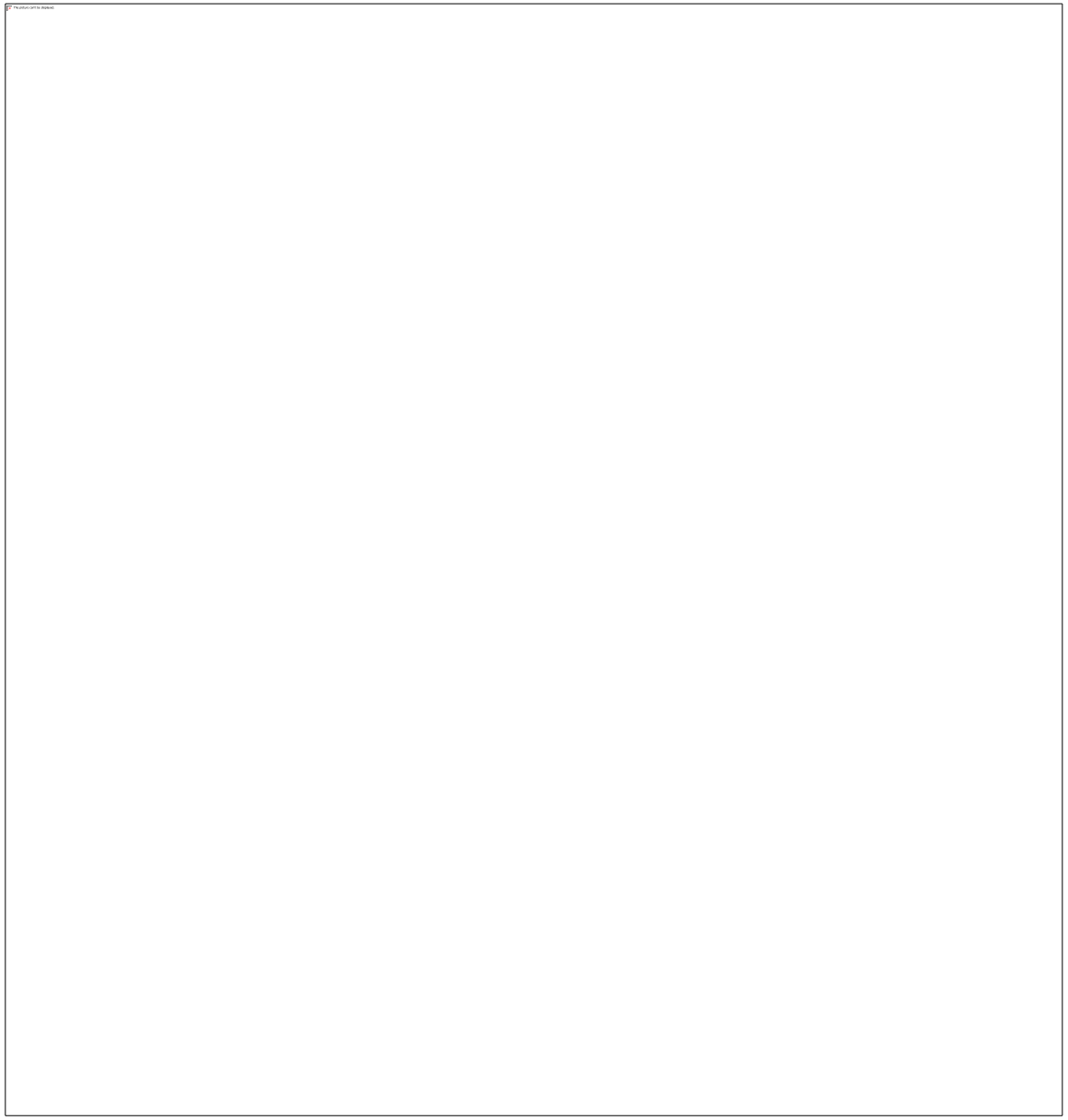
2	3	4	5	6	7 atoms
H_2*,*	C_3*	c-C_3H	C_5*	C_5H	C_6H
AlF	C_2H	l-C_3H	C_4H	l-H_2C_4	CH_2CHCN
AlCl	C_2O	C_3N	C_4Si	C_2H_4	CH_3C_2H
C_2**	C_2S	C_3O	l-C_3H_2	CH_3CN	HC_5N
CH	CH_2	C_3S	c-C_3H_2	CH_3NC	$HCOCH_3$
*CH^+	HCN	C_2H_2*	CH_2CN	CH_3OH	NH_2CH_3
CN	HCO	CH_2D^+?	CH_4*	CH_3SH	c-C_2H_4O
CO	HCO^+	HCCN	HC_3N	HC_3NH^+	H_2CCHOH
CO^+	HCS^+	$HCNH^+$	HC_2NC	HC_2CHO	
CP	HOC^+	HNCO	HCOOH	NH_2CHO	
CSi	H_2O	HNCS	H_2CHN	C_5N	
HCl	H_2S	$HOCO^+$	H_2C_2O	l-HC_4H*	
KCl	HNC	H_2CO	H_2NCN		
HD*	*H_3^+,H_2D^+,HD_2^+				
	HN_2^+	NH_3, ND_3			

* Infrared **Optical l - linear c-cyclic



Big Molecules

8 atoms 9 10 11 12 13

CH_3C_3N CH_3C_4H CH_3C_5N ? HC_9N C_6H_6*? $HC_{11}N$

$HCOOCH_3$ CH_3CH_2CN $(CH_3)_2CO$

CH_3COOH $(CH_3)_2O$ $(CH_2OH)_2$?

C_7H CH_3CH_2OH H_2NCH_2COOH Glycine??

H_2C_6 HC_7N

CH_2OHCHO? C_8H

l-HC_6H*


Copyright Dominique Dierick

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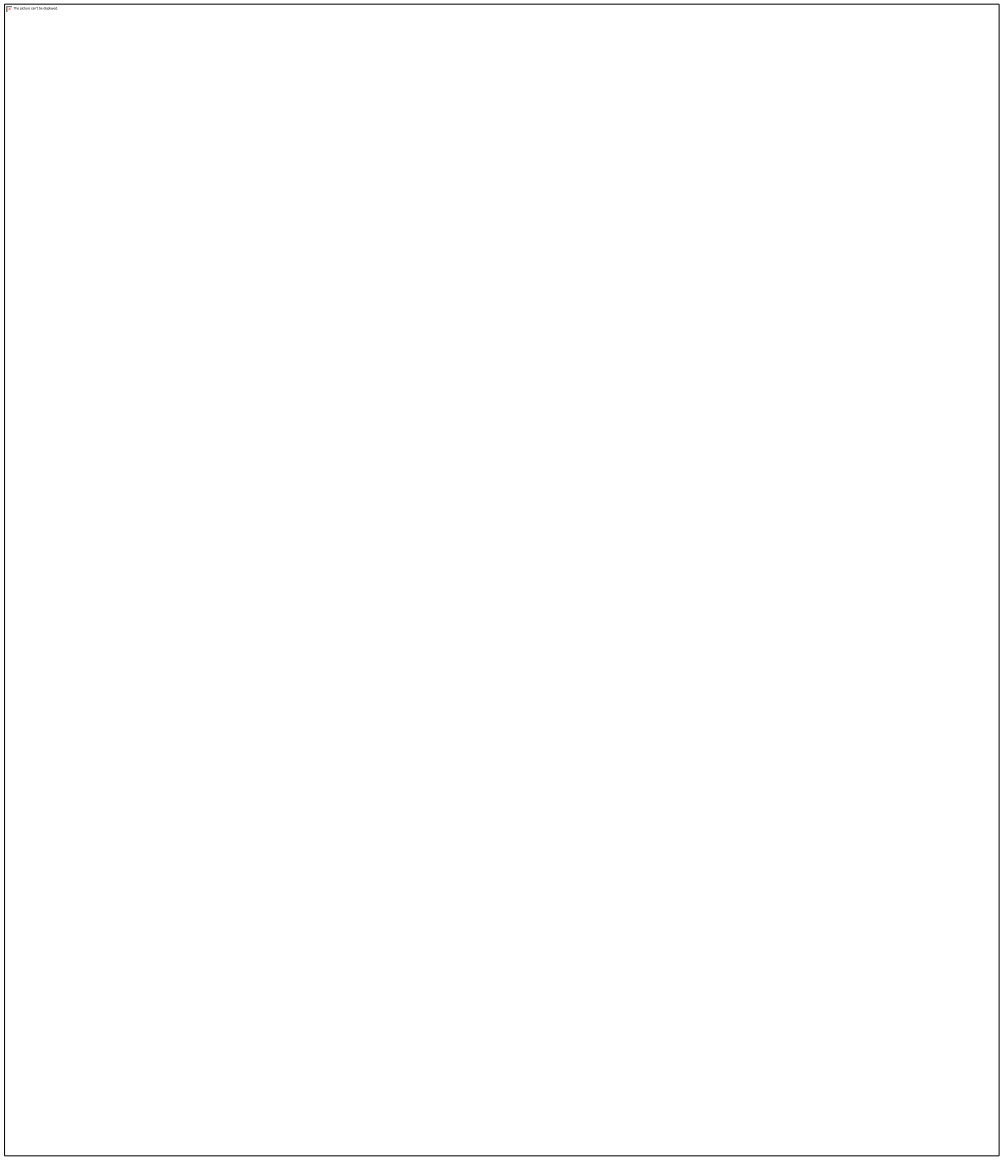
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137—135 n=109—>108 He C

