http://www.astro.uni-koeln.de/site/vorhersagen/molecules/

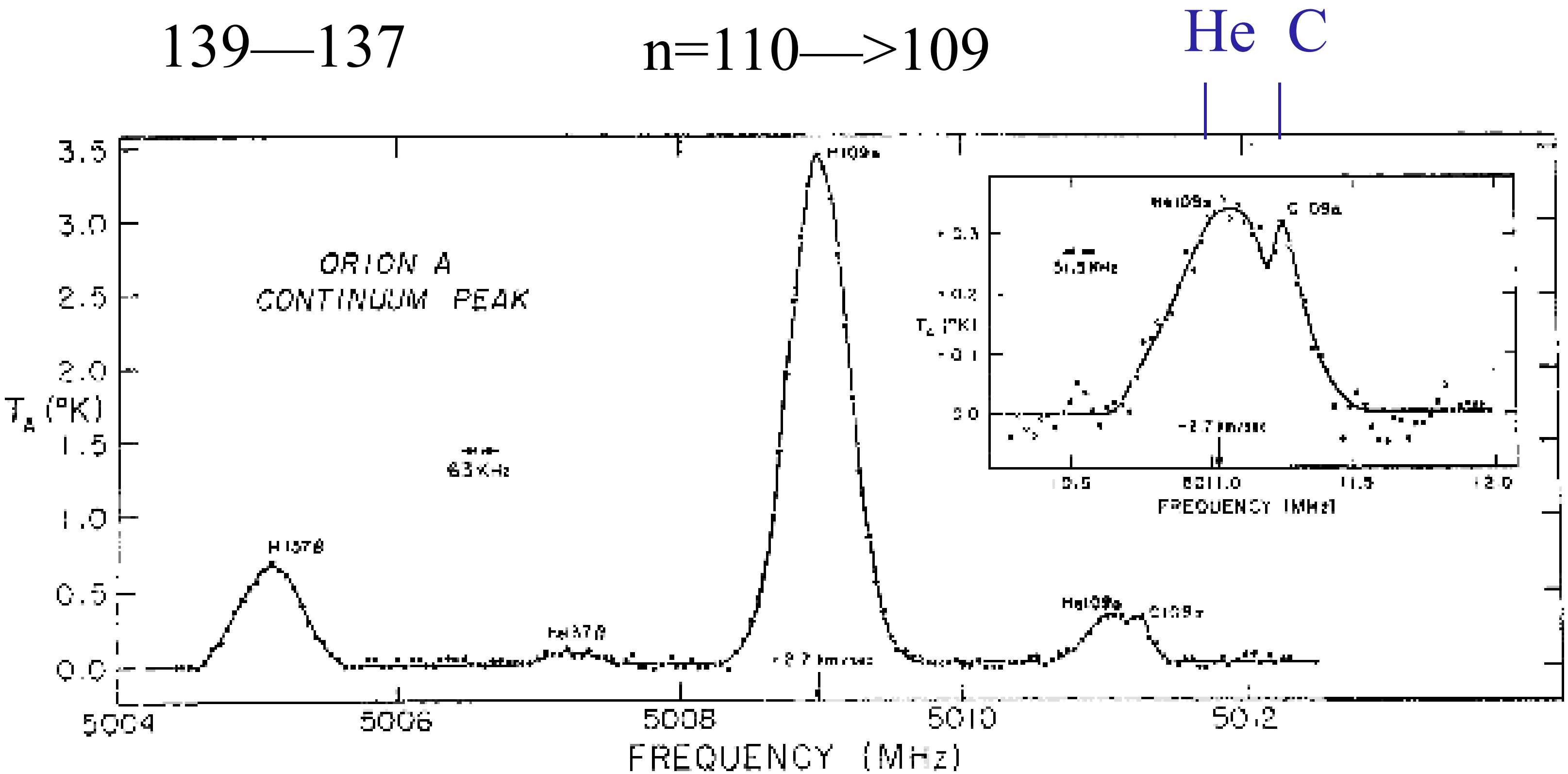
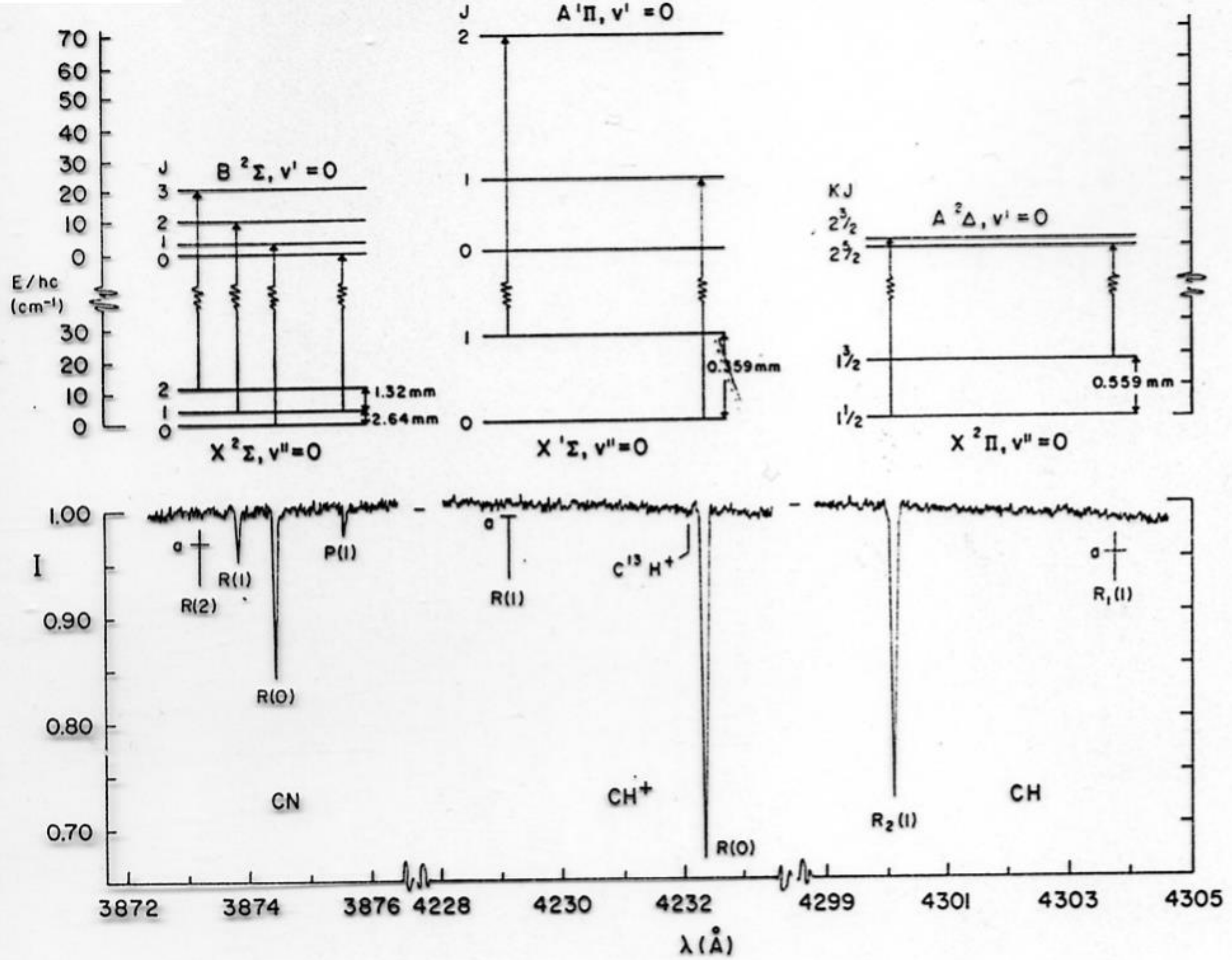


