APO and Diffuse Interstellar Bands 1982-2014

Donald G. York
University of Chicago

APO 20th (30th ?) reunion

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What are Diffuse Interstellar Bands?

- 570 interstellar lines between 4000A and 8500A (more to the red, developed by SDSS III IR spectrograph). Interstellar because they are stationary in spectra of spectroscopic binaries.
- Known from first 2 discovered in 1919, for 95 years, unidentified by type of material or QM system in all that time.

- Diffuse: widths >30 km/sec, compared to atomic line widths of 0.3 km/sec
- Thought now to be molecular, species not agreed on.
- If molecular, the diffuseness would be explained by radiative pumping of low lying rotational levels by the Cosmic Microwave Background (as for CN), but many more levels.

The personal story-- What APO means to me.

1. Thesis on Diffuse Interstellar Bands with Carnegie image tube of gain 0.1 and photographic plates. Tube was removed and thesis completed. Realized there had to be a better way. Dreams of having own large, private telescope to do long programs. I moved to Princeton to have such access (UV).

2. There is pre-history only known by rumor. (1970s)(NMSU, Washington, Howard).

3. Wallerstein talks to Jenkins (an ISM collaborator) at Princeton, Jenkins suggests Wallerstein talk to Ostriker.

4. JPO shows interest but cannot take on the full 1/3 partnership needed.

5. JPO asks me to be point person for Princeton and find out more. Travel to Sunspot, meets Anderson and Balick.

6. York uses Kitt Peak 4 meter (1980) to observe DIBs. CCD read noise, 50 electrons. Peer reviewed time highly restrictive.

7. John Lowrance, Princeton entrepreneur and engineer, suggests using remote observing using new technology (1400 baud modems) to control telescope from remote sites. Princeton did that with Stratoscope in the 1960s.

8. York moves in 1982 to Chicago, informs colleagues of possibility.

9. Dean Stuart Rice urges astronomers to be more ambitious and go for the partnership.

10. Consortium formed. Washington, Washington State, NMSU, Princeton, Chicago. 1983. Roads started

11. Around 1988, instruments were decided, including an echelle (NSF proposal).

12. 8 years of waiting, for mirror, instruments, etc. Remote operation worked almost out of the box, by 1988, in trial runs.

1998 Echelle on telescope with SDSS-SITE 2kx2K CCD, 5 electron read noise. Mirror from Arizona, Lots of organizing and engineering.

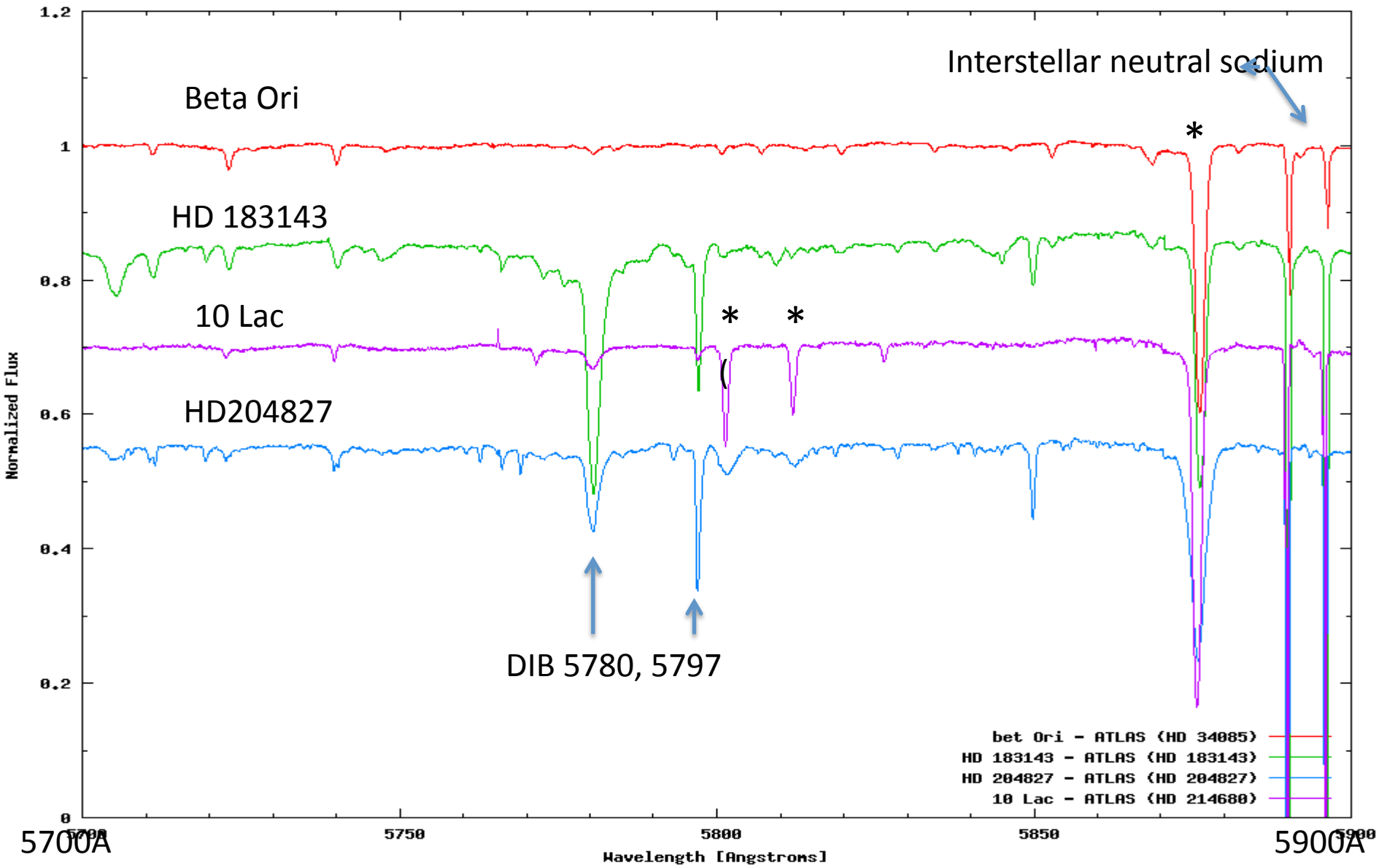
January 7, 1999, first DIB spectra taken, 15 Mon and rho Leo. Signal to noise 500 in single spectra. The dream had come true. Technology, private telescope, lots of time, remote observing