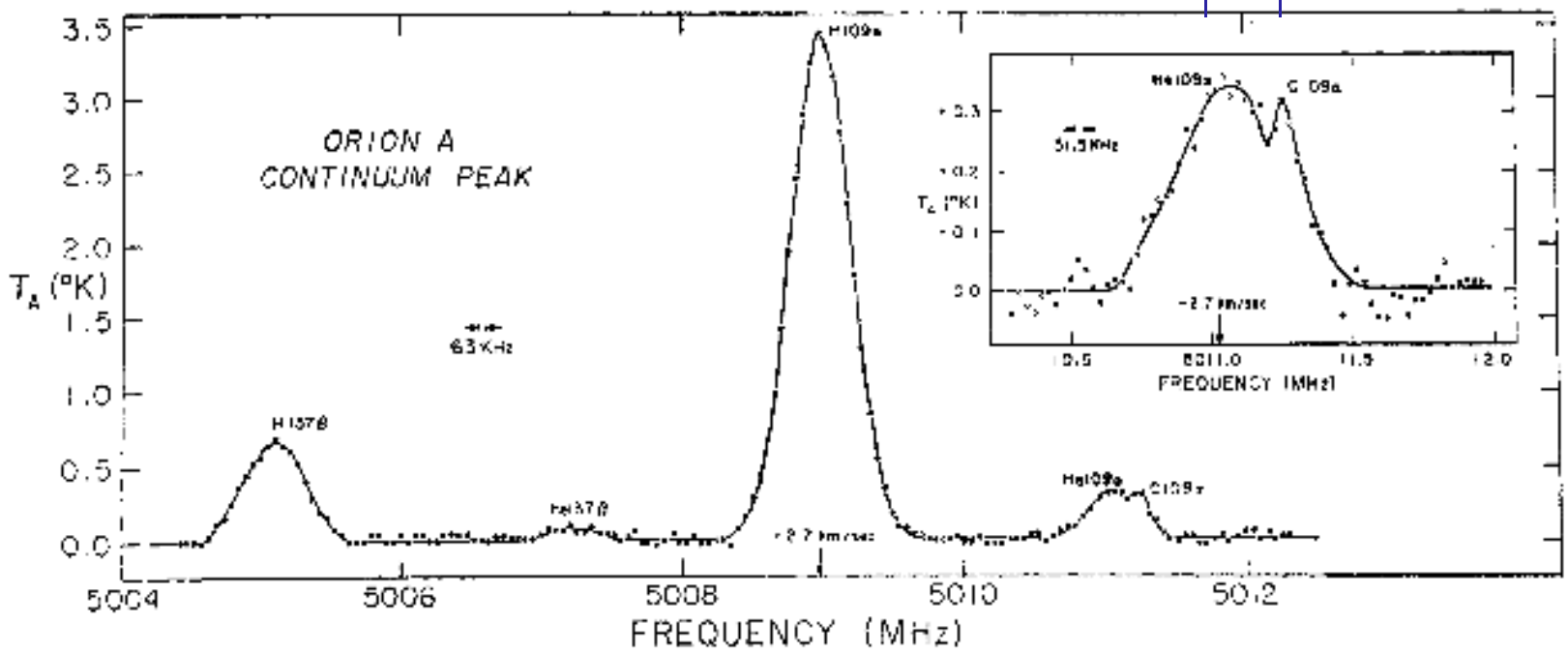
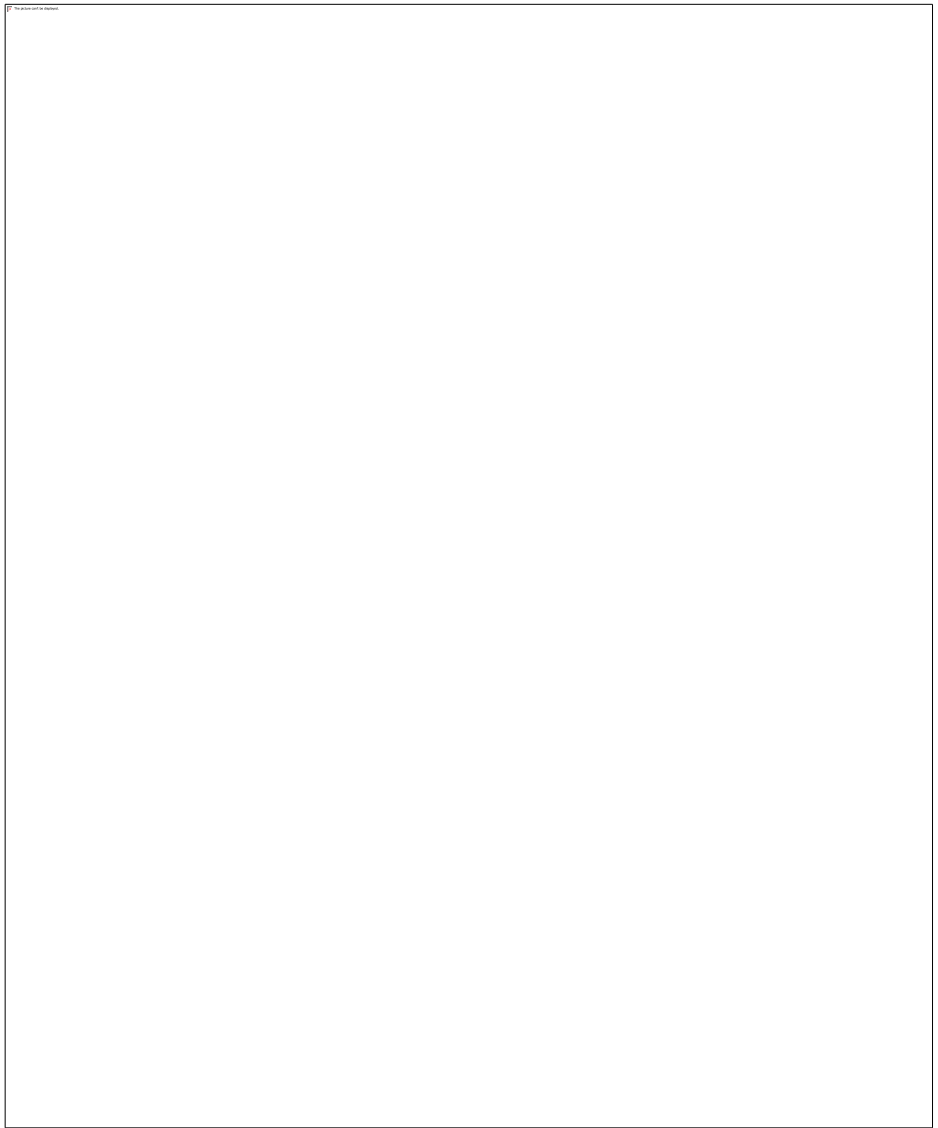


FIGURE 1. A broadband spectrogram showing recombination lines at the center of Orion A (M42). These observations were made with the 400-channel autocorrelator at the 140′ telescope of the NRAO in Green Bank, West Virginia by Churchwell & Mezger (1970). Five recombination lines are indicated: H 137β, He 137β, H 109α, He 109α, and the narrow anomalous line labeled C 109α. The bandwidth corresponds to 3.8 km sec^{-1} in the large figure, and 1.9 km sec^{-1} in the insert.

CECILIA PAYNE-GAPOSCHKIN: ASTRONOMER AND ASTROPHYSICIST 1900-1980 "THE MOST BRILLIANT Ph.D. THESIS EVER WRITTEN IN ASTRONOMY"

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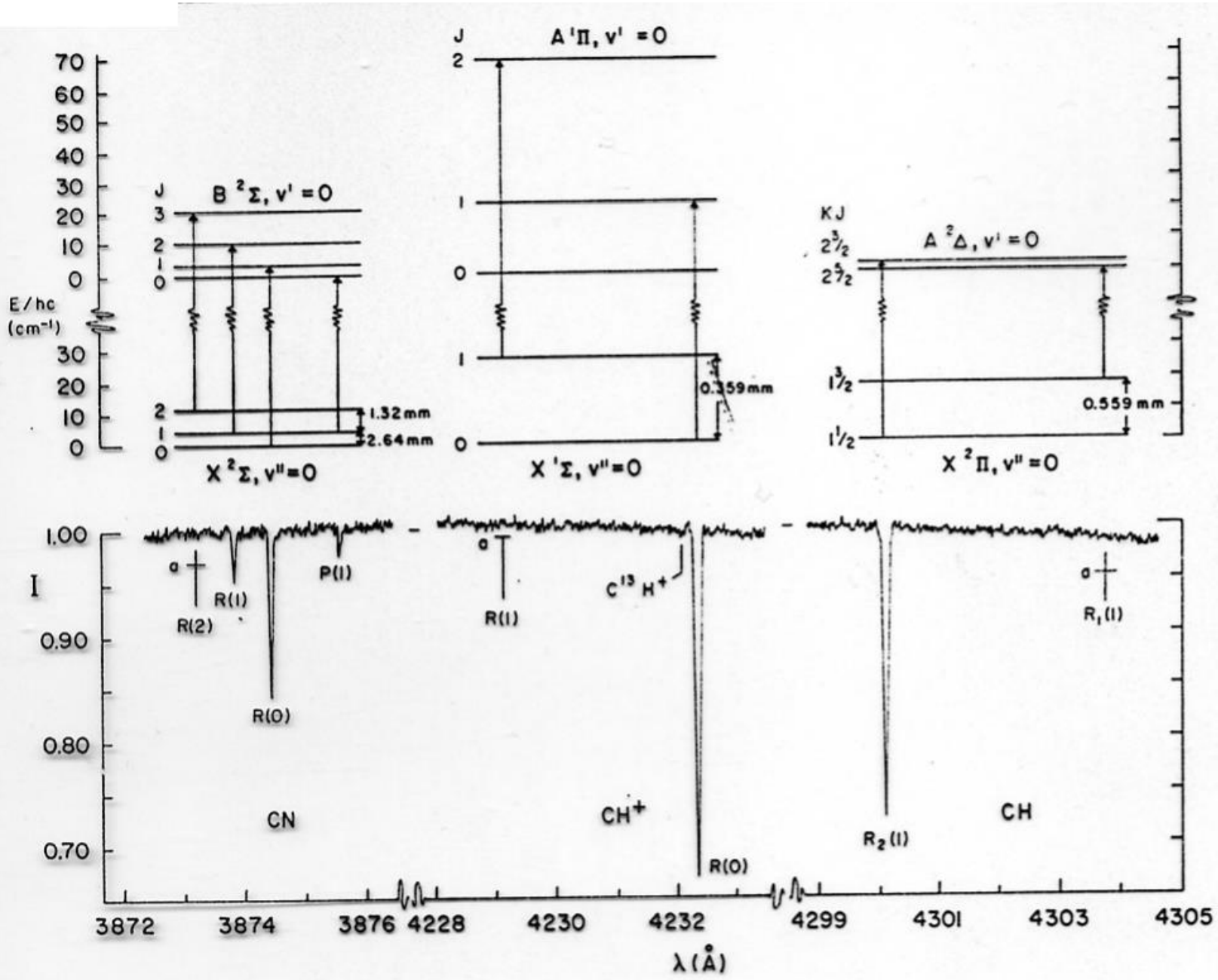
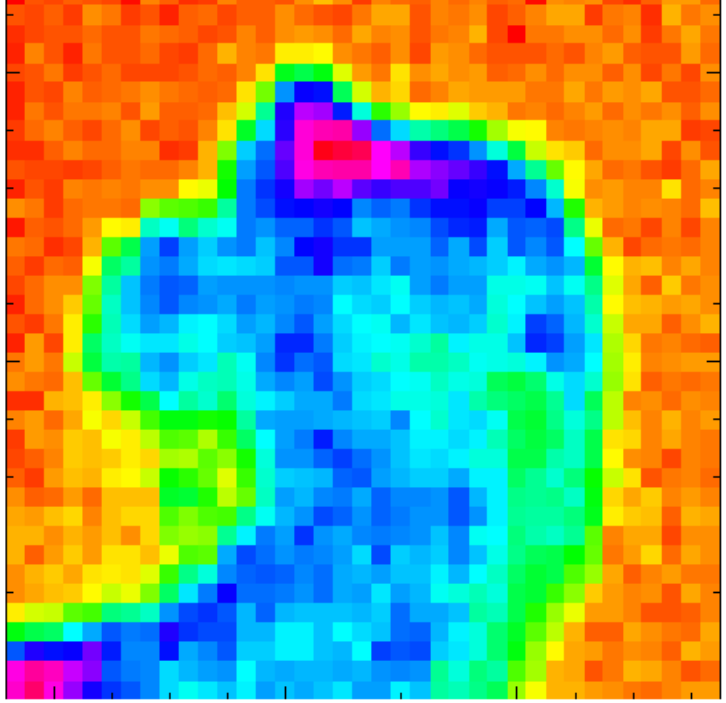

E/hc (cm⁻¹)
70
60
50
40
30
20
10
0
30
20
10
0
J
B ²Σ, v' = 0
3
2
1
0
2
1
0
1.32mm
2.64mm
X ²Σ, v''=0
J
A ¹Π, v' = 0
2
1
0
1
0
0.359mm
X ¹Σ, v''=0
KJ
A ²Δ, v' = 0
2 3/2
2 5/2
1 3/2
1 1/2
0.559 mm
X ²Π, v''=0
I
1.00
0.90
0.80
0.70
a
R(2)
R(1)
R(0)
P(1)
CN
a
R(1)
C 13 H+
R(0)
CH+
a
R1(1)
R2(1)
CH
3872
3874
3876
4228
4230
4232
4299
4301
4303
4305
λ(Å)

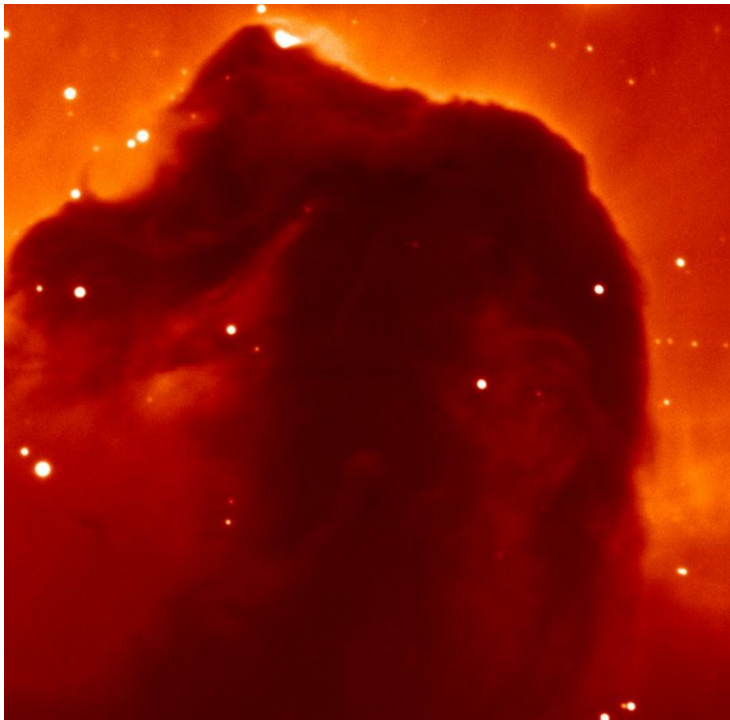
CO J=1—0 in Orion 115.3GHz

Galaxy • M104

Horsehead nebula in Orion

. Observed by microwave emission of carbon monoxide The green and yellow regions are of greater concentrations of carbon monoxide. Cal Tech