FIGURE 1. A broadband spectrogram showing recombination lines at the center of Orion A (M42). These observations were made with the 400-channel autocorrelator at the 140′ telescope of the NRAO in Green Bank, West Virginia by Churchwell & Mezger (1970). Five recombination lines are indicated: H 137β, 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.



E/hc (cm⁻¹)
J
B ²Σ, v' = 0
1.32 mm
2.64 mm
X ²Σ, v'' = 0
A ¹Π, v' = 0
0.359 mm
X ¹Σ, v'' = 0
K J
A ²Δ, v' = 0
0.559 mm
X ²Π, v'' = 0
I
R(2)
R(1)
R(0)
P(1)
CN
R(1)
C¹³H⁺
R(0)
CH⁺
R₂(1)
R₁(1)
CH
λ (Å)

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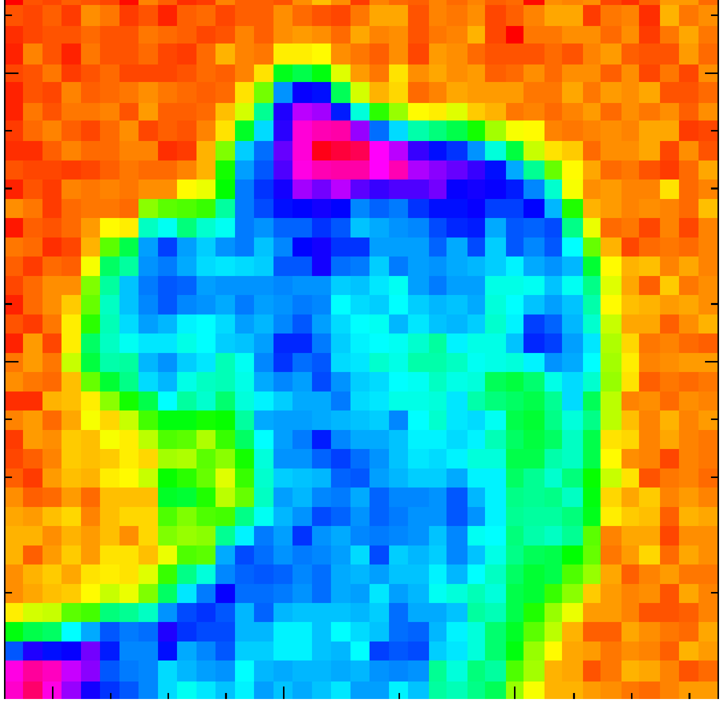
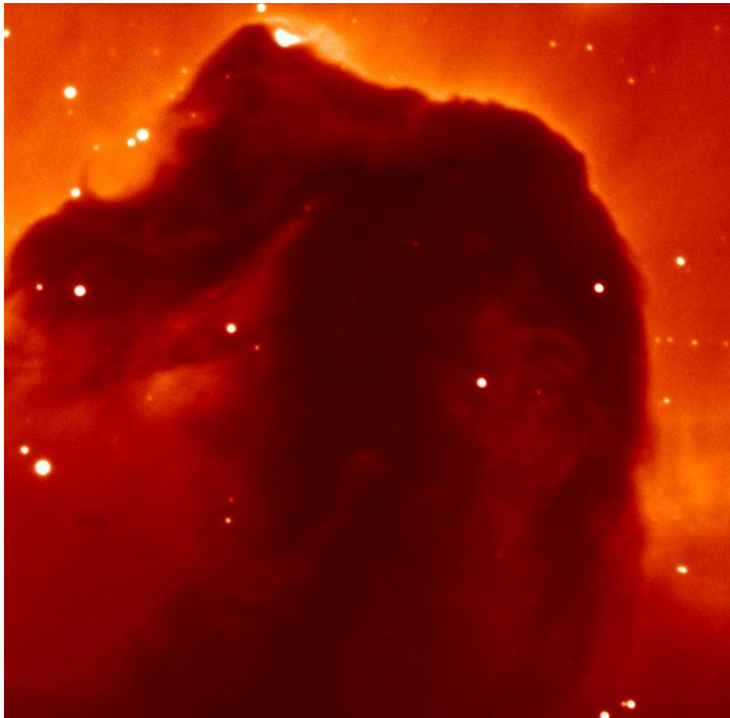
CO J=1—0 in Orion 115.3GHz

