l-C_3H_2 A DIFFUSE INTERSTELLAR BAND CARRIER

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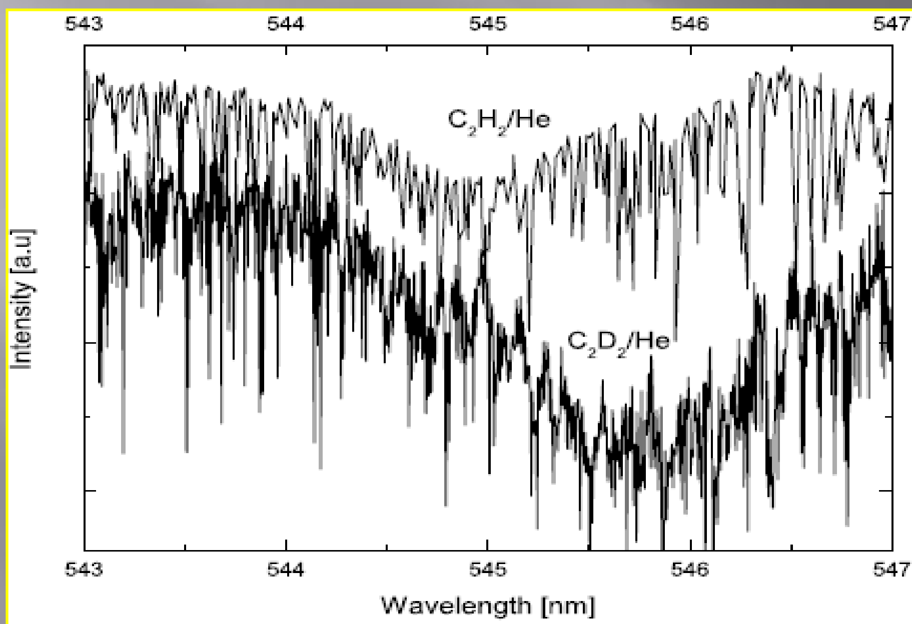
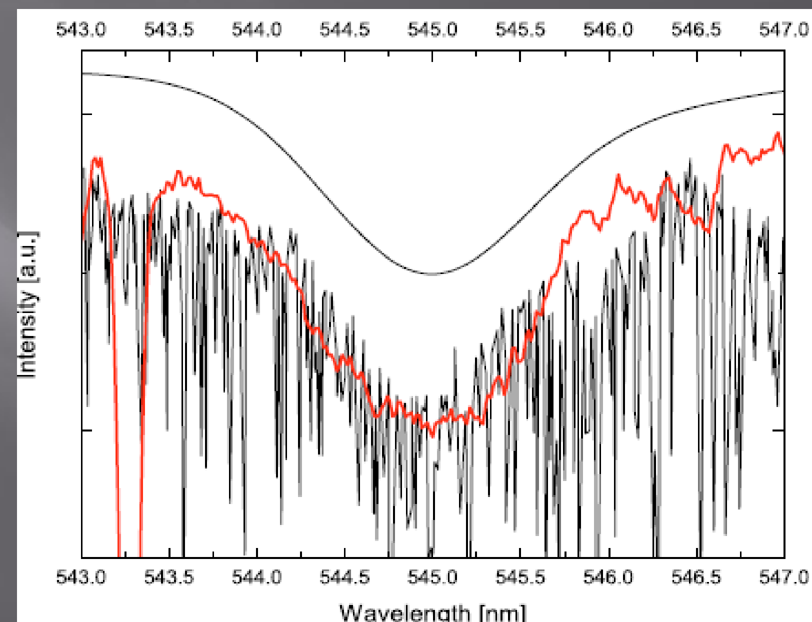
Astrophys. J., **726**(1), 41, 2011.

The start...
DIB coincidence @ 5450 Å
An unknown Gas Phase Absorption





H. Linnartz, N. Wehres, H. Van Winckel, G.A.H. Walker, D.A. Bohlender, A.G.G.M. Tielens, T. Motylewski, and J.P. Maier
Astron. Astrophys., 511, L3, 2010.

The BIG Question…

Which molecule is it??