Chemical Equilibrium

$$CO + 3H_2 = CH_4 + H_2O$$

$$\Delta H^0 = -49.3 \text{ kcal}; \Delta G^0 = -45 \text{ kcal}$$

(20K)

$$K=[CH_4][H_2O]/[CO][H_2]^3=10^{490}\ cm^6$$

Observation $[CO]/[H_2] = 10^{-4}$

$$[H_2O] \leq 10^{-4}\,[CO]$$

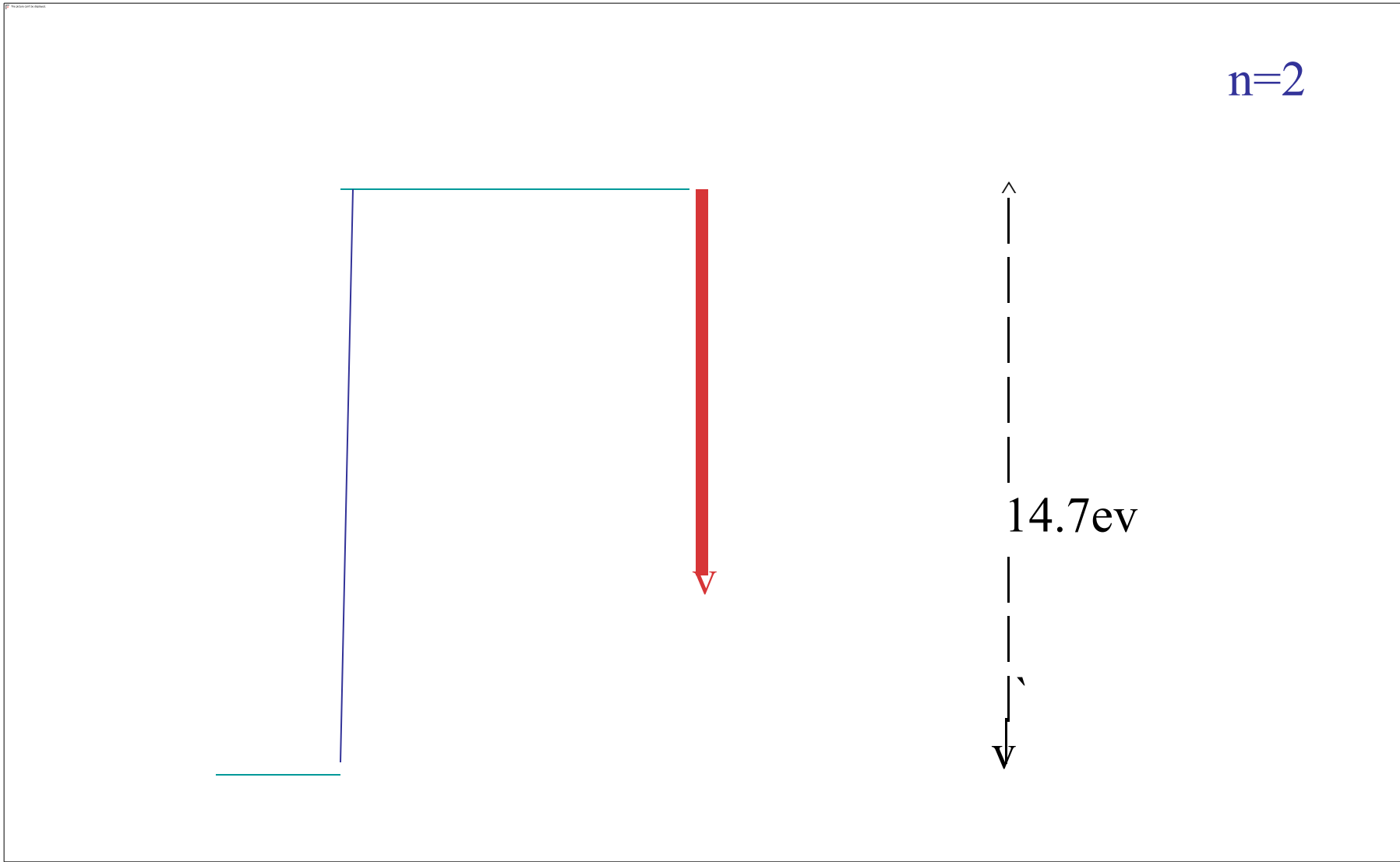
$$[CH_4] < 10^{-4}\,[CO]$$

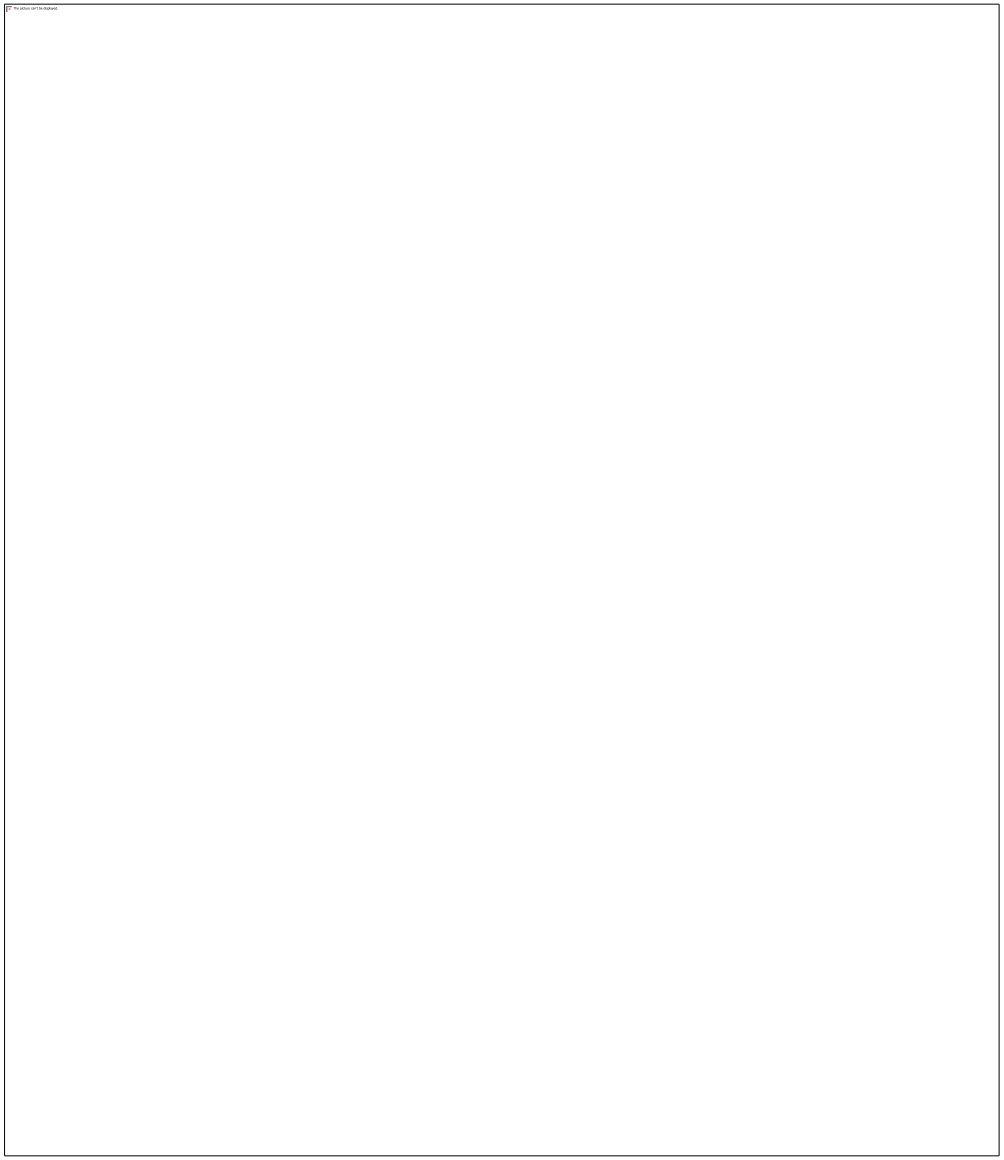
Prediction/Observation $> 10^{500}$

$[H]/[H_2]$ = ??

H + H = H_2 grain surface

$H_2 + h\nu = 2\ H$

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Primary Ionization

$$H_2 + crp(\geq 100Mev) = H_2^+$$

$$He + crp(\geq 100Mev) = He^+$$

Secondary Reactions

$$H_2^+ + H_2 = H_3^+ + H \quad \text{fast (10 min } [H_2] = 10^6 \text{ cm}^{-1}$$

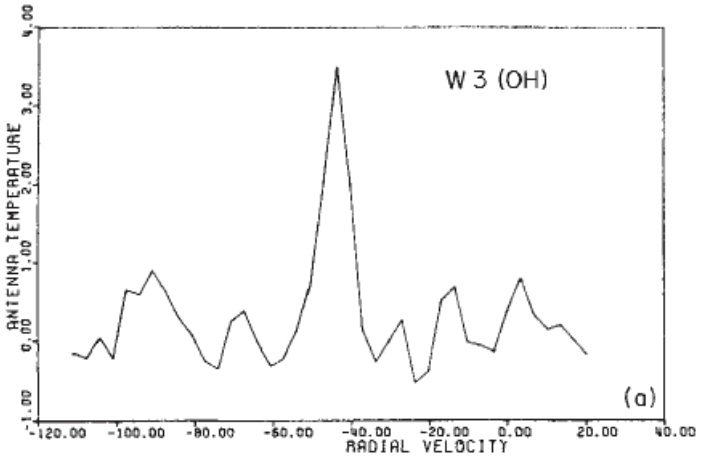
$$He^+ + H_2 \neq HeH^+ + H \quad \text{very slow at low T}$$