Since then, we have observed over 200 half-nights, over 300 stars

Co authors:
Julie Dahlstrom (Carthage)
Dan Welty, Tak Oka, Lew Hobbs, Reid Sherman, Sean Johnson, Zihao Jiang (Chicago)
Scott Friedman, Paule Sonnentrucker (STScI)
Brian Rachford (Embry-Riddle Aeronautical University).
Ted Snow (University of Colorado)

arXiv:1305.3003

Multiple Spectrum Plot



Return to star choice menu

Redraw

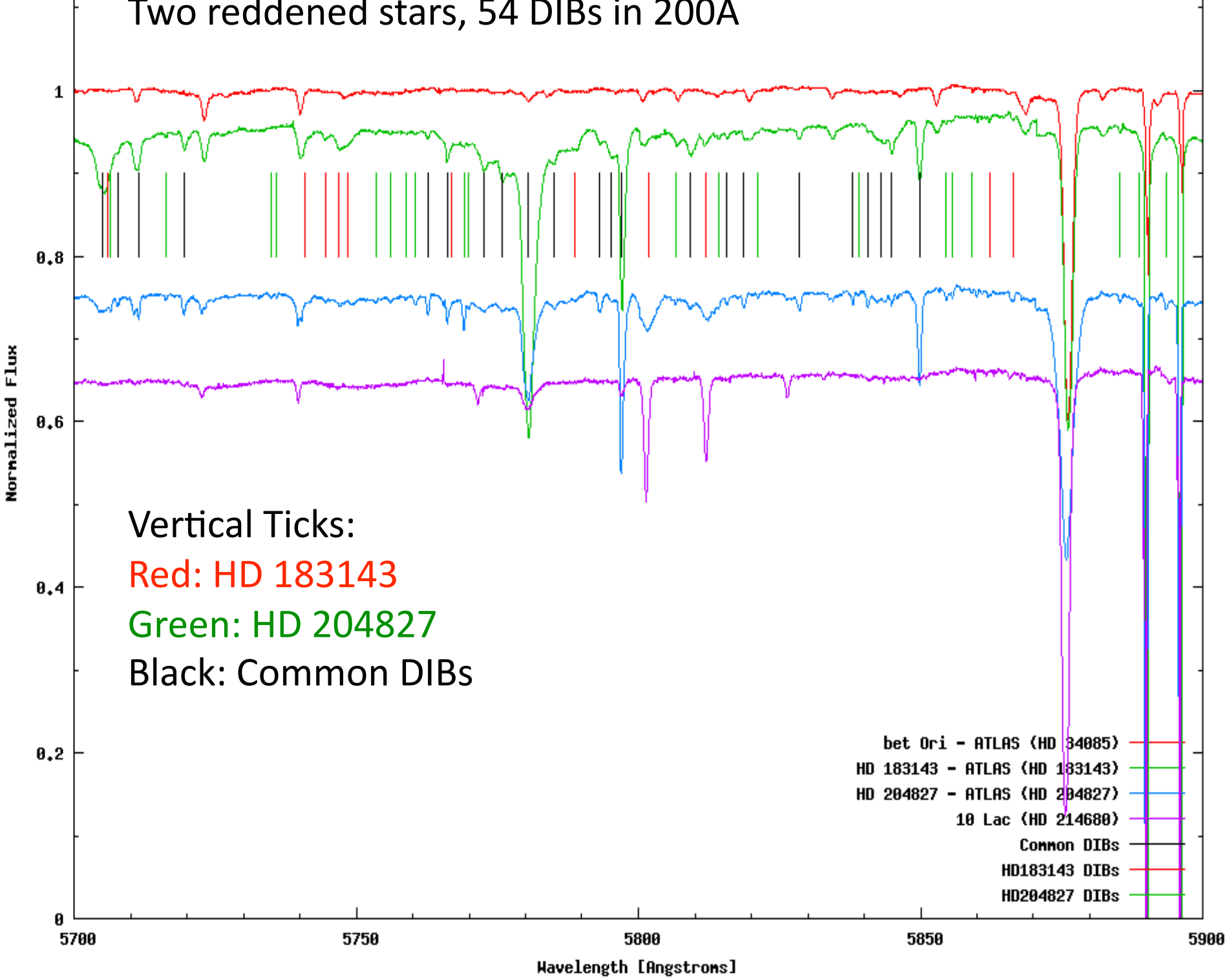
<< Move wavelength window >>

Redraw with plotting range:

x = 5700 to 5900

y = 0 to 1.2

Include marks of known DIBs with offset



Return to star choice menu

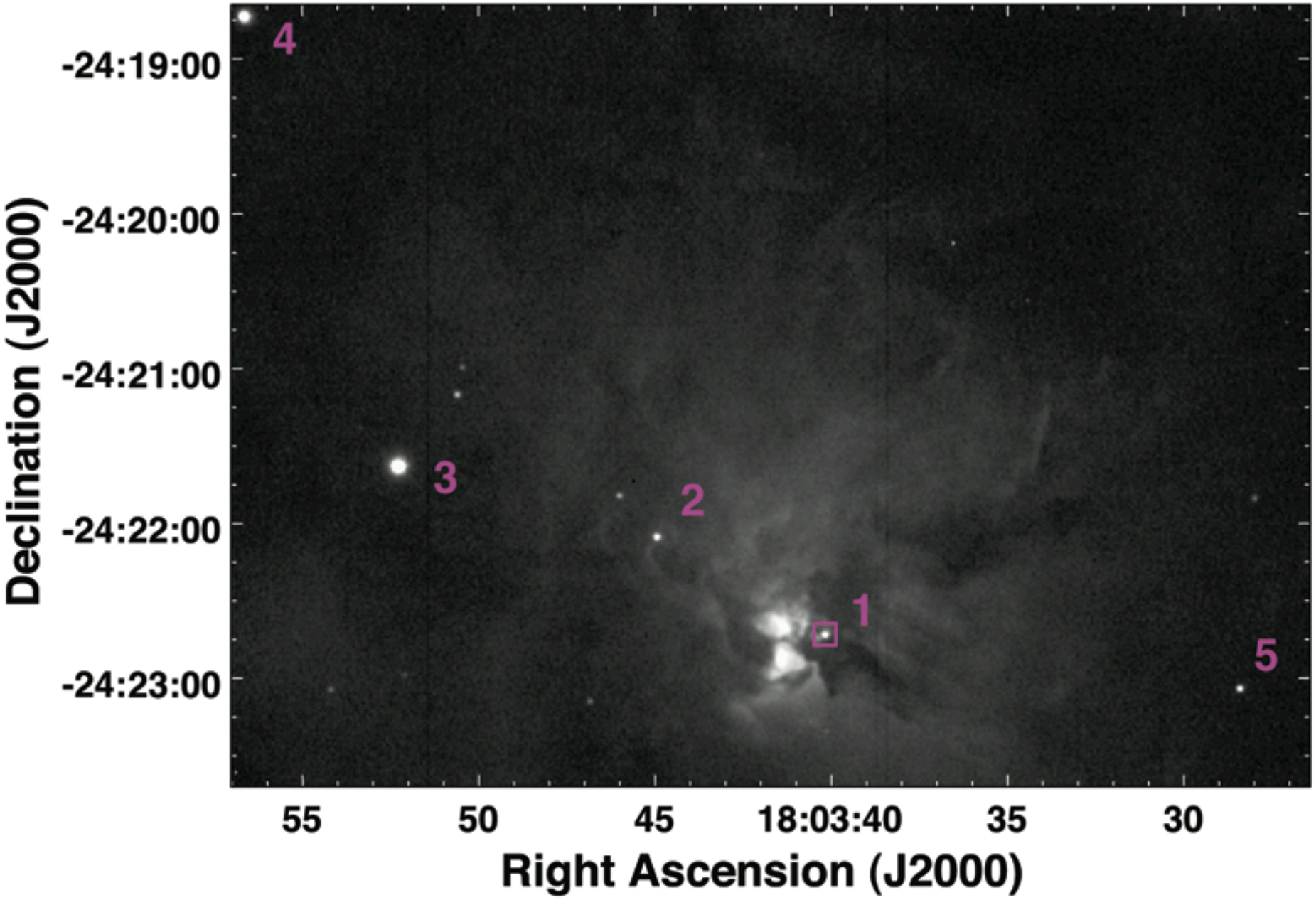
The key to identification lies in laboratory matching of spectra. (This has been tried since the time of Herzberg with no success.)

Observations of DIB profiles. This is what we can do.

