Is C_7^- Really a Diffuse Interstellar Band Carrier???

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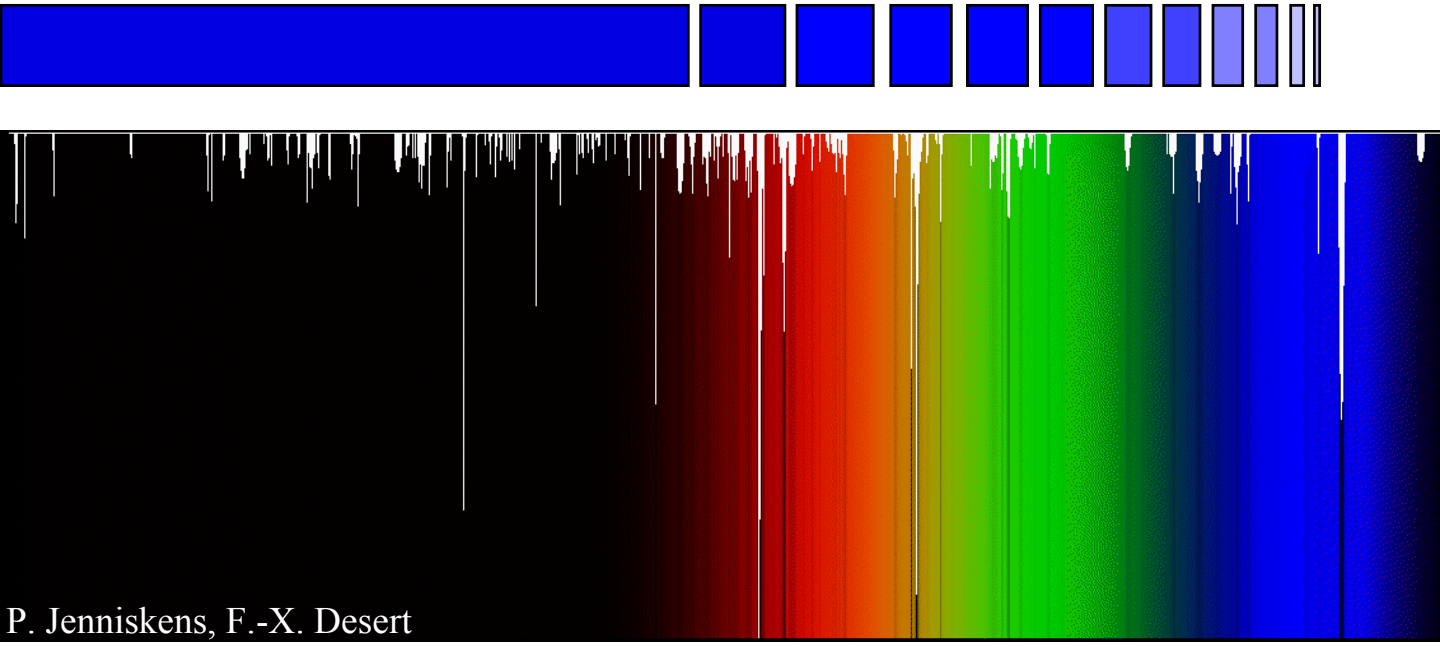
Special Thanks to John Maier

Diffuse Interstellar Bands



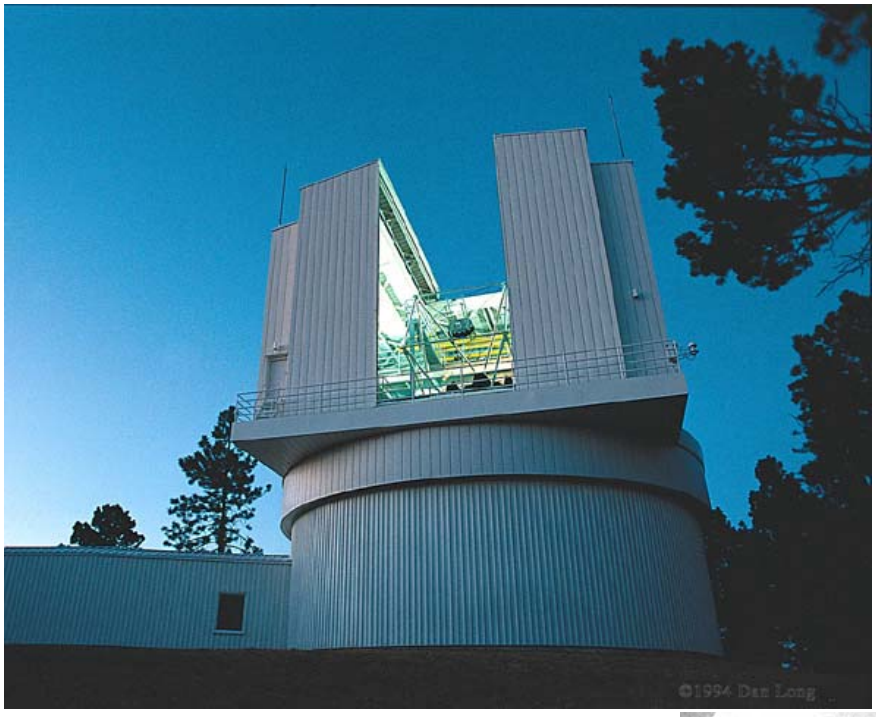
- ★ Over 200 sharp and broad ("diffuse") bands
- ★ Seen in absorption against reddened stars
- ★ Range from ~4430 Å to >8000 Å
- ★ Associated with diffuse ($n \sim 10^2$ cm^{-3}) clouds
- ★ Not all correlated; roughly increase with E_{B-V}

