING MEMBER OF THE ROYAL INSTITUTE OF SCIENCES OF PARIS, OF THE ROYAL ACADEMIES
OF BERLIN AND NAPLES, OF THE ACADEMY OF SCIENCE AND LITERATURE AT PALERMO,
OF THE AMERICAN ACADEMY OF ARTS AND SCIENCES, ETC. ETC.
LONDON:
PUBLISHED BY RICHARD AND JOHN E. TAYLOR,
RED LION COURT, FLEET STREET.
1845.

1850

VY Canis Majoris

HISTOIRE CÉLESTE

FRANÇAISE,

CONTENANT LES OBSERVATIONS

FAITES

PAR PLUSIEURS ASTRONOMES FRANÇAIS;

PUBLIÉE PAR JÉRÔME DELALANDE,

De l'Institut national de France, des Académies de Londres, de Berlin, de Pétersbourg, de Stockholm, de Copenhague, de Bologne, &c. ancien Directeur de l'Observatoire national de Paris.

TOME PREMIER.

A PARIS,

DE L'IMPRIMERIE DE LA RÉPUBLIQUE.

AN IX [1801].

NOMS des ÉTOILES.	Grandeurs.	PASSAGES. Premier fil.	Milieu.	Troisi. fil.	DISTANCES au ZÉNIT.
1791.		H. M. S.	M. S.	M. S.	D. M. S.
27 Sept.			+ 3″6		+ 1′ 20″

NOMS des ÉTOILES.	Grandeurs.	PASSAGES. Premier fil.	Milieu.	Troisi. fil.	DISTANCES au ZÉNIT.
1801.		H. M. S.	M. S.	M. S.	D. M. S.
15 Janvier.					+ 1′ 52″
	8	3	52 29		25 57 20
36 Taure.	6	3	52 37,3	53 7,5	25 15 45
	8. 9	3		53 38,3	25 51 26
	8	3		54 2,5	25 34 3
		3		55 25	25 50 27
		3		55 55	26 2 26
	6 22		29 17,3		4 43 2
	7 22			29 51,3	4 3 49

VY Canis Majoris

Je termine ici, le 16 ventôse an 9 [7 mars 1801] l'impression des cinquante mille étoiles, qui nous occupent depuis onze ans; les dernières zones sont des répétitions, comme on le verra ci-après dans la table des zones; les C.ens Lefrançais Lalande et Burckhardt ayant entrepris de les repasser toutes, j'espère les publier dans les volumes suivans de notre *Histoire céleste*: il y en aurait déjà un plus grand nombre à la fin de ce volume, si depuis deux mois le ciel n'eût été perpétuellement contraire, ce qui arrive quelquefois à Paris, dans les hivers doux et pluvieux.

LALANDE.

Translation: *Here's 50000 stars. I quit.*

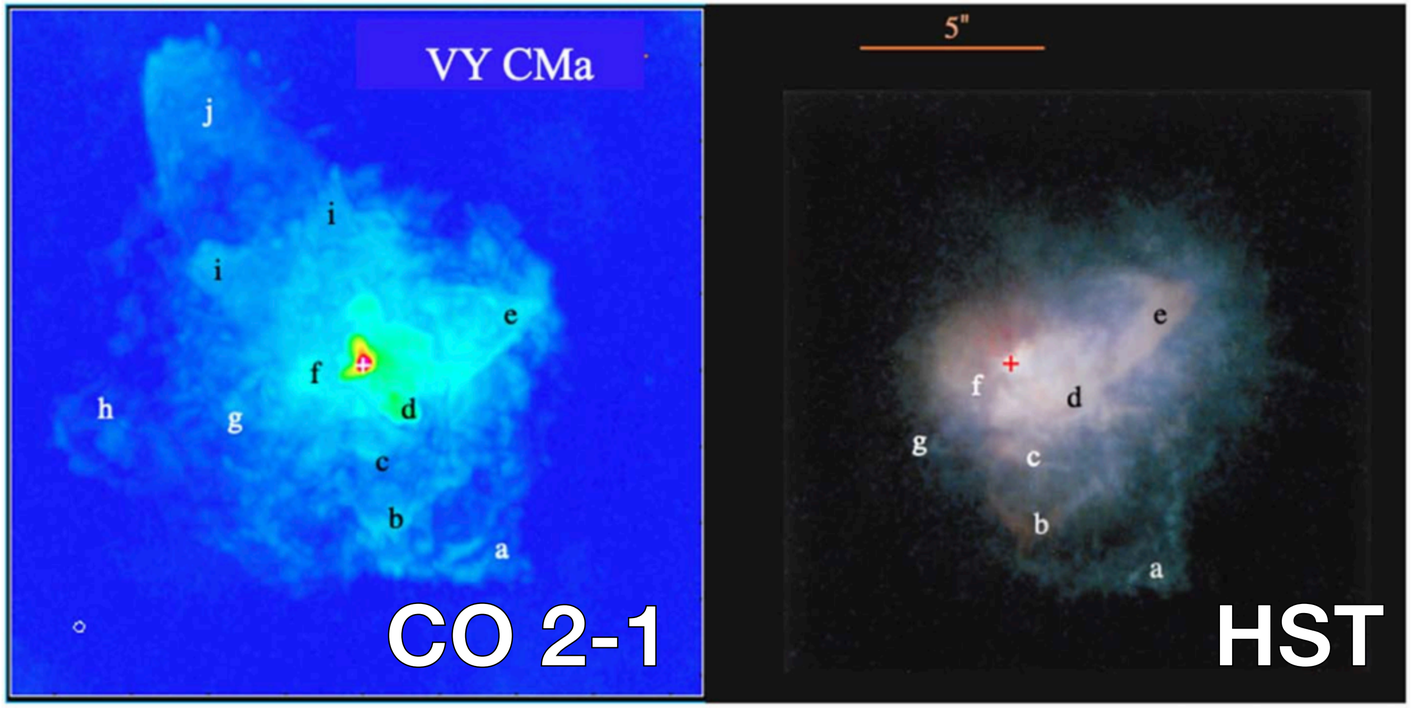
A Complex Source

Singh et al. 2023 *ApJL* 954 L1

The Astrophysical Journal Letters, 954:L1 (7pp), 2023 September 1 https://doi.org/10.3847/2041-8213/ace7cb

ALMA Reveals Hidden Morphologies in the Molecular Envelope of VY Canis Majoris

A. P. Singh[1], A. M. S. Richards[2], R. M. Humphreys[3], L. Decin[4], and L. M. Ziurys[5]



EGADS - REAL METALS!

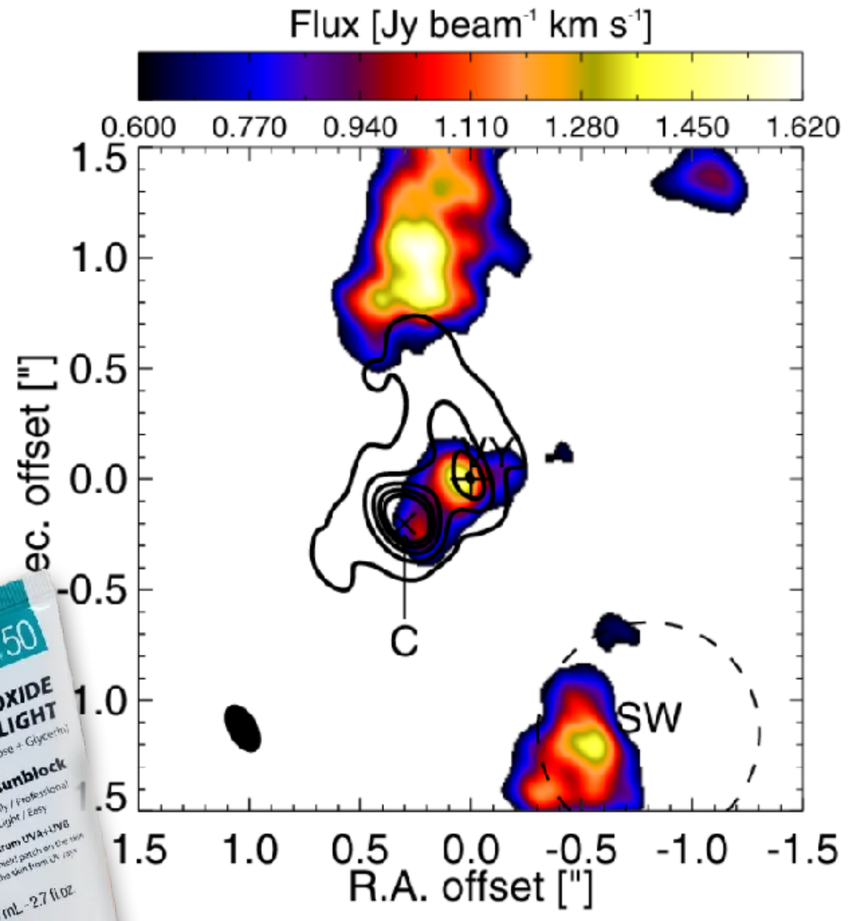
Kamiński et al. 2013 *A&A* 551 A113

Pure rotational spectra of TiO and TiO_2 in VY Canis Majoris*,**

T. Kamiński[1], C. A. Gottlieb[2], K. M. Menten[1], N. A. Patel[2], K. H. Young[2], S. Brünken[3], H. S. P. Müller[3], M. C. McCarthy[2], J. M. Winters[4], and L. Decin[5,6]

ALMA observations of TiO_2 around VY Canis Majoris*

E. De Beck[1], W. Vlemmings[1], S. Muller[1], J. H. Black[1], E. O'Gorman[1], A. M. S. Richards[2], A. Baudry[3,4], M. Maercker[1], L. Decin[5,6], and E. M. Humphreys[7]



(e) 312.73 GHz

Massachusetts Institute of Technology

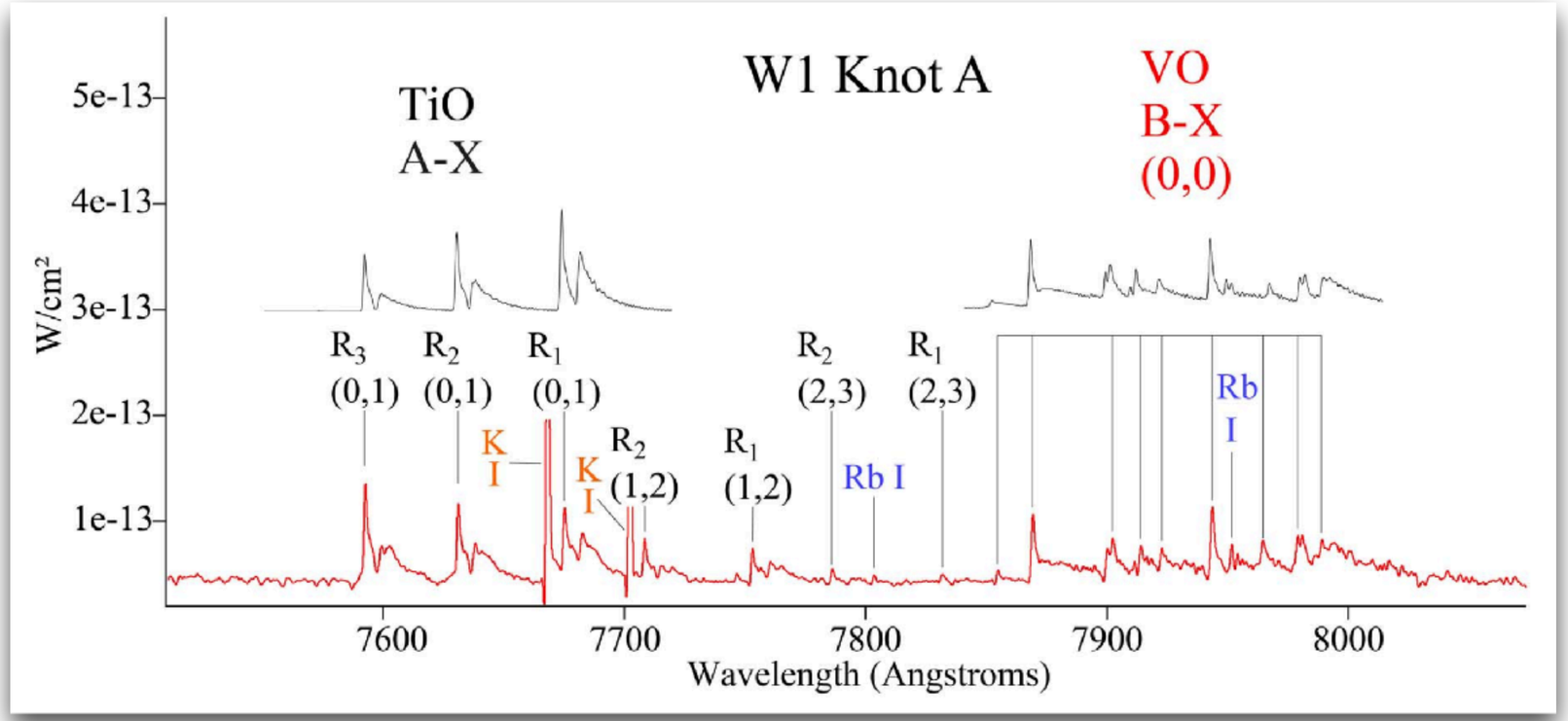
EGADS - REAL METALS!

Humphreys et al. 2019 *ApJL* 874 L26

THE ASTROPHYSICAL JOURNAL LETTERS, 874:L26 (6pp), 2019 April 1 https://doi.org/10.3847/2041-8213/ab11e5

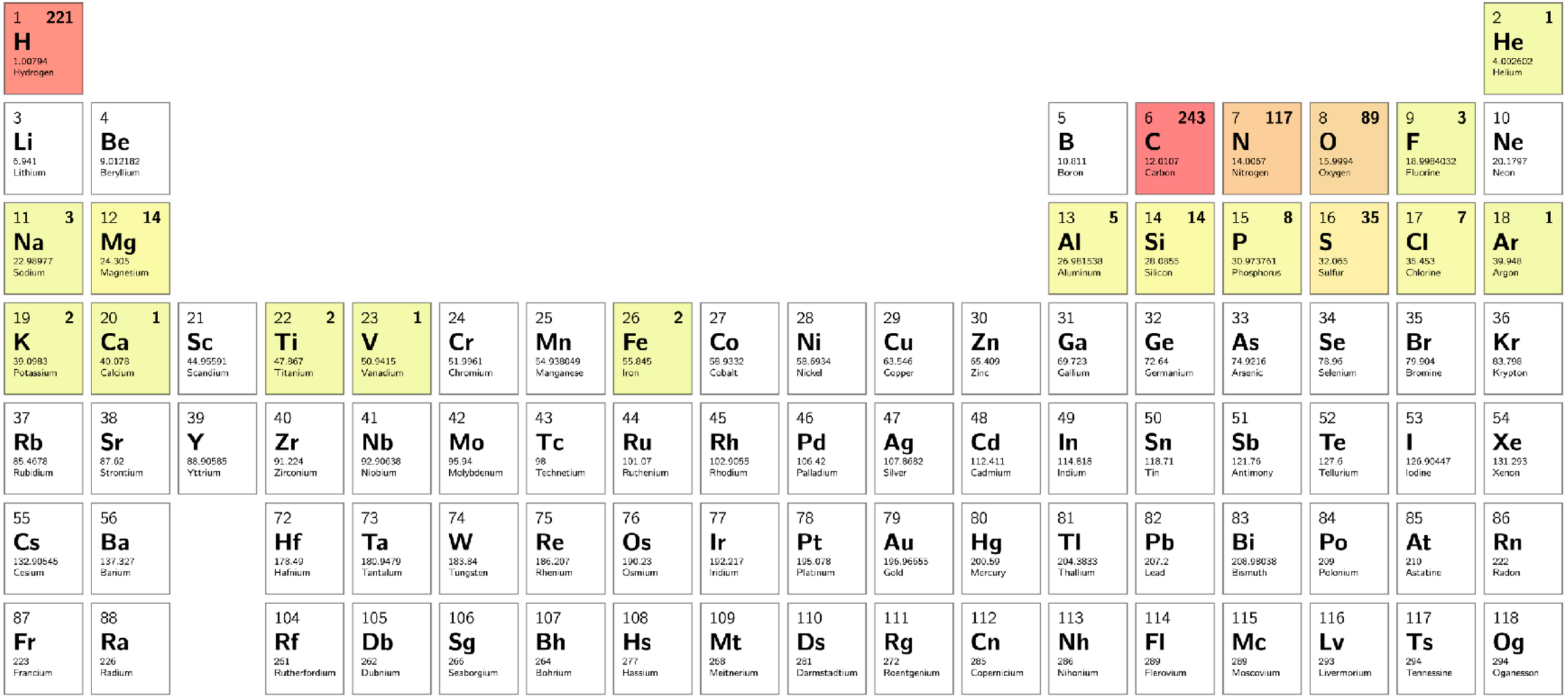
The Unexpected Spectrum of the Innermost Ejecta of the Red Hypergiant VY CMa*

Roberta M. Humphreys[1], L. M. Ziurys[2], J. J. Bernal[3], Michael S. Gordon[4], L. Andrew Helton[4], Kazunori Ishibashi[5], Terry J. Jones[1], A. M. S. Richards[6], and Wouter Vlemmings[7]



EGADS - REAL METALS!