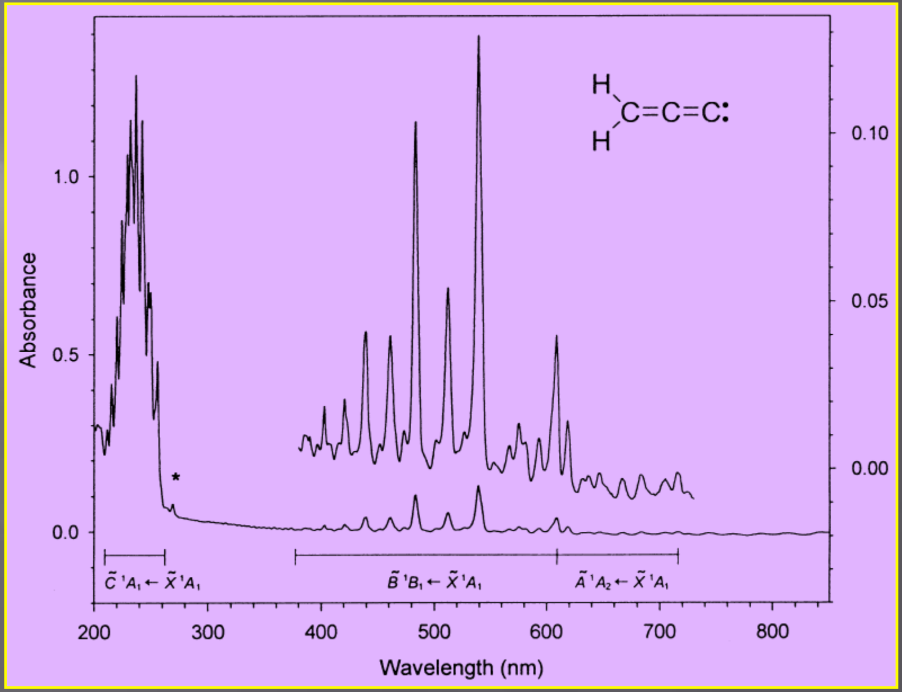
Previous Ne Matrix Studies: *l*-C_3H_2

» 3 electronic transitions

Vis: $A^1A_2 \leftarrow X^1A_1$

$B^1B_1 \leftarrow X^1A_1$

UV: $C\ ^1A_1 \leftarrow X^1A_1$

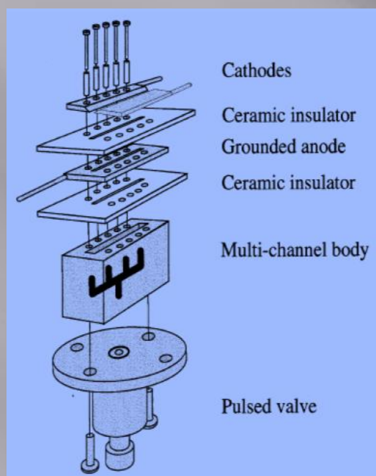


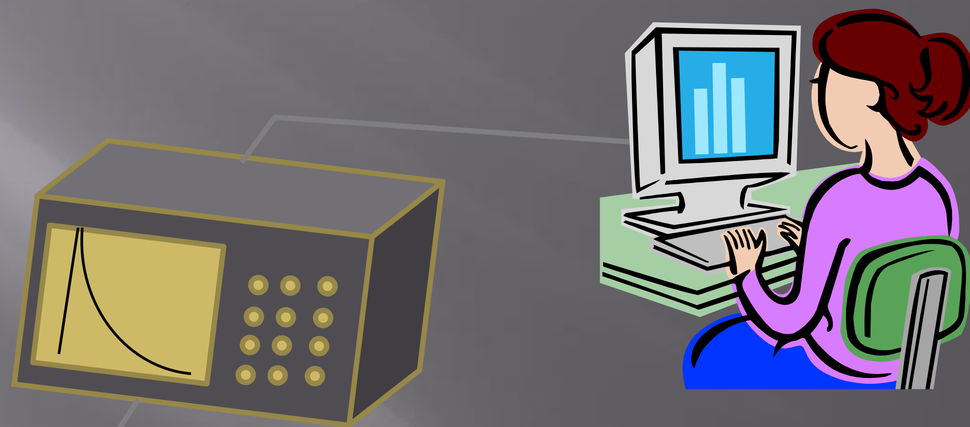
J. A. Hodges, R. J. McMohan, K. W. Sattelmeyer and J. F. Stanton
Astrophys. J. 544, 838, 2000.