- ★ Long-standing astrophysical mystery!
  (also CH^+ and H_3^+)

Diffuse Cloud Survey

- Visible spectroscopy of DIBs, atoms, diatomics
  - Apache Point Observatory (APO)
- Ultraviolet spectra of H, H_2, C, C^+, CO
  - Far Ultraviolet Spectroscopic Explorer (FUSE)
  - Hubble Space Telescope (HST)
- Infrared spectroscopy of H_3^+ and CO
  - United Kingdom Infrared Telescope (UKIRT)
  - Phoenix (Kitt Peak $\rightarrow$ Cerro Tololo)
  - Subaru (Japan Large National Telescope)
- "World's largest correlation analysis"
- Large collaboration
  - Chicago: York, Hobbs, Thorburn, Welty, Oka, McCall
  - Colorado: Snow, Rachford
  - Johns Hopkins: Friedman, Sonnentrucker
  - Gemini: Geballe
  - NOAO: Hinkle
  - Subaru: Goto, Kobayashi, Terada, Usuda

Apache Point Observatory



3.5 meter telescope

near Alamogordo, New Mexico

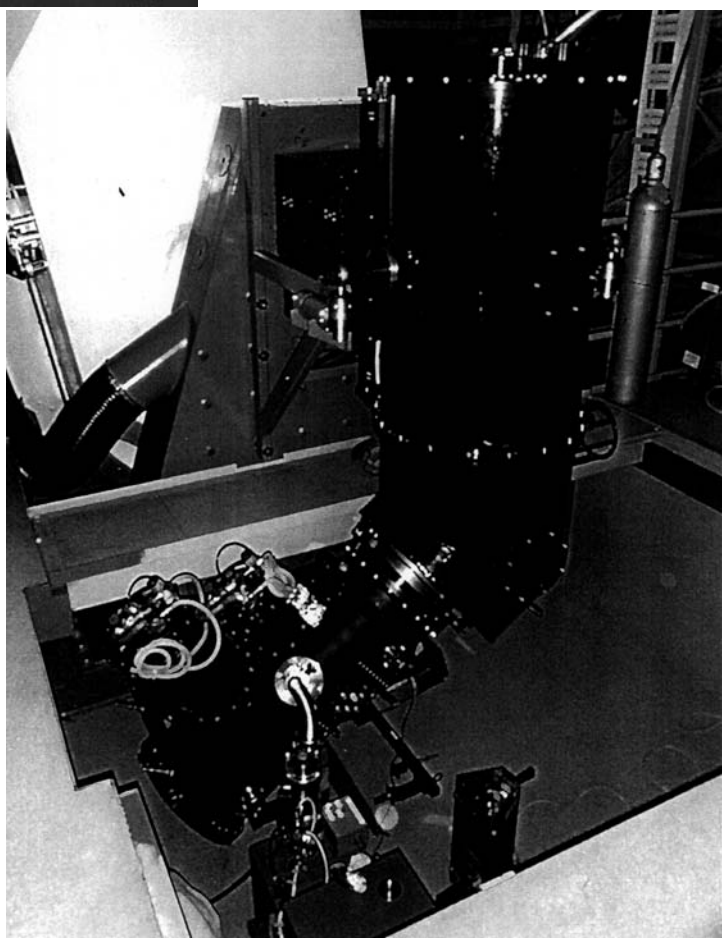
Astrophysical Research Consortium

Echelle Spectrometer:

Blazeless spectrum from 4000 — 10,000 Å in single exposure

High resolution ($\lambda / \Delta\lambda \sim 37{,}500$)

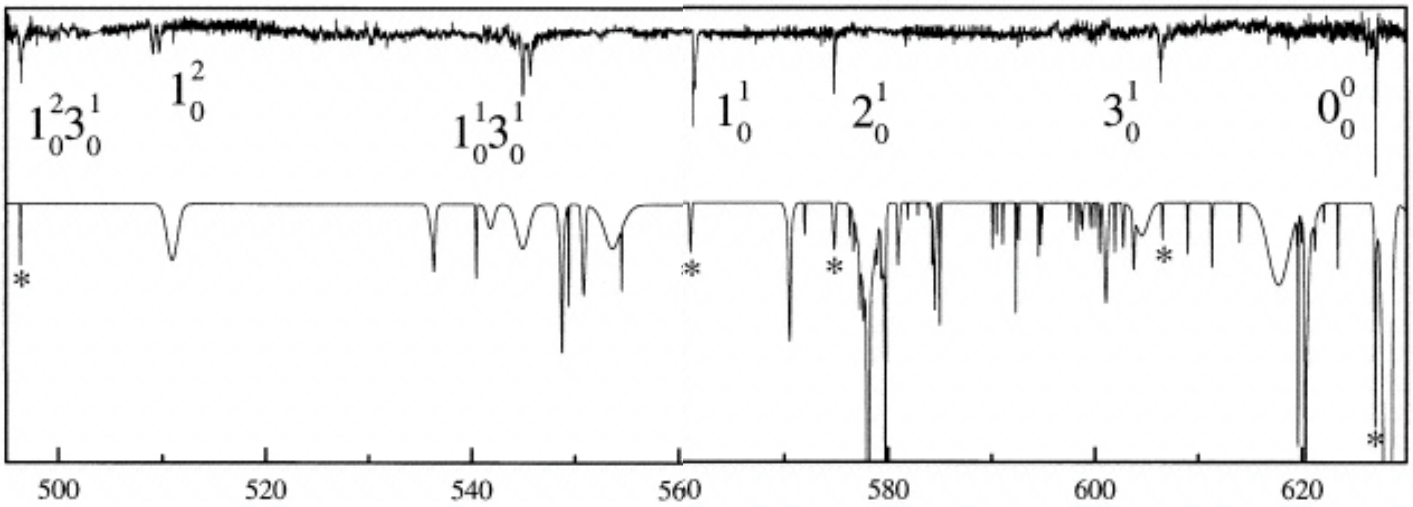
High sensitivity (S/N~1000)