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





Primary Ionization

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

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

Secondary Reactions

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

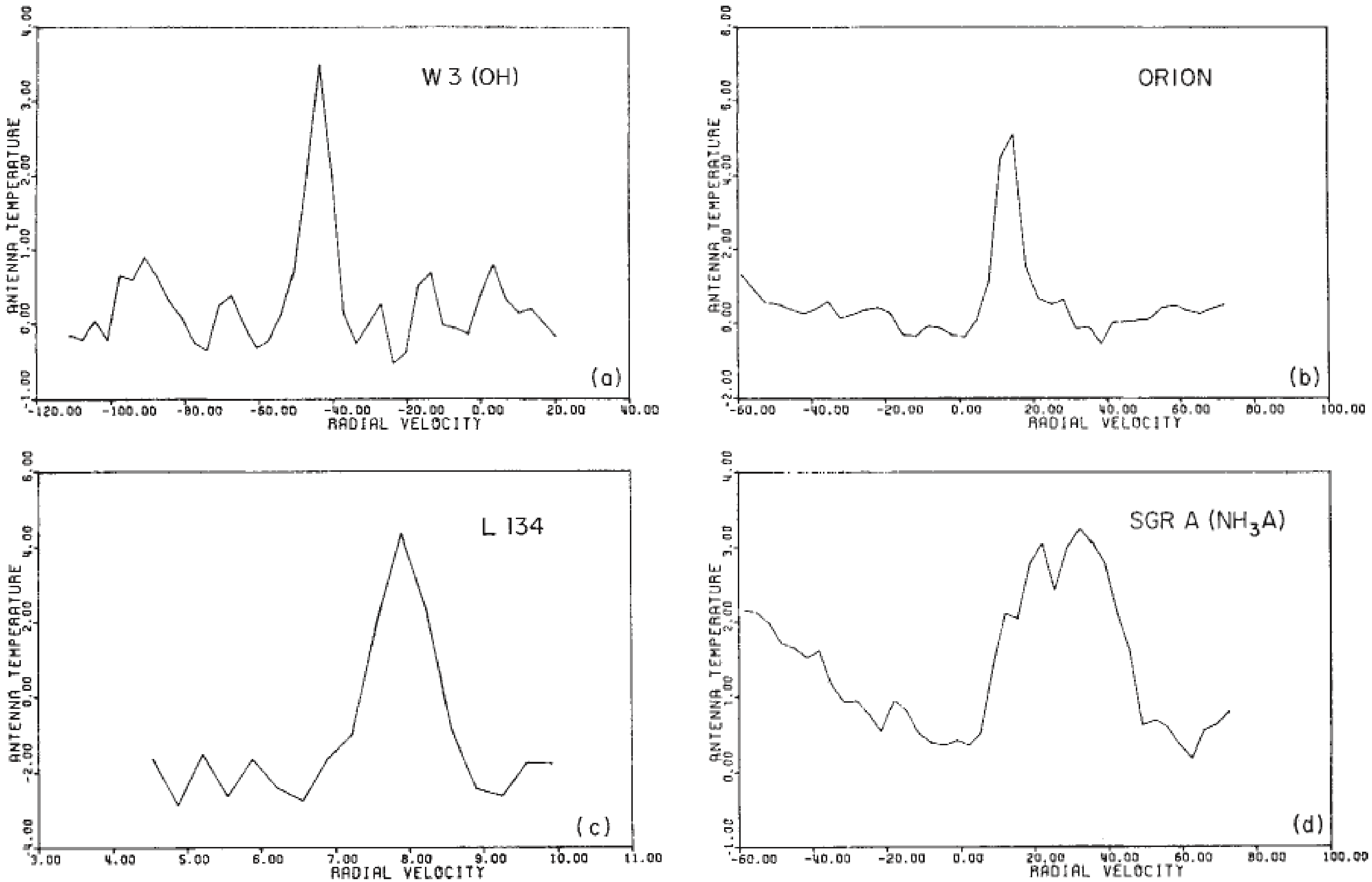
$He^+ + H_2 \neq HeH^+ + H$ very slow at low T

$He + H^+ + H$ ”

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

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

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



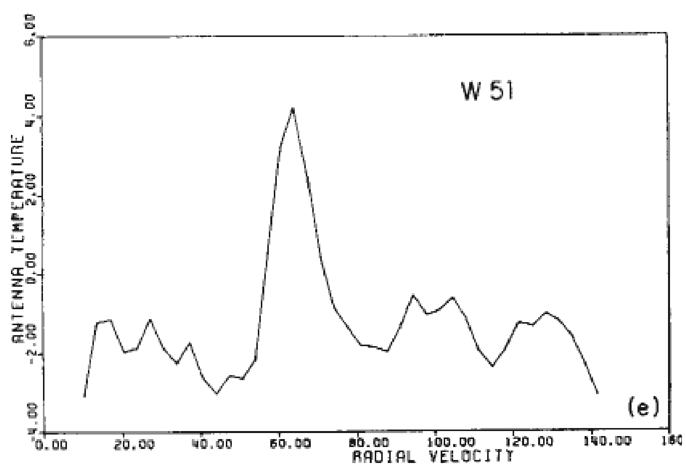
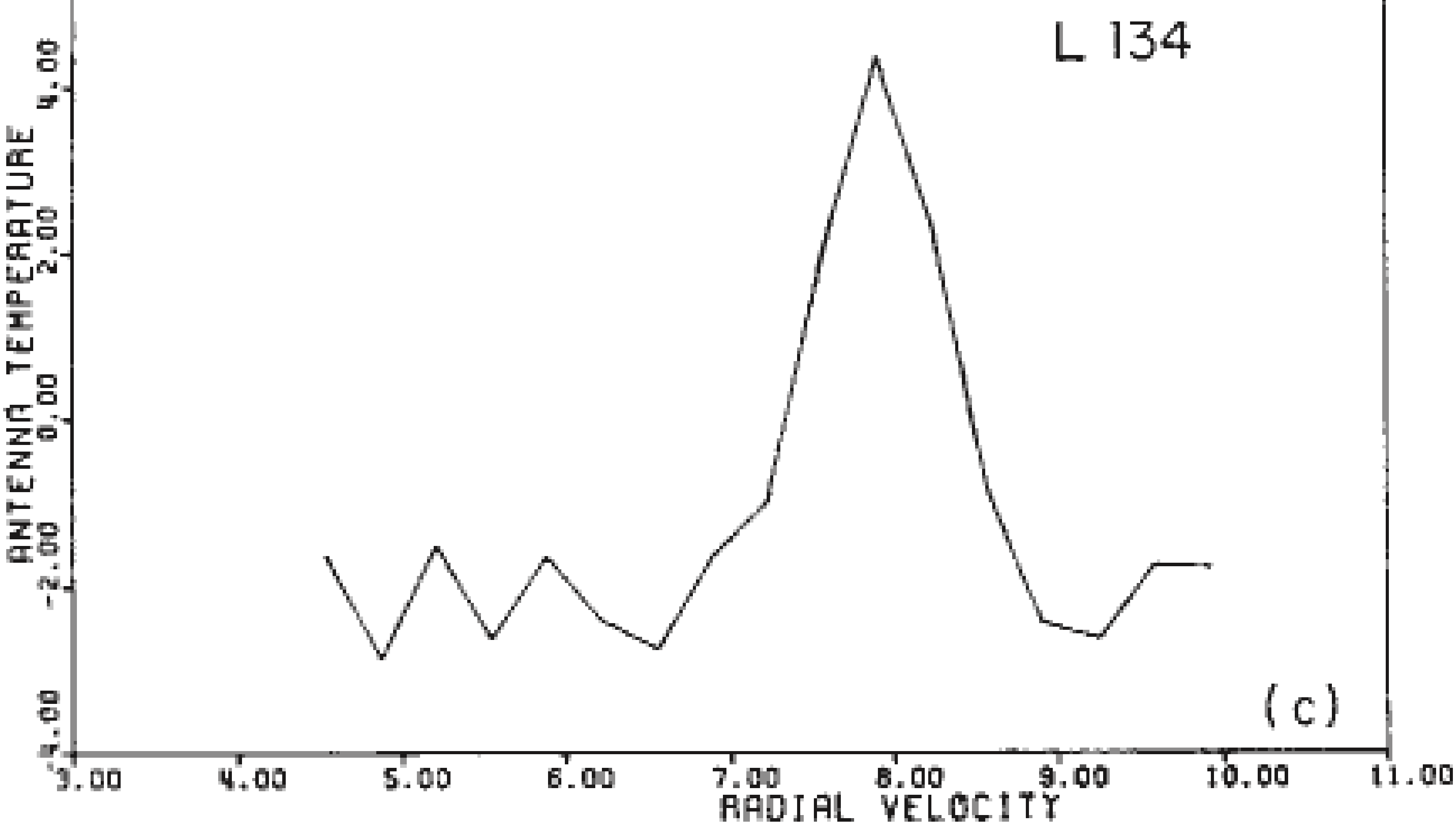