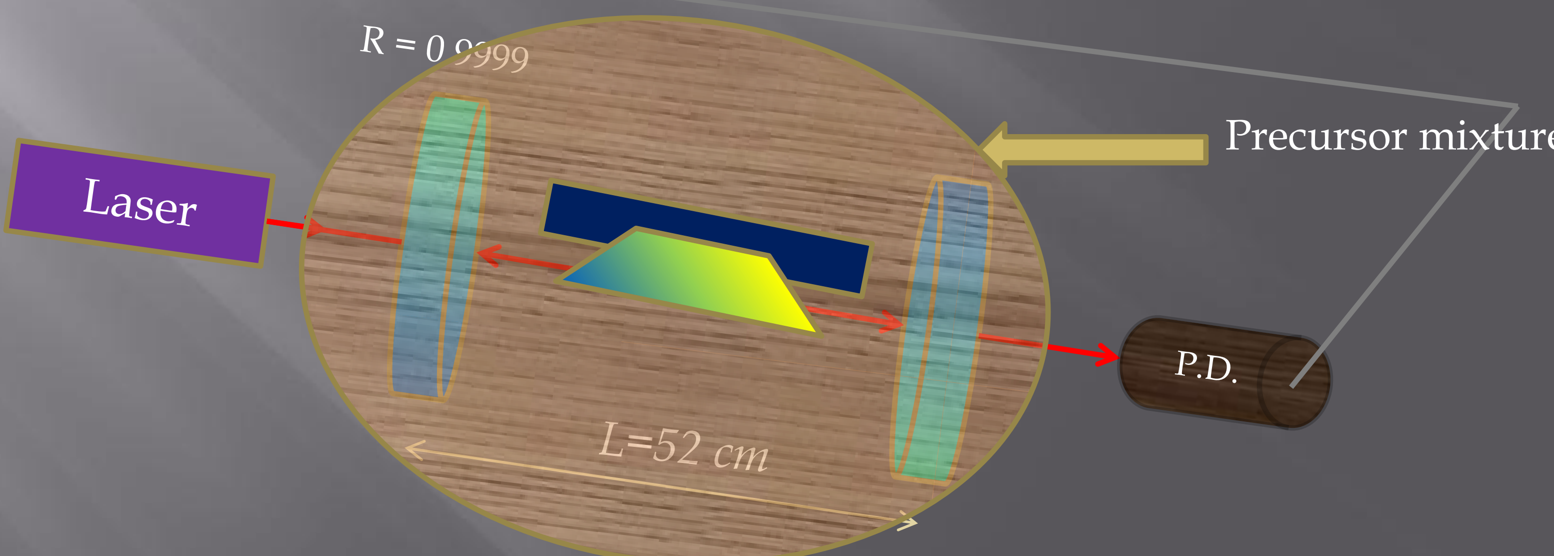
Experimental Set-up

Pulsed slit jet discharge

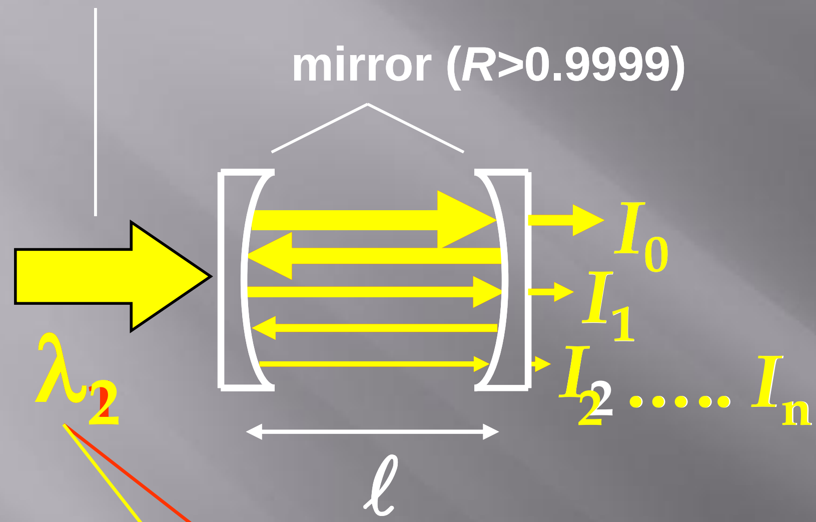
CRDS

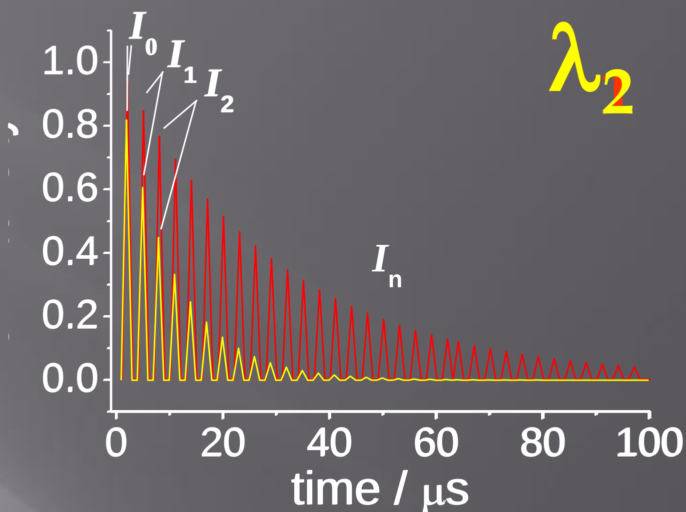






Principle – Cavity Ring-down Spectroscopy

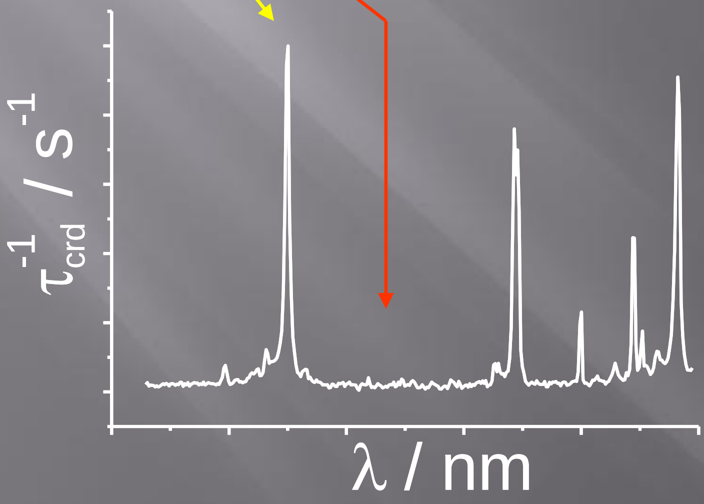




fit

$$I = I_0 \exp(-t/\tau_{crd})$$

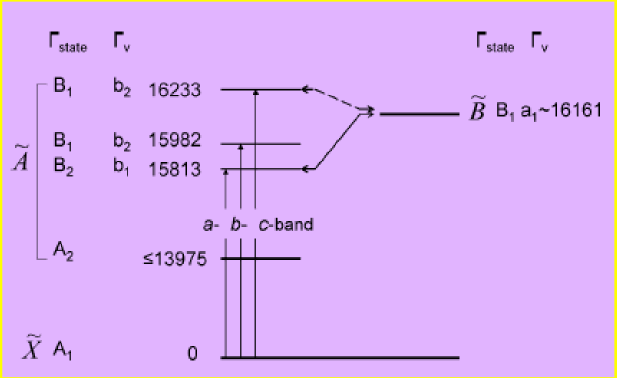
absorption



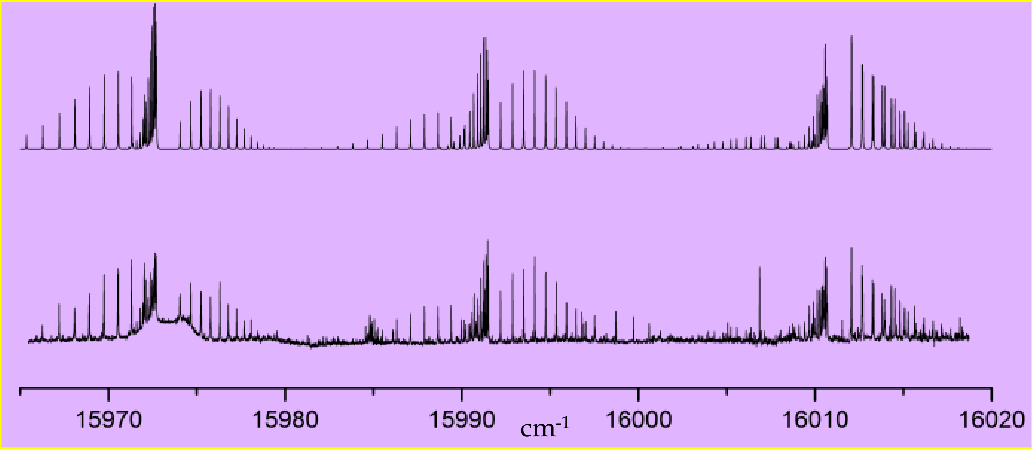
$$\tau_{crd}^{-1} = \alpha(\lambda)\,c + \frac{(1-R)\,c}{\ell}$$

Previous Gas-Phase Measurements

- Attempts to measure $B^1B_1 \leftarrow X^1A_1$ unsuccessful - lifetime broadening
- Forbidden $A^1A_2 \leftarrow X^1A_1$ detected