The C_7^- Hypothesis

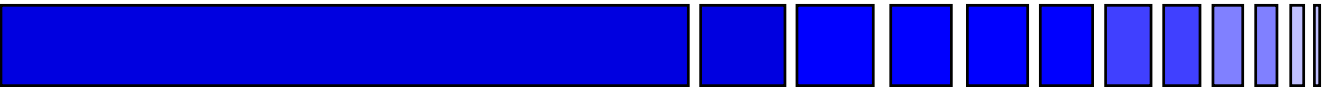
M. Tulej et al., Astrophys. J. 506, L69 (1998)

- Gas phase spectrum by Maier's group
  - mass-selection of ion beam
  - resonance-enhanced two-color photodetachment
  - low resolution, limit of sensitivity
  - seven vibronic bands of A←X
  - several (broad) bands of B←X



- Comparison with DIB catalog of Jenniskens
  - five A←X bands agree within 2 Å
  - astronomical lines marginal (except 0_0^0)
  - promising, but not convincing
  - experiment didn't yield constants
  - difficult to determine temperature dependence

Our Initial Comparison



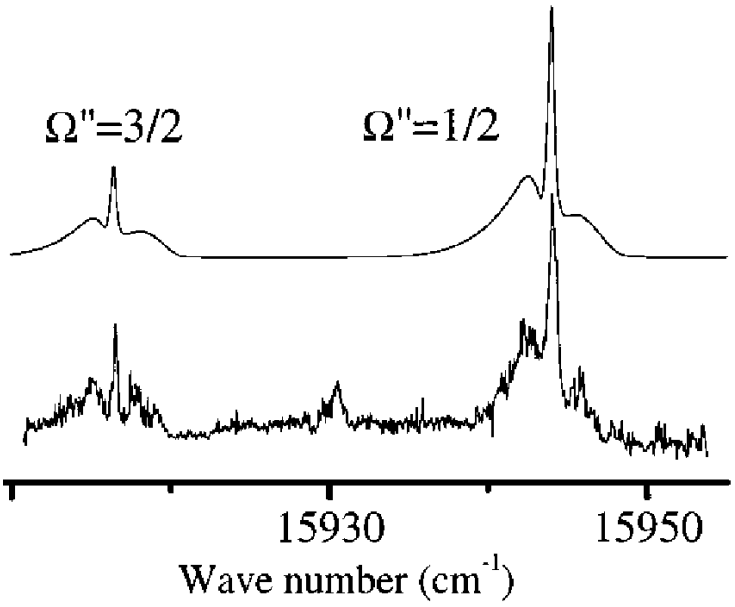
B. J. McCall, D. G. York, & T. Oka, Astrophys. J. 531, 329 (2000)

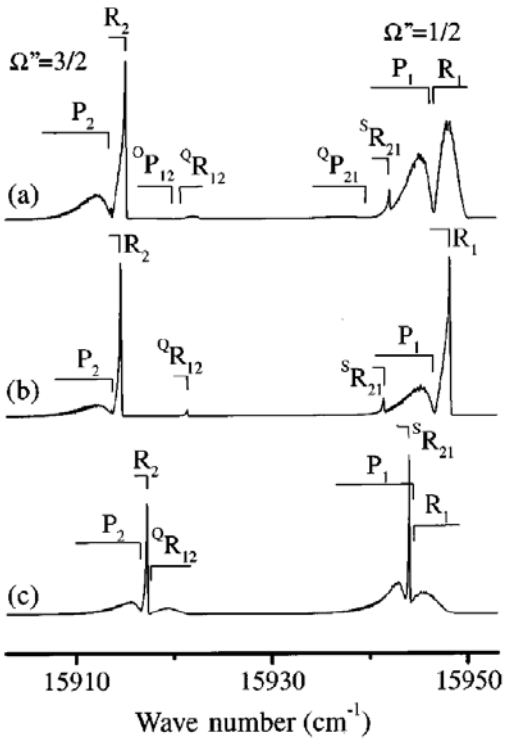
- First four stars from survey
  - Cyg OB2 12, HD 183143, HD 46711, HD 50064
- Confirmed features near 4 A←X bands
  - λ6270, λ6065, λ5610, λ4964
  - 2^1_0 "match" probably not a DIB
- Reasonable intensity correlation (4 bands)
- Wavelength shift for 1^1_0 band (2 Å)