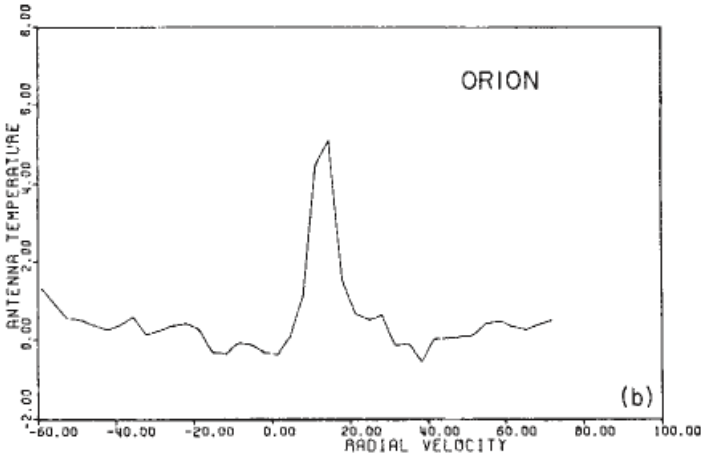
$$He + H^+ + H \quad \text{"}$$

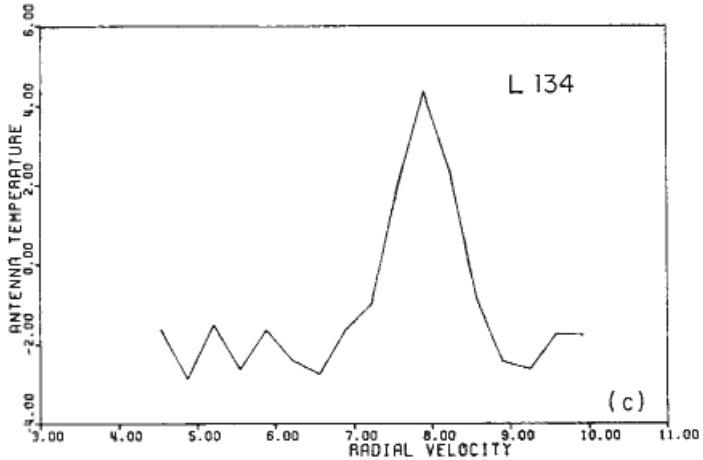
$$H_3^+ + CO = HCO^+ + H_2$$

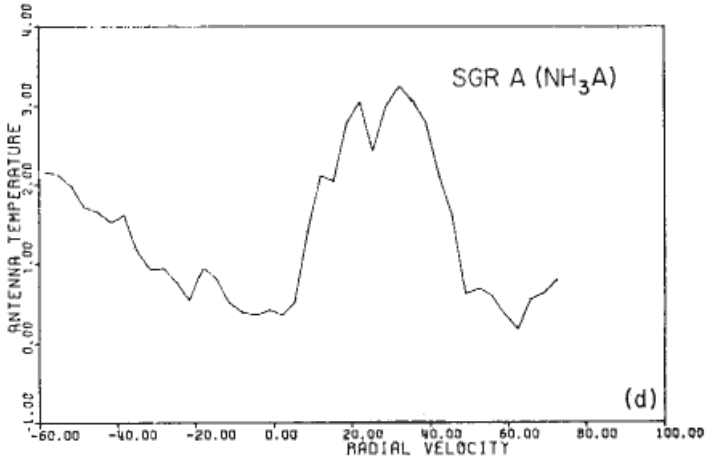
$$He^+ + CO = C^+ + O + He$$

$$[He] \approx 10^3 [CO]$$









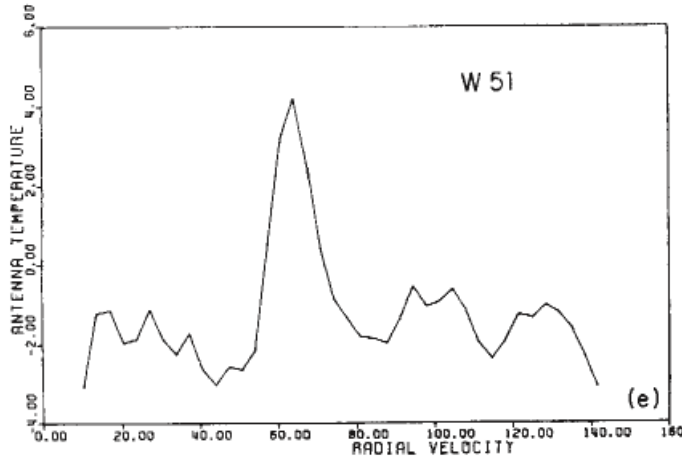
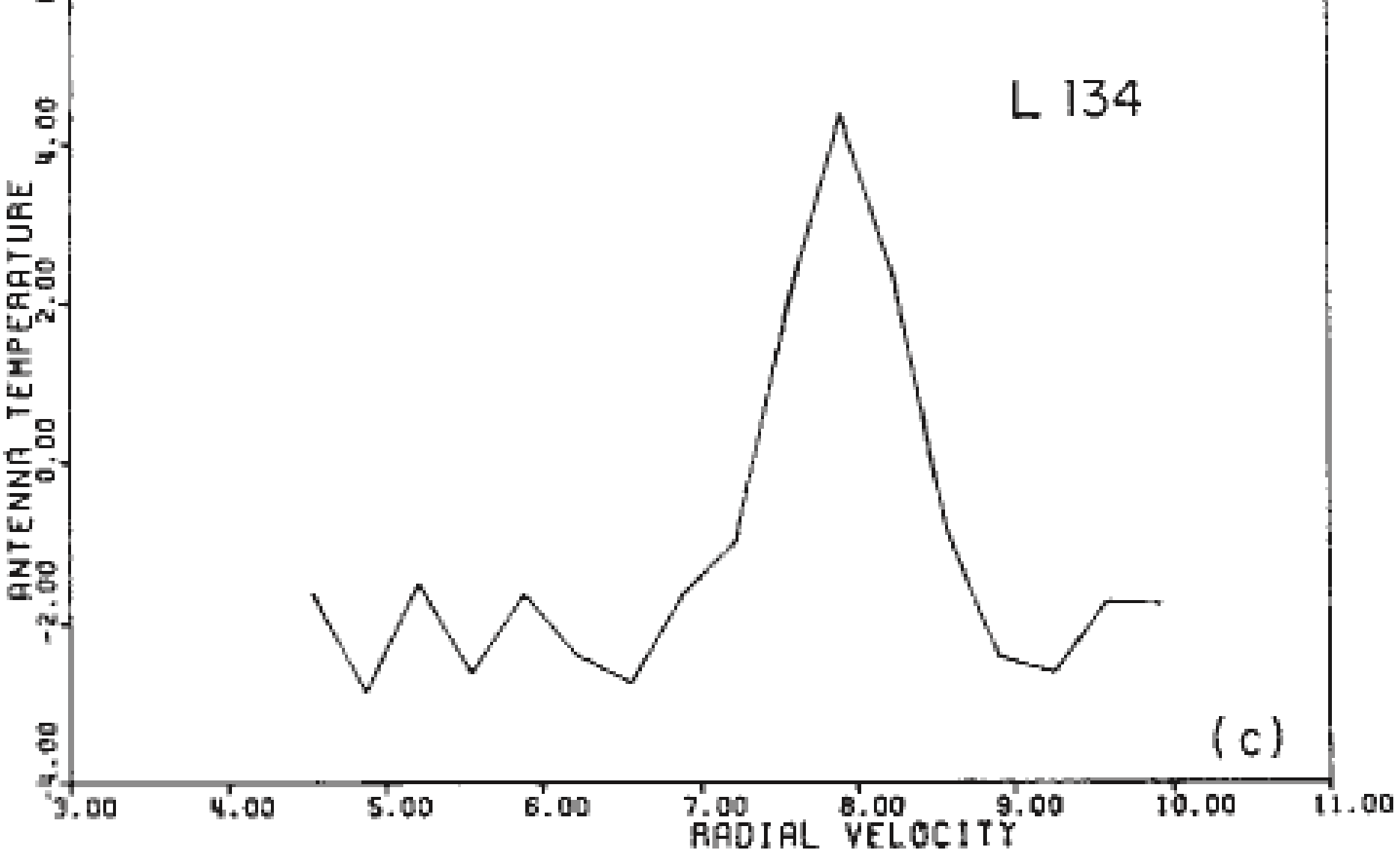


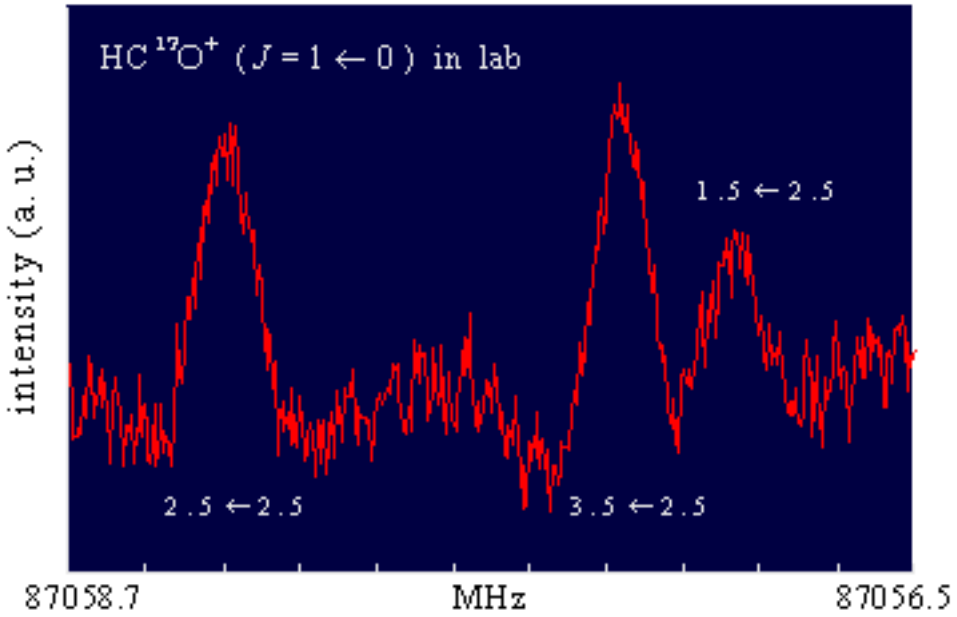
Fig. 1. X-ogen spectra observed for: *a*, W3 (OH); *b*, Orion; *c*, L134; *d*, Sgr A (NH_3A); and *e*, W51. Antenna temperature is in degrees Kelvin uncorrected for antenna efficiency (and dome attenuation in the case of Orion). Radial velocity is in km s^{-1} corrected to the local standard of rest. Spectrum for L134 taken with 100 kHz filter spacing.

Unidentified Interstellar Microwave Line

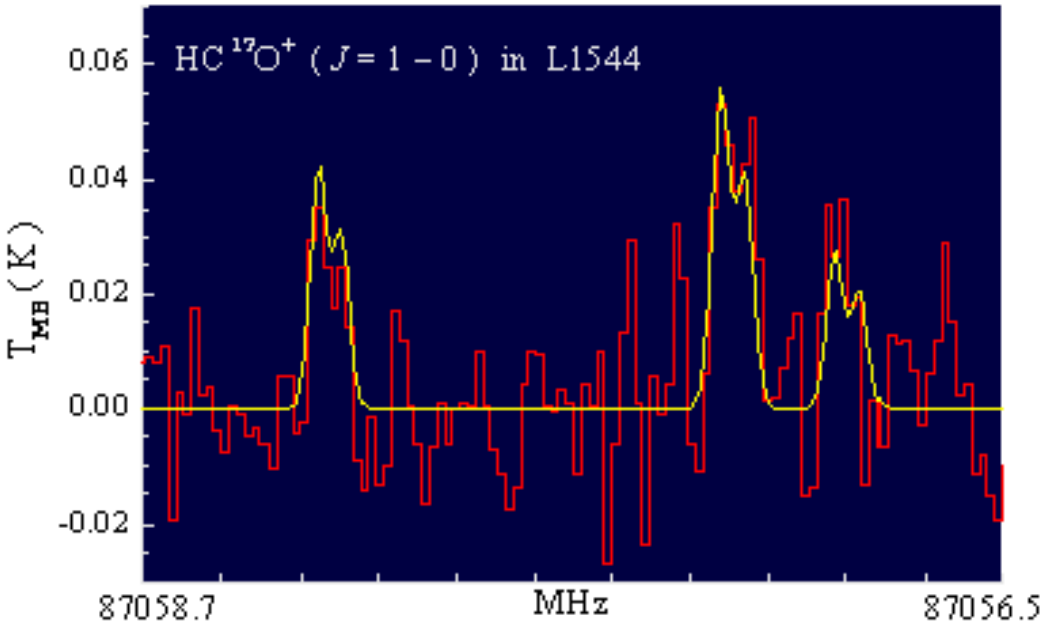
L. E. Snyder D. Buhl



lation. Klemperer[5] has suggested the molecular ion $H^{12}C^{16}O^+$ and calculated the $J = 1 - 0$ transition frequency to be 89,246 MHz which is only 55 MHz above the X-ogen frequency. There is no apparent identification conflict