Fig. 1. X-ogen spectra observed for: *a*, W3 (OH); *b*, Orion; *c*, L134; *d*, Sgr A (NH_3A); and *e*, W51. Antenna temperature is in degrees Kelvin uncorrected for antenna efficiency (and dome attenuation in the case of Orion). Radial velocity is in km s^{-1} corrected to the local standard of rest.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

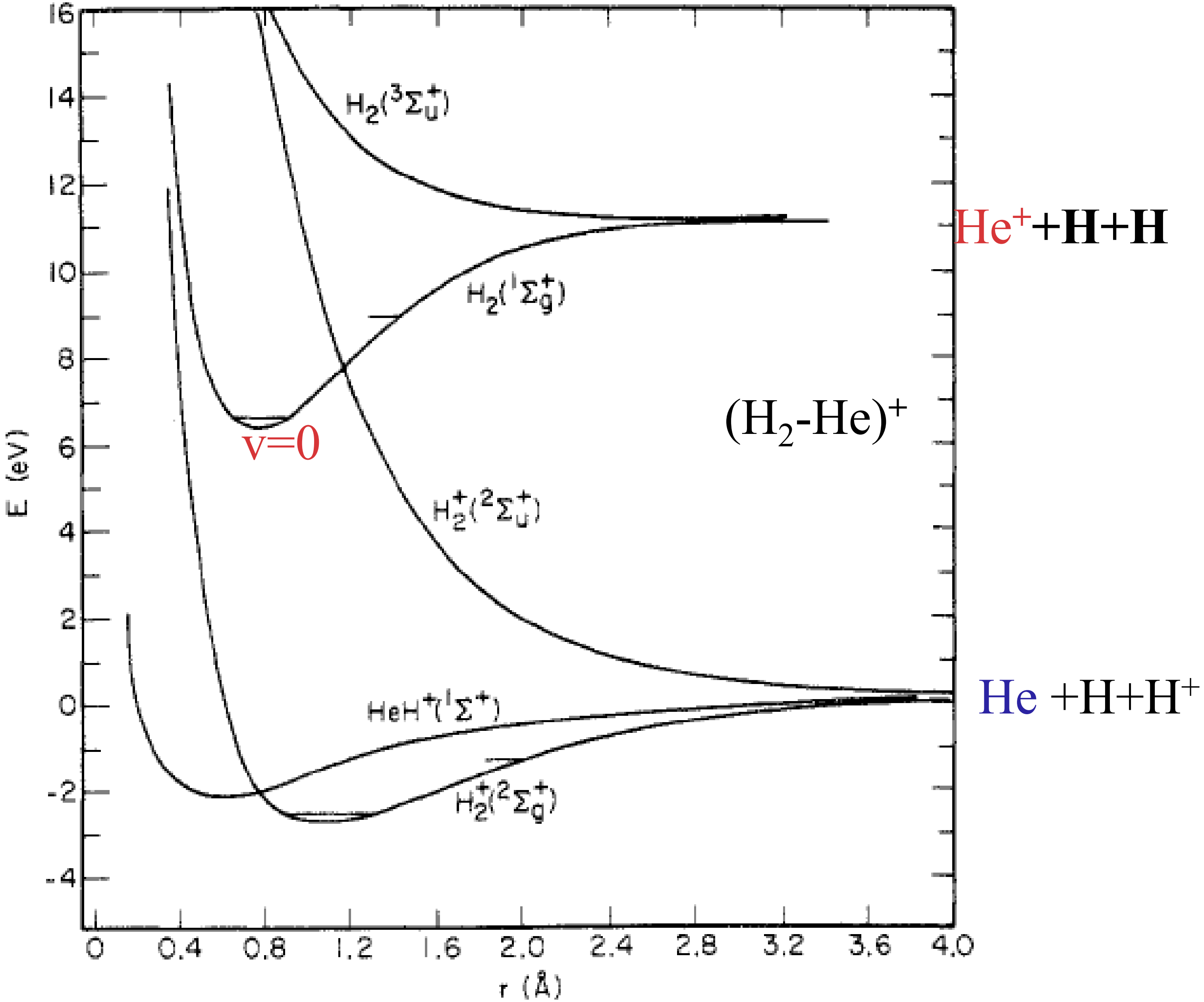
Unidentified Interstellar Microwave Line

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

Bruce Mahan Accounts Chem. Research 1975



Chemical Equilibrium

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

$\Delta H^0 = -49.3$ kcal; $\Delta G^0 = -45$ 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 $> 10^{500}$

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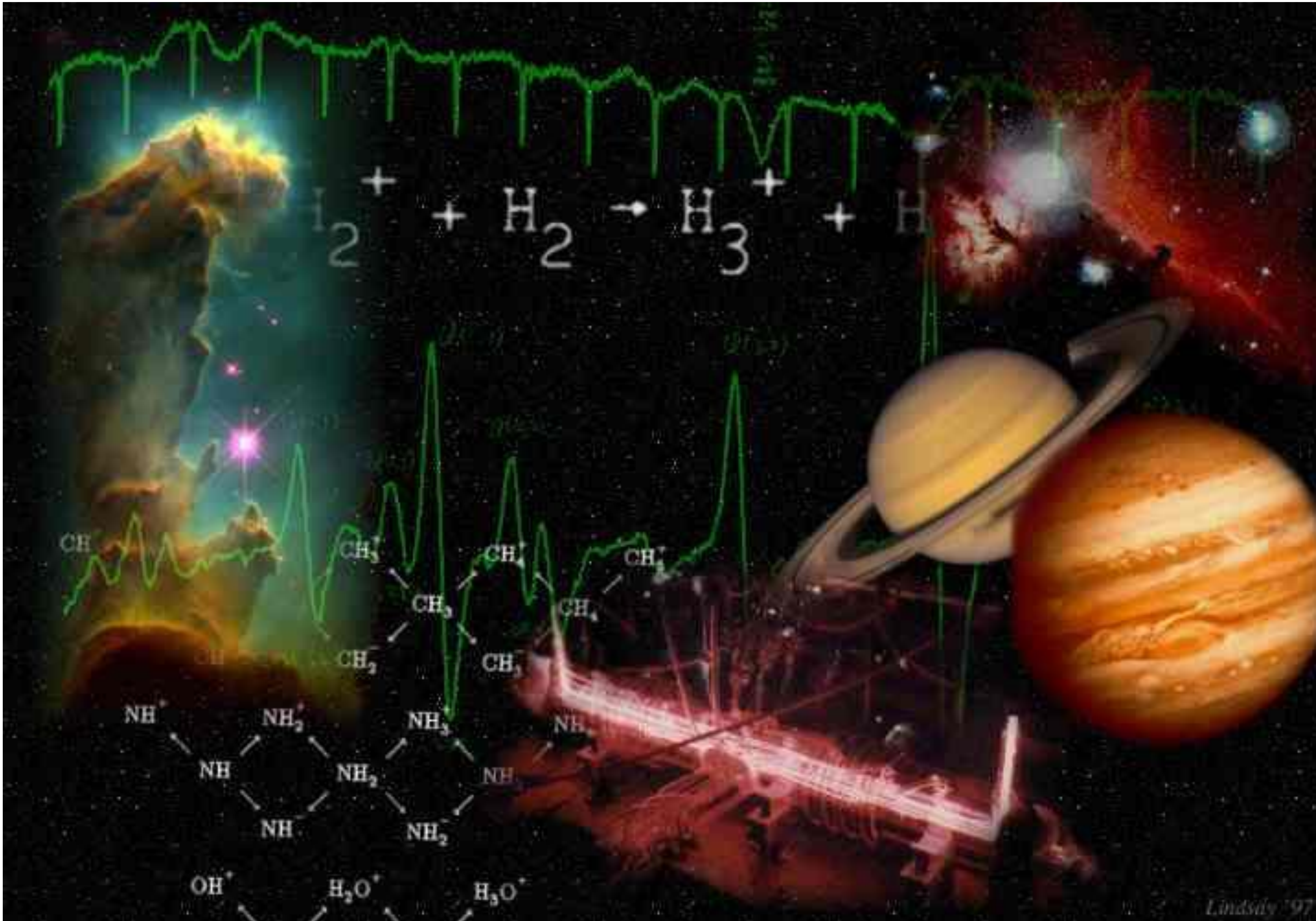
$H_2^+ + H_2 \rightarrow H_3^+ + H$
CH_3^+
CH_4^+
CH_5^+
CH_3
CH_4
CH_2^-
CH_3^-
NH^+
NH_2^+
NH_3^+
NH
NH_2
NH^-
NH_2^-
OH^+
H_2O^+
H_3O^+
Lindsay '97

