Diffuse Interstellar Bands: The Good, the Bad, the Unique

Paule Sonnentrucker

the DIB consortium

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esa

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Outline

The Diffuse Interstellar Medium

The Diffuse Interstellar Band (DIB) Story

The DIB Database Project

Summary

The Diffuse Interstellar Medium

- **Low Opacity (A_V< 6 mag) Clouds**:
  => permeated by light from background hot stars

- **Multi-Wavelength Spectroscopy**
  =>FUV, optical, sub-mm & radio instrumentation

Characteristics:
- $n_H < 1000$ cm^{-3}
- 40 K < T_{gas} < 300 K
- Mostly atomic: $f(H_2) < 1$
- UV-photon dominated physics and chemistry

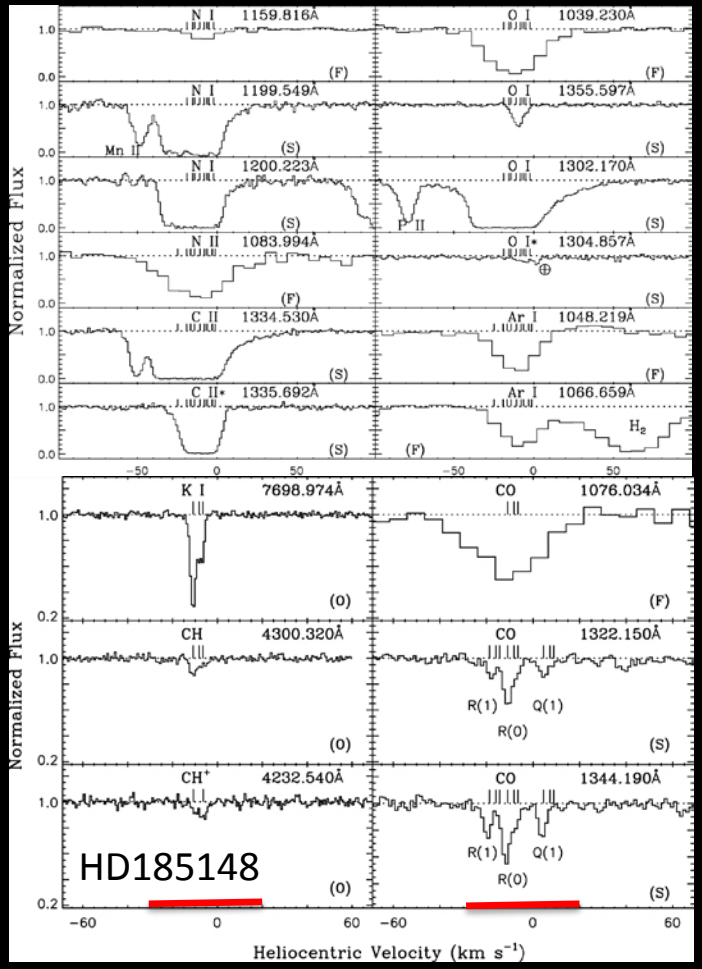
Credit: NASA/ESA, M. Robberto and the HST Orion Treasury Program Team.

The Diffuse Interstellar Medium (cont.)

A typical Galactic sight line: multi-phase system

Diffuse atomic (neutral + ionized)

Diffuse molecular (neutral + ionized)



Sonnentrucker et al. (2003)

ISM phases overlap in velocity space

Introduces degeneracies:

- **when deriving cloud physical properties**
- **when studying chemical composition**

- **Need diagnostic tracers for each phase**

The Diffuse Interstellar Medium (cont.)

- **Low Opacity (A_V< 6 mag) Gas Clouds**:
  -> permeated by light from background hot stars