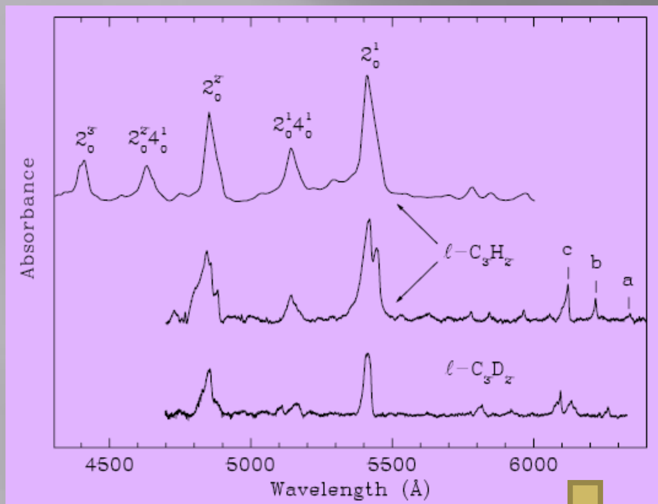


K_a=0-1 K_a=1-0 K_a=2-1

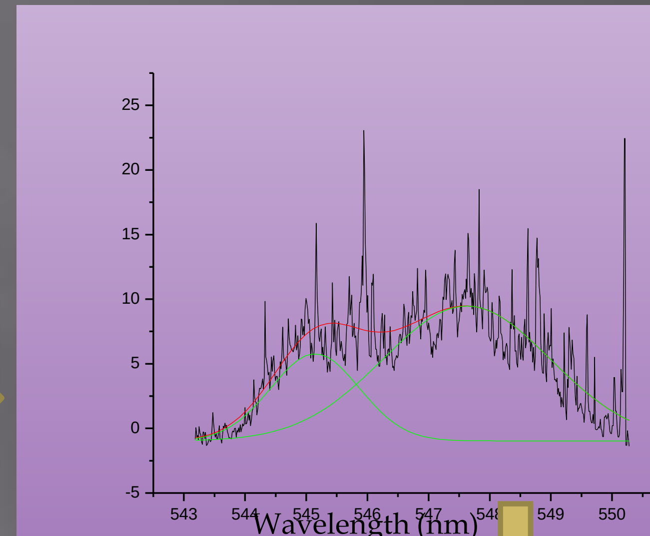


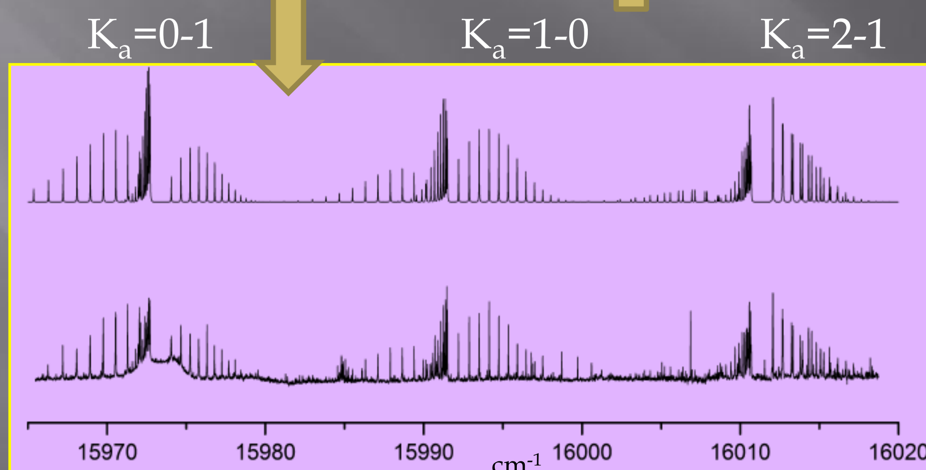
E. Achkasova, M. Araki, A. Denisov and J. P. Maier. J. Mol. Spectrosc. 237, 70, 2006.
P. Birza, A. Chirokolava, M. Araki, P. Kolek and J. P. Maier. J. Mol. Spectrosc. 229 , 276, 2005.

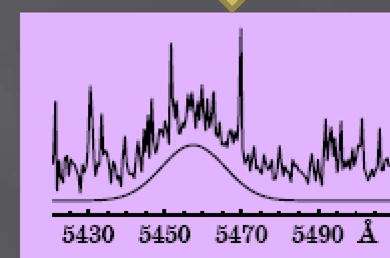
Current Experimental Observations



1







Similar shifts upon deuteration - 17/27 cm^{-1}

3

Precursors used –acetylene, allene Max. Yield, also produced l-C_3H

2

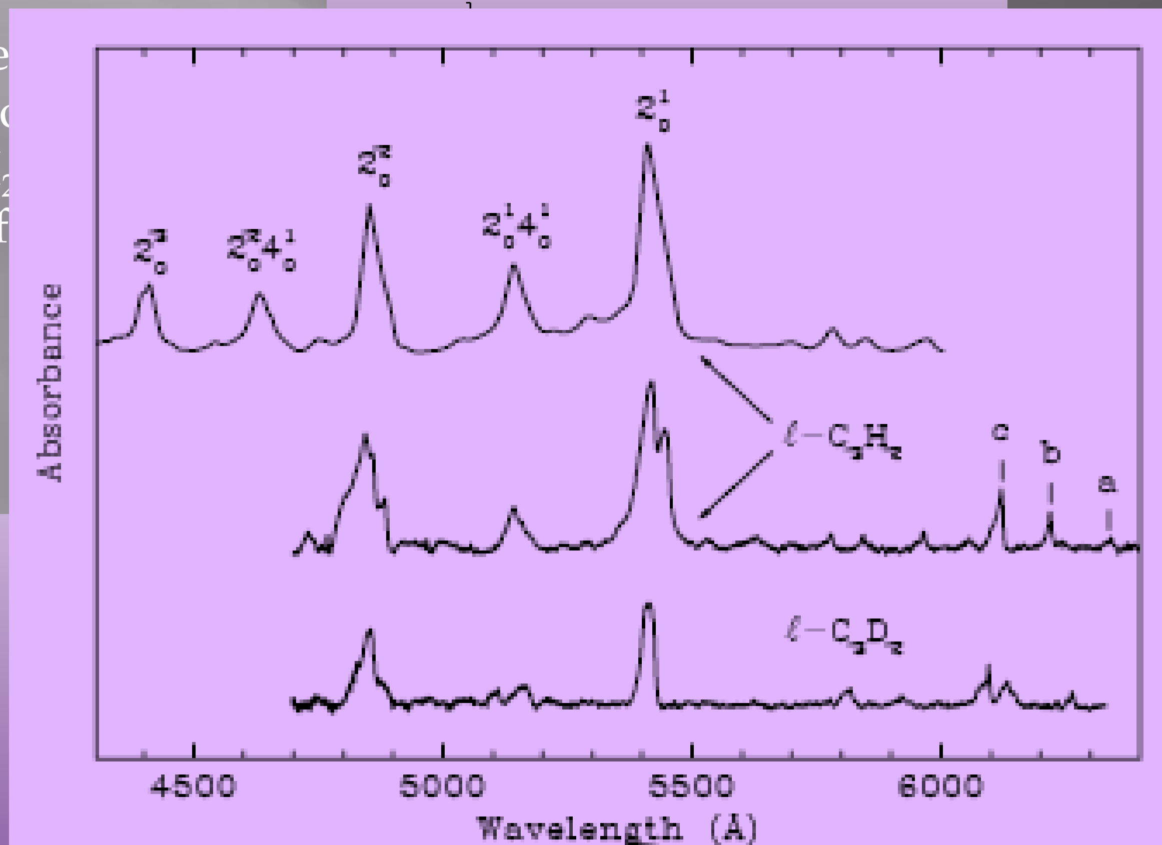
Two peaks-same carrier?