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The picture can't be displayed.

The picture can't be displayed.

Ap. J. **472**, L49 (1996)

Flux

GHz

http://www.astro.uni-koeln.de/site/vorhersagen/molecules/

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]

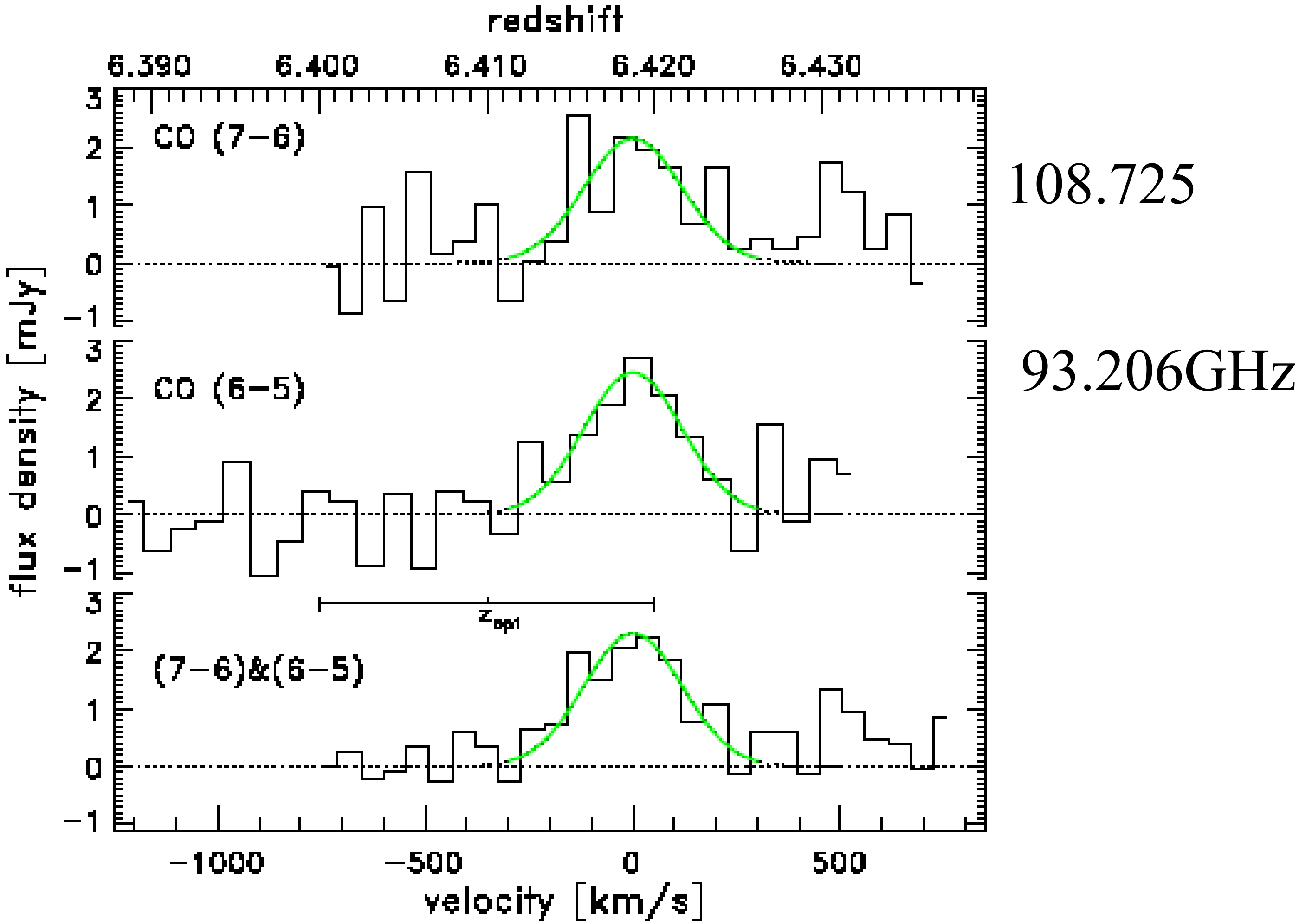

Fig. 1. J1148+5251 spectra of CO (6→5), (7→6), an

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•

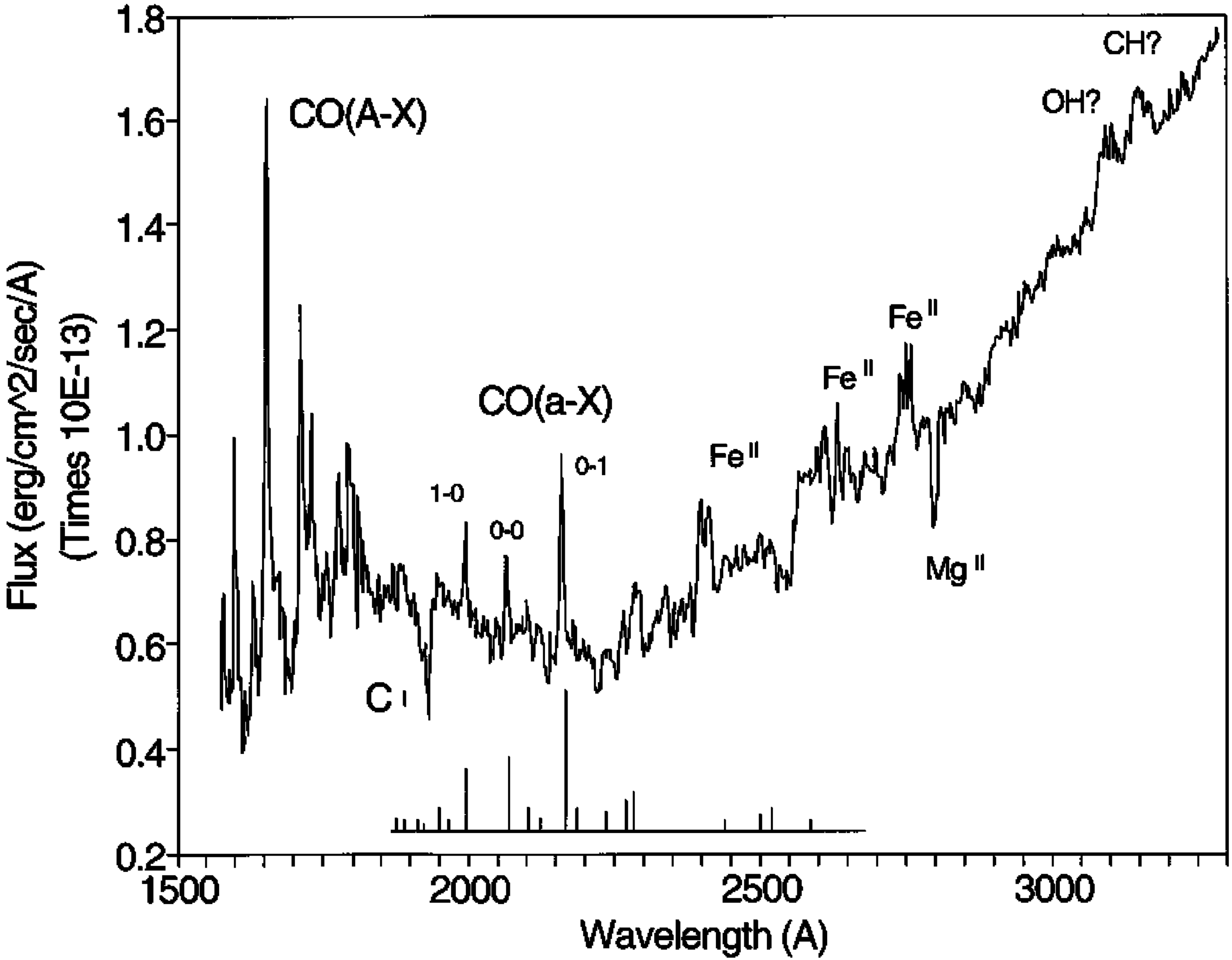

FIG. 1.—Composite *HST* FOS spectrum of the central 1."0 of HD 44179 and

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Orion KL

CISCO (H_2 (v=1-0 S(1)) – Cont)

Subaru Telescope, National Astronomical Observatory of Japan

January 28, 1999

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