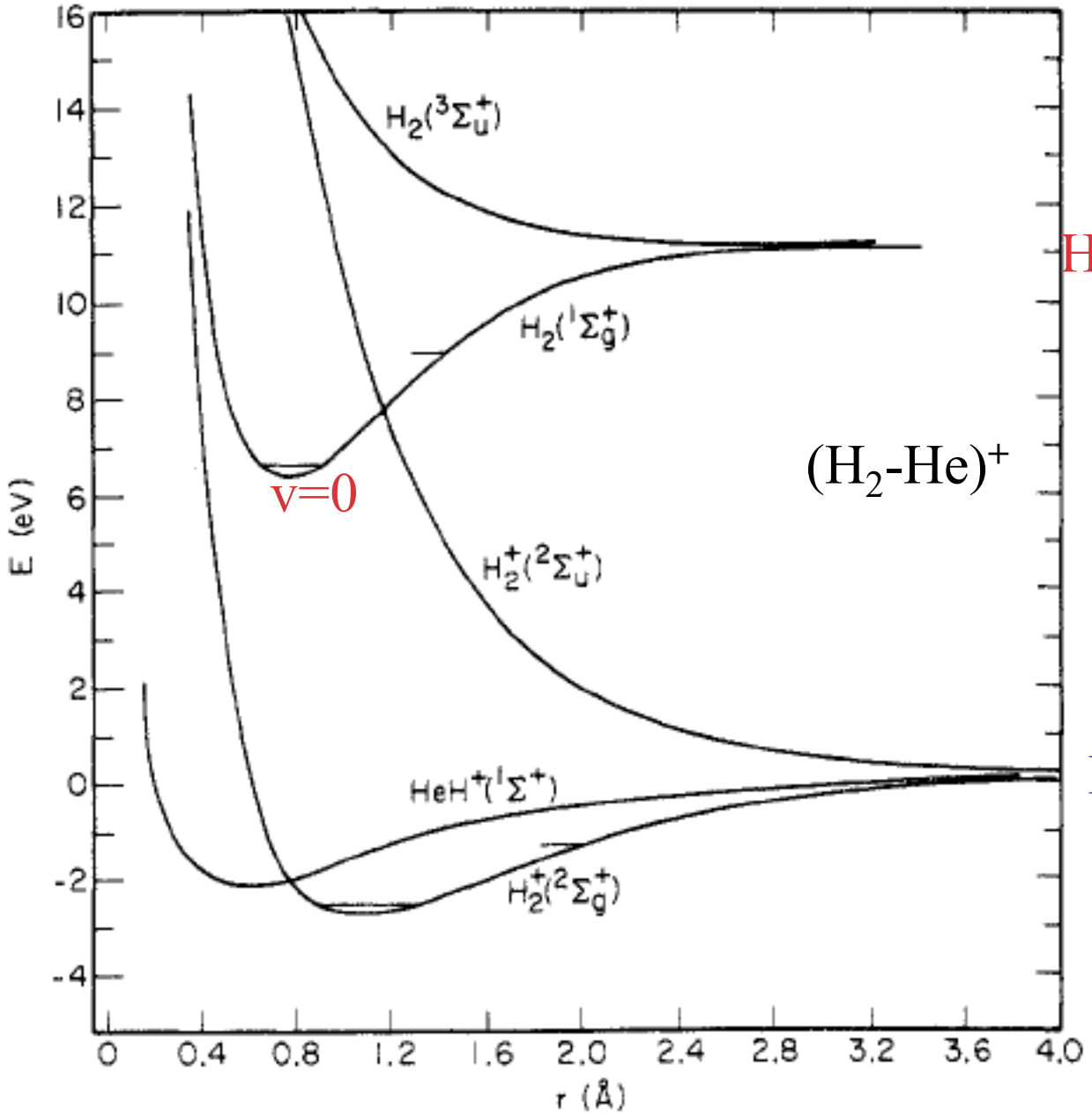
University of Bologna



^{17}O/^{16}O =

0.00037

Bruce Mahan Accounts Chem. Research 1975



He^++H+H

$(H_2\text{-}He)^+$

He +H+H^+

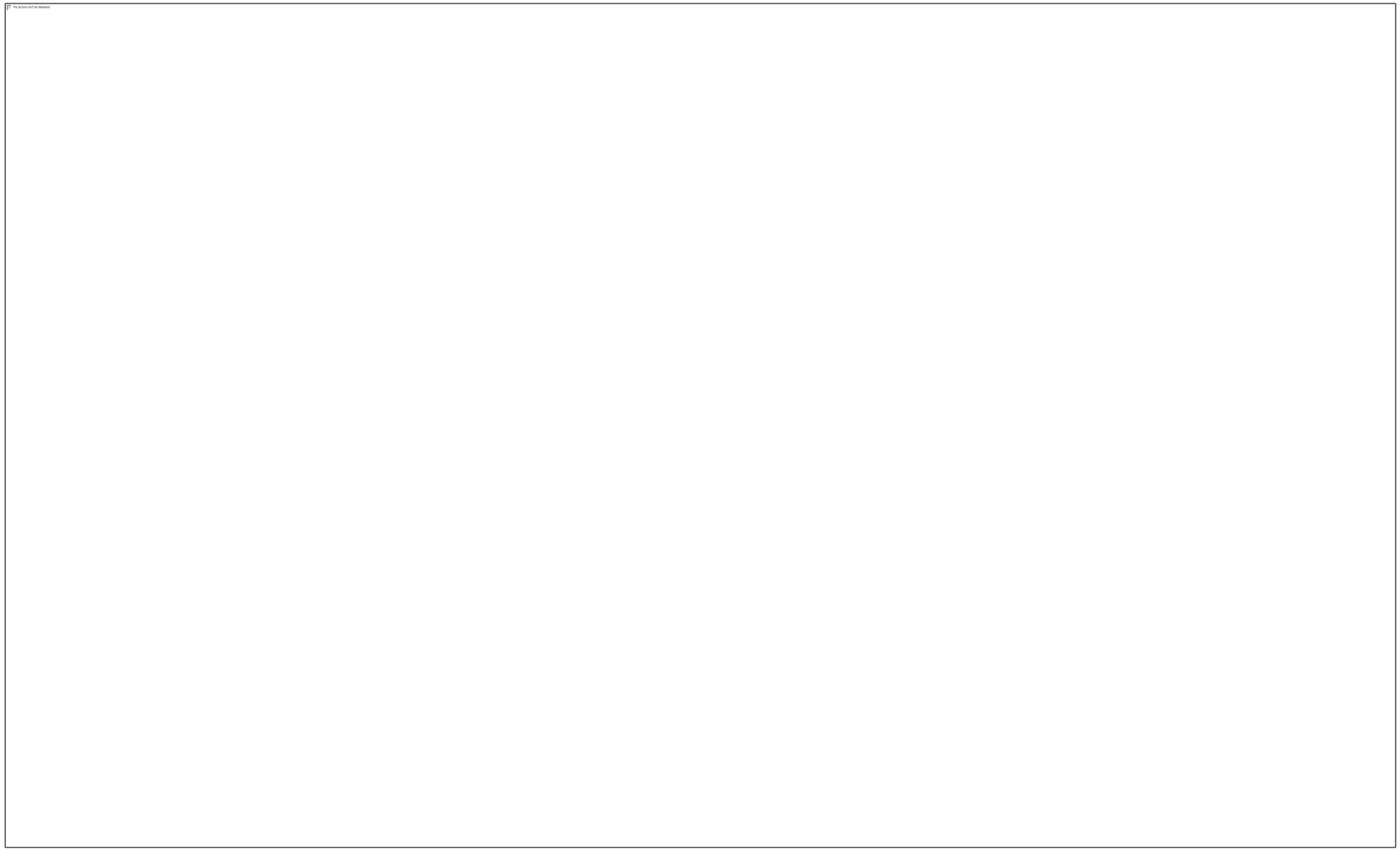
2	3	4	5	6	7 atoms
H_2*,*	C_3*	c-C_3H	C_5*	C_5H	C_6H
AlF	C_2H	l-C_3H	C_4H	l-H_2C_4	CH_2CHCN
AlCl	C_2O	C_3N	C_4Si	C_2H_4	CH_3C_2H
C_2**	C_2S	C_3O	l-C_3H_2	CH_3CN	HC_5N
CH	CH_2	C_3S	c-C_3H_2	CH_3NC	$HCOCH_3$
*CH^+	HCN	C_2H_2*	CH_2CN	CH_3OH	NH_2CH_3
CN	HCO	CH_2D^+?	CH_4*	CH_3SH	c-C_2H_4O
CO	HCO^+	HCCN	HC_3N	HC_3NH^+	H_2CCHOH
CO^+	HCS^+	$HCNH^+$	HC_2NC	HC_2CHO	
CP	HOC^+	HNCO	HCOOH	NH_2CHO	
CSi	H_2O	HNCS	H_2CHN	C_5N	
HCl	H_2S	$HOCO^+$	H_2C_2O	l-HC_4H*	
KCl	HNC	H_2CO	H_2NCN		
HD*	*H_3^+,H_2D^+,HD_2^+				
	HN_2^+	NH_3, ND_3			

* Infrared **Optical l - linear c-cyclic

Big Molecules

8 atoms	9	10	11	12	13 atms
CH_3C_3N	CH_3C_4H	CH_3C_5N ?	HC_9N	C_6H_6*(?)	$HC_{11}N$
$HCOOCH_3$	CH_3CH_2CN	$(CH_3)_2CO$			
CH_3COOH	$(CH_3)_2O$		$(CH_2OH)_2$?		
C_7H	CH_3CH_2OH	H_2NCH_2COOH Glycine??			
H_2C_6	HC_7N				
CH_2OHCHO?	C_8H				
l-HC_6H*					