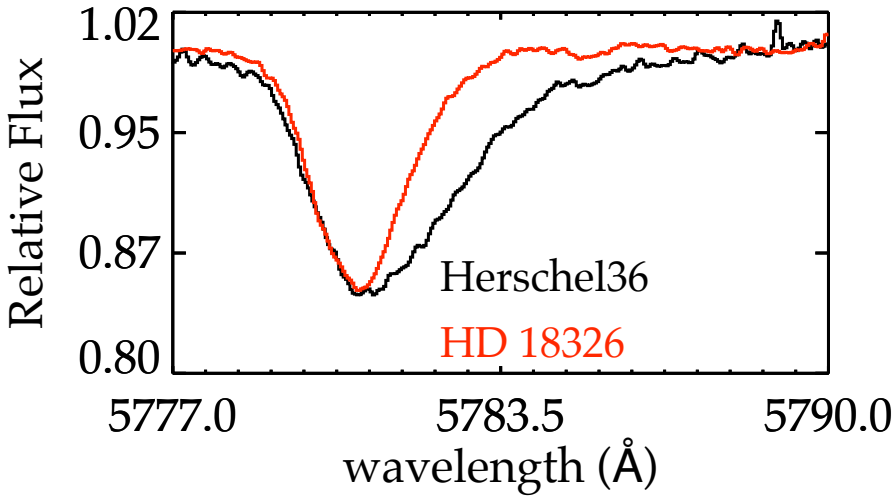
Two stories: a unique star in a nebula

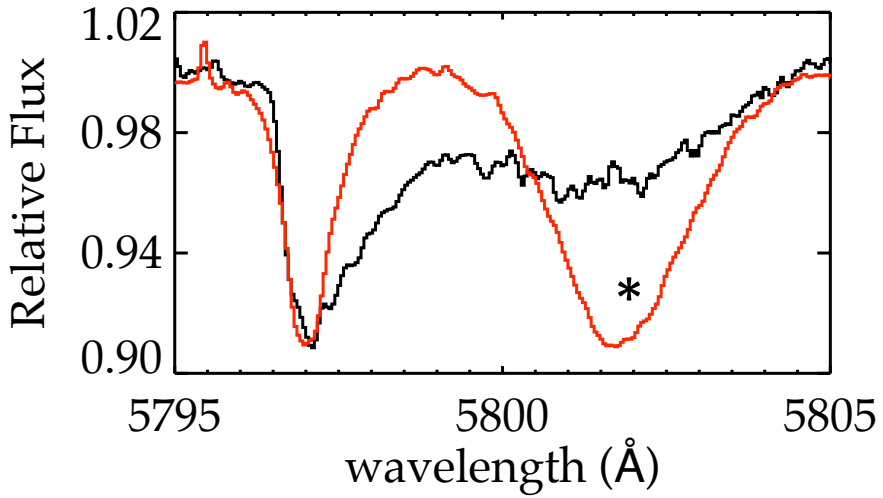
And the recent Supernova 2014J in M82

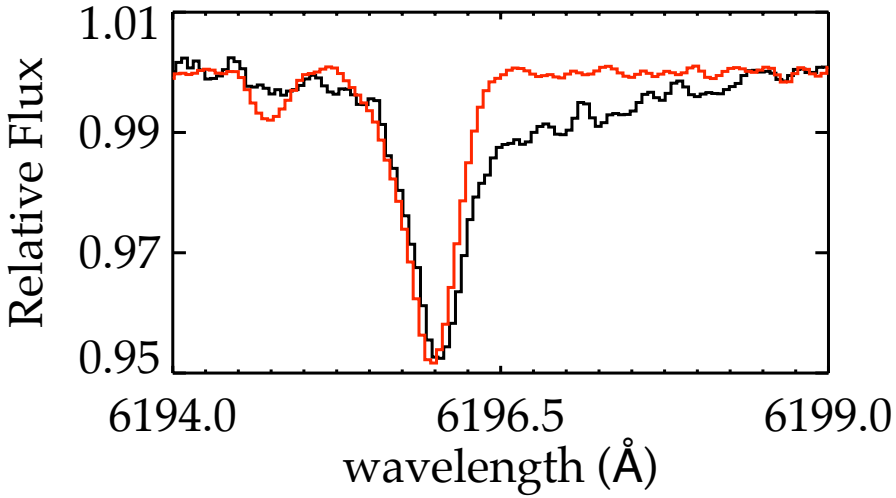
Herschel 36 in NGC 6530

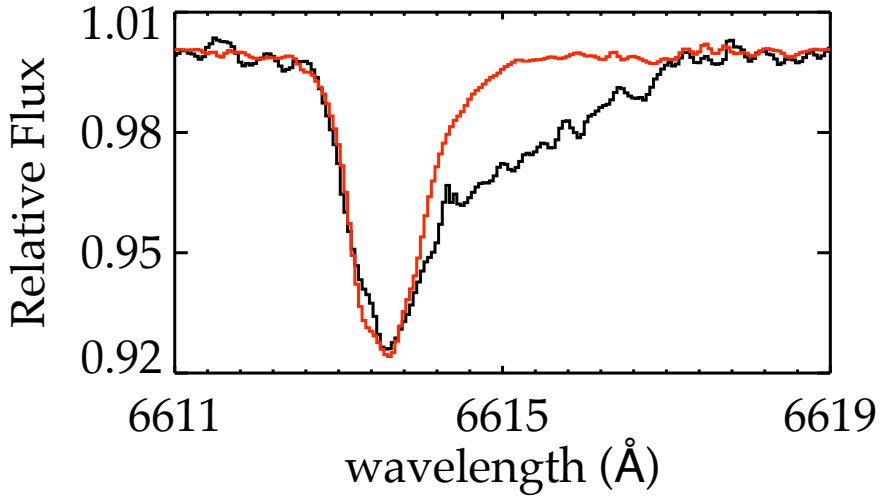


Herschel 36 in NGC 6530, Dumbell Nebula, 33 APO spectra over 13 years.









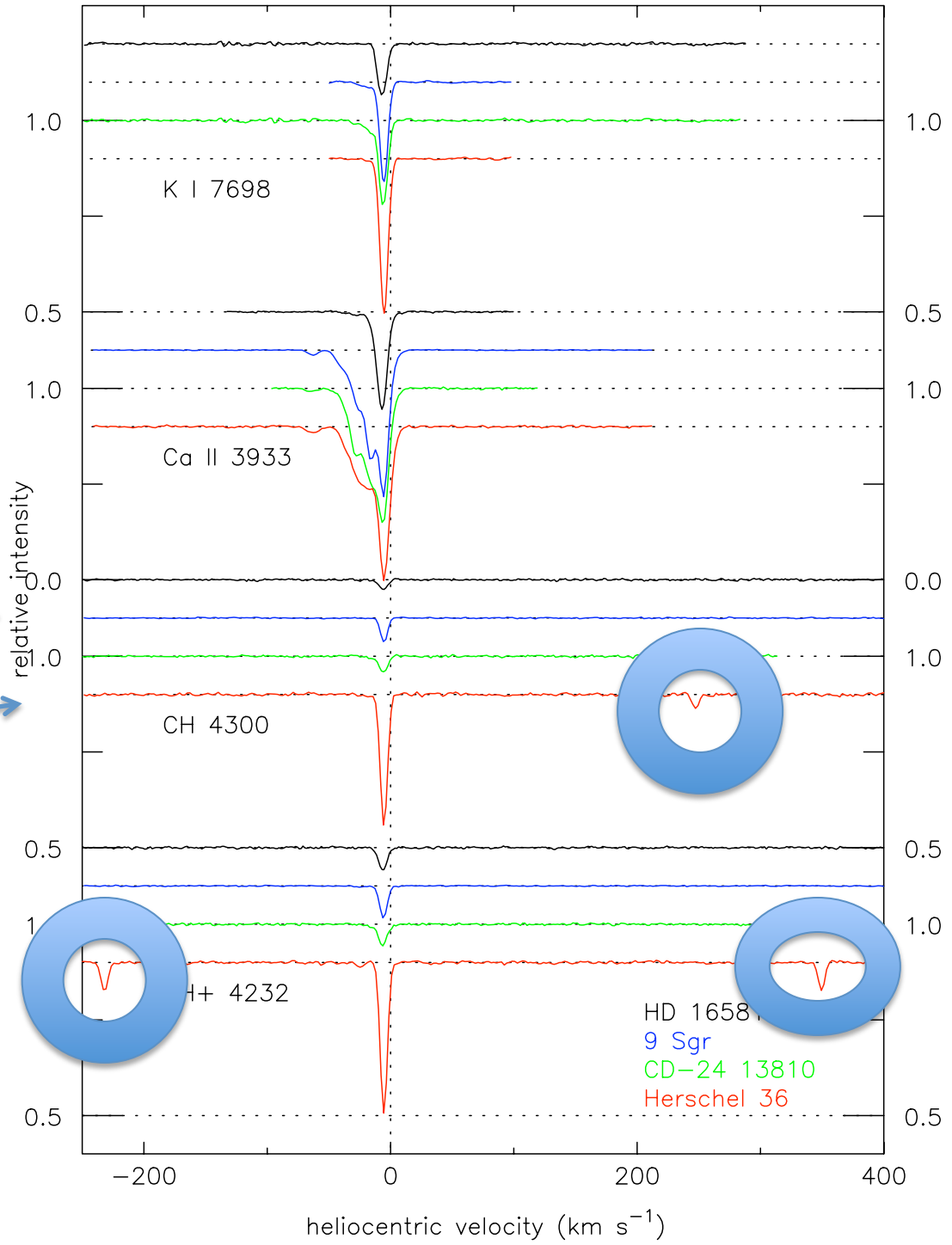
Isolating the anomalous DIB Profiles to within 0.5 pc of Her 36