Infrared Spectrum B_0= 14605.9(±11)MHz ∏ o-H_2

B_0= 14578.9(±16)MHz ∑ 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

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

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

| 2.919Å |

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

B_e=1906 MHz

Heavy Unit (CO) Stretch 312 cm^{-1}

Proton Tunneling 564 cm^{-1}

http://www.astro.uni-koeln.de/site/vorhersagen/molecules/

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

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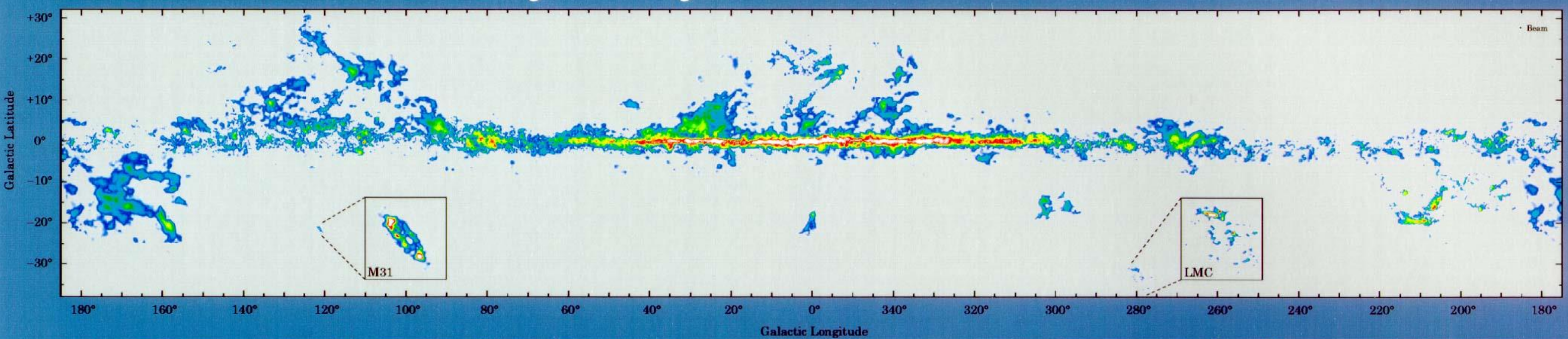
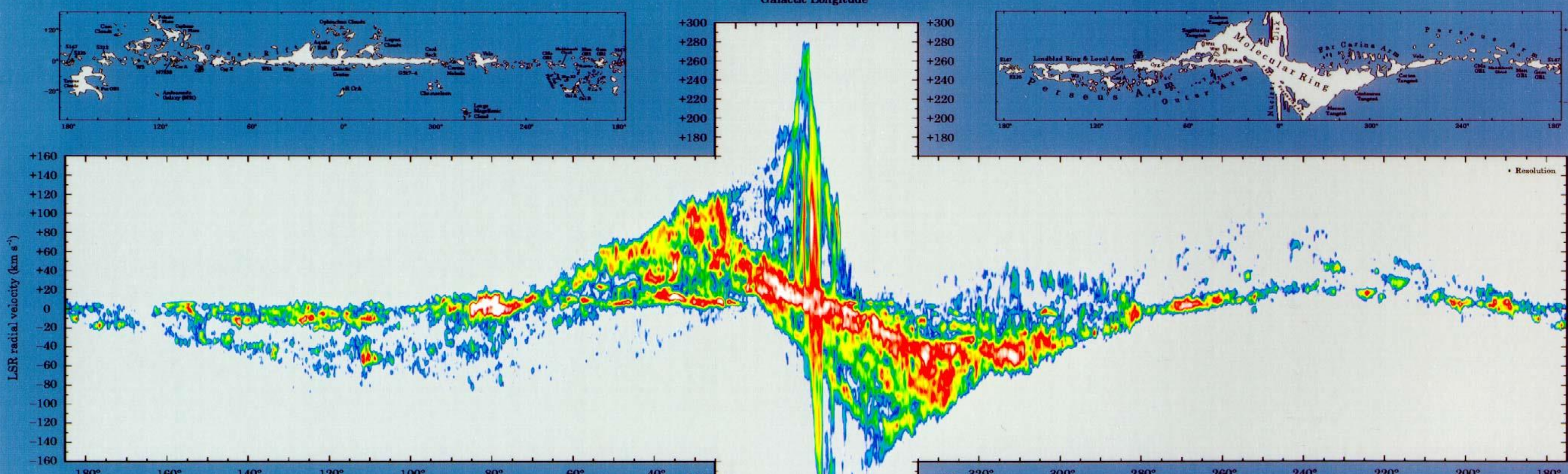
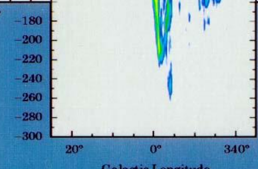
http://www.astro.uni-koeln.de/site/vorhersagen/molecules/