- Need better laboratory data
  - rotational, spin-orbit constants
- Need better observations
  - larger sample of stars
  - higher S/N

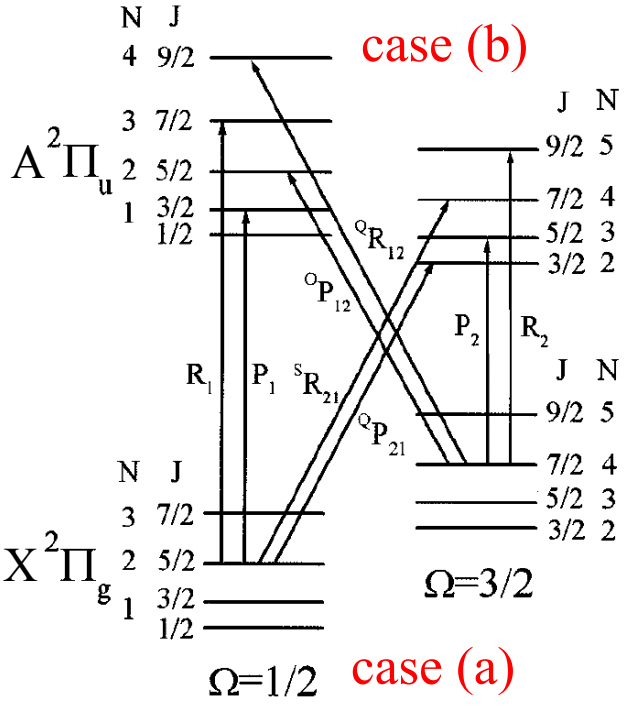
New Lab Results

N. M. Lakin, M. Pachkov, M. Tulej, J. P. Maier, G. Chambaud, & P. Rosmus, JCP 113, 9586 (2000)

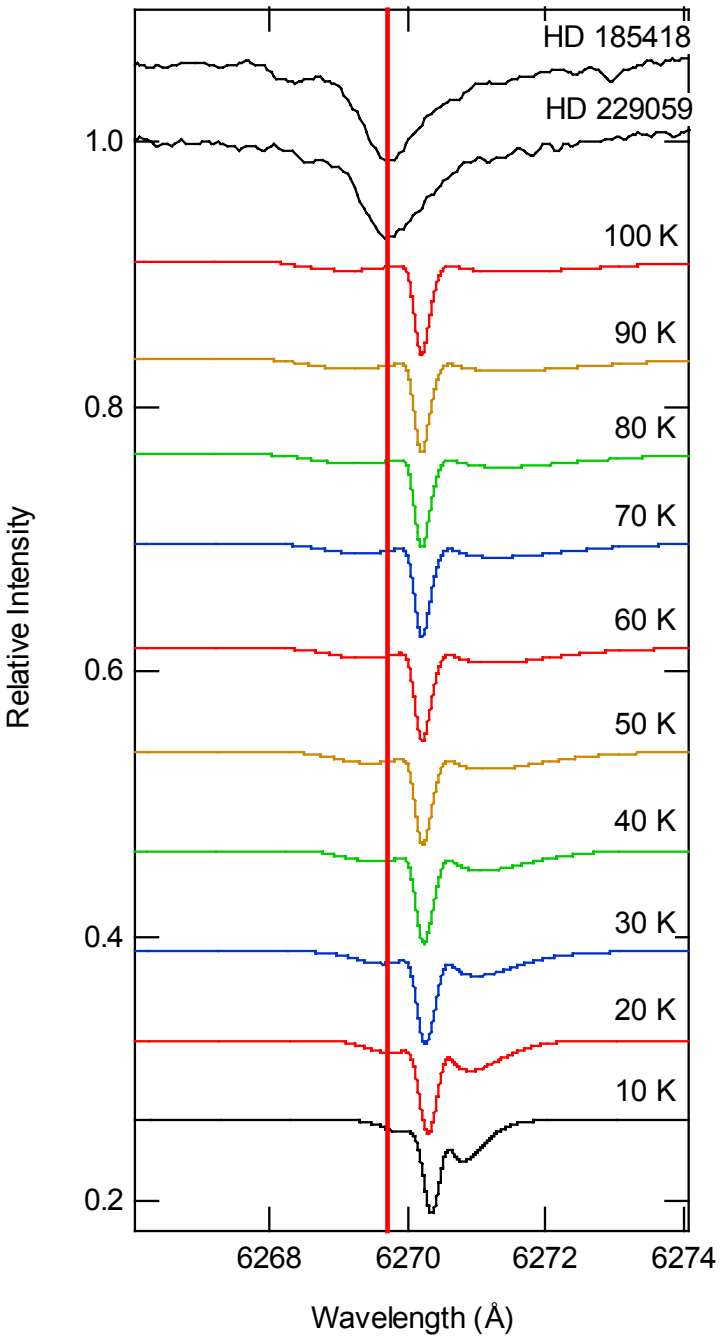




Constant	Theory	Fit
B" (MHz)	897	(fixed)
B' (MHz)	887	(fixed)
A" (cm^{-1})	26.8	27.4
A' (cm^{-1})	– 6.2	0.6