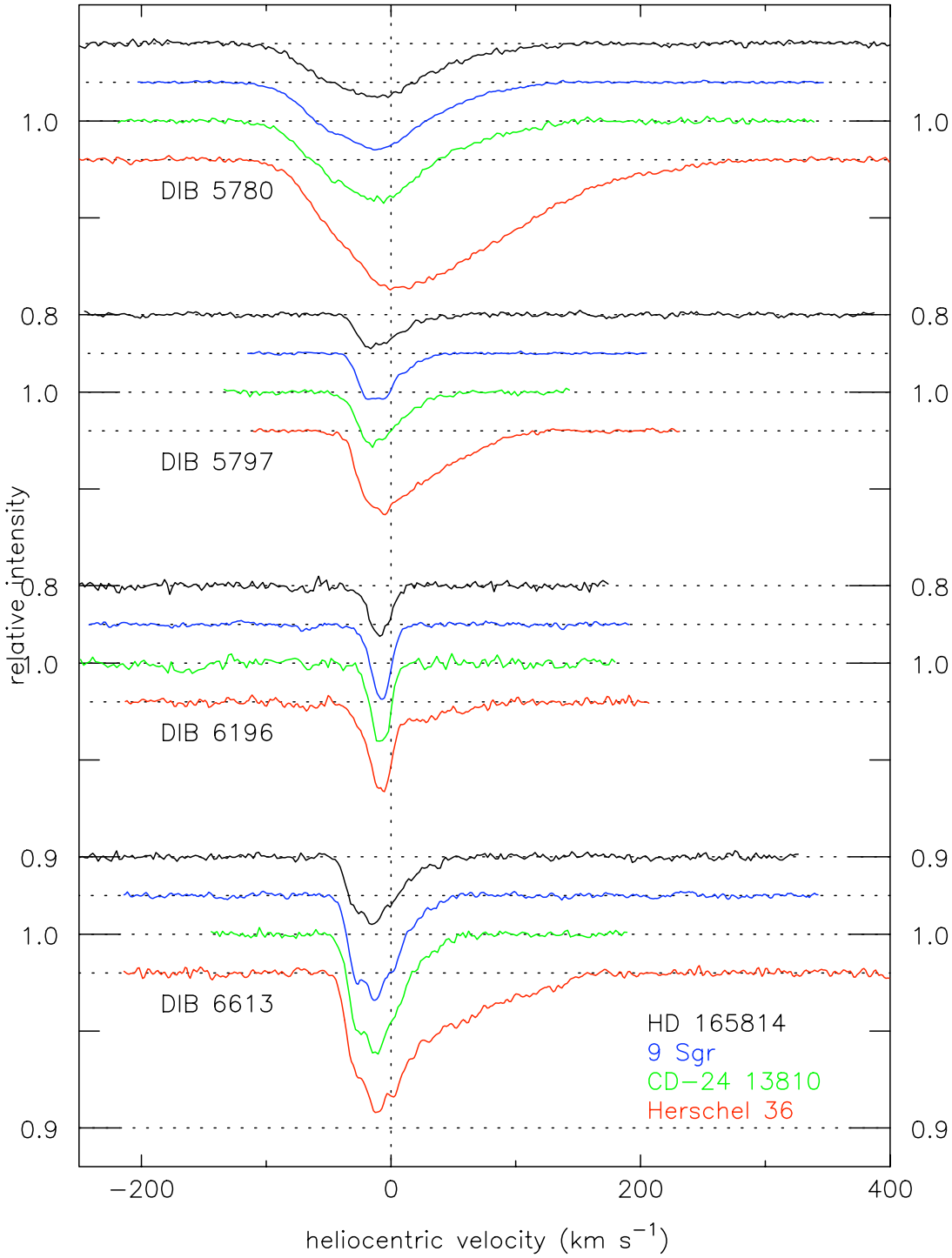
Distance from Her 36

1000 pc
10 pc

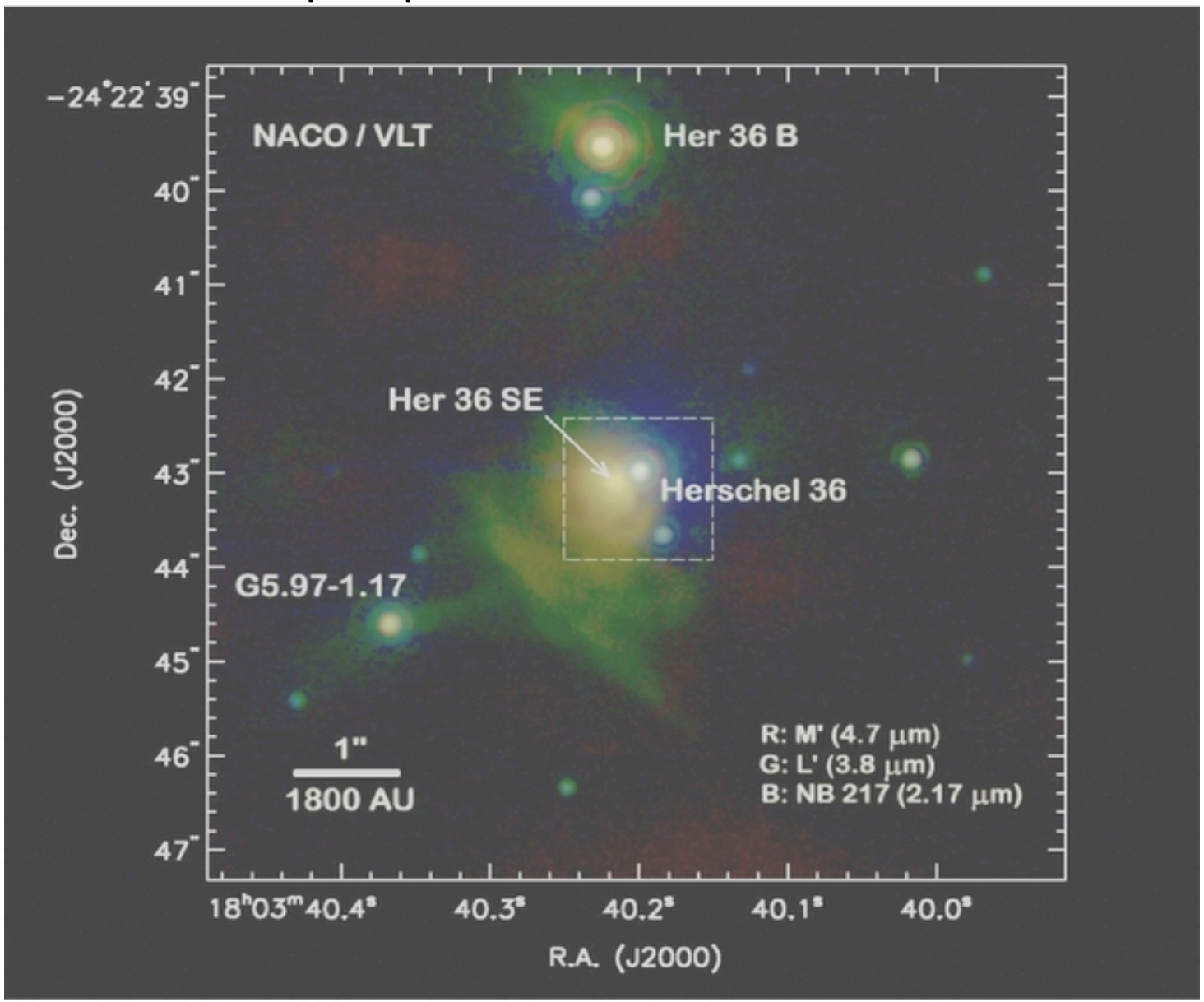
0.5 pc
Herschel 36

IR pumping of
J = 1 level of CH+
(not known anyplace
else In ISM)