The Milky Way in Molecular Clouds







The Milky Way and its nearest neighbors, the Andromeda galaxy (M31) and the Large Magellanic Cloud (LMC), as observed in the 115 GHz line of carbon monoxide (CO), the best tracer of interstellar molecular clouds. These clouds, the location of essentially all star formation, are composed almost entirely of molecular hydrogen and atomic helium, both nearly impossible to detect.

In the top map the colors, from dark blue (weakest) to white (strongest), represent the CO line intensity summed over all radial velocities, a measure of the total amount of molecular gas along the line of sight. The intense yellow-to-white horizontal strip at the center of the map is produced by the large number of molecular clouds in the inner spiral arms of the Galaxy, while elsewhere in the map individual nearby molecular clouds are prominent. Both the LMC and M31 are so weak in CO that their intensities have been scaled up by factors of 3 and 10, respectively. A finder chart is at the left.

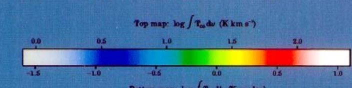
The bottom map shows the distribution of the CO-emitting molecular clouds in radial velocity—crucial information lacking in continuum surveys. Here, the colors represent CO line intensity summed across a ~4° strip of Galactic latitude centered on the Galactic plane. Molecular clouds at higher latitude (and the LMC and M31) are therefore excluded. The observed radial velocities result mainly from the differential rotation of the Galaxy, except near the Galactic center, where a poorly understood outflow of molecular gas exceeding 200 km s⁻¹ occurs. A finder chart is at the right.

This poster is an update of one produced ten years ago which presented the first complete survey of the Milky Way in CO (first reference at right; also Dame 1988, Sky & Telescope, 76, 22). Since well before completion of that survey, done at an effective angular resolution of 0°.5, the same two 1.2 meter telescopes in Cambridge, Mass., and on Cerro Tololo, Chile, have been mapping the Galaxy and its nearest neighbors at several times higher angular resolution—every beamwidth (8.7 arcmin) or half beamwidth—and at 5 to 10 times higher sensitivity per solid angle. These instruments have now mapped in this way nearly the entire Galactic plane over a 4°–6° strip of latitude, as well as many local clouds at higher latitude. The maps above include these 270,000 new spectra; the original 0°.5 map is used in some high-latitude regions (e.g., Taurus) where full-resolution observations do not yet exist.

Roughly half of the new data have already been published as separate surveys of particular clouds or regions (see list at right), and since 1985 have formed the basis for 13 Ph.D. dissertations. The balance was obtained in the past few years in new large-scale surveys of the first and second Galactic quadrants.

This poster was supported by a generous grant from the Atherton Seidell Endowment of the Smithsonian Institution.

Whole Galaxy 0°.5	Dame et al. (1987) ApJ, 322, 706
1st Quad (old)	Cohen et al. (1986) ApJS, 60, 695
1st Quad (new)	Dame & Thaddeus (1994) ApJ, 436, L173
Cygnus X	Leung & Thaddeus (1992) ApJS, 81, 267
2nd Quad	Digel et al. (1996) ApJ, 463, 561
Cas A	Ungerechts et al. (1997) ApJ, submitted
2nd Quad (high b)	Heithausen et al. (1993) A&A, 268, 265
Gem OB1	Stacy & Thaddeus (1988) ASP Conf. 16, 197
Mon OB1	Oliver et al. (1996) A&A, 315, 578
λ Orionis	Lang (1997) Ph.D. thesis, U. Bristol
Orion	Maddalena et al. (1986) ApJ, 303, 375
3rd Quad	May et al. (1993) A&AS, 99, 105
Carina	Grabelsky et al. (1987) ApJ, 315, 122
Chamaeleon	Boulanger et al. (1997) A&A, submitted
Coalsack	Nyman et al. (1989) A&A, 216, 185
4th Quad	Bronfman et al. (1989) ApJS, 71, 481
Galactic Center	Bitran (1987) Ph.D. thesis, U. Florida
Ophiuchus	de Geus et al. (1990) A&A, 231, 137
[illegible]	Leisawitz et al. (1989) ApJS, 70, 731
SNRs	Huang & Thaddeus (1986) ApJ, 309, 804
LMC	Cohen et al. (1988) ApJ, 331, L95
M31	Dame et al. (1993) ApJ, 418, 730