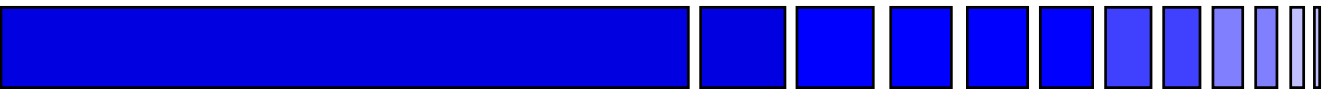
0_0^0 (Ω''=1/2) & λ6270

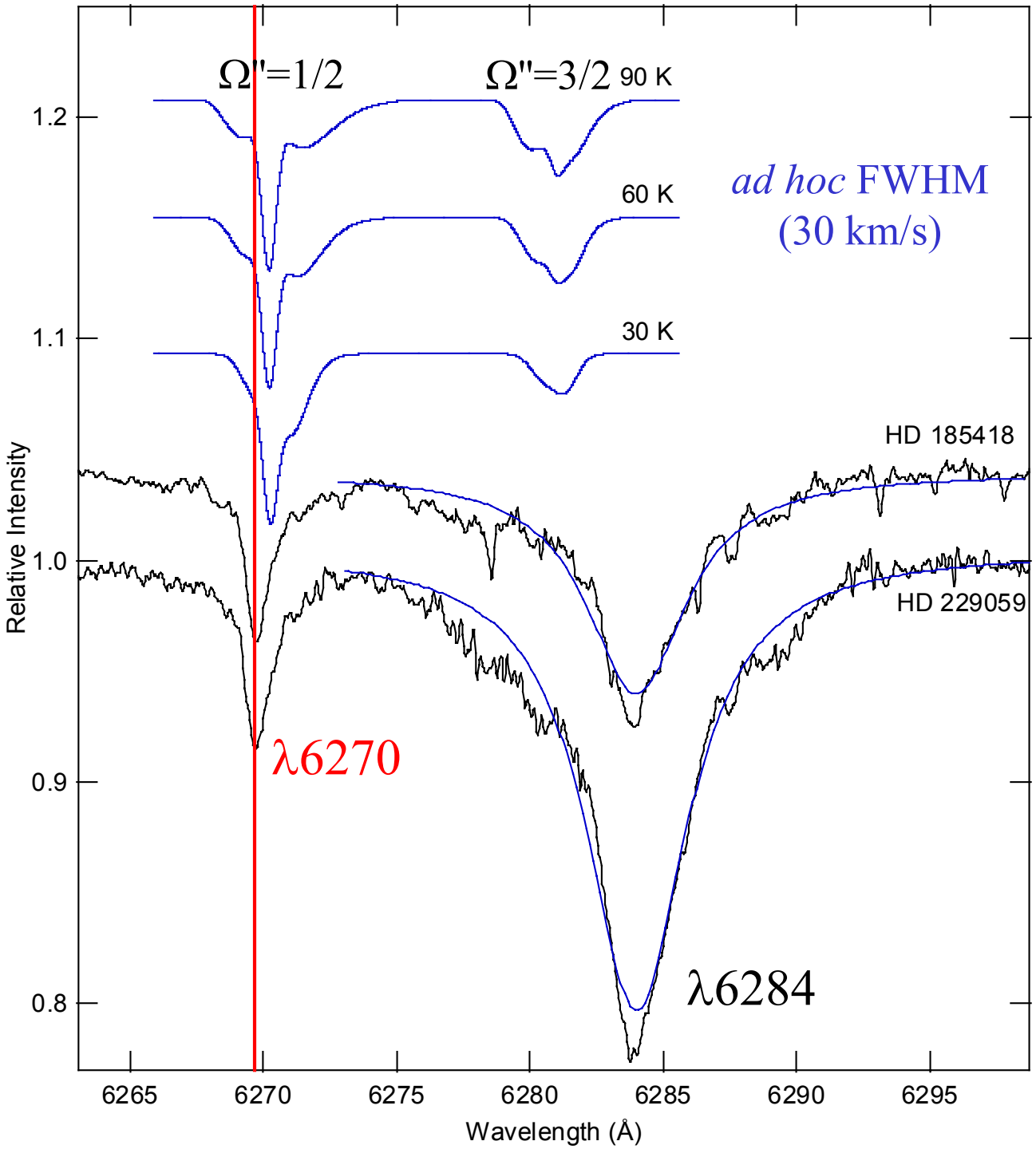


Interstellar K atom
velocity distribution
FWHM = 10 km/s

- Wavelength discrepancy
- Profile mismatch
  (λ6270 too wide)