Gas Phase

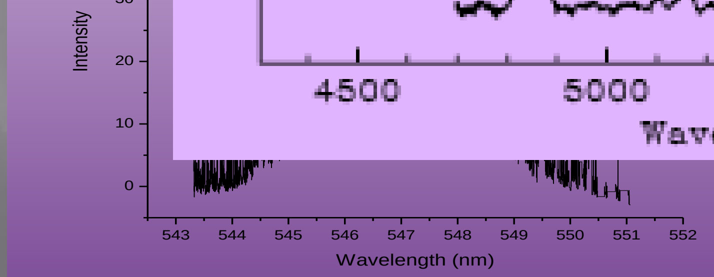
4883Å for $2\nu_2$

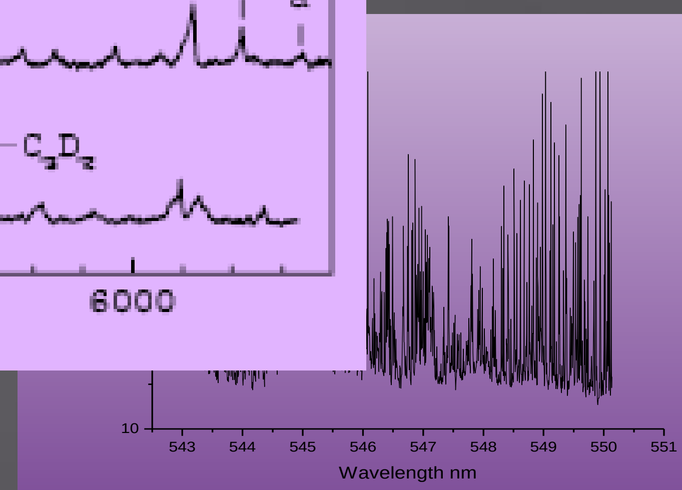
2130 cm^{-1}

The decre
intensity
with C_2H_2
>> that of

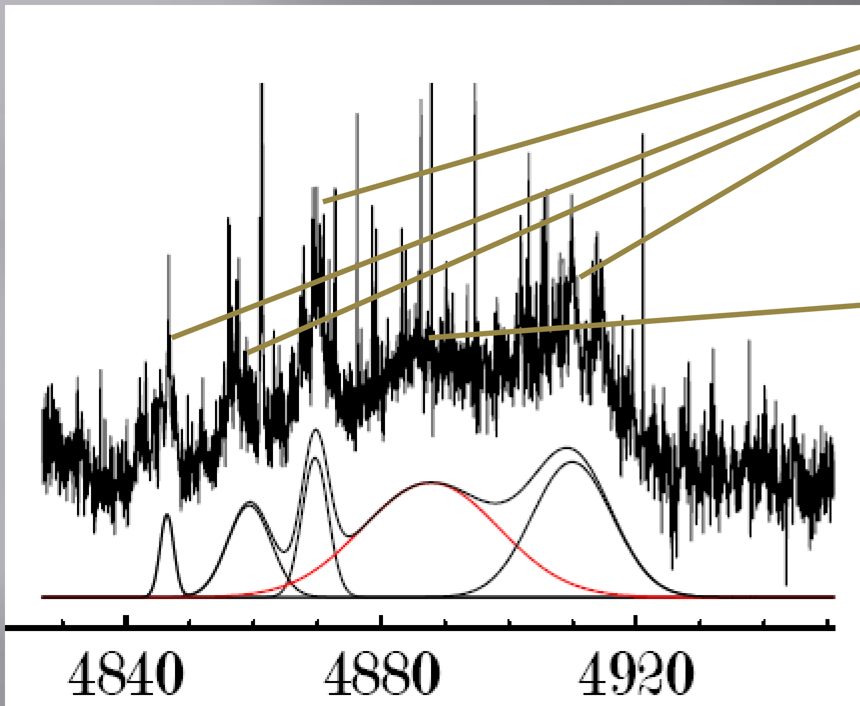


$_2H_2$





Prediction 4883Å for $2\nu_2$

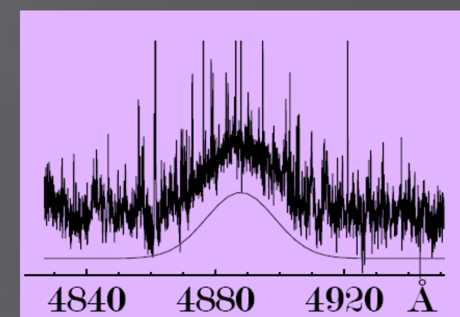


l-C_3H Peaks 1, 2, 3, 5

Ding, H., Pino, T., Güthe, F. and Maier, J. P.
J. Chem. Phys. 115, 6913, 2001.