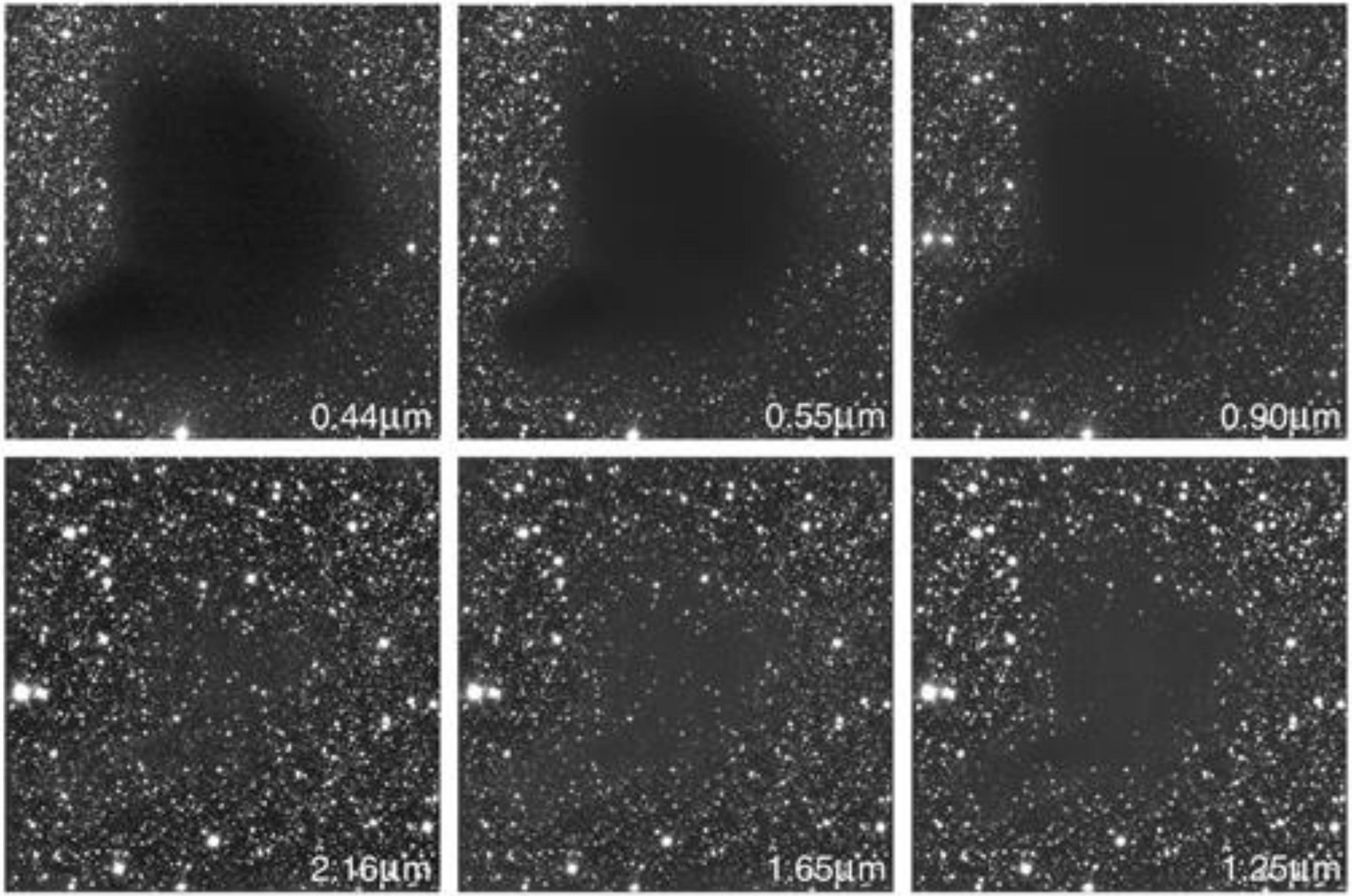


Harvard-Smithsonian Center for Astrophysics
T. M. Dame, Dap Hartmann, & P. Thaddeus

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



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

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

$(2.16/.44)^4=580$

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

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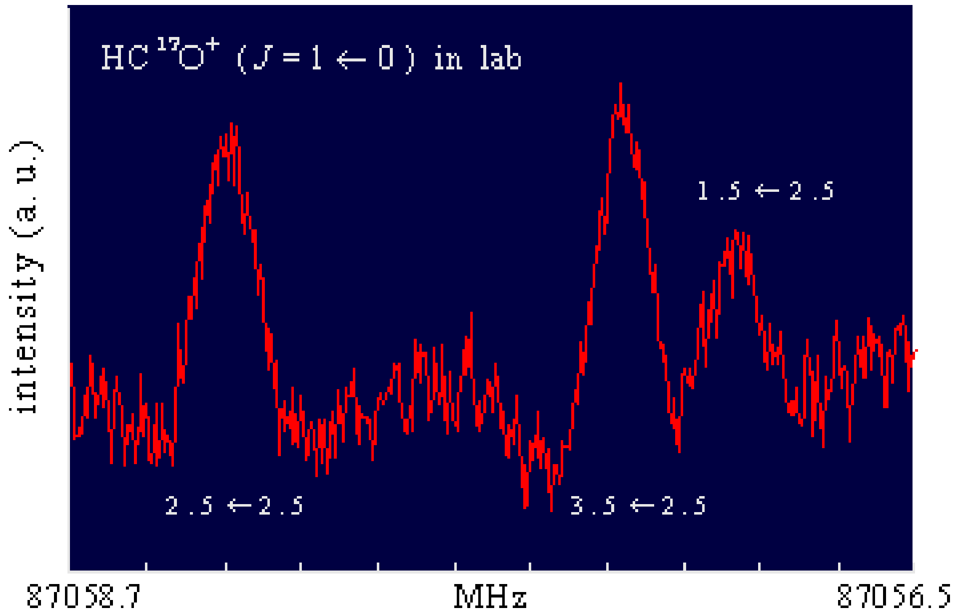
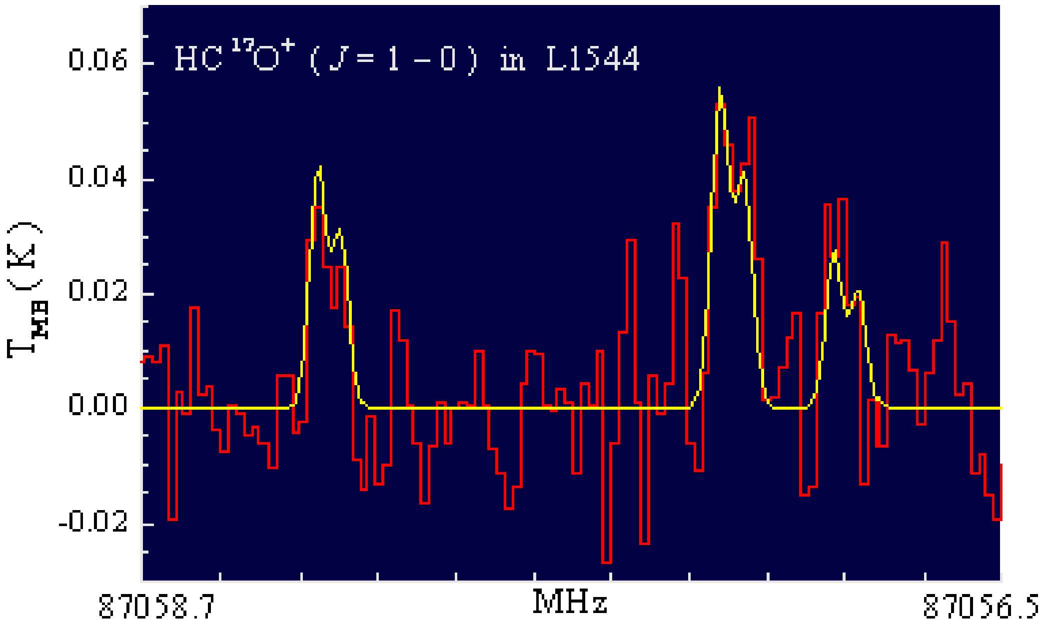


University of Bologna



$^{17}O/^{16}O$ = 0.00037

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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.