Kamiński et al. 2013 *A&A* 551 A113
McGuire 2022 *ApJS* 259 30




IRC+10216
VY Ca Maj

IRC+10216

Becklin et al. 1969 *ApJ* 158 L133

THE UNUSUAL INFRARED OBJECT IRC+10216*

E. E. BECKLIN†
California Institute of Technology, Pasadena

AND

J. A. FROGEL, A. R. HYLAND, J. KRISTIAN, AND G. NEUGEBAUER
Mount Wilson and Palomar Observatories, Carnegie Institute of
California Institute of Technology

Received 1969 October 22

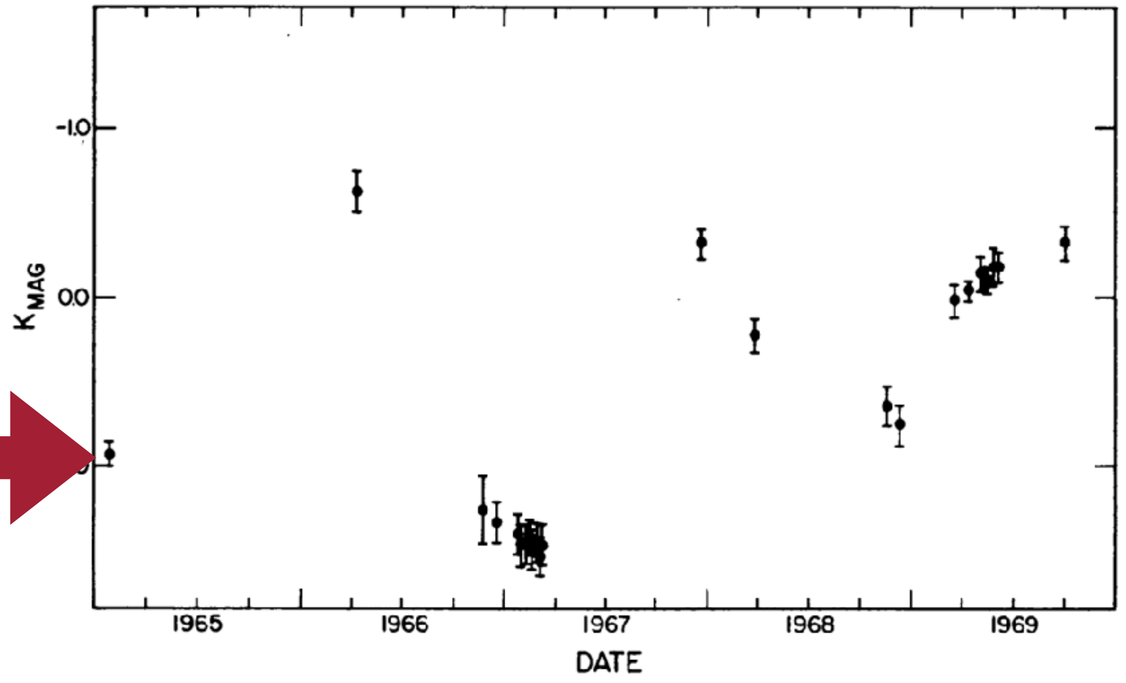
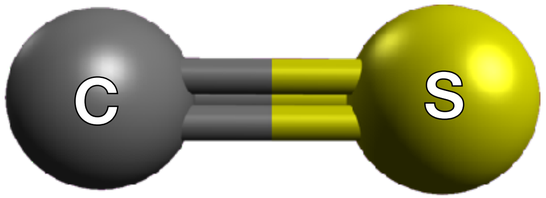


FIG. 1.—Observations of the 2.2-μ magnitude of IRC+10216 over the period 1965–1969

Early Interstellar Detections

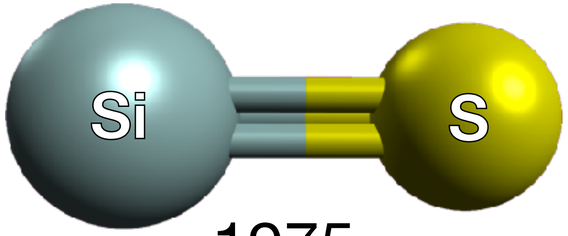
Ridgway et al. 1976 *Nature* 264 345
Morris et al. 1975 *ApJ* 199 L47
Penzias et al. 1971 *ApJ* 168 L53



1971

INTERSTELLAR CARBON MONOSULFIDE

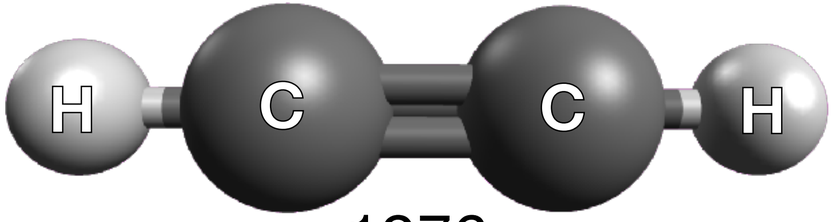
A. A. Penzias
Bell Telephone Laboratories, Inc., Holmdel, New Jersey



1975

DETECTION OF INTERSTELLAR SiS AND A STUDY OF THE IRC+10216 MOLECULAR ENVELOPE

M. Morris
University of Chicago

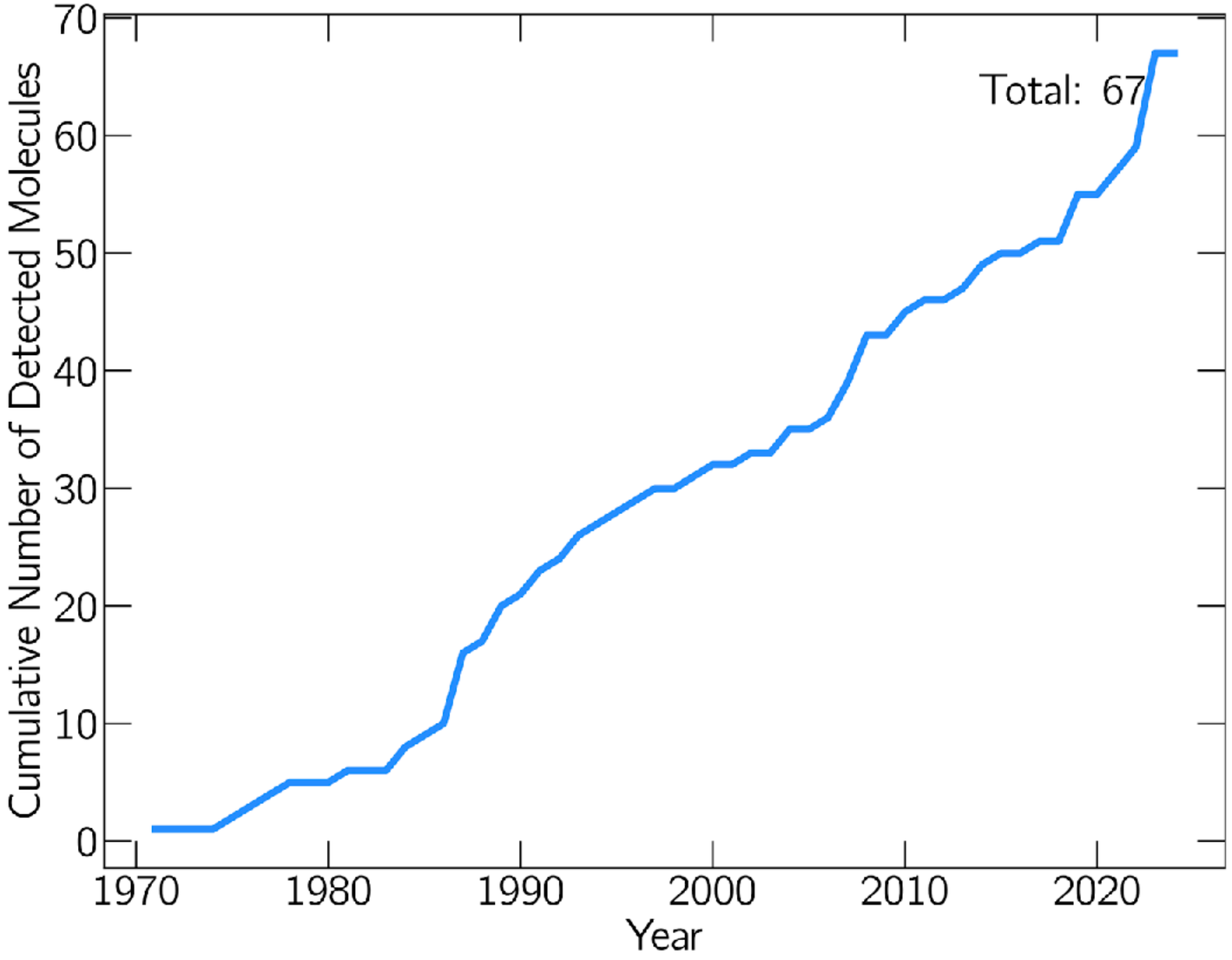


1976

Circumstellar acetylene in the infrared spectrum of IRC +10° 216

IRC+10216 - A Detection Powerhouse

Created with **ASTROMOL** v2021.8.0
bmcguir2.github.io/astromol
McGuire 2022 *ApJS* 259 30



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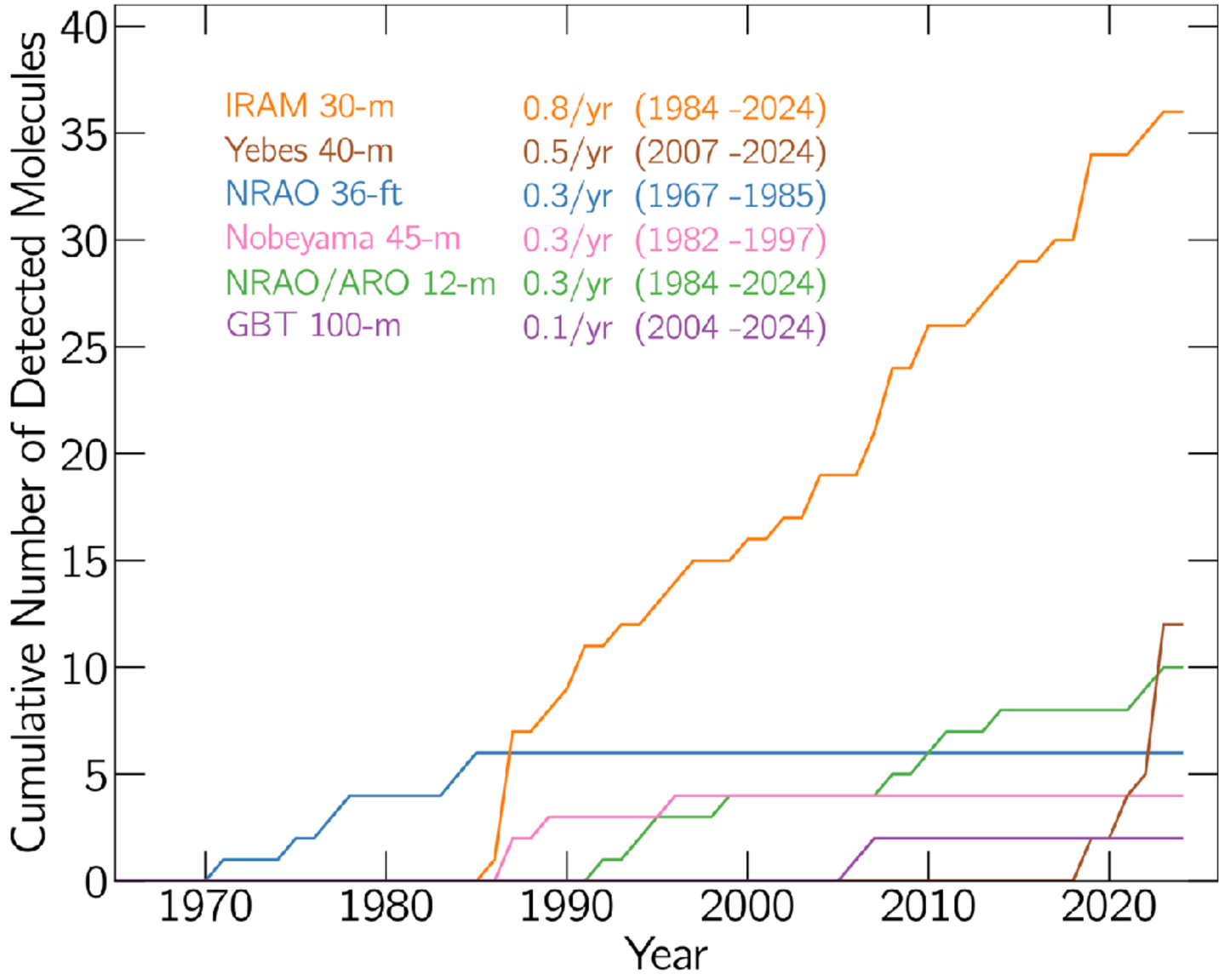

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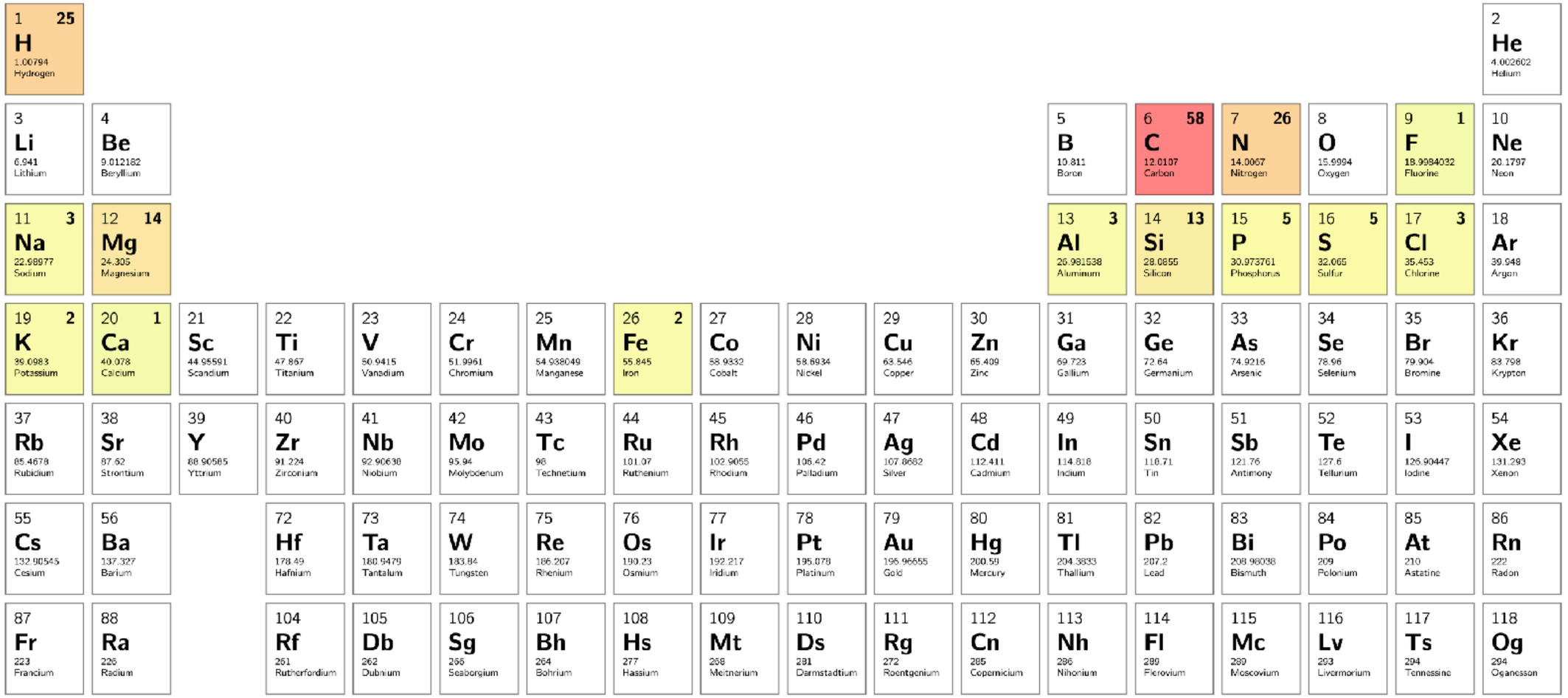