http://www.ph1.uni-koeln.de/vorhersagen/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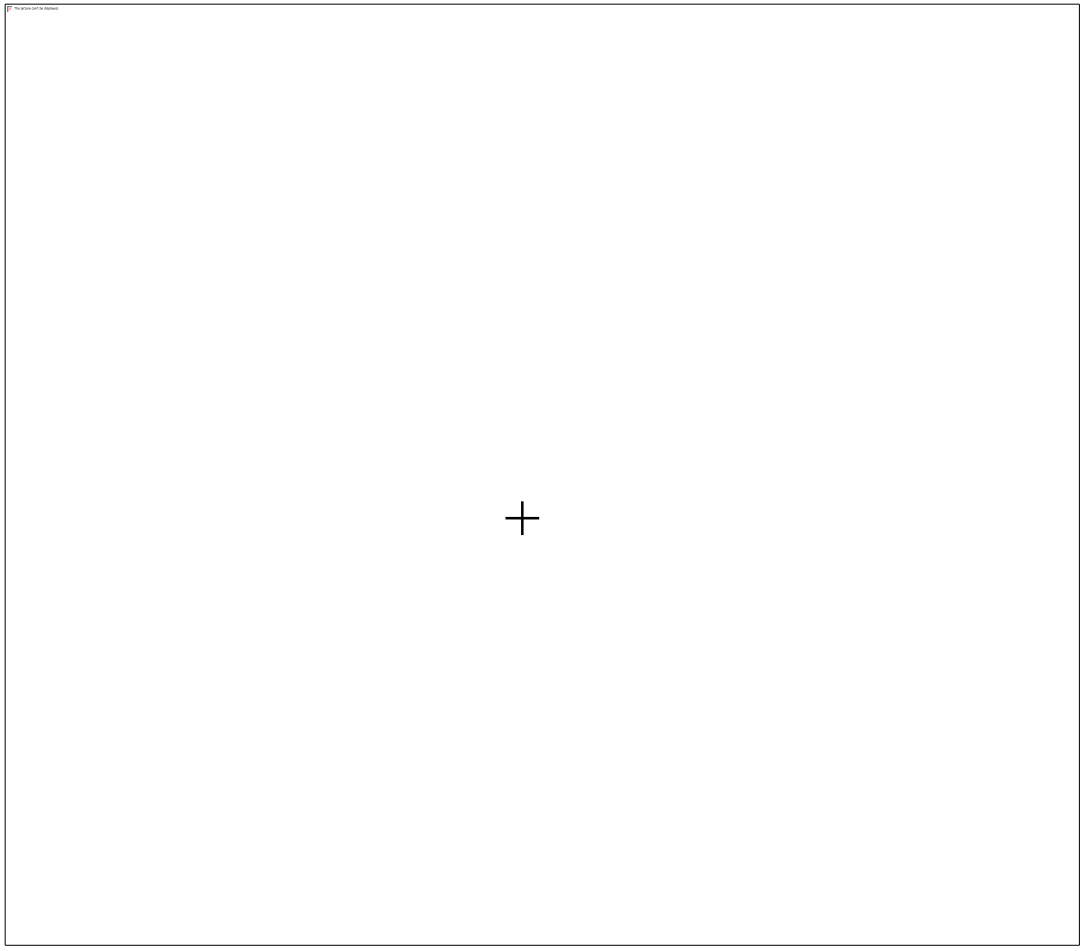
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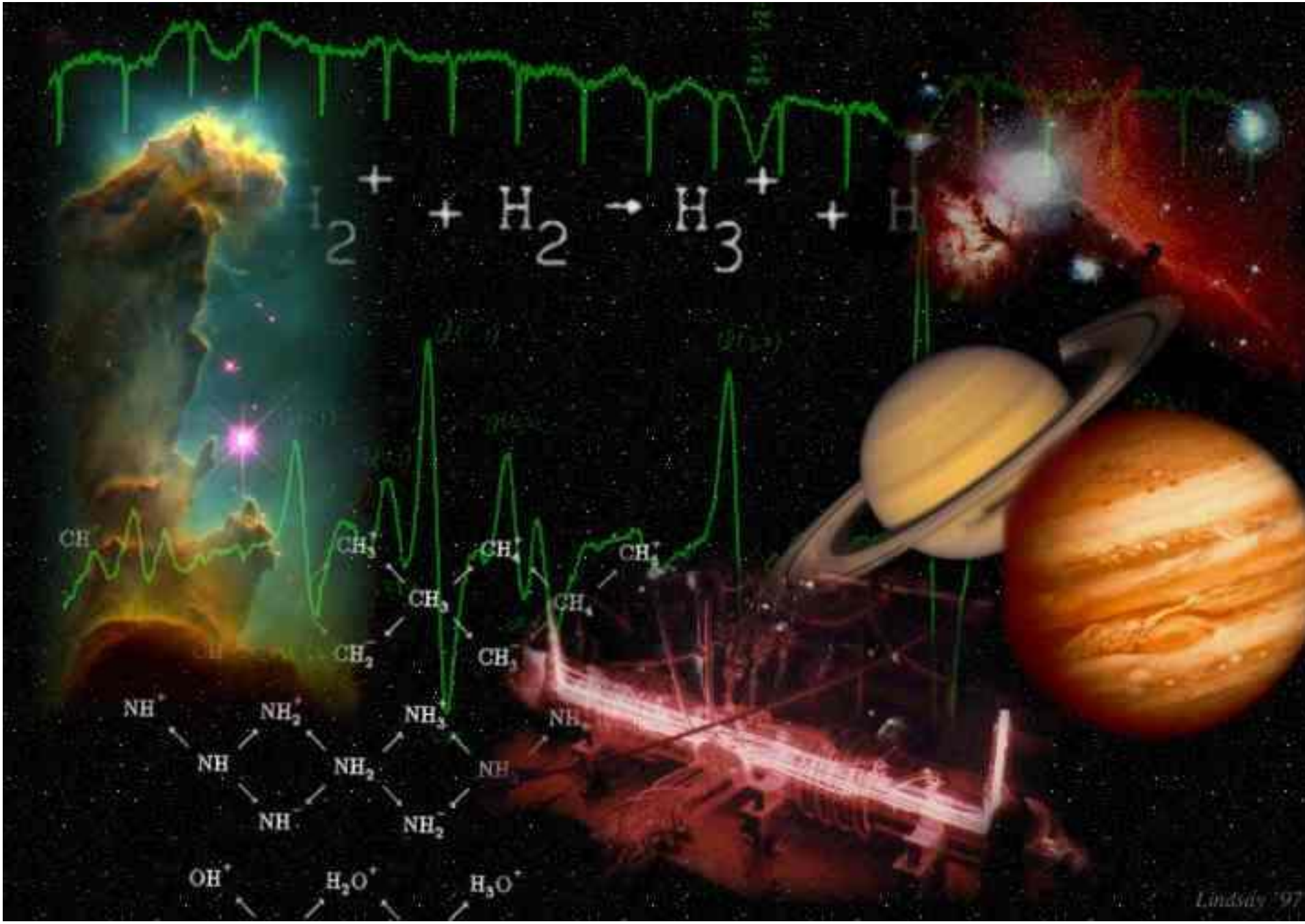
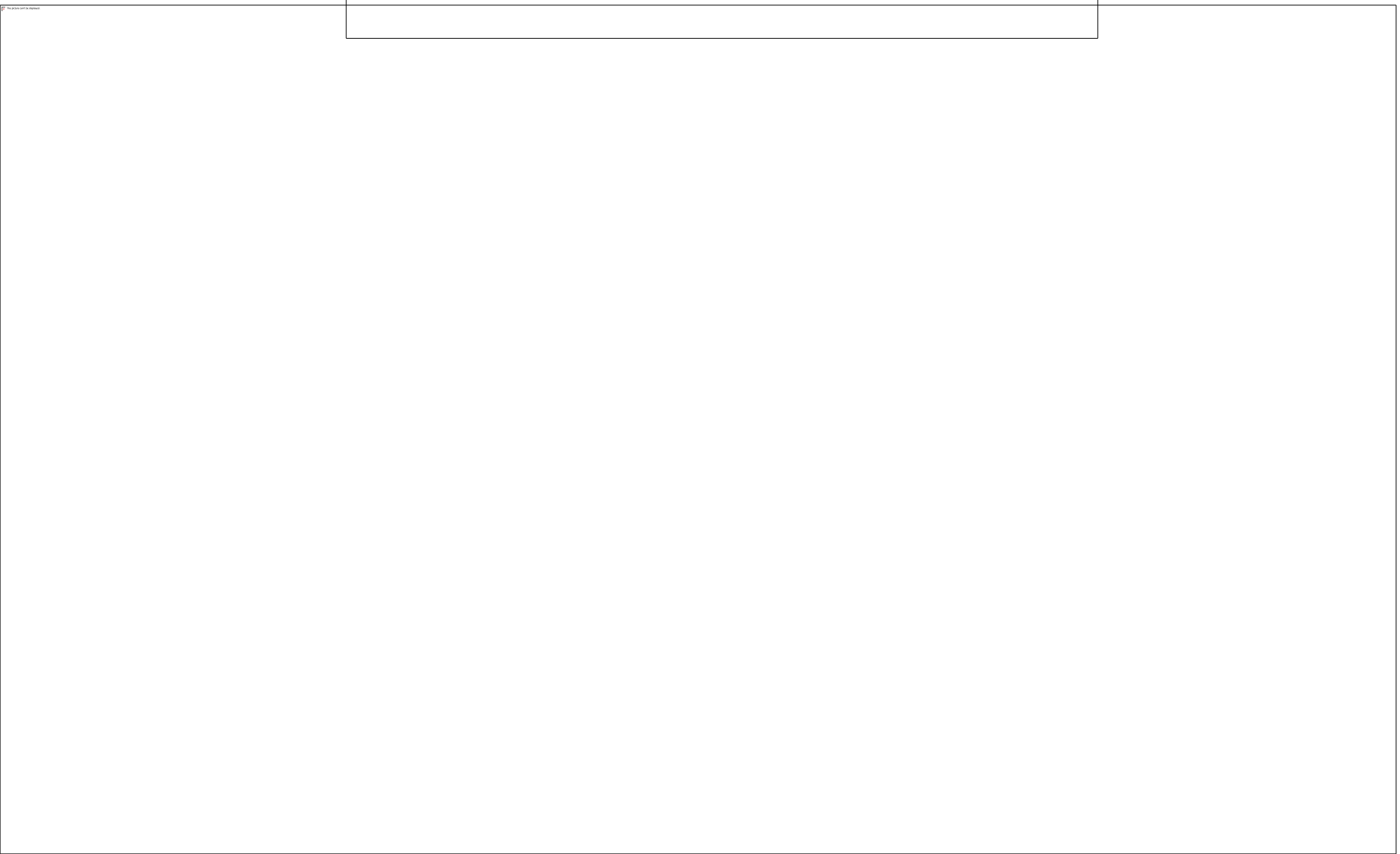

$H_2^+ + H_2 \rightarrow H_3^+ + H$
CH
CH_3^+
CH_4^+
CH_5^+
CH_3
CH_4
CH_2
CH_3^-
NH
NH_2
NH_3
NH_4
NH
NH_2
NH
NH
NH_2^-
OH
H_2O
H_3O
Lindsay '97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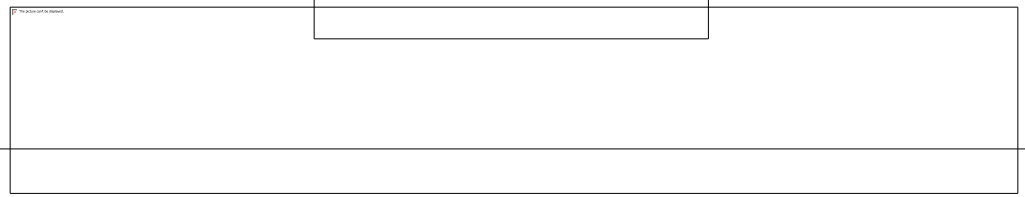
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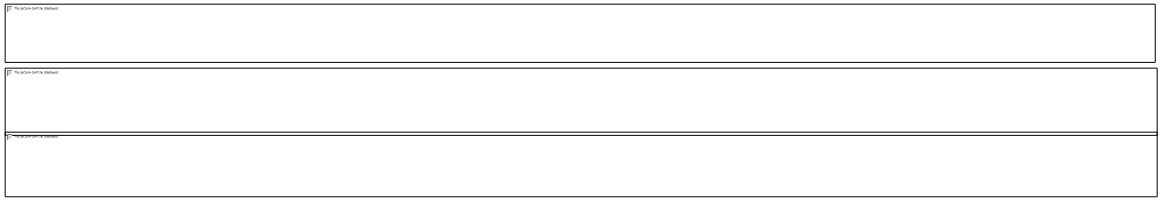
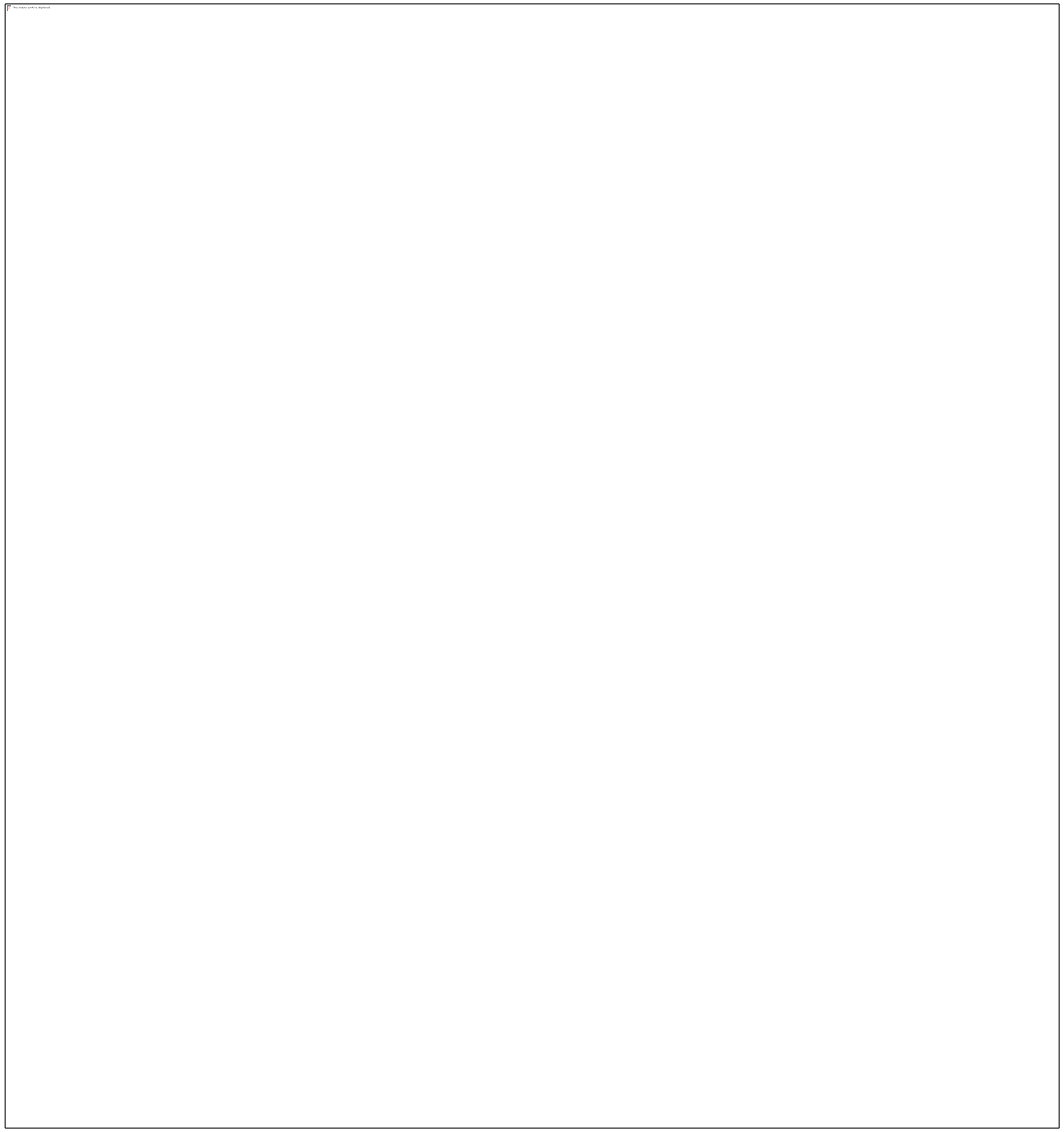