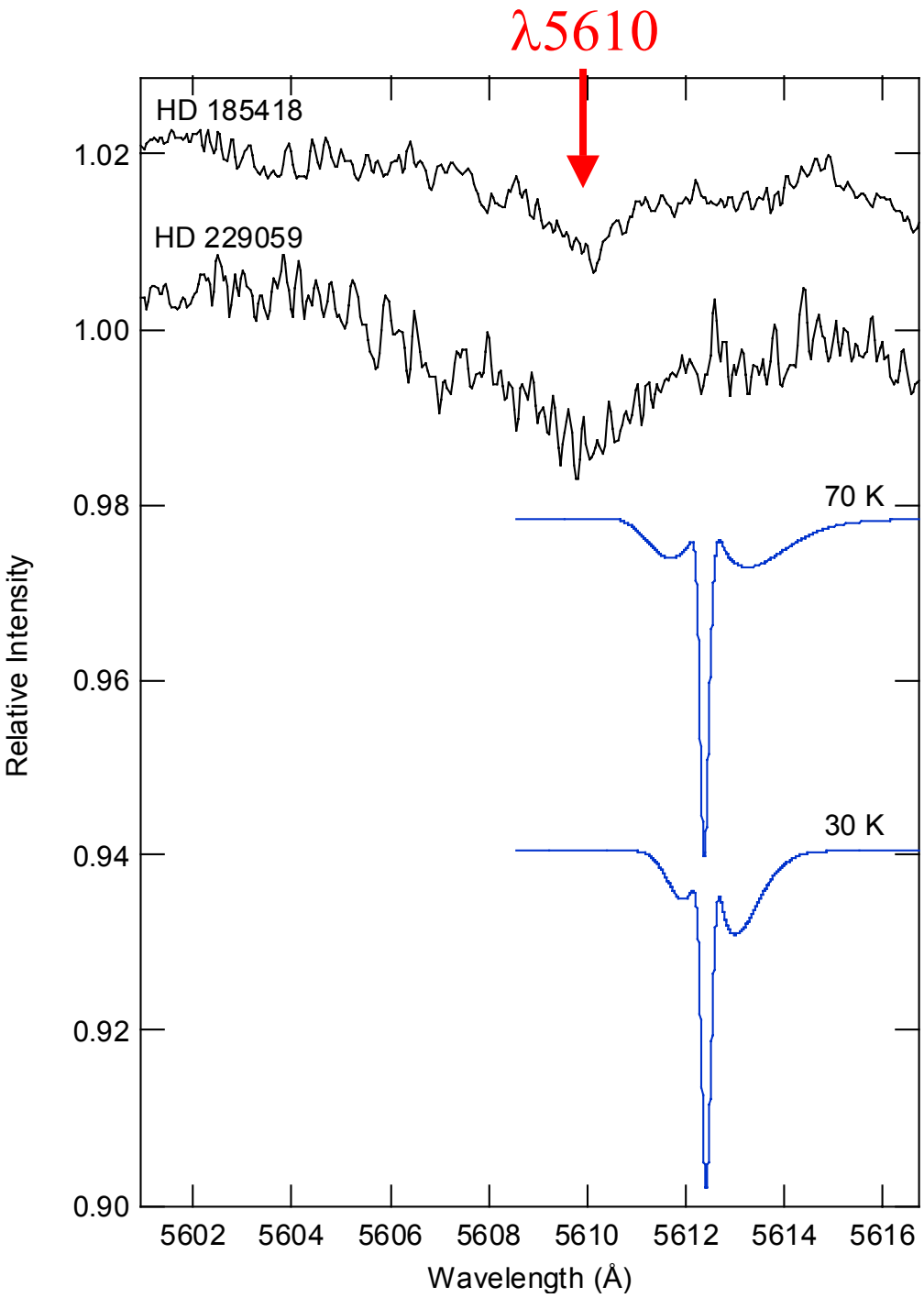
0_0^0 ($\Omega''=3/2$)





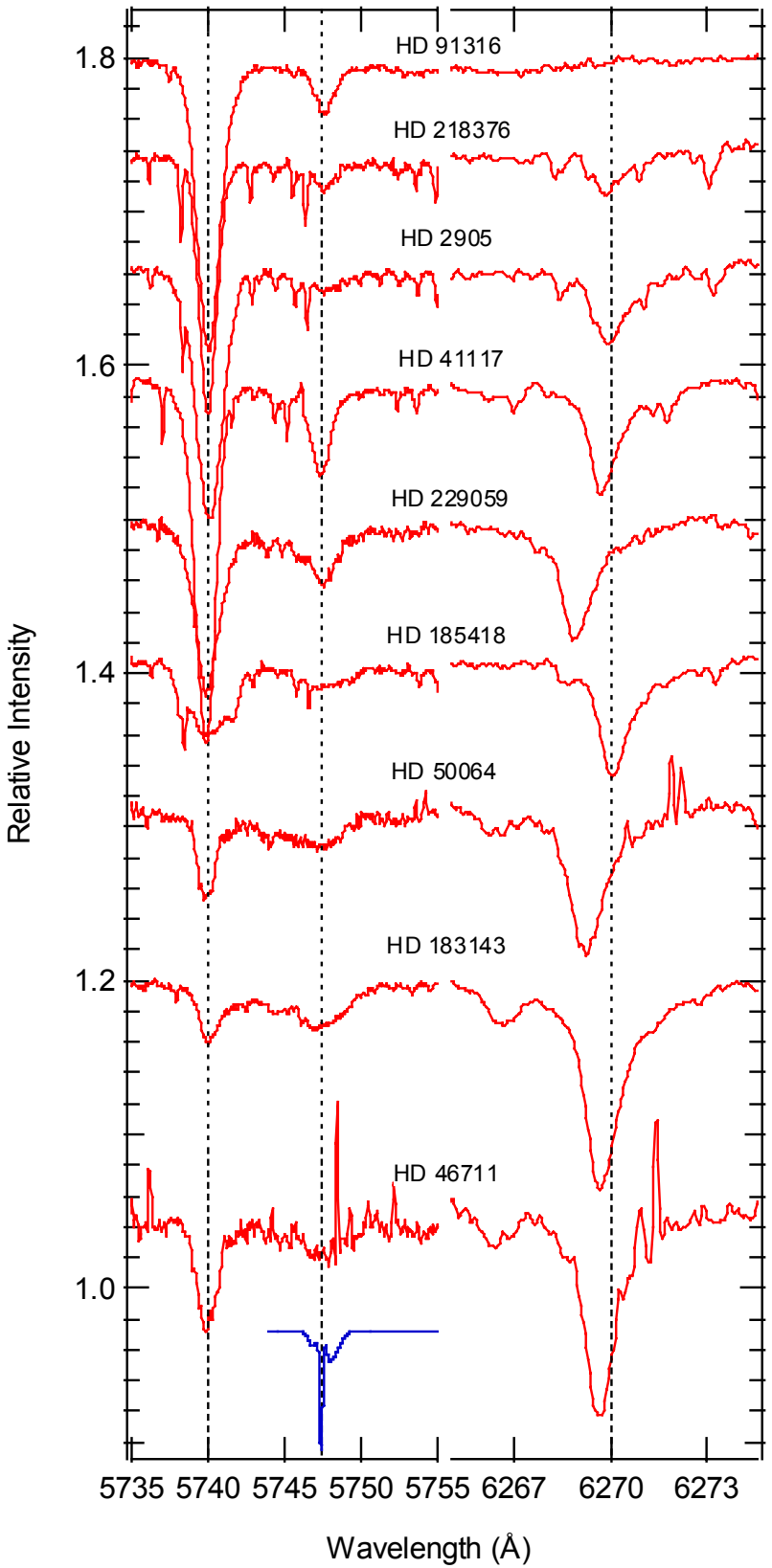
- No sign of $\Omega''=3/2$ component!