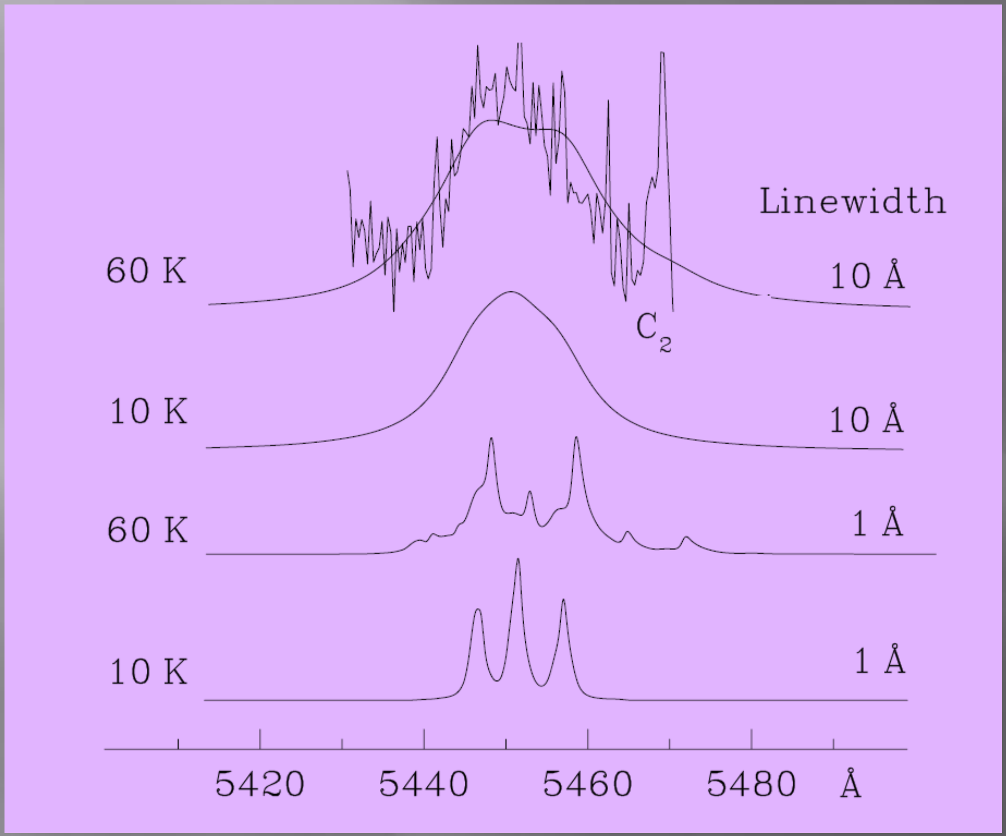
4

Peak 5, 4887(3)Å
In agreement with the prediction,
FWHM~25 Å



Peak	Area	Center λ (nm) vac	Center λ (nm) air	Width (Å) FWHM	Height
1	0.8425	484.78	484.65	2.5	3.0864
2	2.9328	486.07	485.94	7.9	3.4463
3	2.7093	487.10	486.96	4.8	5.2287
4	11.475	488.91	488.77	25.1	4.2932
5	7.9639	491.13	490.99	14.7	5.0723

Simulations-Rotational Temperature



100 fs lifetime

5

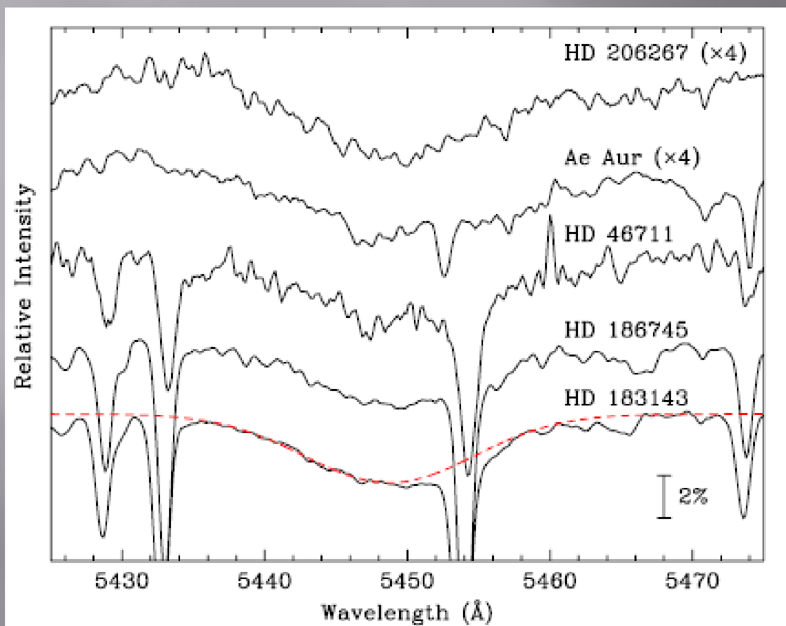
τ(C state)=70 fs

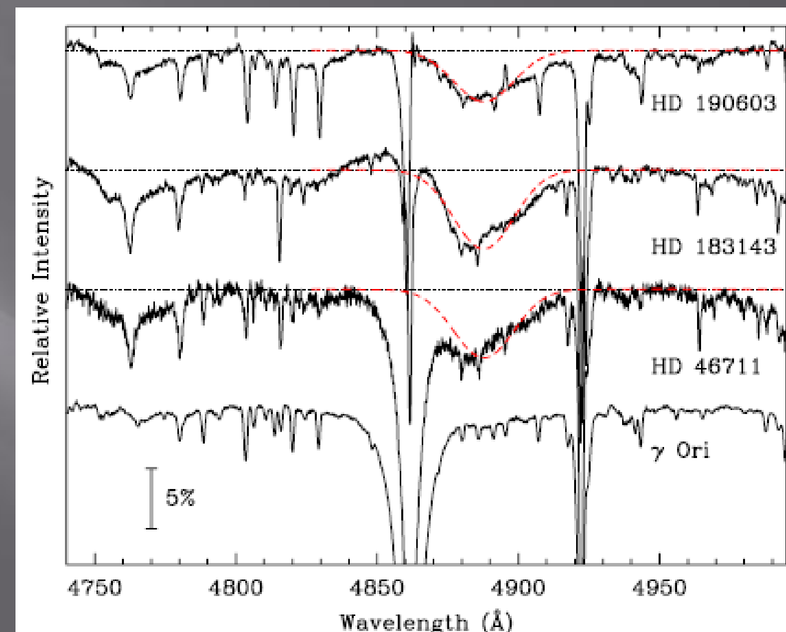
B. Noller, M. Margraf, C. Schröter, T. Schultz, and I. Fischer, Phys. Chem. Chem. Phys. 11, 5353, 2009.