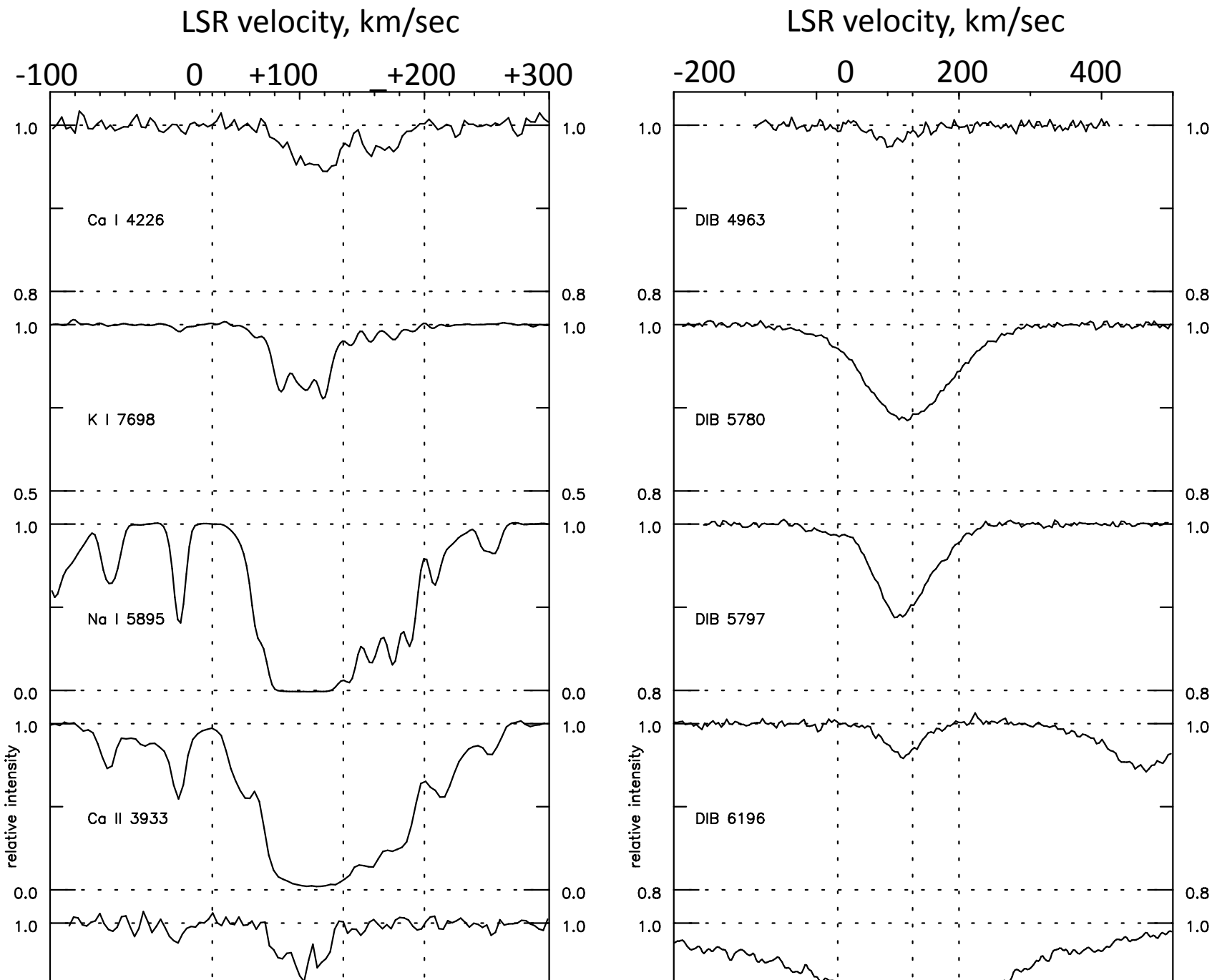



DIB 5780
DIB 5797
DIB 6196
DIB 6613
HD 165814
9 Sgr
CD−24 13810
Herschel 36
relative intensity
heliocentric velocity (km s^{-1})
−200
0
200
400
1.0
0.8
0.9