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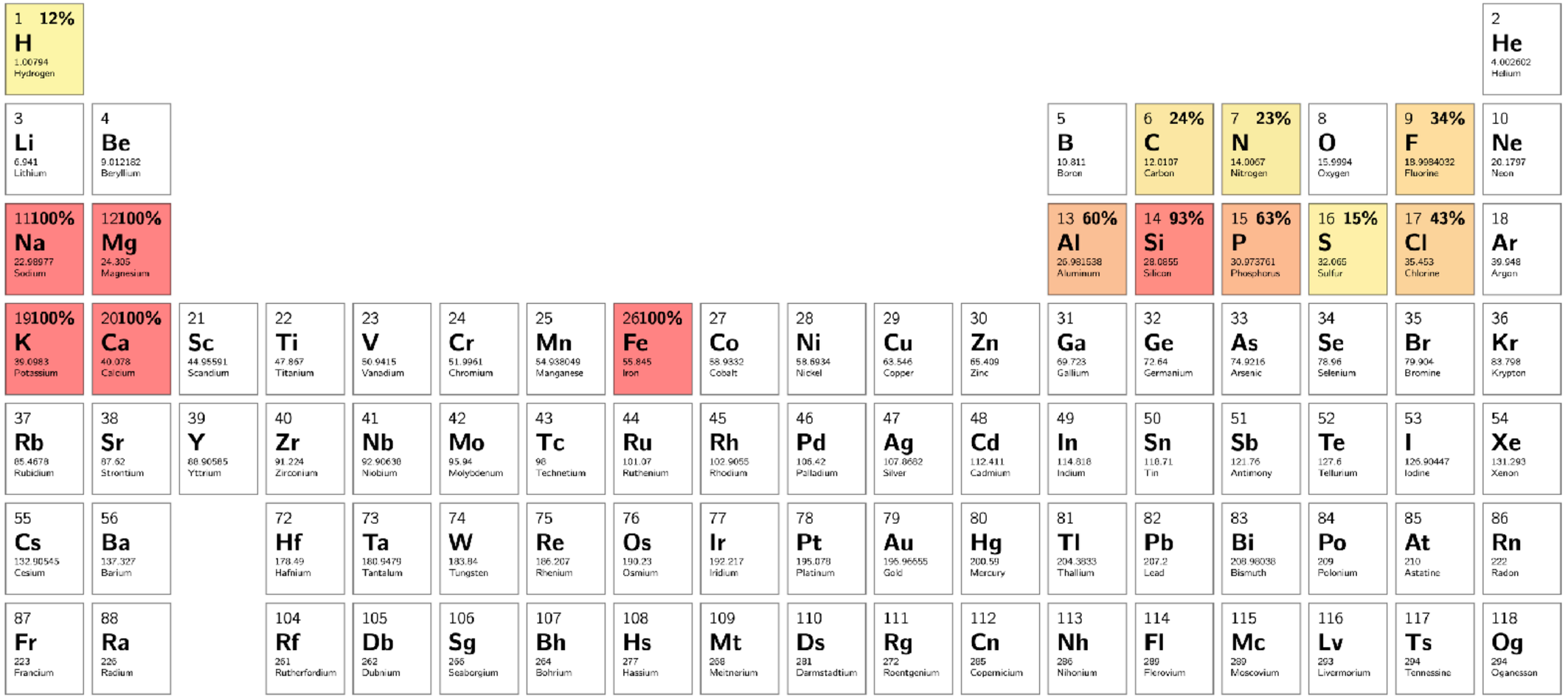
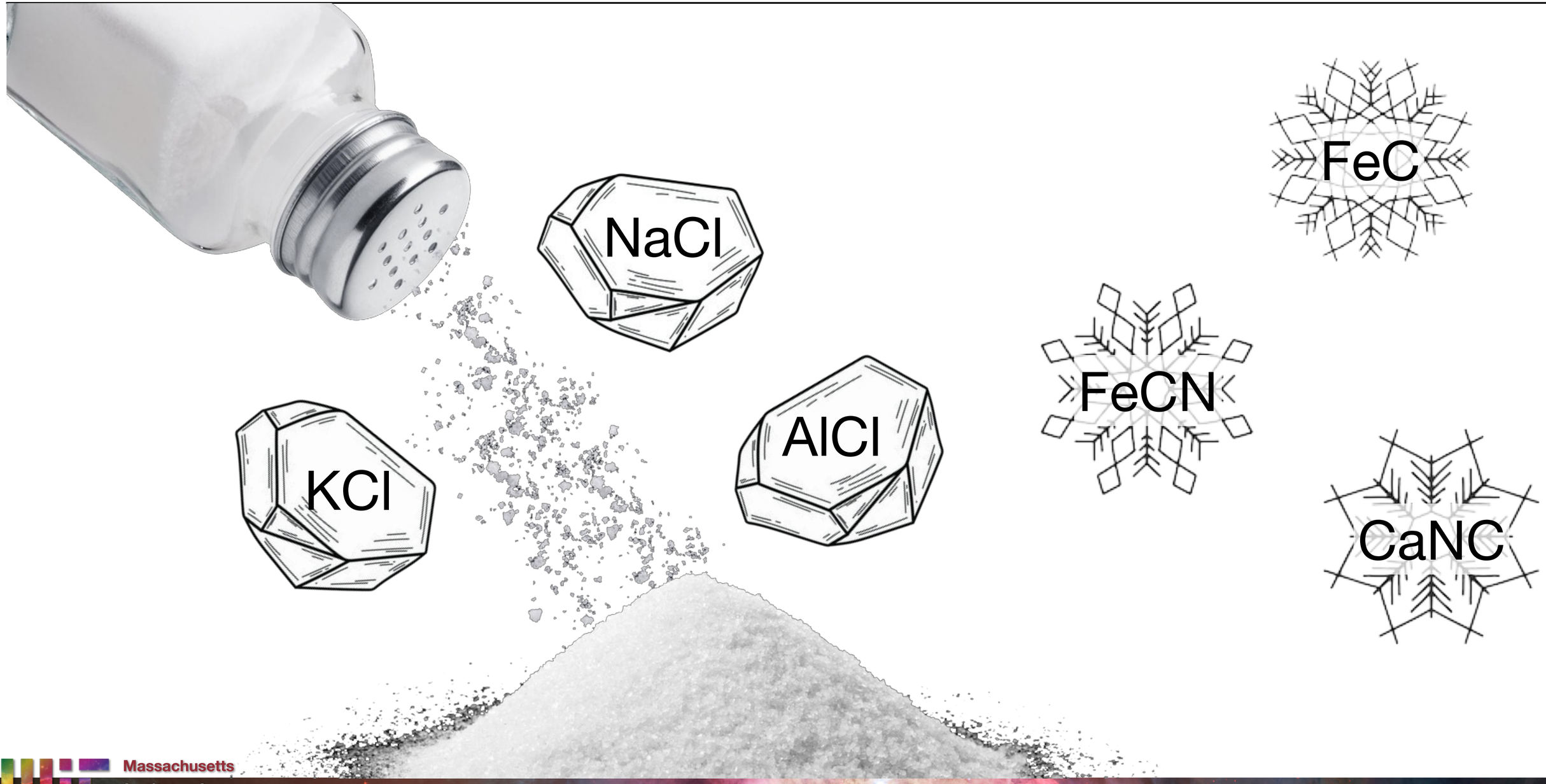
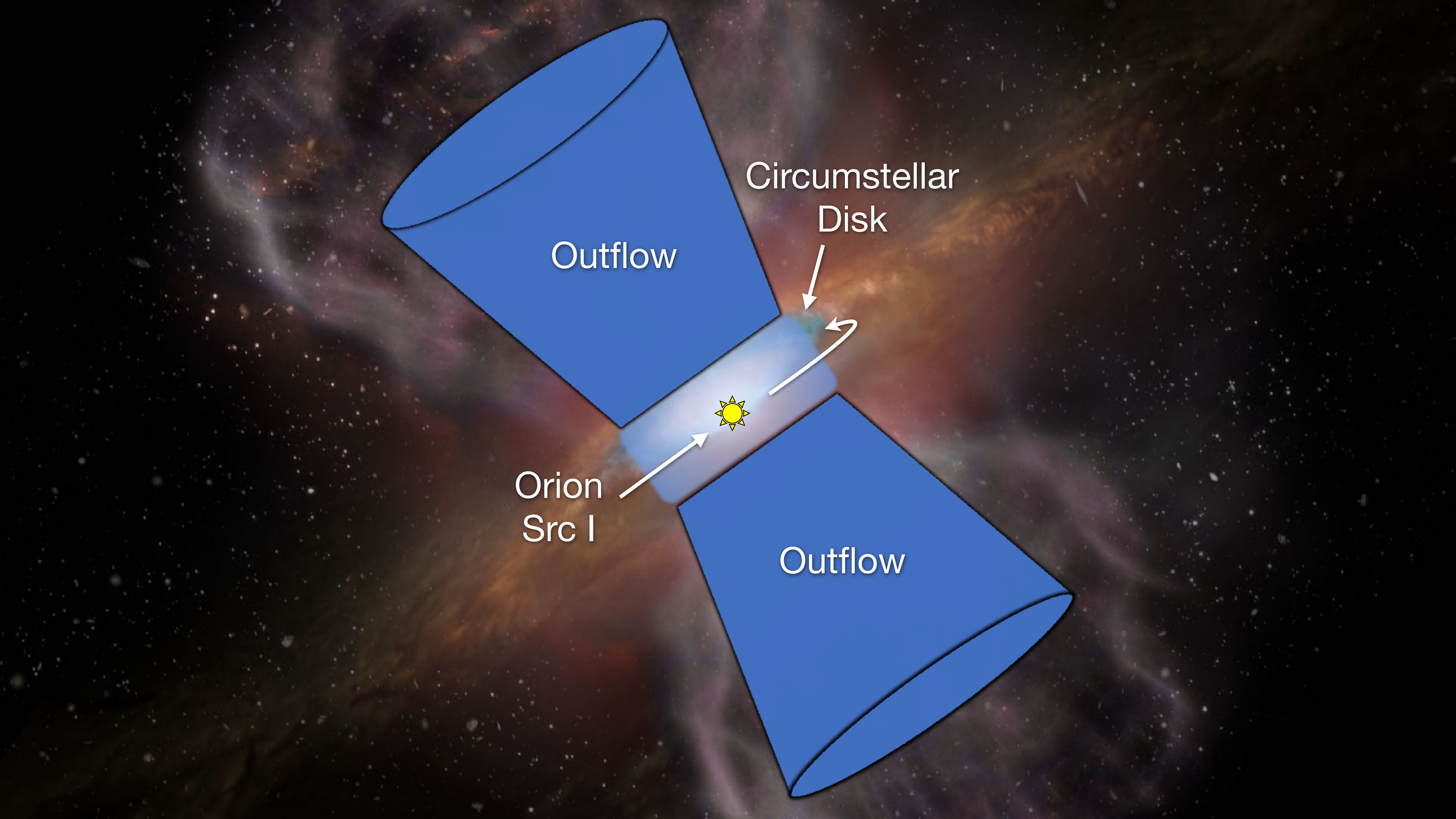


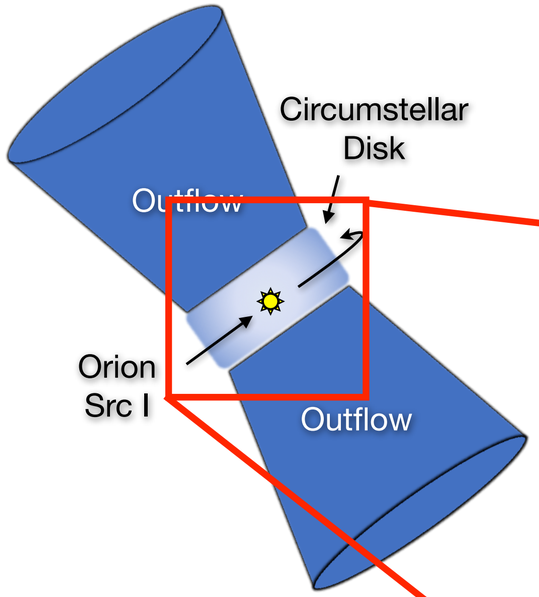
IRC+10216 - Salt + Spice

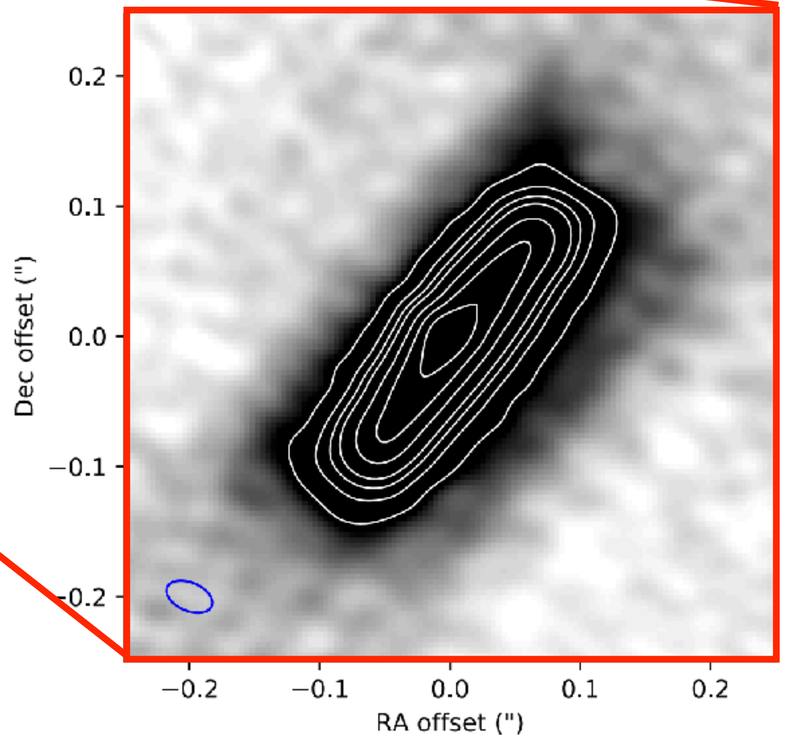



Outflow
Circumstellar
Disk
Orion
Src I
Outflow

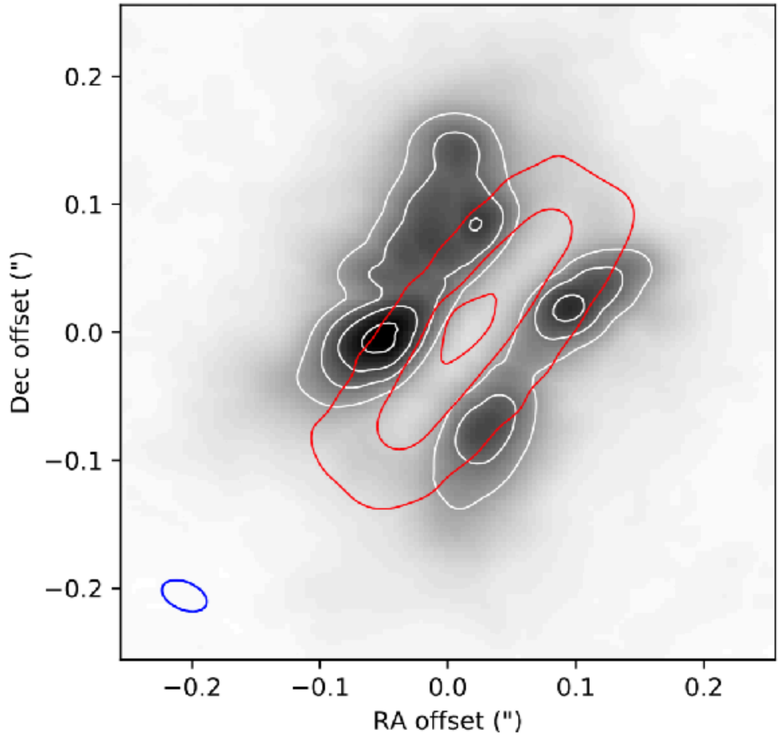
Molecules as Probes

Ginsburg 2018 *ApJ* 860, 119
Ginsburg, McGuire et al. 2019 *ApJL* 872, 54





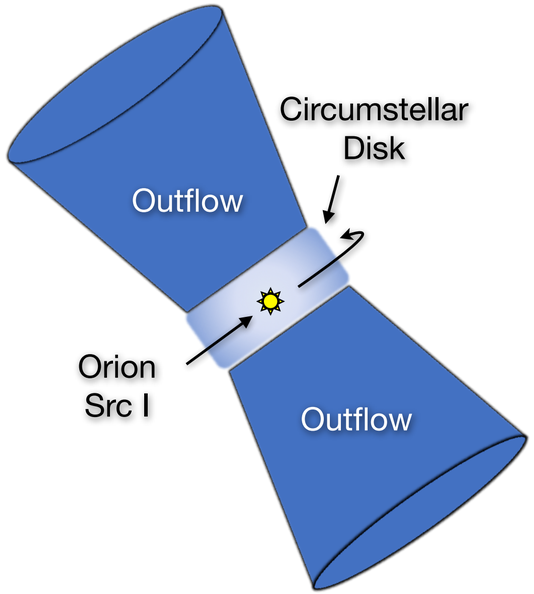
1.3 mm Continuum

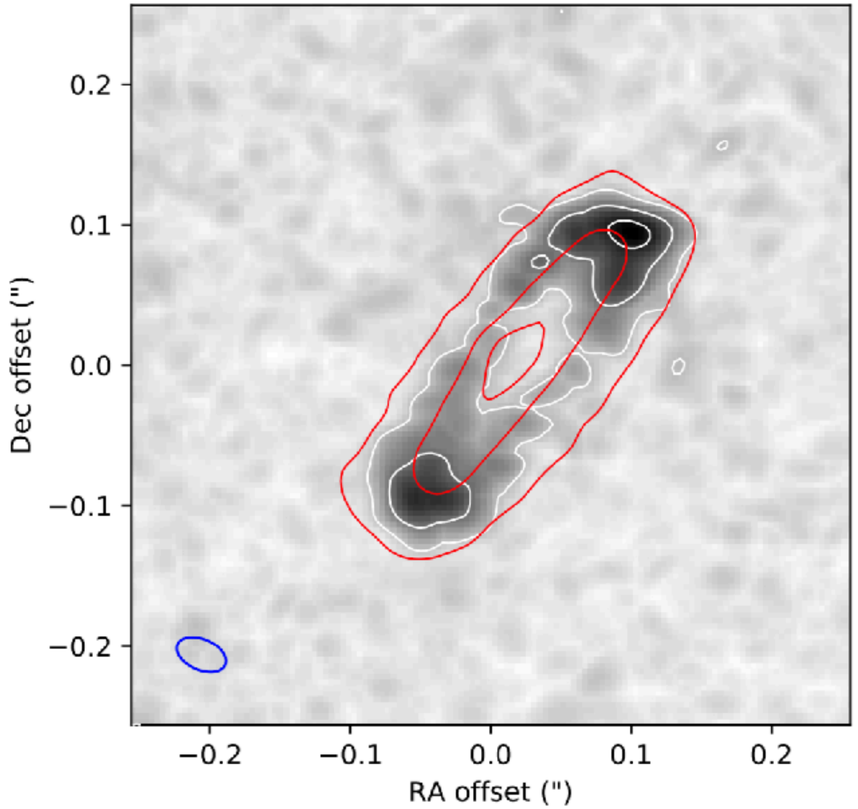


H_2O $(5_{5,0} - 6_{4,3})$

Molecules as Probes

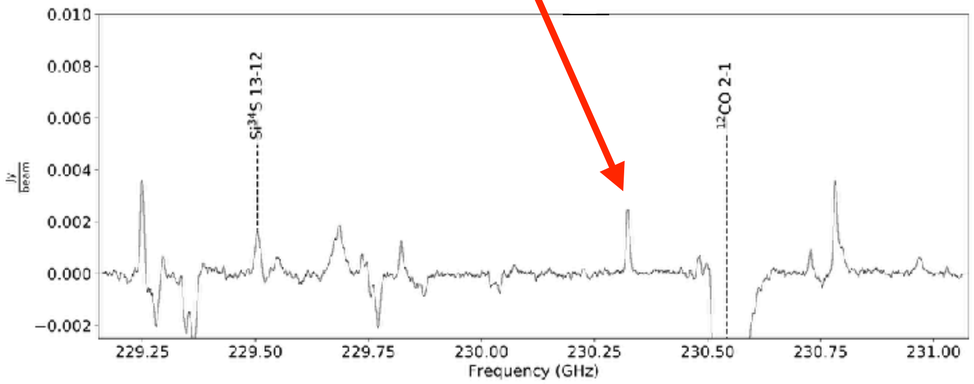
Ginsburg 2018 *ApJ* 860, 119
Ginsburg, McGuire et al. 2019 *ApJL* 872, 54