Ap. J.**472**, L49 (1996)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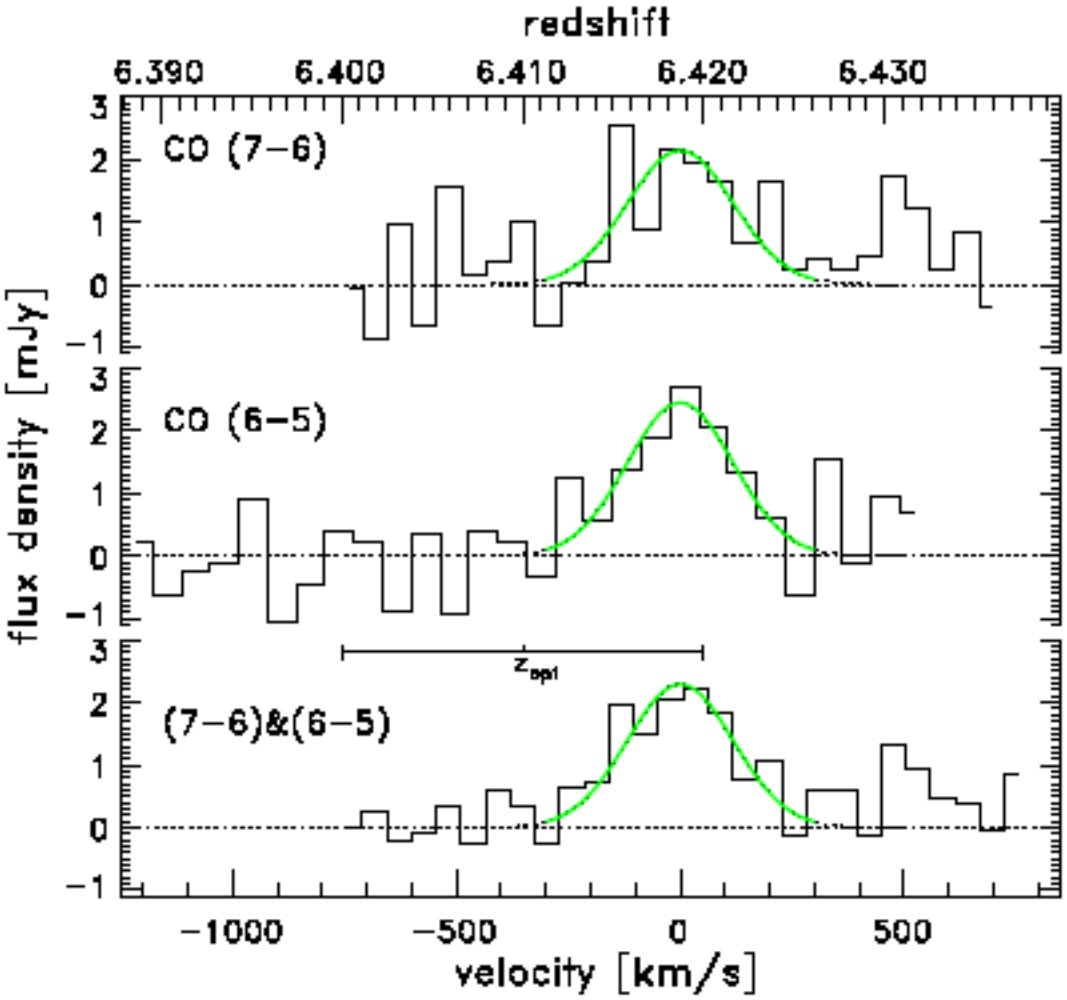
Molecules from Other Galaxies

CO	HCN	HNC	CH	CN
NH_3	**HCO^+**	N_2H^+	C_3H_2	
CH_3OH	C_2H	OCS	H_2CO	
OH	H_2O	SiO	SO	
HCCCN	HNCO	CH_3CCH	CH_3CN	

Phil Solomon

High-excitation CO in a quasar host galaxy at $z = 6.42$ ⋆

F. Bertoldi[1], P. Cox[2], R. Neri[3], C.L. Carilli[4], F. Walter[4], A. Omont[5], A. Beelen[2], C. Henkel[1], X. Fan[6], Michael A. Strauss[7], K.M. Menten[1]



93.206GHz

Fig. 1. J1148+5251 spectra of CO (6→5), (7→6), an

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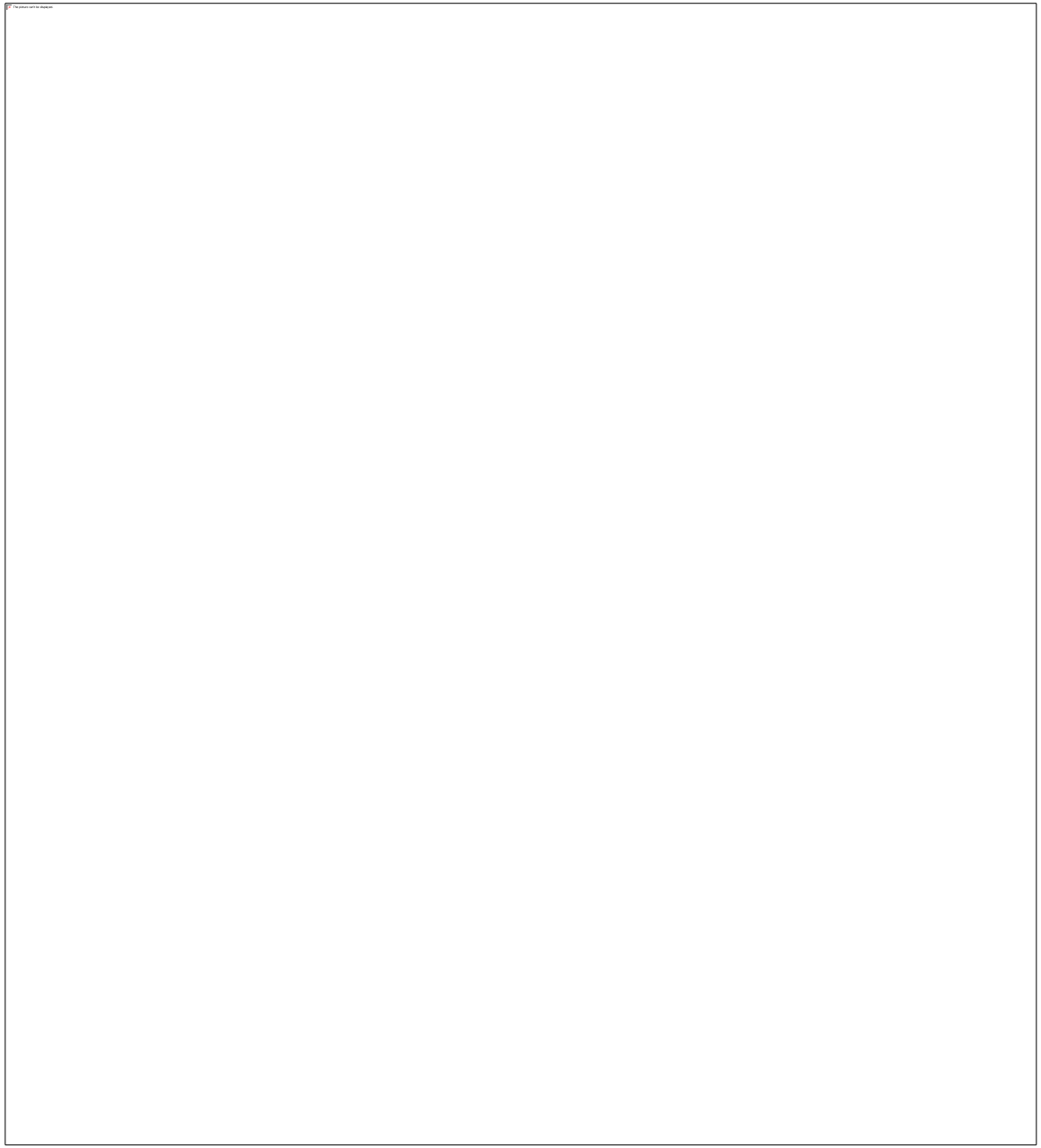

Very recently, there has been a report on the detection of glycine in Sgr B2(N-LMH), Orion KL, and W51 e1/e2:
Y.-J. Kuan, S. B. Charnley, H.-C. Huang, W.-L. Tseng, and Z. Kisiel,
Interstellar Glycine
Astrophys. J. **593**, 848–867 (2003).
This paper has caused quite a stir in the astronomical community, if one considers the following paper:
J. M. Hollis, J. A. Pedelty, L. E. Snyder, P. R. Jewell, F. J. Lovas, P. Palmer, and S.-Y. Liu,
A Sensitive Very Large Array Search for Small-Scale Glycine Emission toward OMC-1
Astrophys. J. **588**, 353–359 (2003).

It should be noted that the number of supposedly positively identified transitions reported by Kuan *et al.* is fairly large. Therefore, the report may be considered quite convincing.
However, it was brought to our attention that there seem to be some inconsistencies in the intensities of the lines. In particular, some of the observed lines seem to be too weak by a substantial amount that seems to be incompatible with the derived abundances and rotational temperatures. This may cast doubt on the derived abundances and possibly even on the interstellar detection.
At the moment it appears as if the publication of these reported inconsistencies will not settle the dispute of the glycine detection.

The paper alluded to in the previous paragraph is about to appear:
L. E. Snyder, F. J. Lovas, J. M. Hollis, D. N. Friedel, P. R. Jewell, A. Remijan, V. V. Ilyushin, E. A. Alekseev, and S. F. Dyubko,
A Rigorous Attempt to Verify Interstellar Glycine
Astrophys. J. **619**, 914–930 (2005).

Overall, we would recommend the detection of glycine to be taken very cautiously.