The 1_0^1 Band & λ5610



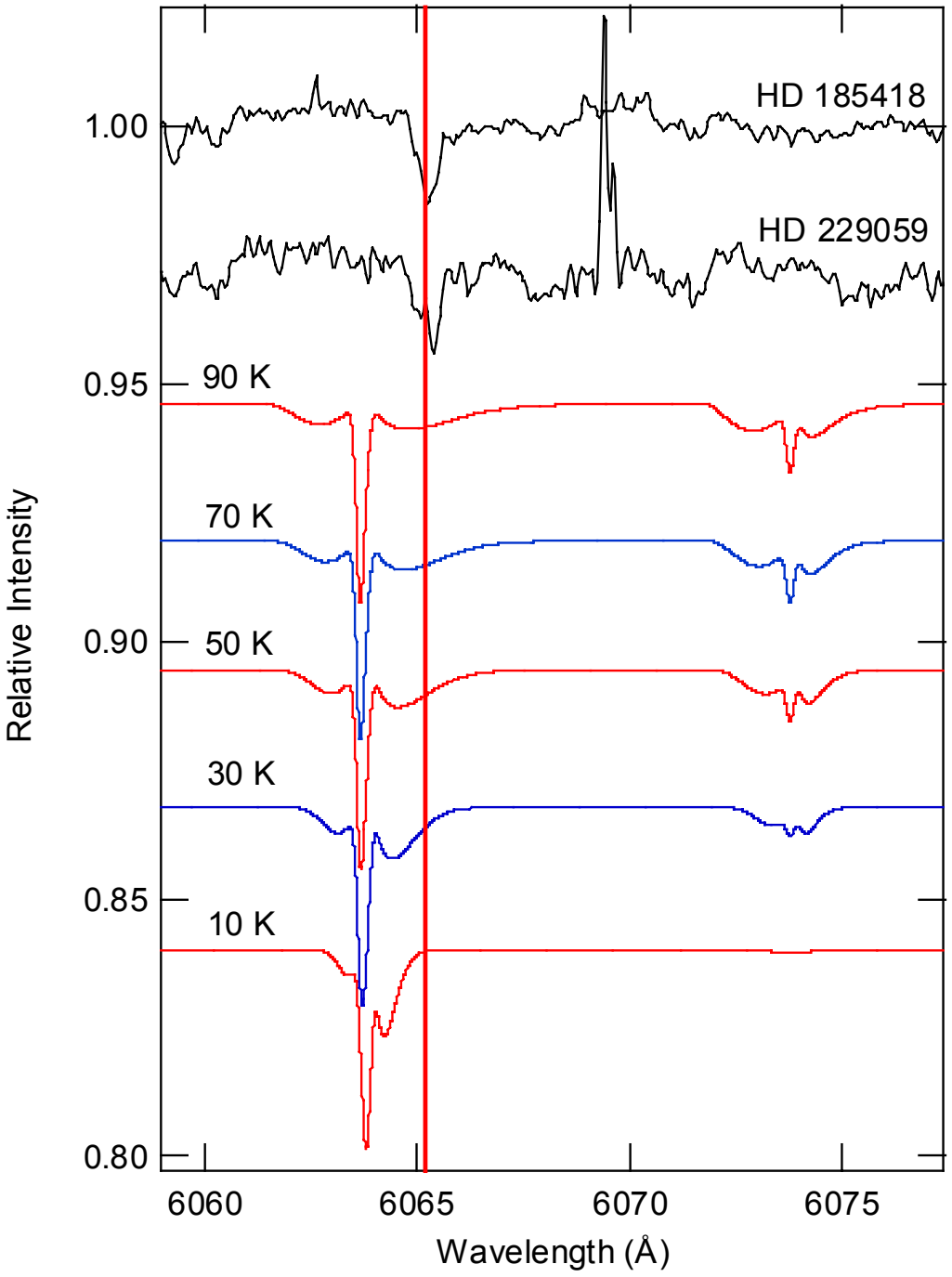
- Serious wavelength discrepancy
- Profile mismatch (λ5610 too wide)