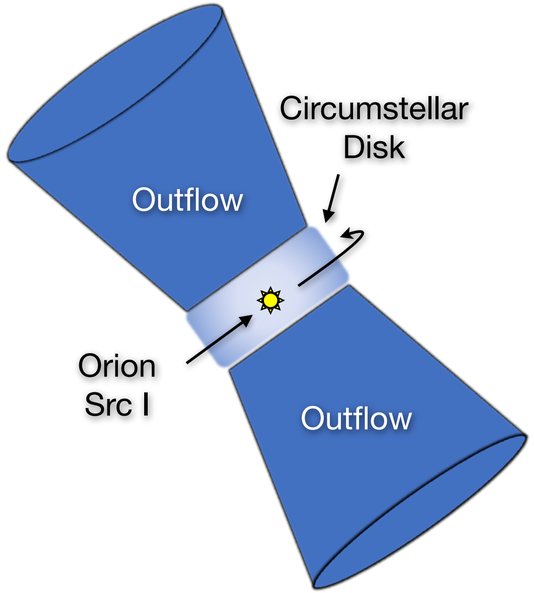
U230.322

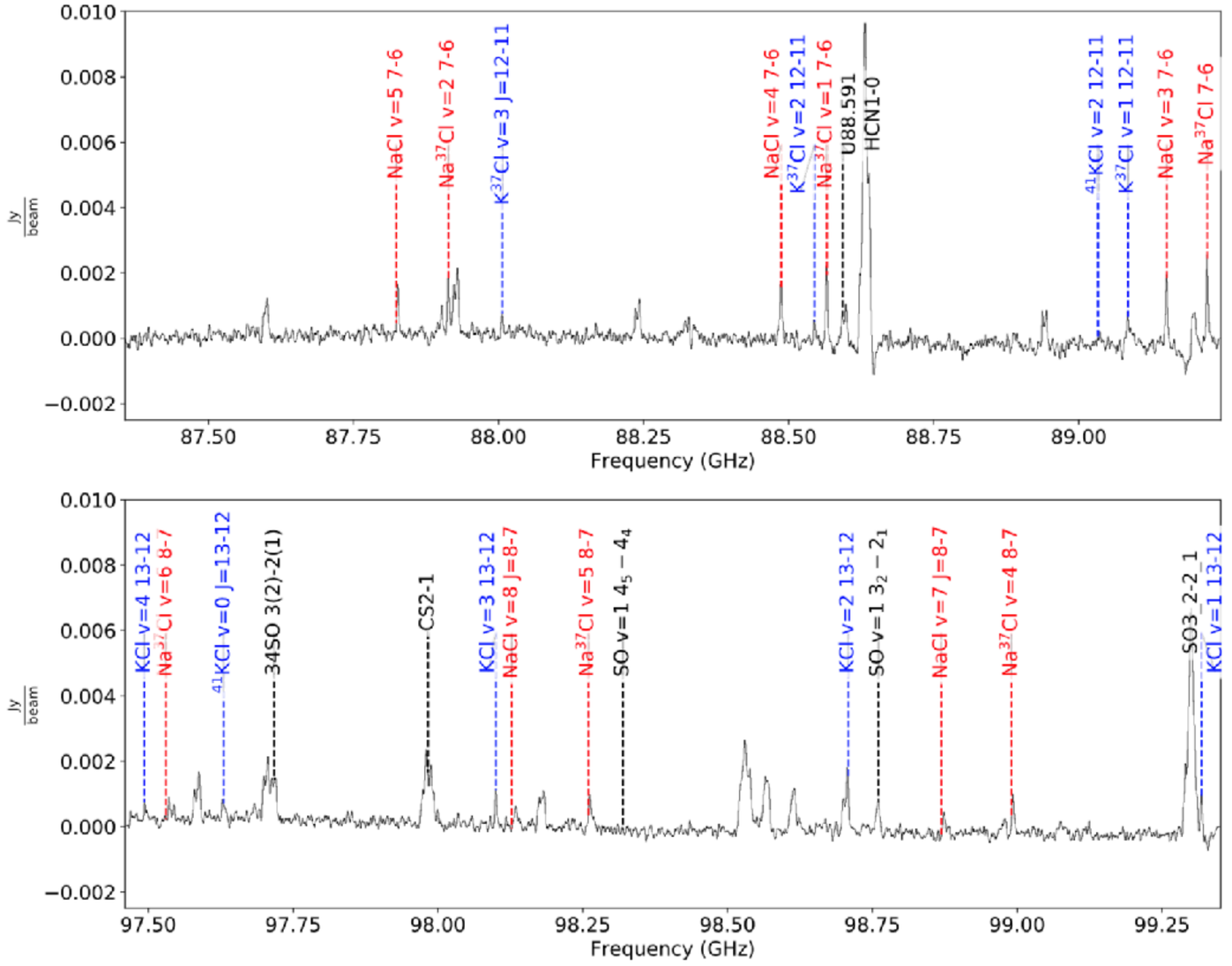
U230.322



Molecules as Probes

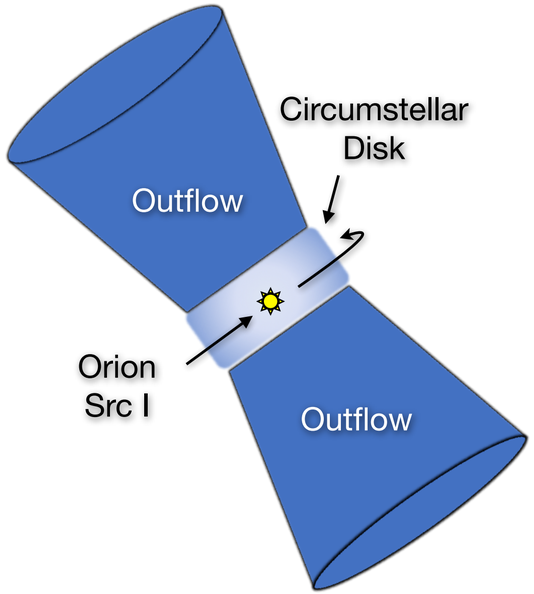
Ginsburg 2018 *ApJ* 860, 119
Ginsburg, McGuire et al. 2019 *ApJL* 872, 54

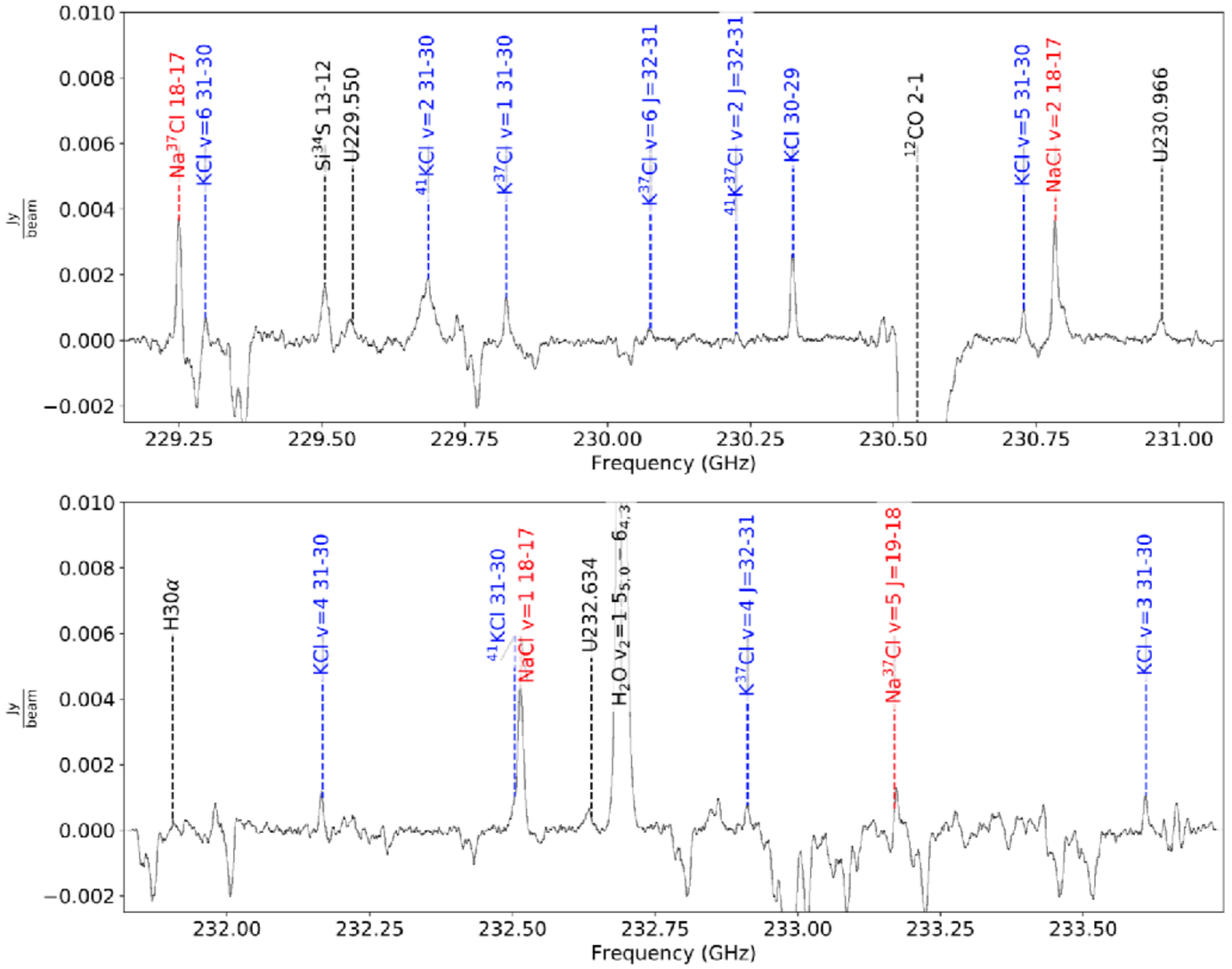




MOLECULES AS PROBES

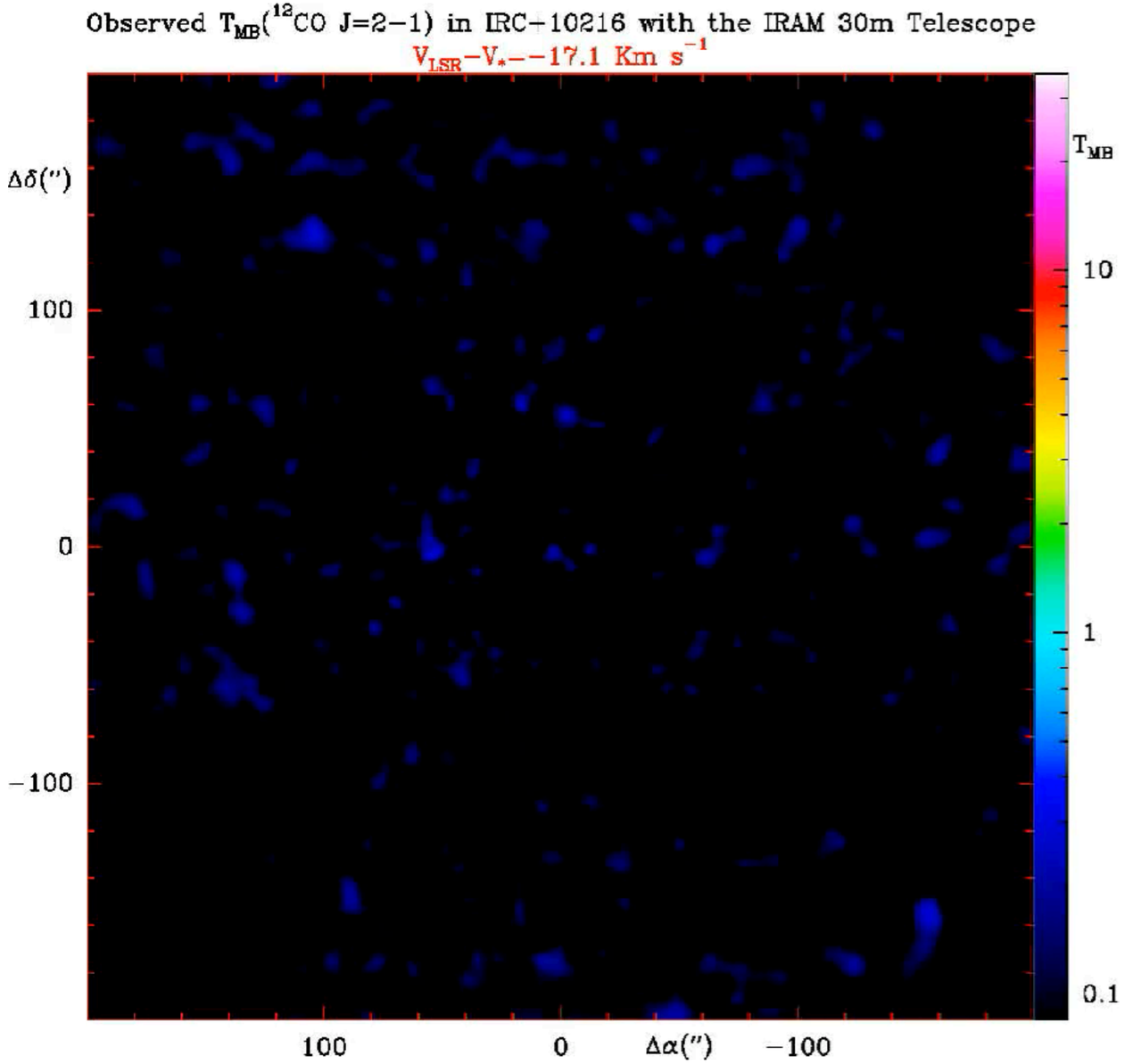
Ginsburg 2018 *ApJ* 860, 119
Ginsburg, McGuire et al. 2019 *ApJL* 872, 54