2^1_0 $B^1B_1 \leftarrow X^1A_1$ l- C_3H_2 : 5450 Å DIB

A DIB corresponding to the $2\nu_2$ vibronic band of l-C_3H_2 ?

YES!!





J.P. Maier, G.A.H. Walker, D.A. Bohlender, F.J. Mazzotti, R. Raghunandan, J. Fulara, I. Garkusha, and A. Nagy, *Astrophys. J.*, **726**(1), 41, 2011.
L. M. Hobbs, D. G. York, J. A. Thorburn, T. P. Snow, M. Bishof, S. D. Friedman, B. J. McCall, T. Oka, B. Rachford, P. Sonnentrucker, and D. E. Welty, *Astrophys. J.* **705**, 32, 2009.

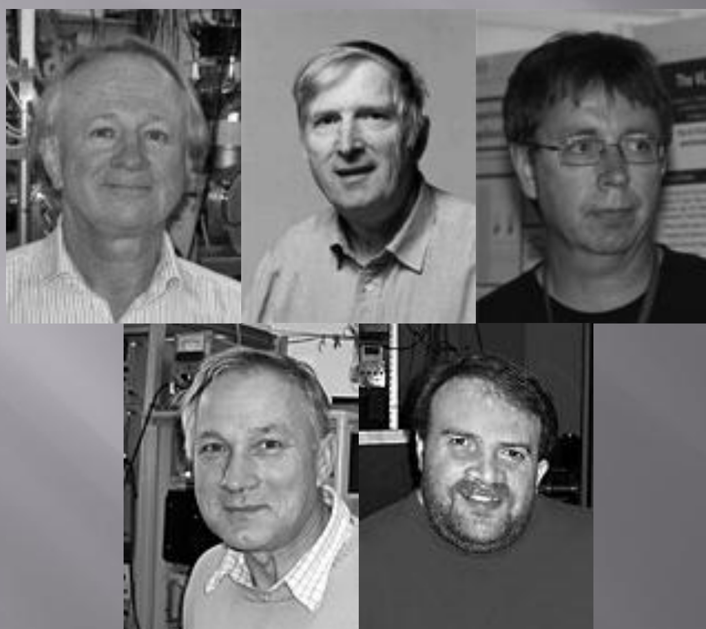
Conclusion

- Lab absorptions of l-C_3H_2 match the two DIBs in wavelength, FWHM, EW!
- DIB separation equals 2^1_0 - 2^2_0 vibronic spacing of C_3H_2

Discussion

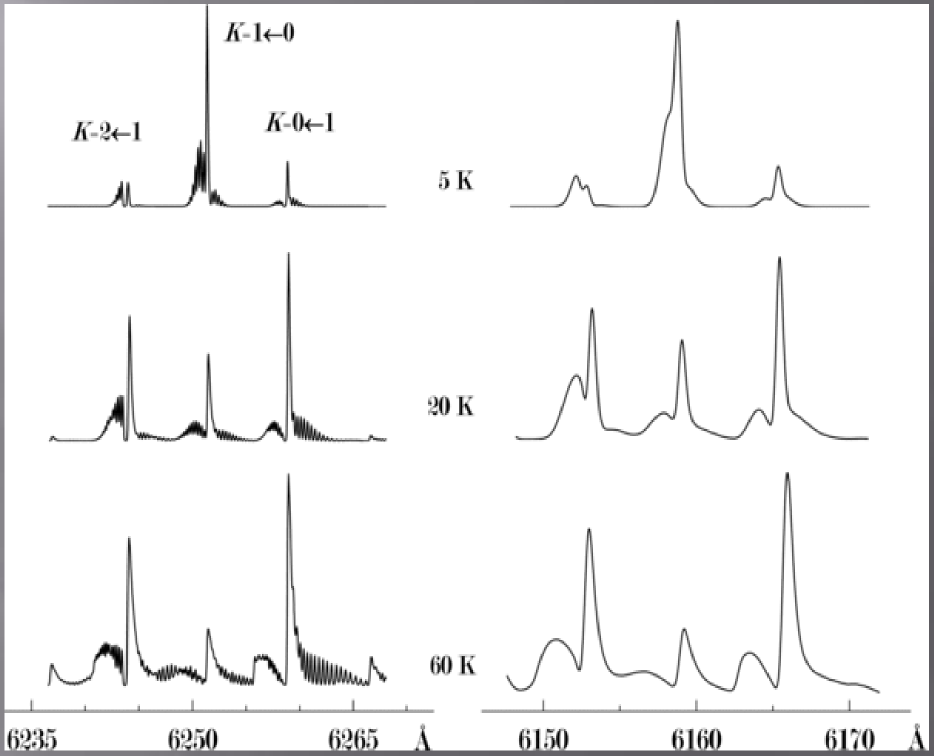
- Column density toward HD 183143 calculated from theoretically predicted f, N~10^{14} cm^{-2}
  - C_3, C_2 strong absorptions in HD 204827, weak in HD 183143.
  - C_3 depletion?
  - Do these DIBs correlate????

Acknowledgement



Swiss National Science Foundation

"The human brain is a wonderful organism. It works from the day we are born until the moment we stand up to speak in public."
(Financial Times)


K-1←0
K-2←1
K-0←1
5 K
20 K
60 K
6235
6250
6265
Å
6150
6160
6170
Å

Arguments

Table 1. Absorption band maxima (Å) of l-C_3H_2 and l-C_3D_2 measured in a 6 K neon matrix and in the gas phase (K=1←0).