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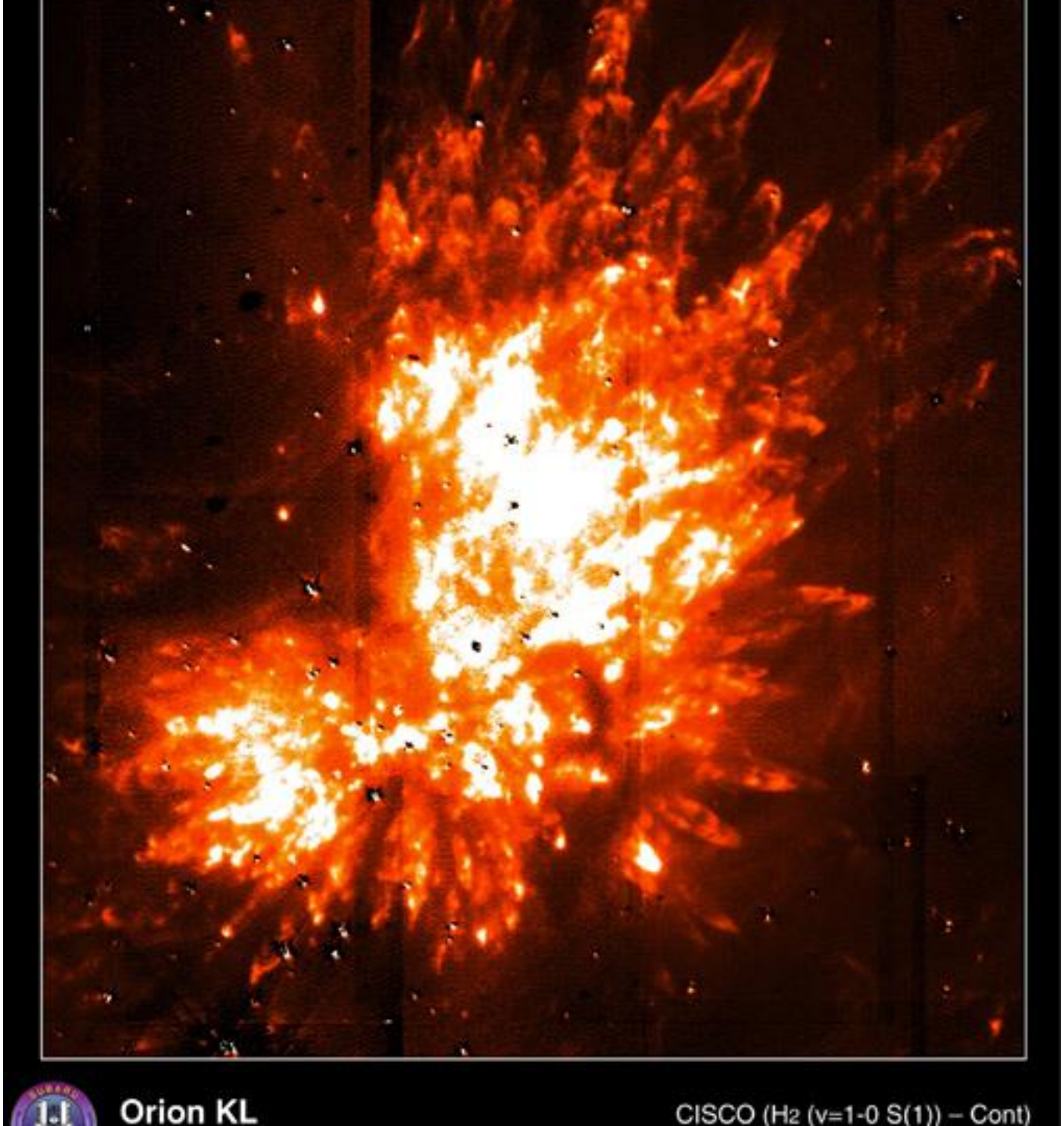

Orion KL

CISCO (H_2 (v=1-0 S(1)) – Cont)

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The picture can't be displayed.

The picture can't be displayed.

The picture can't be displayed.

The picture can't be displayed.

$HCO^+ + H_2 = H_2$-- HCO^+ 3.9kCal/m 1370cm^{-1}

Infrared Spectrum B_0= 14605.9(±11)MHz $\prod$ o-H_2

B_0= 14578.9(±16)MHz $\sum$ p-H_2

Bieske, Nizkorodov, Bennett,Maier J.Chem Phys. **102**, 5152 (1995)

$HCO^+ + CO = OC$- HCO^+ 14kcal/m 4900cm^{-1}

O—C----------H—C—O $\nu_{CH} \approx 2700 cm^{-1}$

| 2.919Å |

O—C-------H-------C—O $\Delta E = 1100\ cm^{-1}$

B_e=1906 MHz

The UMIST Database for Astrochemistry 1999

Y.H. Le Teuff, T.J. Millar & A.J. Markwick

Astronomy & Astrophysics Supplement Series, 146, 157, 2000.

http://www.rate99.co.uk/

> 4000 Reaction Rates

Extragalactic Molecules (as of 09/2005)

2 atoms	3 atoms	4 atoms	5 atoms	6 atoms	7 atoms
OH	H_2O	H_2CO	c-C_3H_2	CH_3OH	CH_3CCH
CO	HCN	NH_3	HC_3N	CH_3CN	
H_2	HCO^+	HNCO	CH_2NH		
CH **	C_2H	H_2CS (?)	NH_2CN		
CS	HNC	$HOCO^+$			
CH^+ **	N_2H^+	C_3H			
CN	OCS				
SO	HCO				
SiO	H_2S				
CO^+ (?)	SO_2				
NO	HOC^+				
NS	C_2S				

Table created by S. Thorwirth (09/2005) based on information kindly provided by S. Martín.


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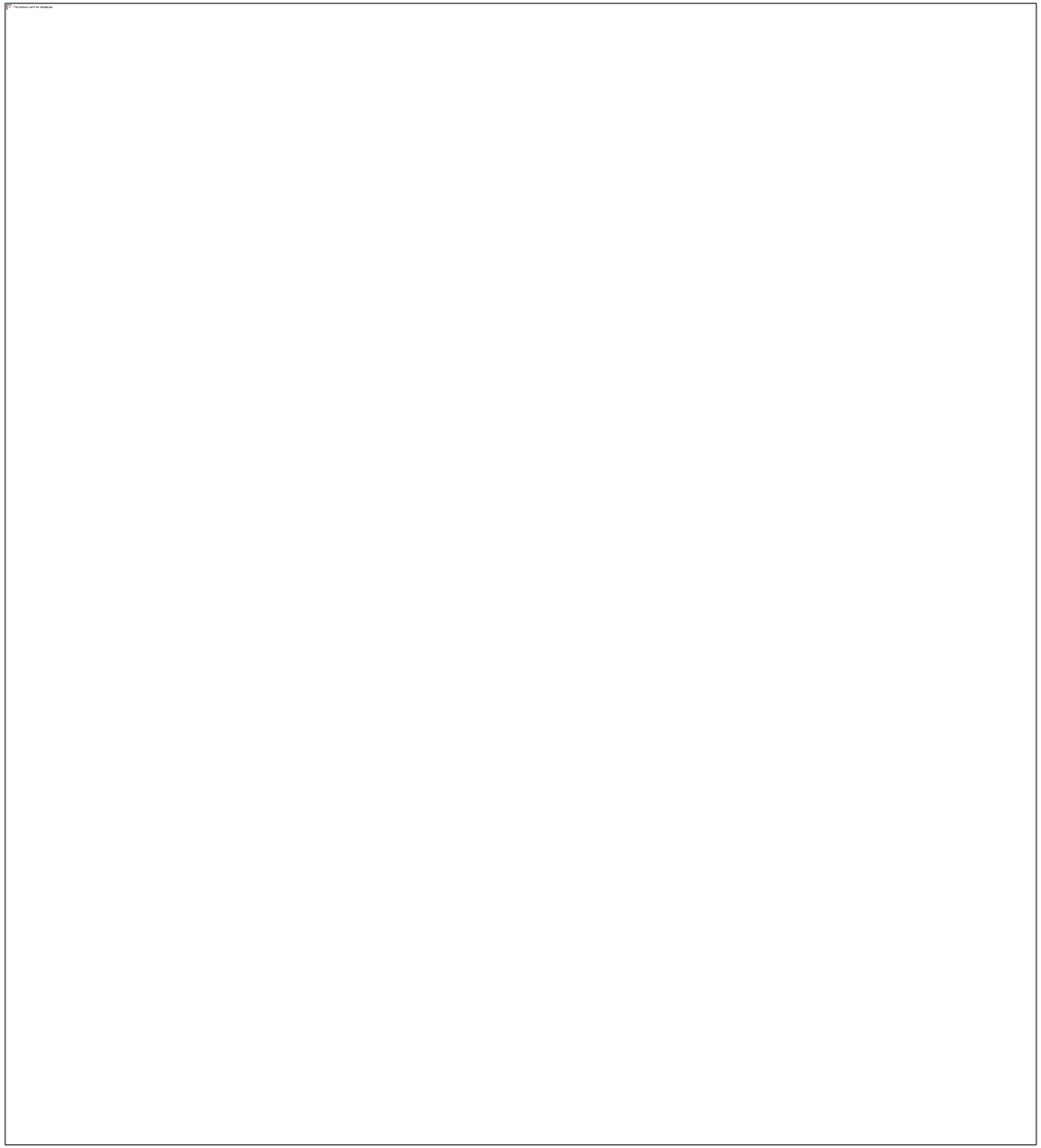

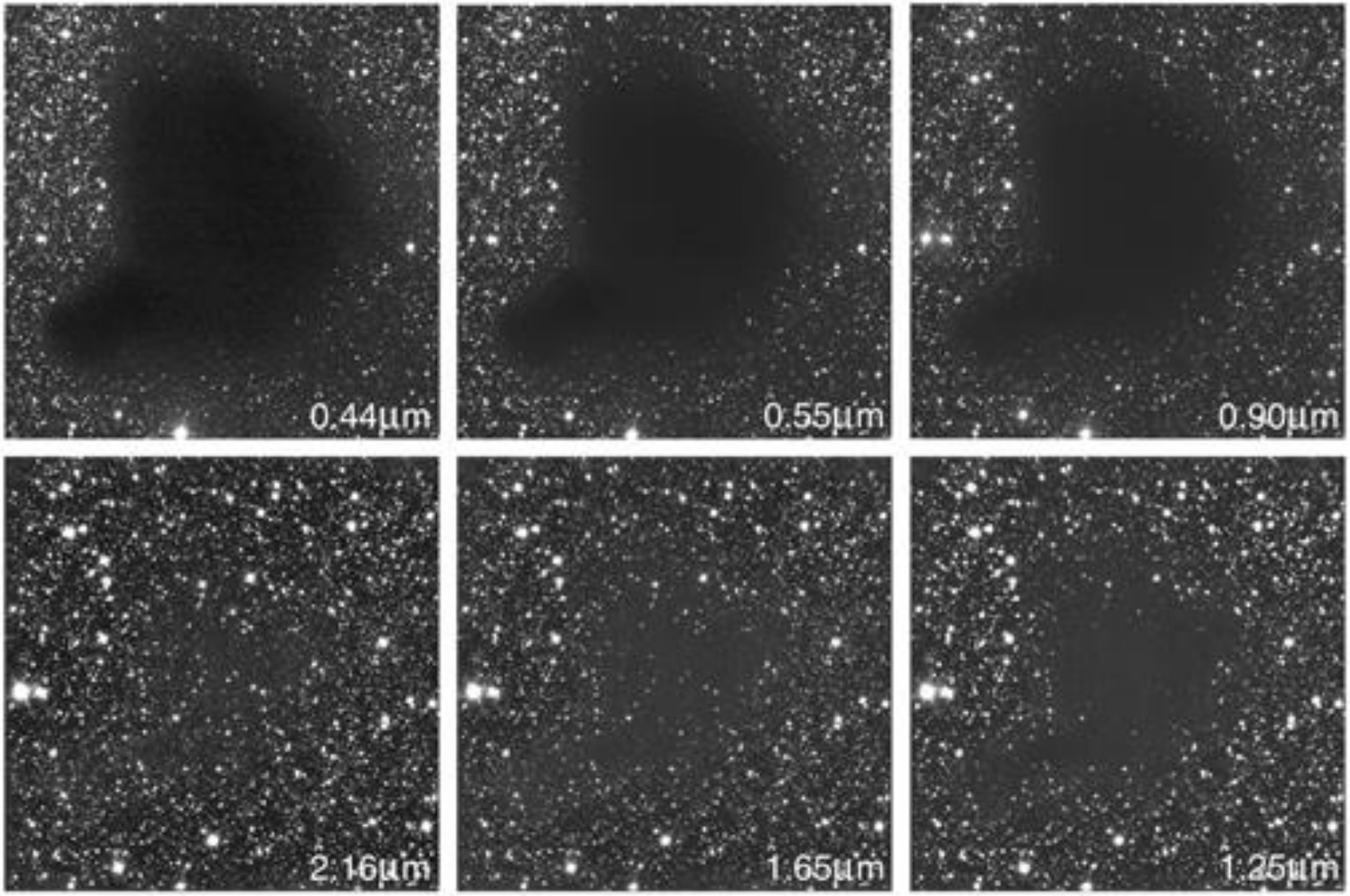

The Dark Cloud B68 at Different Wavelengths (NTT + SOFI)

ESO PR Photo 29b/99 (2 July 1999)


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