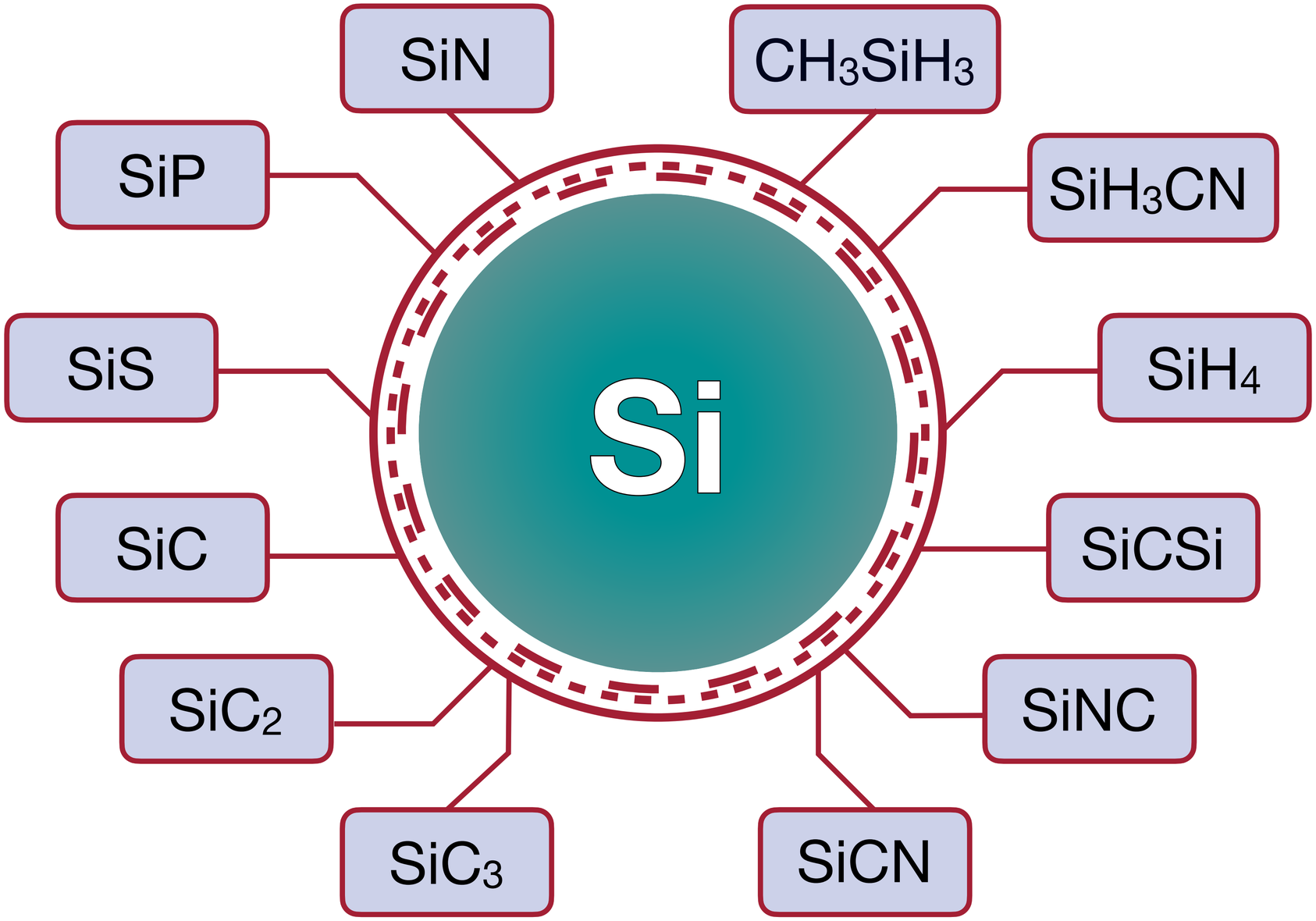
IRC+10216 Structure

Cernicharo et al. 2015 *A&A* 575 A91



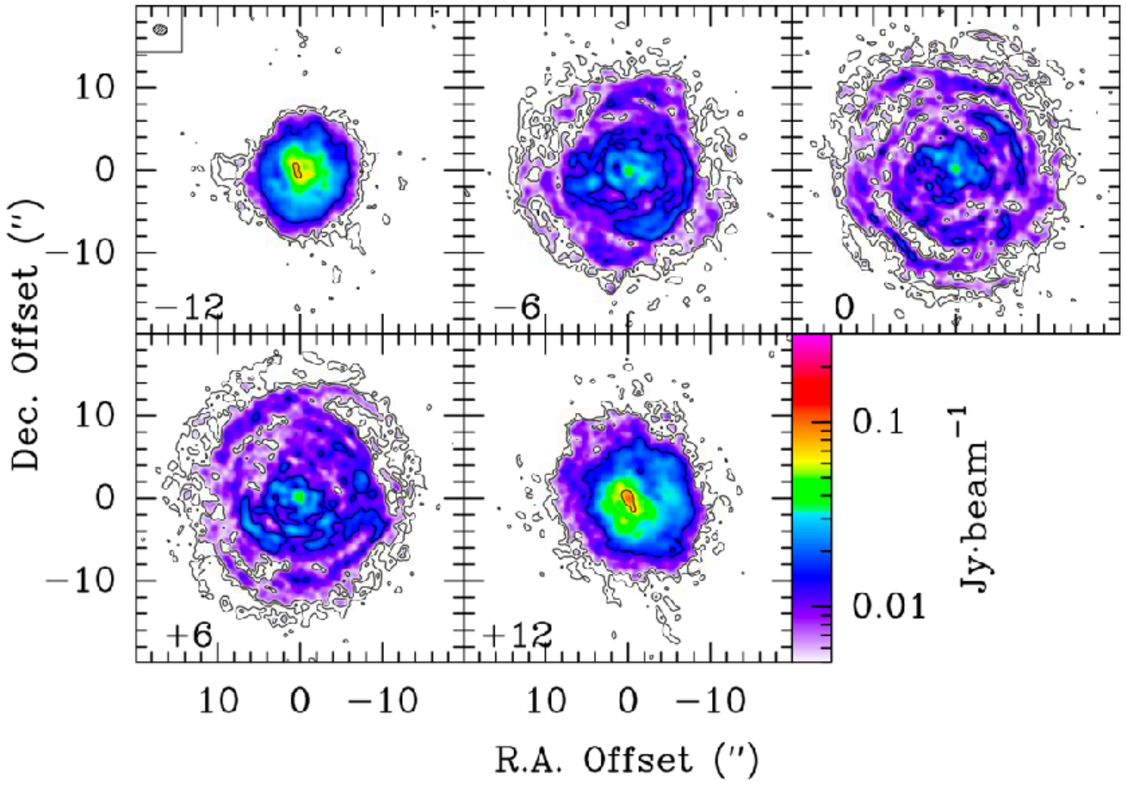
Silicon in IRC+10216 - Grains + Shocks

McGuire 2022 *ApJS* 259 30

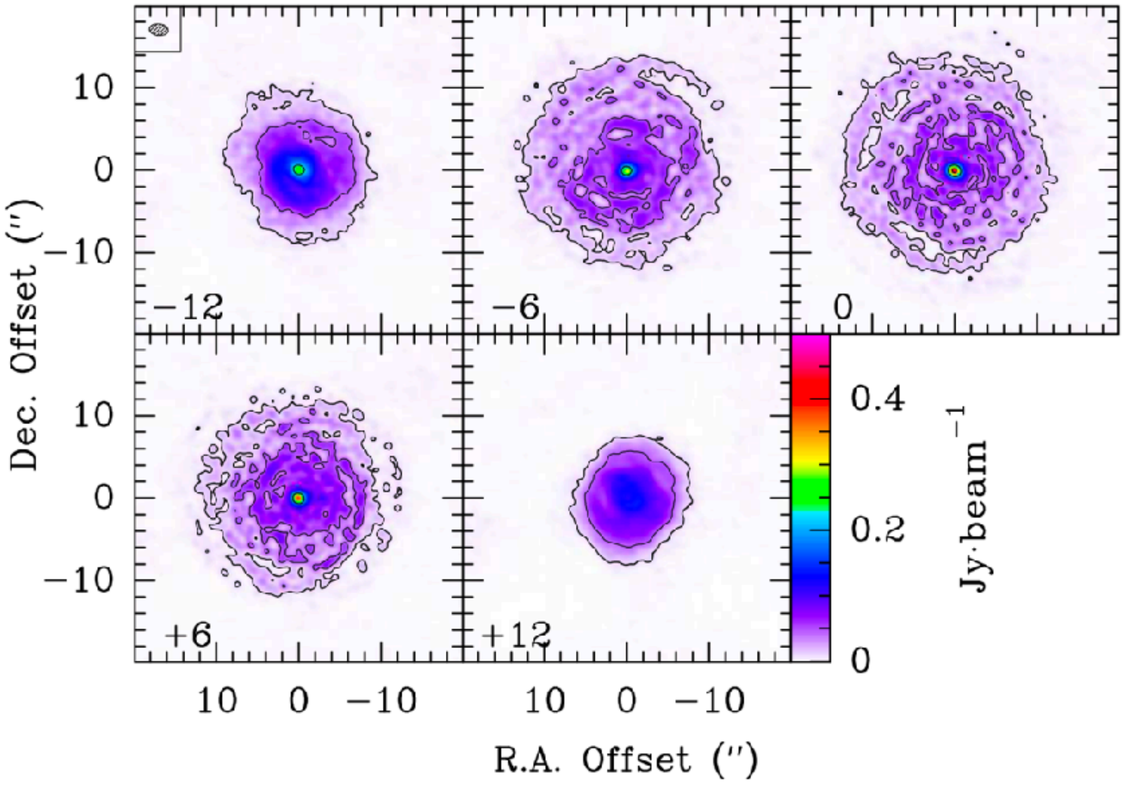


SILICON IN IRC+10216

Velilla-Prieto et al. 2019 *A&A* 629 A146



SiO 2-1

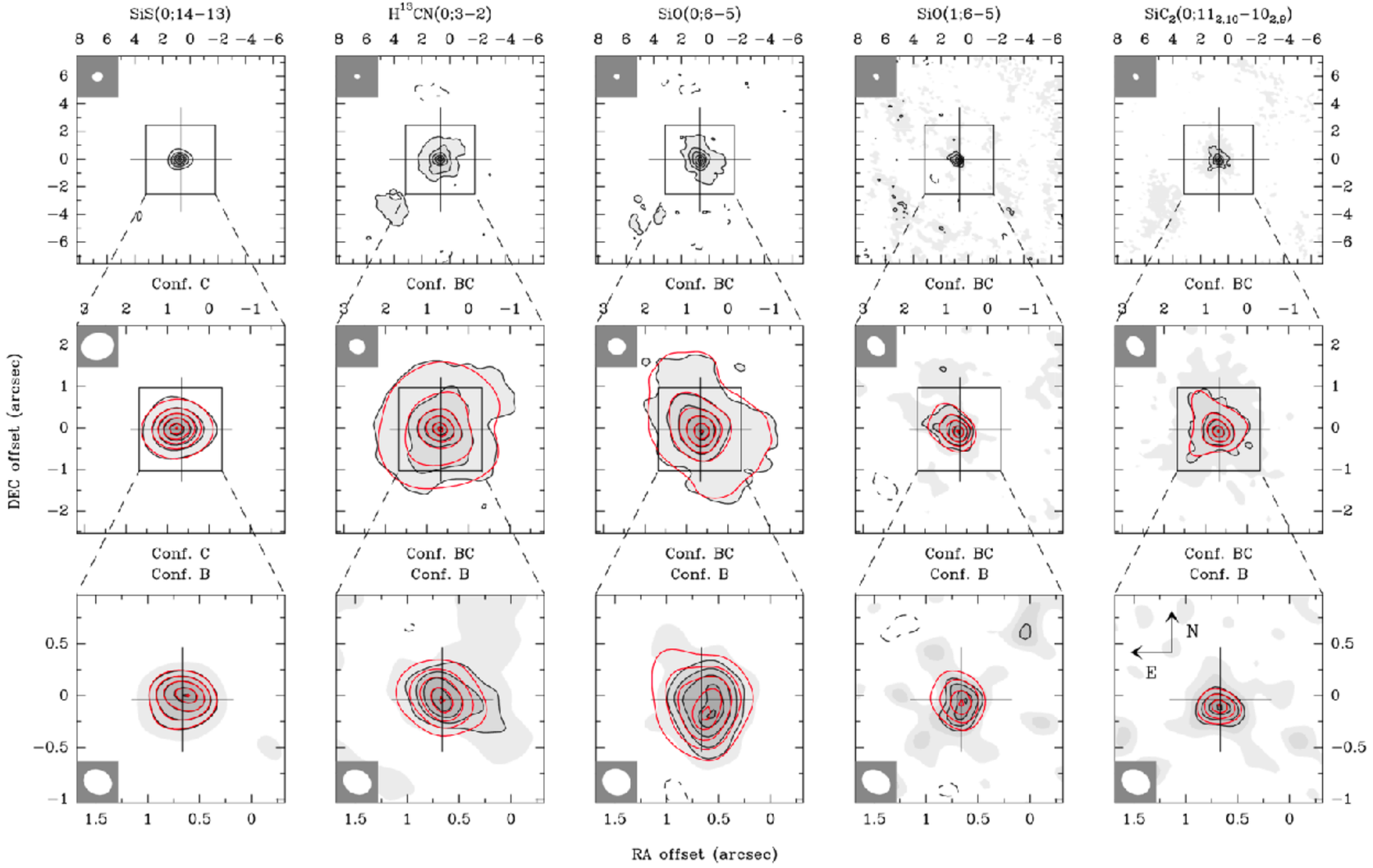


SiS 6-5

ALMA

SILICON IN IRC+10216

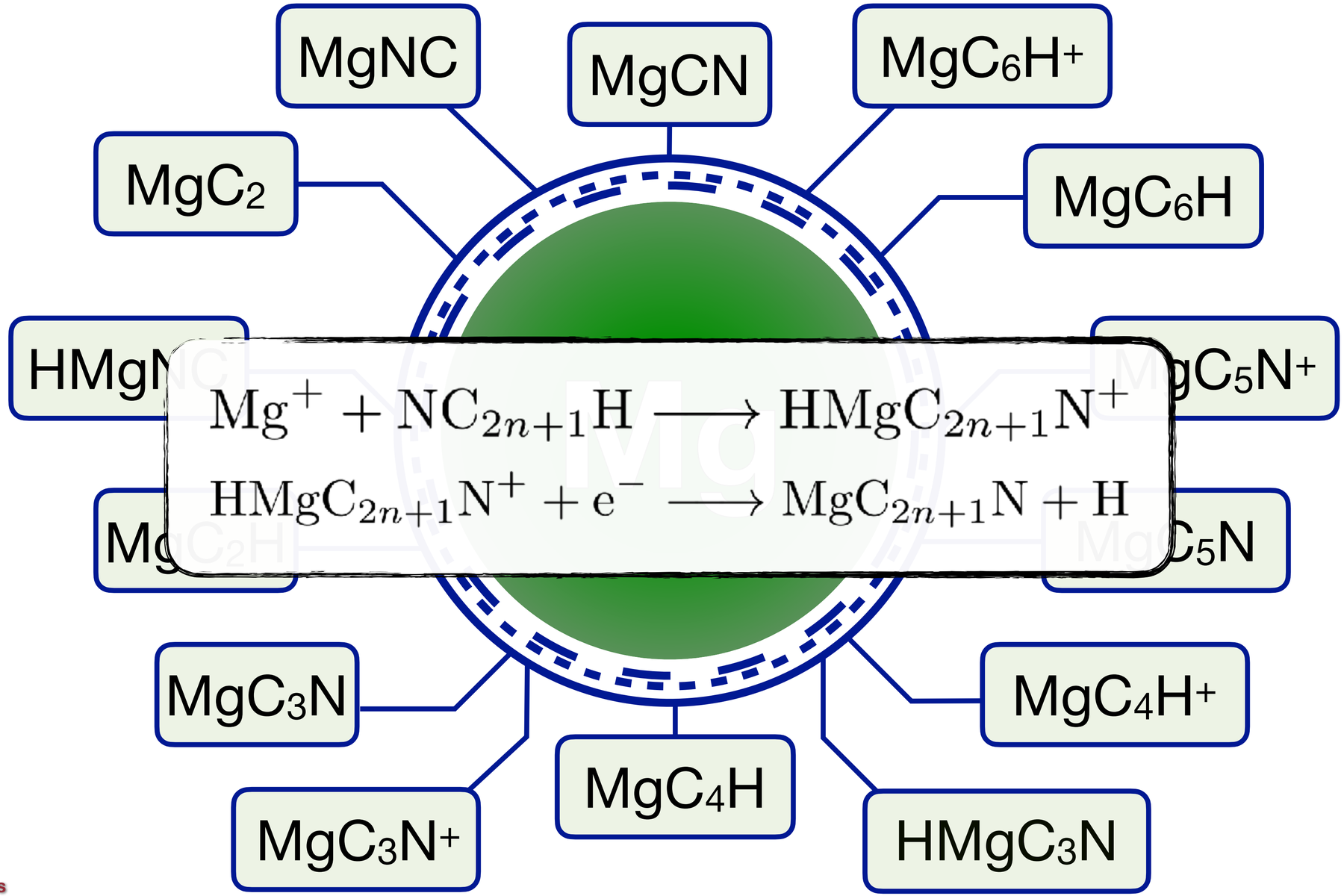
Fonfriá et al. 2014 *MNRAS* 445 3289



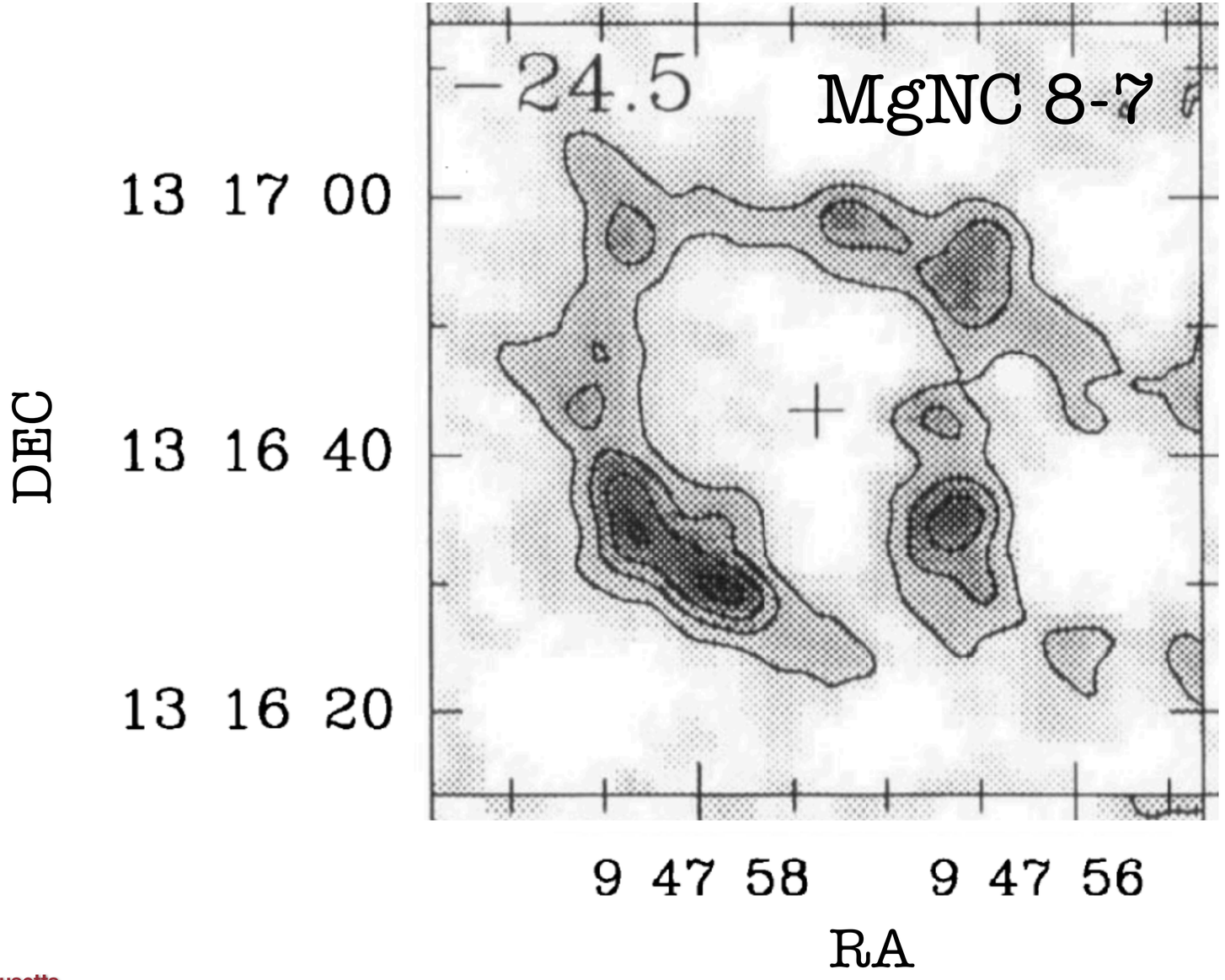
SMA

Magnesium in IRC+10216

McGuire 2022 *ApJS* 259 30



MAGNESIUM IN IRC+10216



15″Shell

Chemistry as Probe of Circumstellar Environment

The Astrophysical Journal, 941:90 (12pp), 2022 December 10 https://doi.org/10.3847/1538-4357/ac9e52

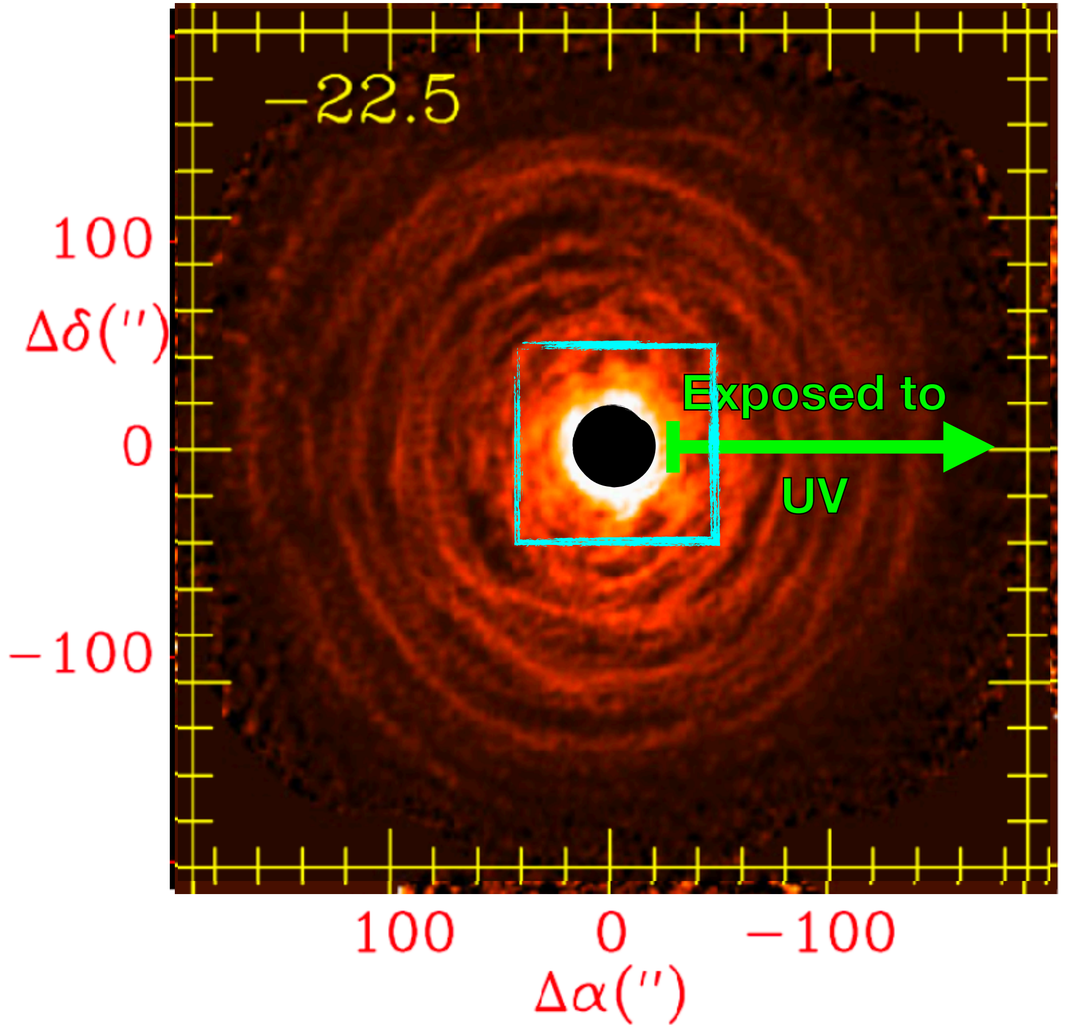
Investigating Anomalous Photochemistry in the Inner Wind of IRC+10216 through Interferometric Observations of HC_3N