Neon Matrix				Gas Phase		Transition	Band
$\lambda(l\text{-}C_3H_2)$	I	$\lambda(l\text{-}C_3D_2)$	I	$\lambda(l\text{-}C_3H_2)$	$\lambda(l\text{-}C_3D_2)$		
6284	0.2	6260	0.4	6318.9		$A\,^1A_2 \leftarrow X\,^1A_1$	a
6219	0.3	6130	1.4	6251.7		″	b
6122	0.9	6093	1.5	6159.2		″	c
5445/5417[1]	10	5412	10	5450(3)	5458(3)	$B\,^1B_1 \leftarrow X\,^1A_1$	2^1_0
5143	3	5160	3.5	5165–5185[2]		″	$2^1_0\,4^1_0$
4856	9	4857	12	4887(3)		″	2^2_0
4633	4.4			4645–4665[2]		″	$2^2_0\,4^1_0$
4412	4.7			4425–4445[2]		″	2^3_0

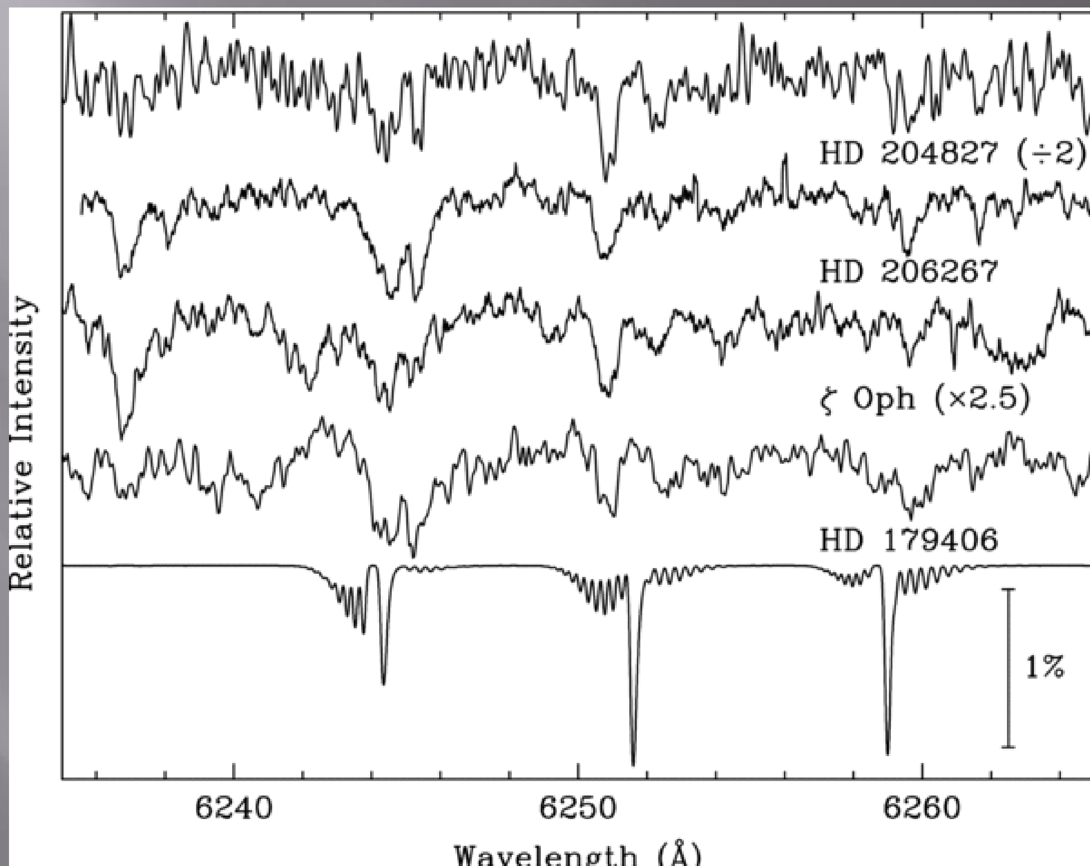
[1] most intense site

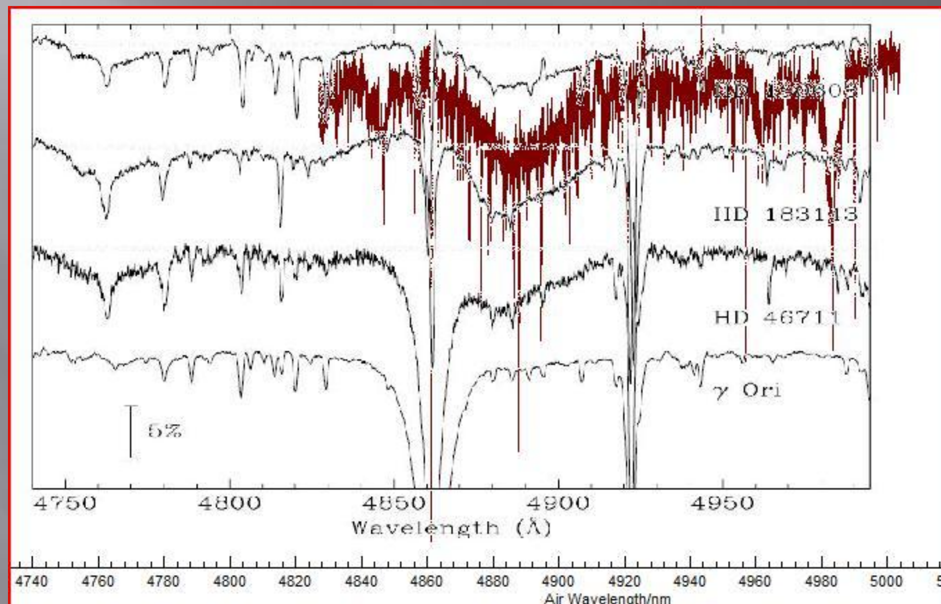
[2] extrapolated values based on neon/gas shifts of the 2^1_0 band

- Precursors used: allene, acetylene

Maximum yield, also produced l-C3H bands

- Similar matrix-gas wavelength shifts
- Similar deuterated shifts - 17/27 cm^{-1}
- Same production conditions for the 5450 band and the rotationally resolved bands
- Detection of the 4881 vibronic band as predicted by Ne measurements


HD 204827 (÷2)
HD 206267
ζ Oph (×2.5)
HD 179406
1%
Relative Intensity
6240
6250
6260
Wavelength (Å)



HD 183143
HD 46711
γ Ori
5%
4750 4800 4850 4900 4950
Wavelength (Å)
4740 4760 4780 4800 4820 4840 4860 4880 4900 4920 4940 4960 4980 5000
Air Wavelength/nm

JD94 λc (Å)	TC00 λc (Å)	λc (Å)	FWHM (Å)	Wλ (mÅ)	ΔWλ (mÅ)	DIB λc*(Å)	β Ori λc*(Å)	β Ori Wλ (mÅ)	No.
49.63		5450.52	12.30	359.5	14.4	50.15	> 1.	159.0	32
81.83	82.56	4881.06	11.31	343.7	16.2	80.73	> 1.	49.8	10