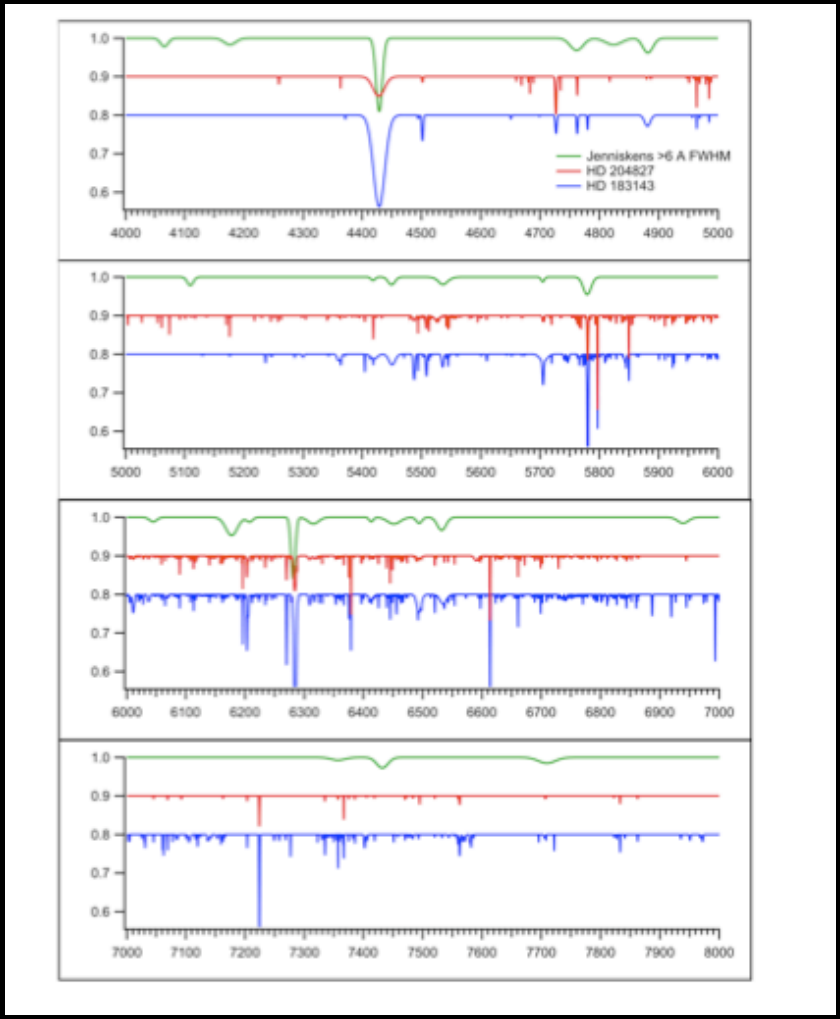
- **Multi-wavelength Effort:**
  -> FUV, optical, sub-mm & radio instrumentation

Decades-long Lab-Astro Collaboration!
Atomic & molecular databases

Characteristics:
- $n_H < 1000$ cm^{-3}
- 40 K < T_{gas} < 300 K
- Mostly atomic: $f(H_2)$ <1
- UV-photon dominated physics and chemistry

Identified in Space:
- **Over 20 atomic species**
- **Over 160 molecules!**

The Diffuse Interstellar Band (DIB) Story



- First DIB detection around 4428 Å in ~1920s
- Detections increased DIB number to ~400 by the ~2000s
- Ubiquitous and confined in 4400-10 170 Å range
- Mostly narrow DIBs (FWHM <2Å)
- DIB strength varies with local physical conditions
- Half-dozen claimed identifications
  => None confirmed

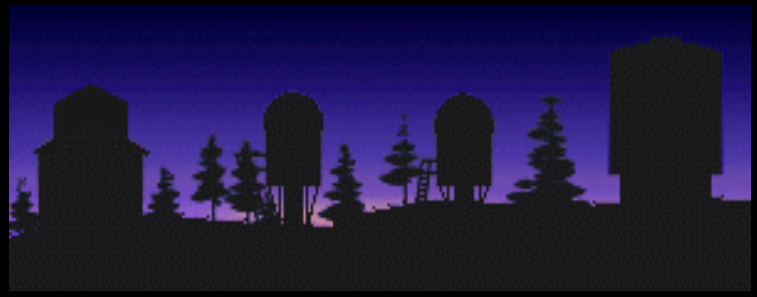
Diffuse Infamous Bands…

The DIB Database Project

A 17+ year Adventure….