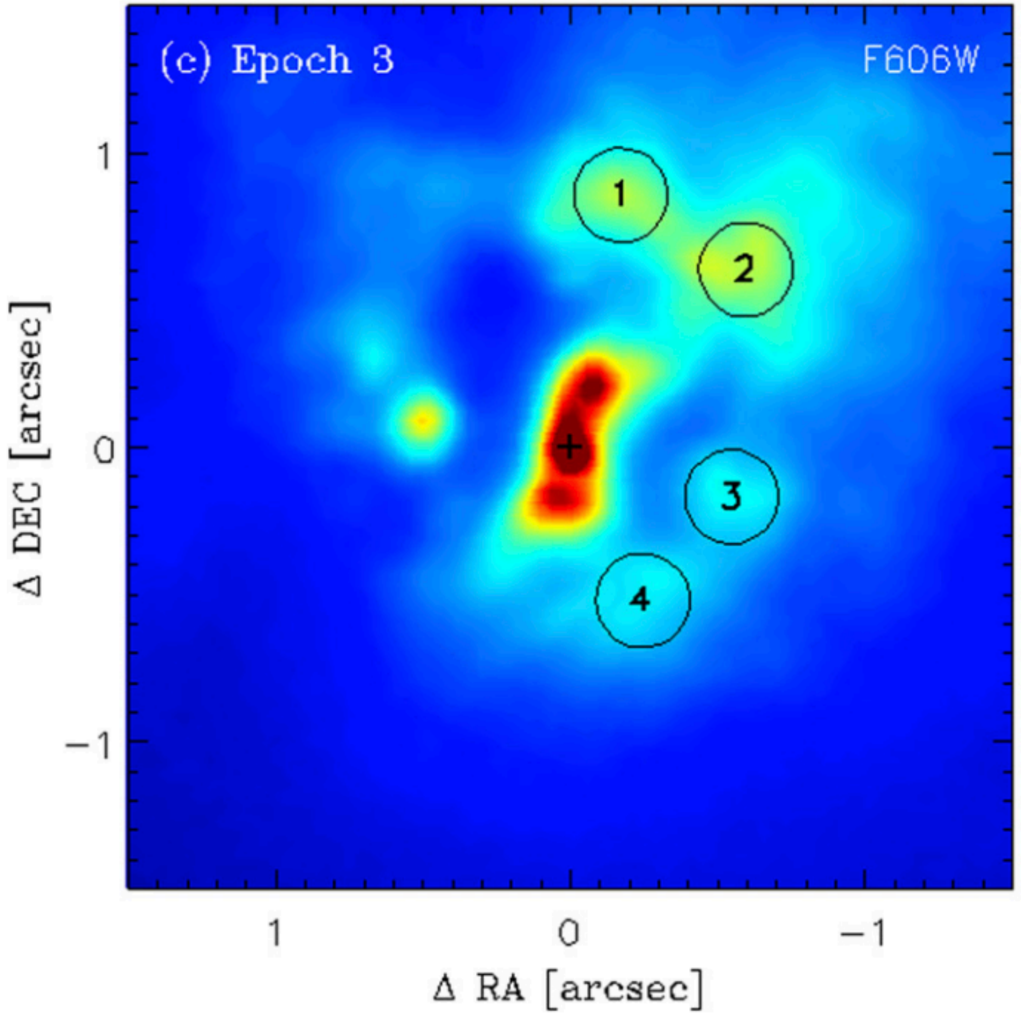
Mark A. Siebert[1], Marie Van de Sande[2], Thomas J. Millar[3], and Anthony J. Remijan[4]
[1] Department of Astronomy, University of Virginia, Charlottesville, VA 22904, USA
[2] School of Physics and Astronomy, University of Leeds, Leeds, UK
[3] School of Mathematics and Physics, Queen's University Belfast, Belfast, UK
[4] National Radio Astronomy Observatory, Charlottesville, VA 22903, USA
ived 2022 July 8; revised 2022 October 25; accepted 2022 October 26; published 2022 December 14

SUGGESTIONS OF A COMPANION

Kim et al. 2015 *ApJL* 804 L10
Guélin et al. 2018 *A&A* 610 A4
Cernicharo et al. 2015 *A&A* 575 A91