Herschel 36SE, 400 pc from Herschel 36, the infrared source that pumps rotational levels of CH+ and DIBs



Supernova 2014J, M82, DIB profiles, stack of 47 spectra, 15 hours

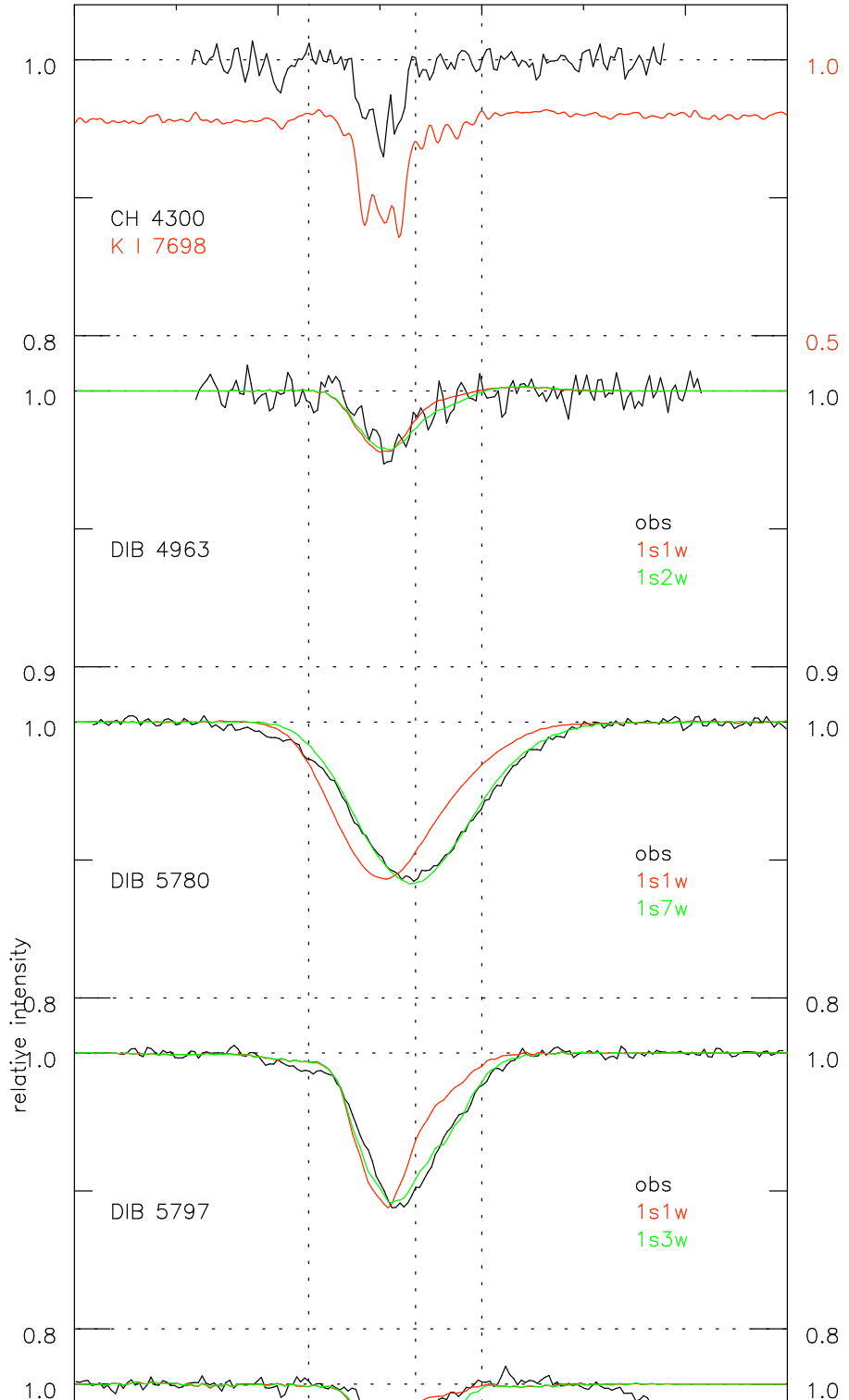


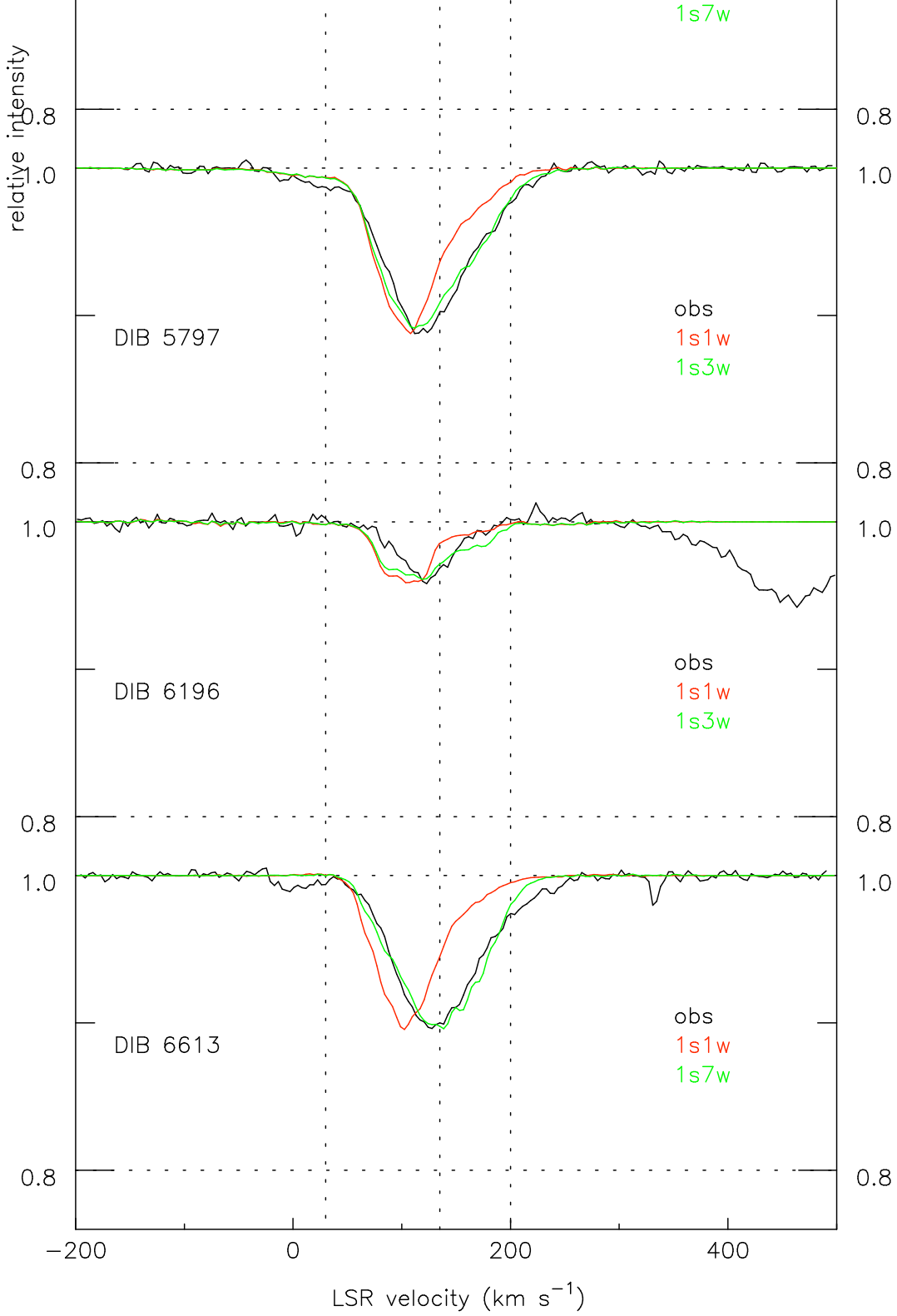
Individual line profiles
For SN2014J
Welty (Chicago)
Ritchey (UW)
Dahlstrom (Carthage)
York (Chicago)

Black trace—data

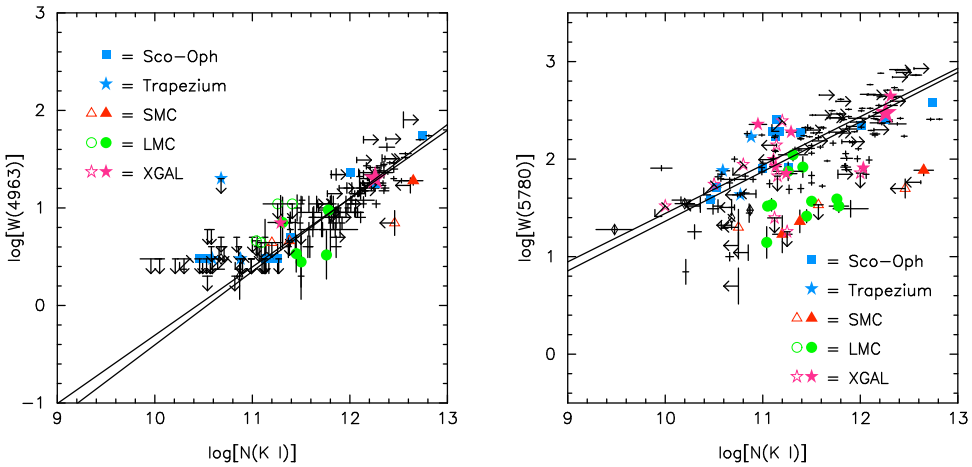
Red trace—DIB proportional to K I