The 2^1_0 Band & λ5748



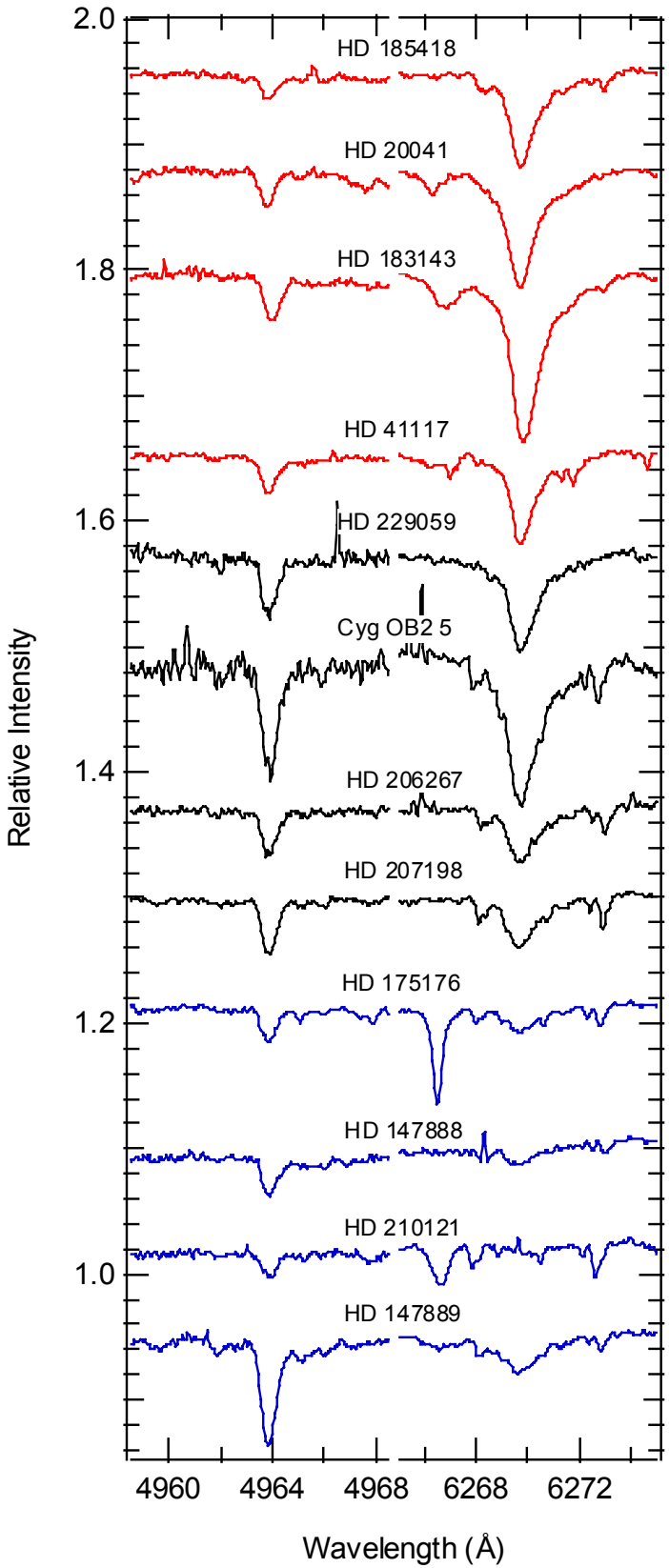
- Jenniskens claimed "certain" DIB λ5748
- If spectra aligned by λ5748, stellar lines at 5740 Å all line up, and real DIB λ6270 ("0^0_0") no longer lines up!
- Appears in unreddened stars where DIB λ6270 absent
- λ5748 is a stellar line, <u>not</u> a DIB!
- Cannot be a match for C_7^-

The 3^1_0 Band & λ6065



- Wavelength discrepancy
- Much narrower than λ6270 ("0^0_0")

The $1_0^2 3_0^1$ Band & λ4964



- No new lab work
- DIB at 4964, old lab measurement was 4963
- Absolutely NO correlation with λ6270 ("origin band") !

Conclusions

0_0^0	[λ6270]	wavelength discrepancy (~0.5 Å) profile inconsistent (too wide) Ω"=3/2 component not detected
1_0^1	[λ5610]	wavelength discrepancy (~2 Å) profile inconsistent (too wide)
2_0^1	[λ5748]	not a DIB
3_0^1	[λ6065]	wavelength discrepancy (~1 Å) much narrower than λ6270 seems to correlate with λ6270
$1_0^2 3_0^1$	[λ4964]	not correlated with λ6270!

C_7^- is NOT really a DIB carrier!