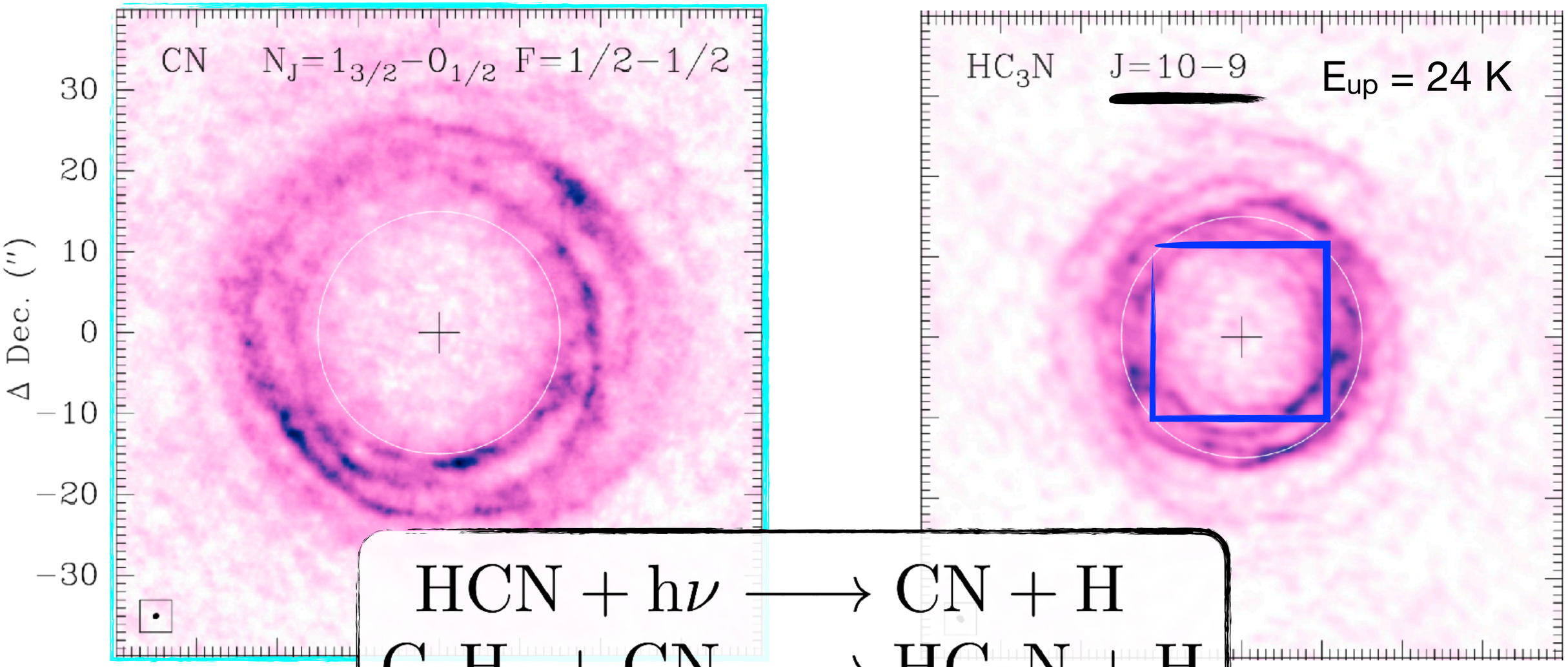
IRAM 30m SMA SMA + IRAM 30m HST





A Chemical Investigation

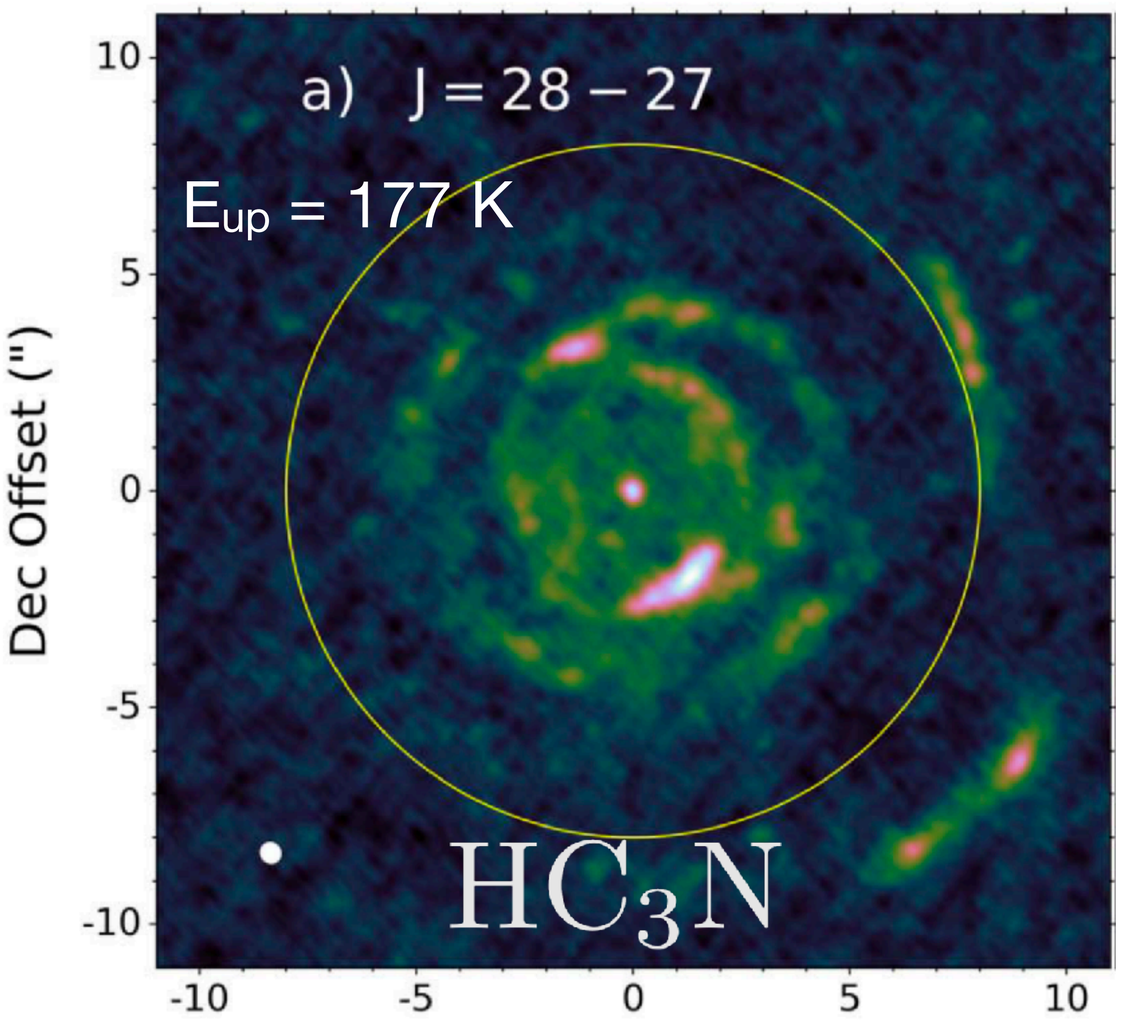
Agúndez et al. 2017 *A&A* 601 A4

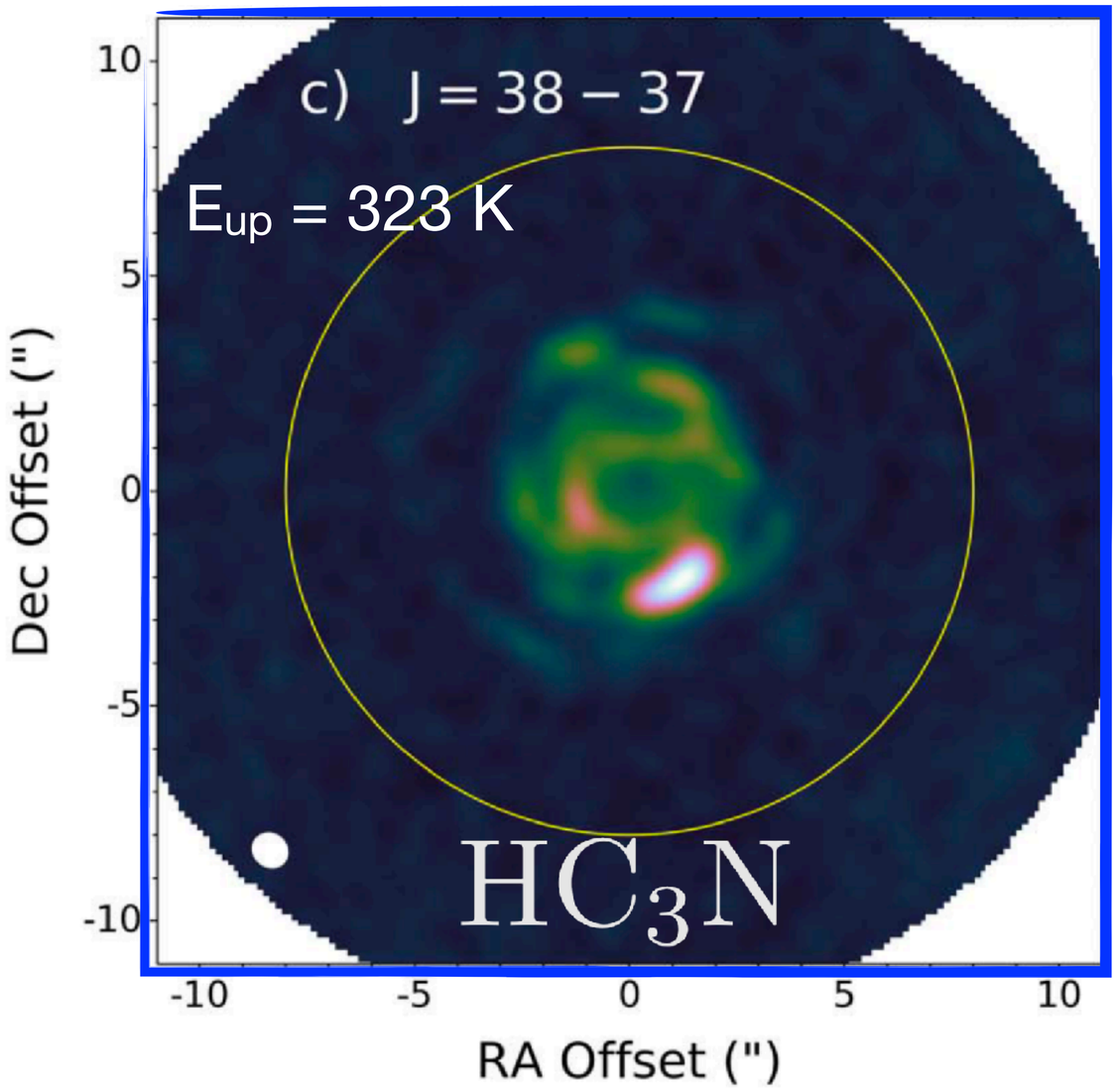


$$HCN + h\nu \longrightarrow CN + H$$
$$C_2H_2 + CN \longrightarrow HC_3N + H$$

A Chemical Investigation

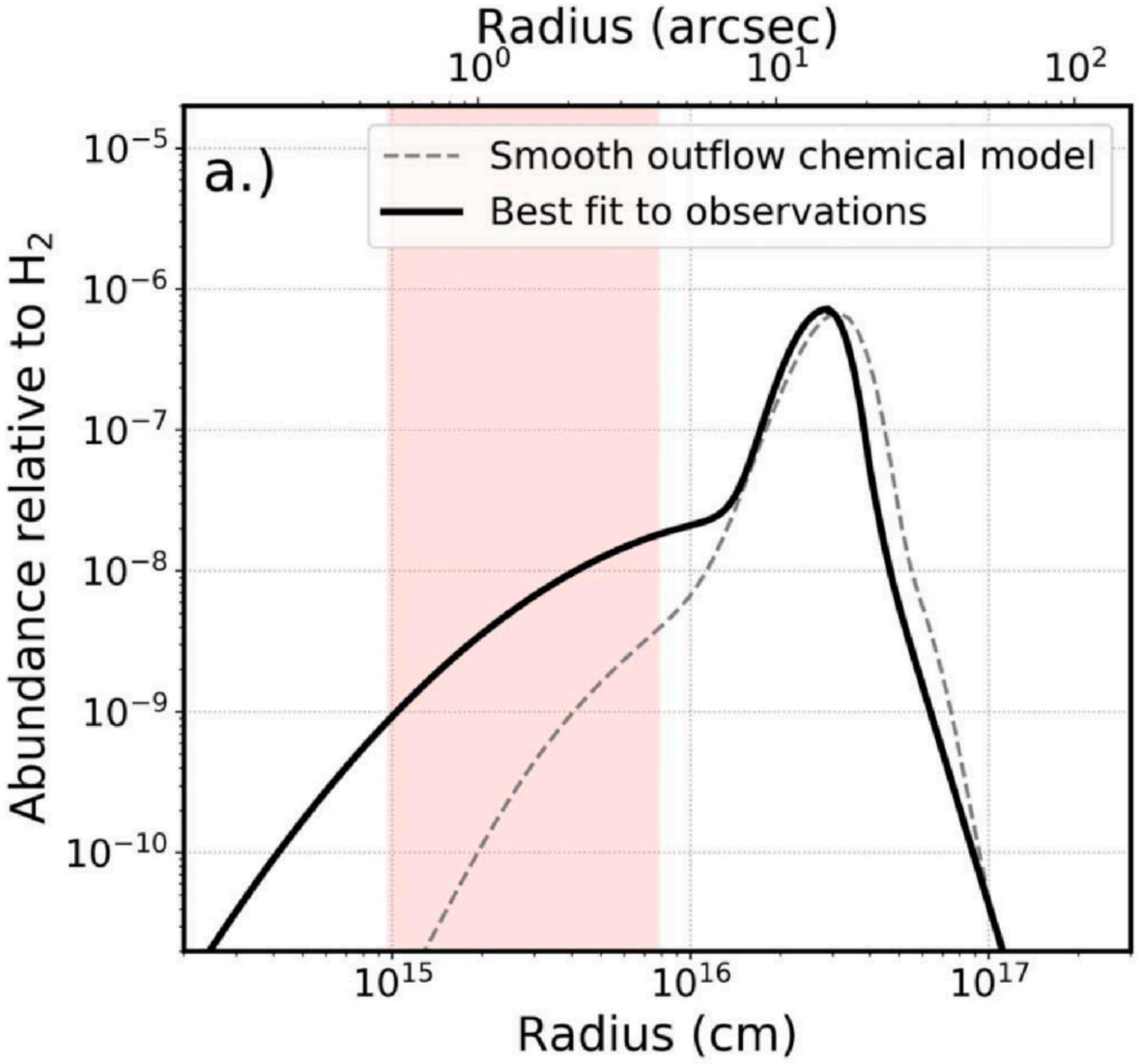
Siebert et al. 2022 *ApJ* 941 90





A Chemical Investigation

Siebert et al. 2022 *ApJ* 941 90



→ Not enough UV deep in

→ Cannot be explained by gaps in the outflow alone

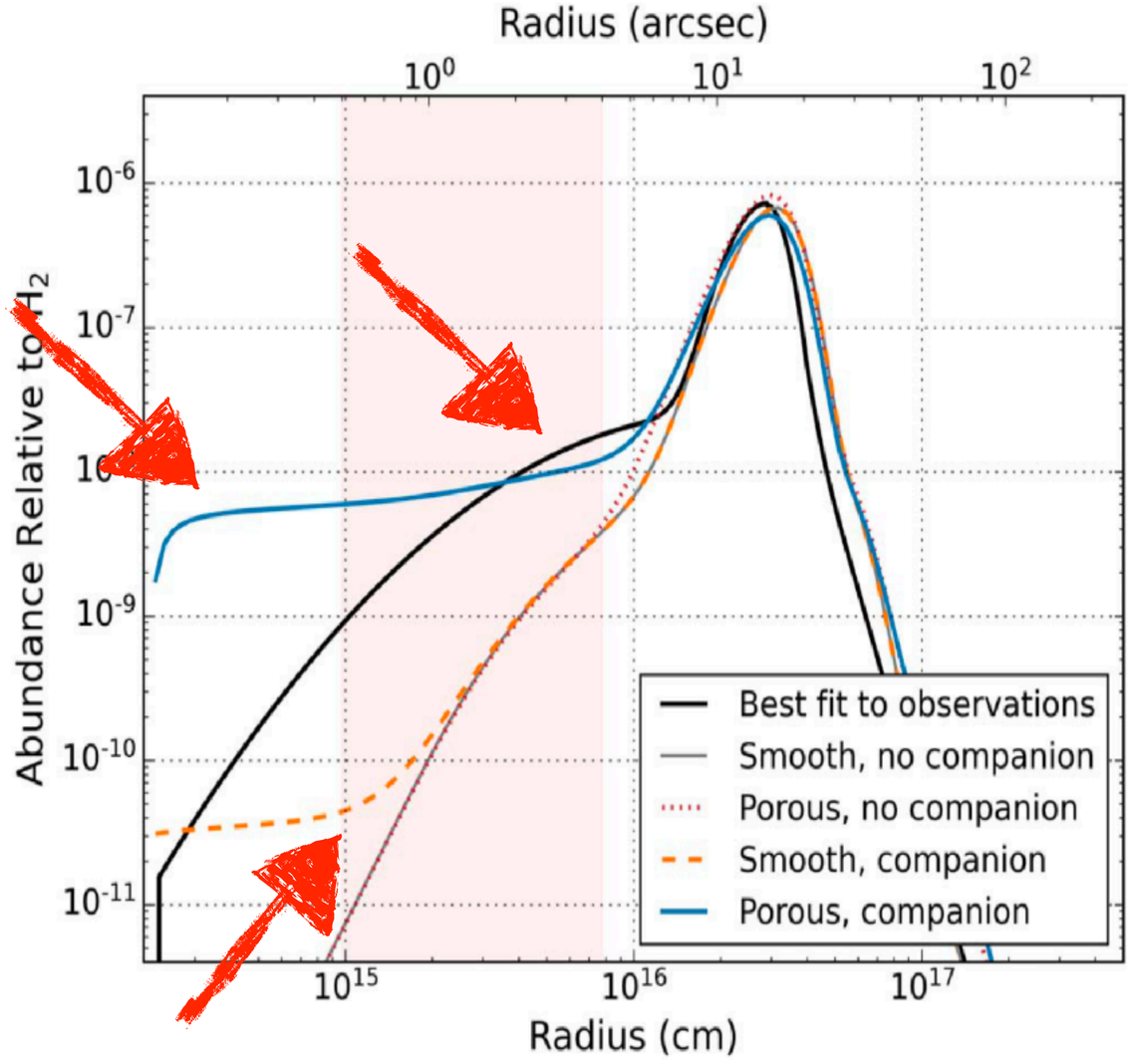
→ IRC+10216 just too cold

→ A hotter close-in companion could explain the abundance *and* asymmetry

A Chemical Investigation

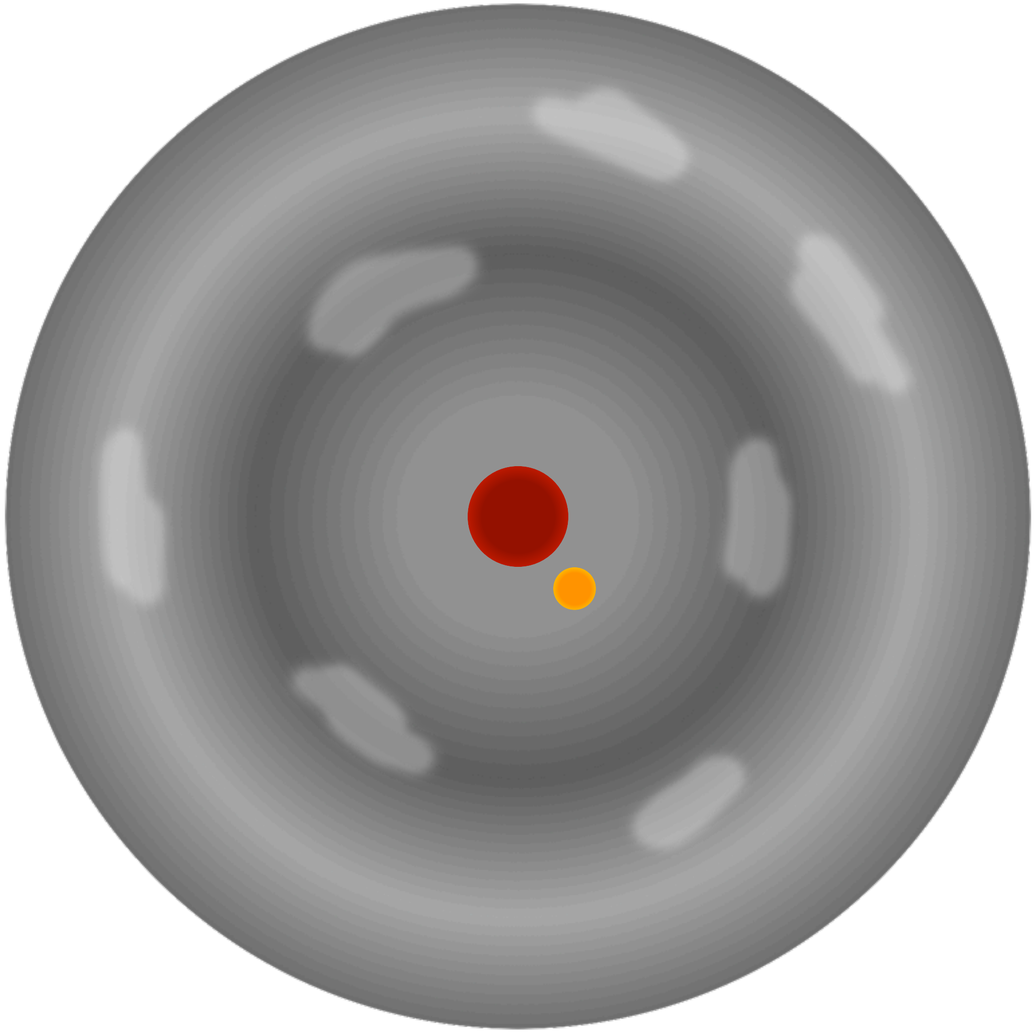
Siebert et al. 2022 *ApJ* 941 90

Best fit is to a solar-type companion with a chunky outflow



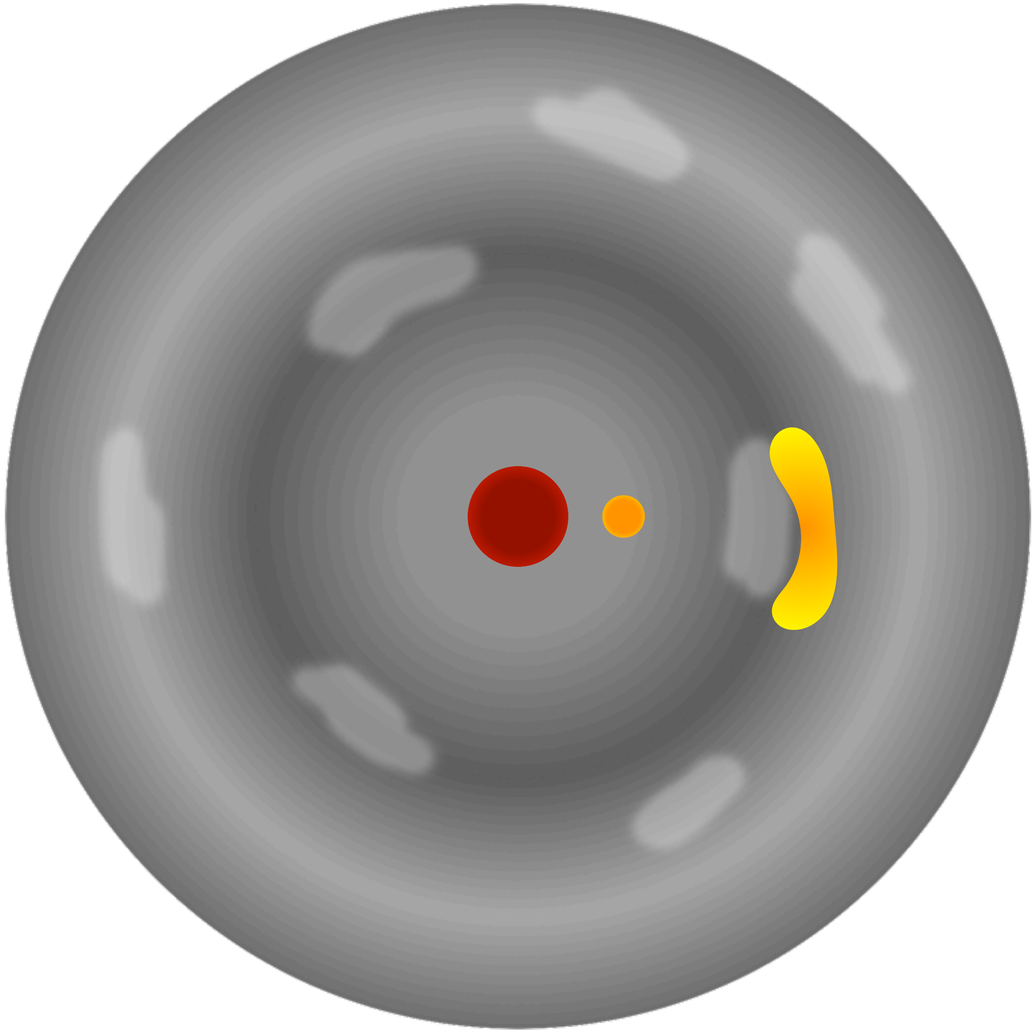
A Chemical Investigation

Siebert et al. 2022 *ApJ* 941 90



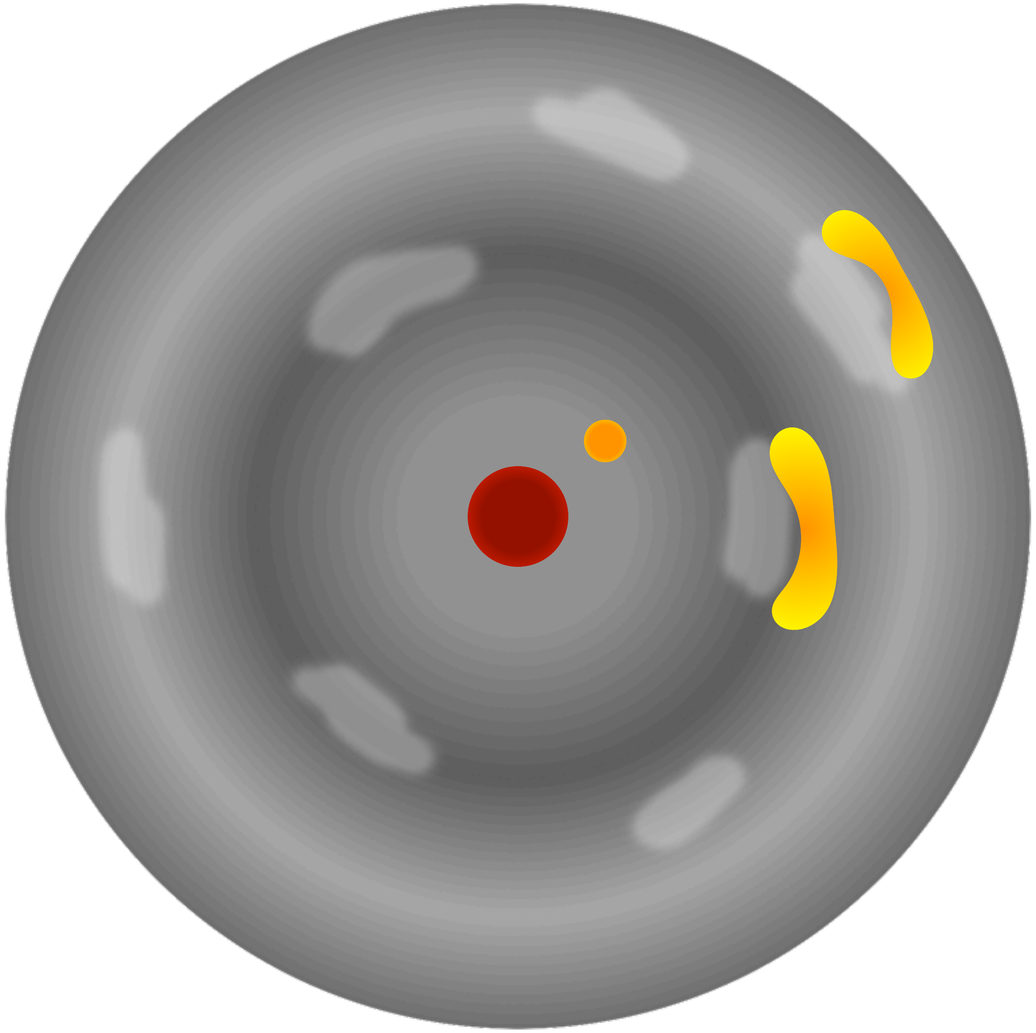
A Chemical Investigation

Siebert et al. 2022 *ApJ* 941 90



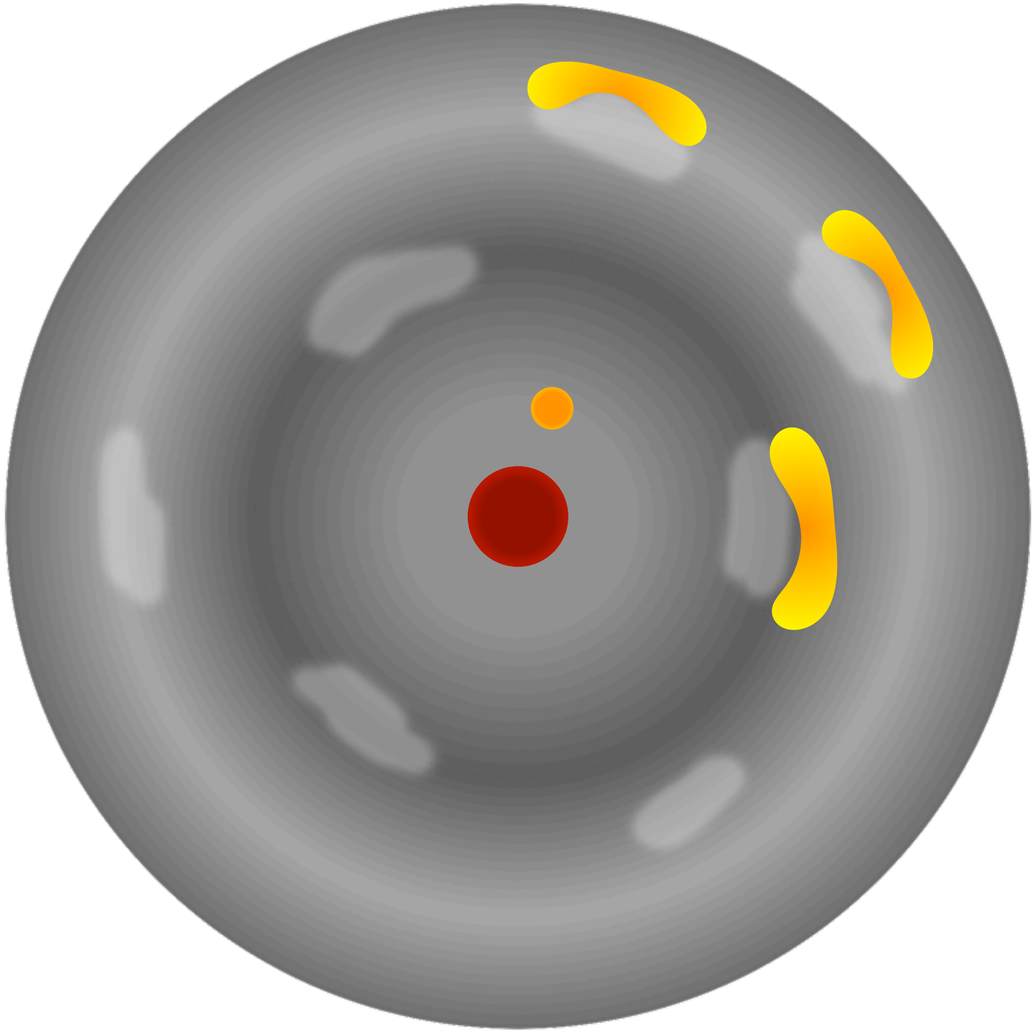
A Chemical Investigation

Siebert et al. 2022 *ApJ* 941 90



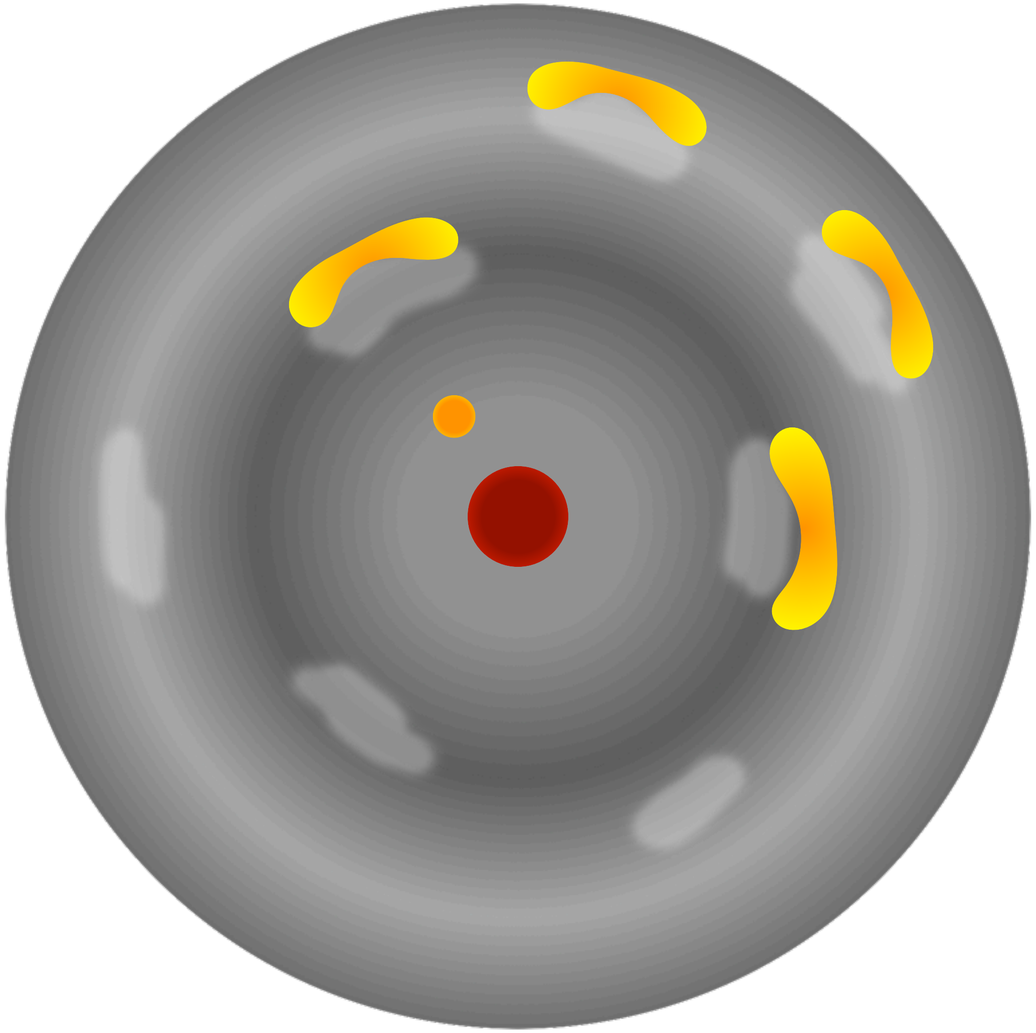
A Chemical Investigation

Siebert et al. 2022 *ApJ* 941 90



A Chemical Investigation

Siebert et al. 2022 *ApJ* 941 90



A Chemical Investigation

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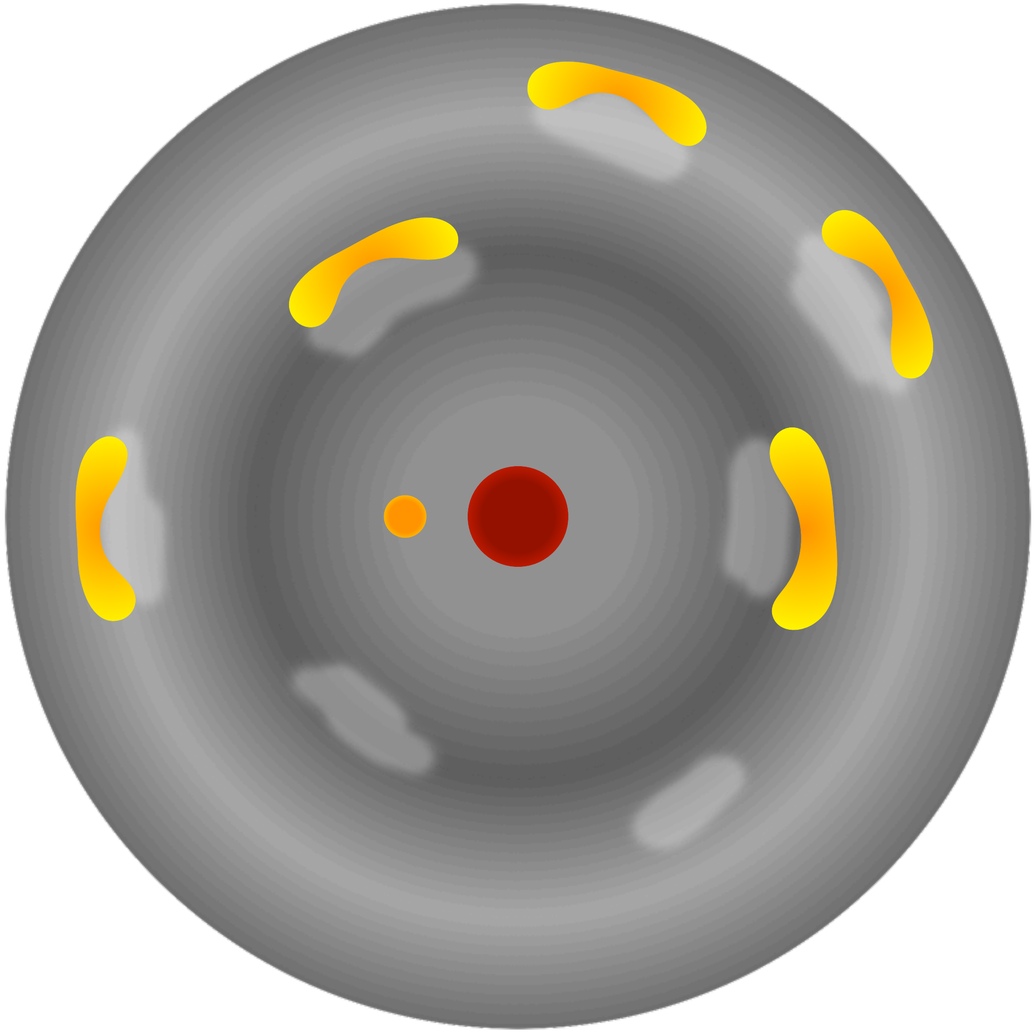

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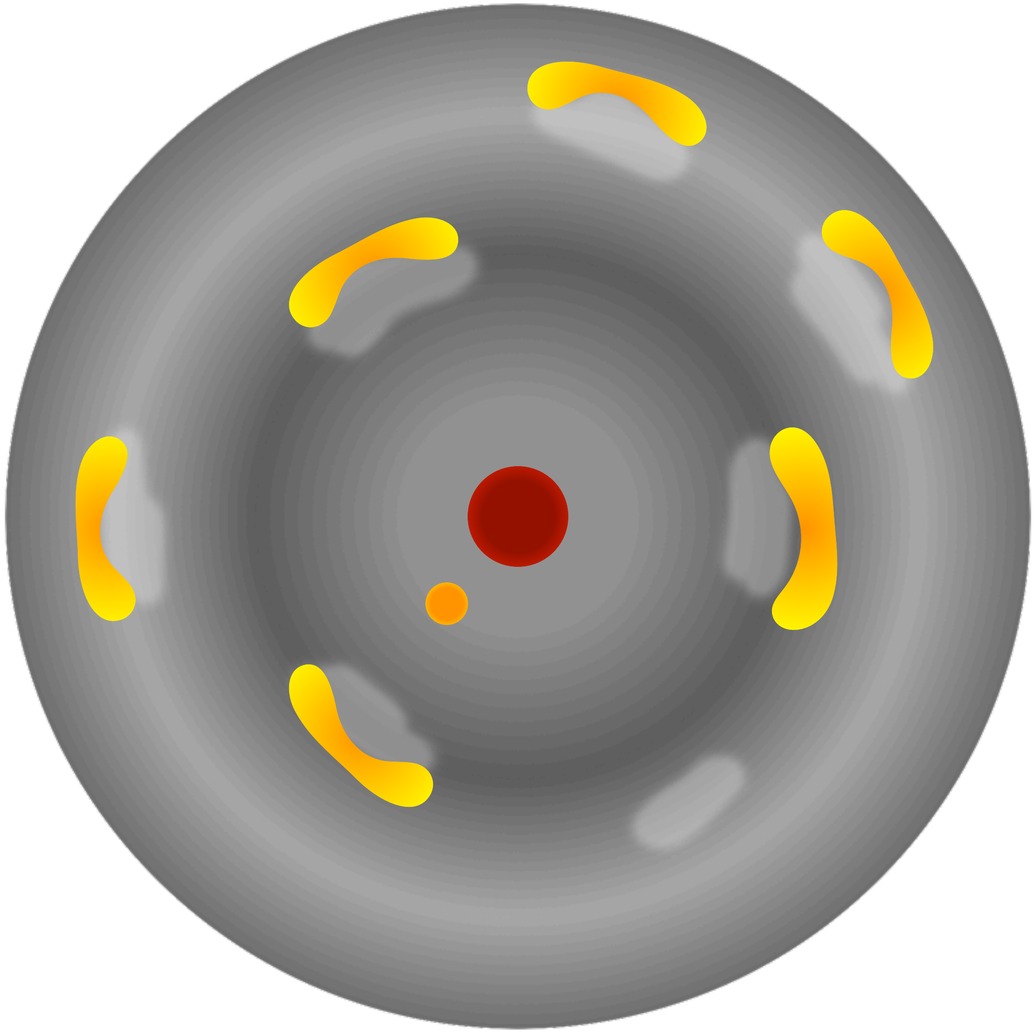

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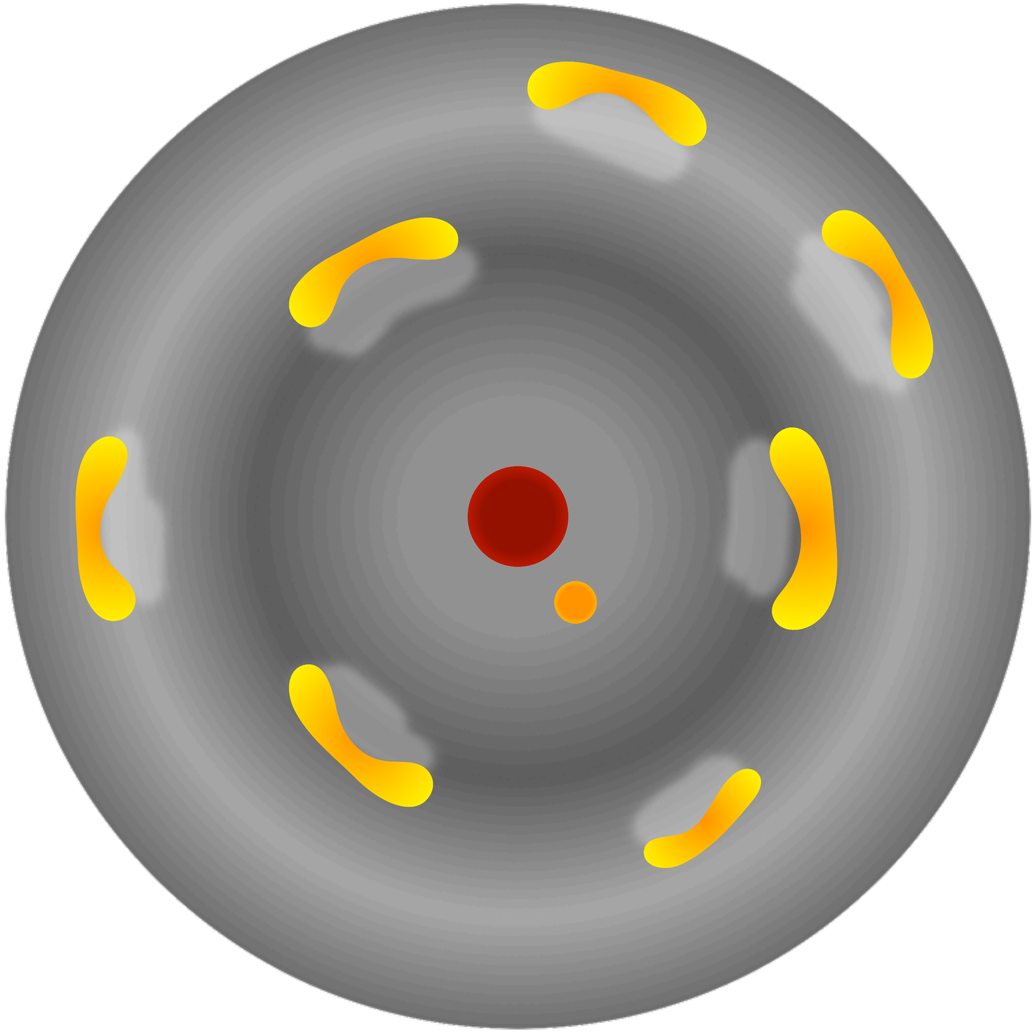

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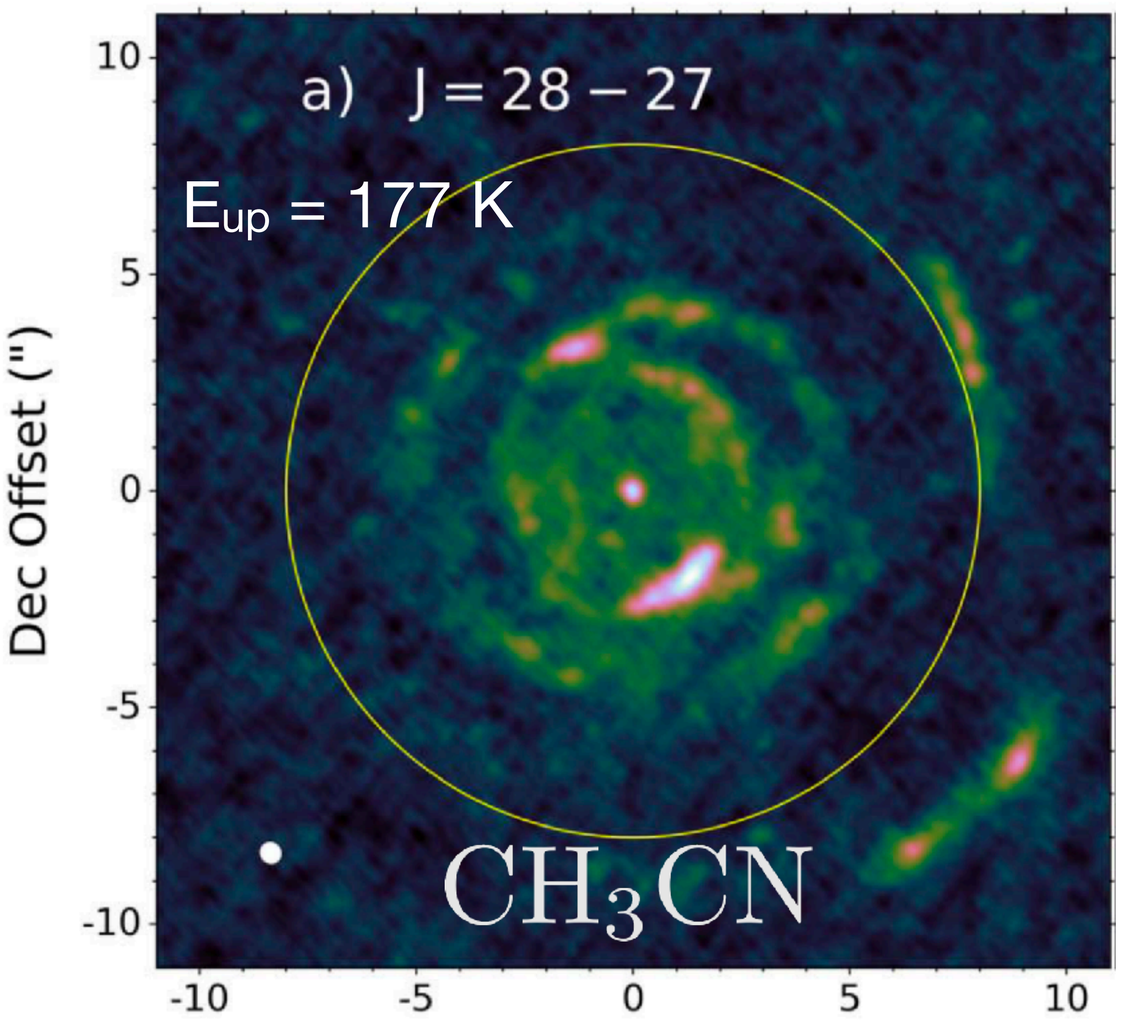