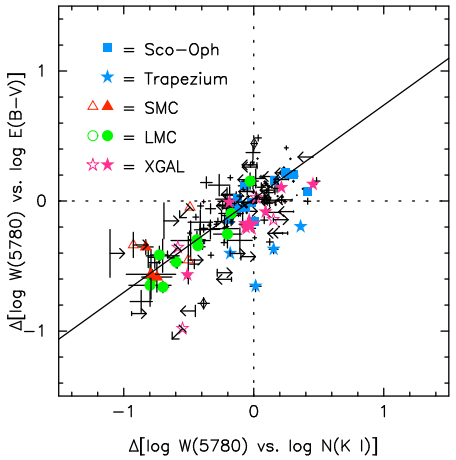
Green trace– x 7 weighting for DIB in K I components.




1s7w
relative intensity
0.8
1.0
DIB 5797
obs
1s1w
1s3w
DIB 6196
DIB 6613
1s7w
−200
0
200
400
LSR velocity (km s^{-1})

FIN


log[W(4963)]
log[N(K I)]
= Sco−Oph
= Trapezium
= SMC
= LMC
= XGAL
log[W(5780)]
log[N(K I)]
= Sco−Oph
= Trapezium
= SMC
= LMC
= XGAL


= Sco−Oph
= Trapezium
= SMC
= LMC
= XGAL
Δ[log W(5780) vs. log E(B−V)]
Δ[log W(5780) vs. log N(K I)]
1
0
−1
−1
0
1