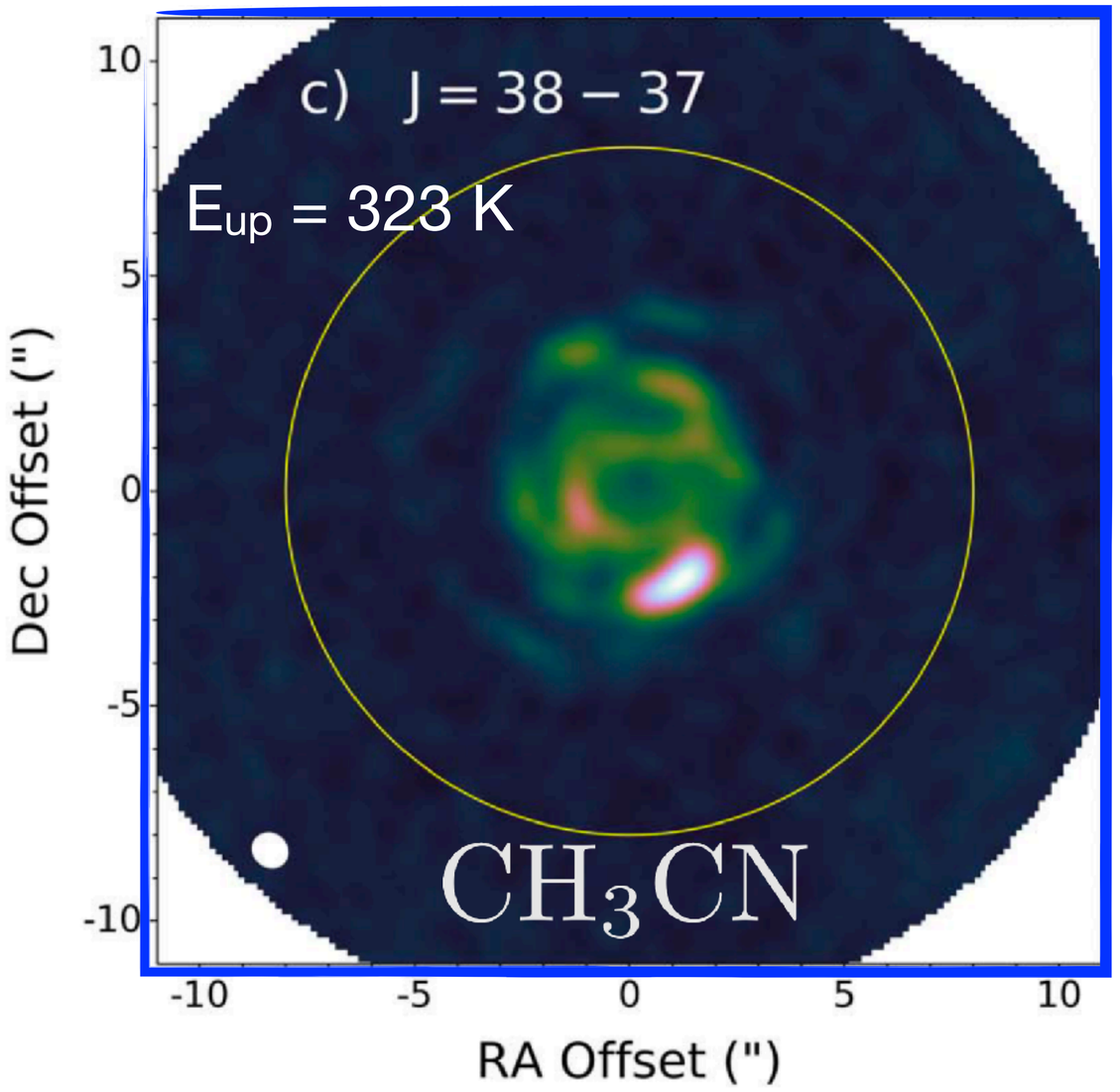

Chemistry as Probe of Circumstellar Environment

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ived 2022 July 8; revised 2022 October 25; accepted 2022 October 26; published 2022 December 14

IRC+10216

YOUR AWARD-WINNING NEWSPAPER
Manchester Evening News
38,773 MONDAY, FEBRUARY 28, 1994

Monday 28 February 1994
Manchester Evening News

Cosmic clues to the birth of a star

MOST mathematicians find adding up their sums interesting enough in themselves.

But for students and staff at Umist the sky is the limit.

When, back in the 1960s, the then head of physics decreed that his department would only study pure theoretical science topics, the astrophysicists moved en masse into the maths department.

Since then, generations of maths graduates have found an added plus in coming to Manchester.

For the last 10 years Dr Tom Millar and his colleagues have been developing a theoretical model of how molecules and particles are distributed around carbon rich stars such as CW Leonis, the nearest star of its type.

Exotic molecules never seen on earth are found in this great cosmic chimney which is helping astronomy understand more about the ways that stars are formed.

CW Leonis is currently passing through the red giant phase on its way to becoming a white dwarf surrounded by planetary nebula.

This is thought to be the final stage of evolution as the star exhausts its nuclear fuel of hydrogen and helium.

He has worked on the project with radio-astronomers in Sweden and last year spent a month at Columbus University in Ohio.

This week he is leaving to spend six months at Leiden University in the Netherlands.


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