First Homogenous DIB Database (PI: York D.G. Chicago U.):

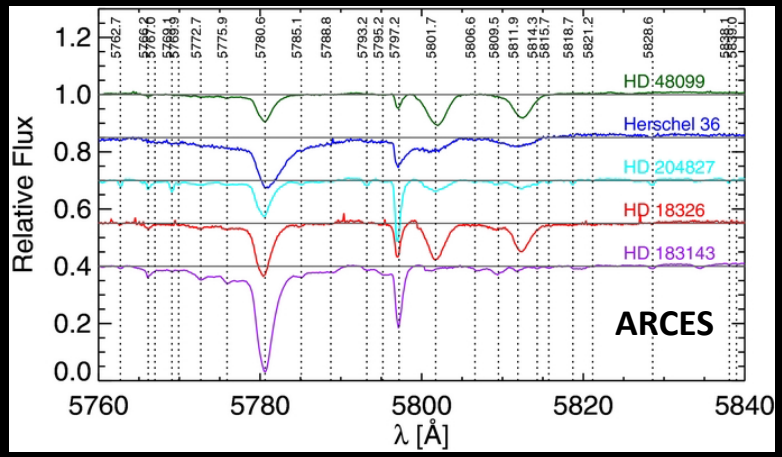
- Over 150 Galactic stars (Sp. t. O6-A3)
- Reddening range 0.02 – 3.5 mag
- S/N ~ 1000 at 5500 Å
- Probing known range in physical conditions



Apache Point Observatory (NM, USA)
3.5 m telescope + ARCES (R~38 000) + DIS (R~1000) spectrographs

Goals:

- Census of narrow, weak DIBs
- Census of Broad DIBs (FWHM>6Å)
- DIBs as diagnostics of ISM phases
- Guide DIB carriers Identification



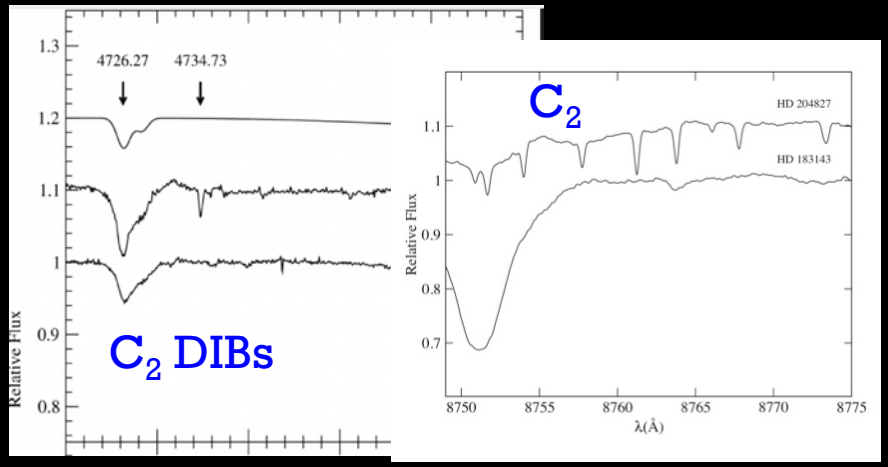
The DIB Database Project (cont.)

A few highlights

Narrow DIB Surveys:

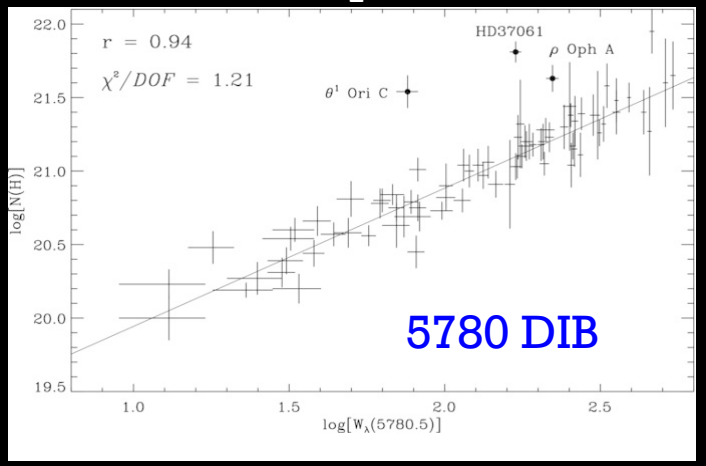
- 150 new DIBs detected => ~550 narrow features
- DIB distribution: Narrow DIBs: 92% - Broad DIBs (FWHM > 6Å): 8%
- 2 distinct classes of DIBs: C_2 DIBs and Classical DIBs

18 DIBs appear when C_2 and CN present



DIB carriers seem favored in denser ISM phase traced by C_2 and CN.
(Thorburn et al. 2003)

"Classical" DIBs are indifferent to C_2 presence



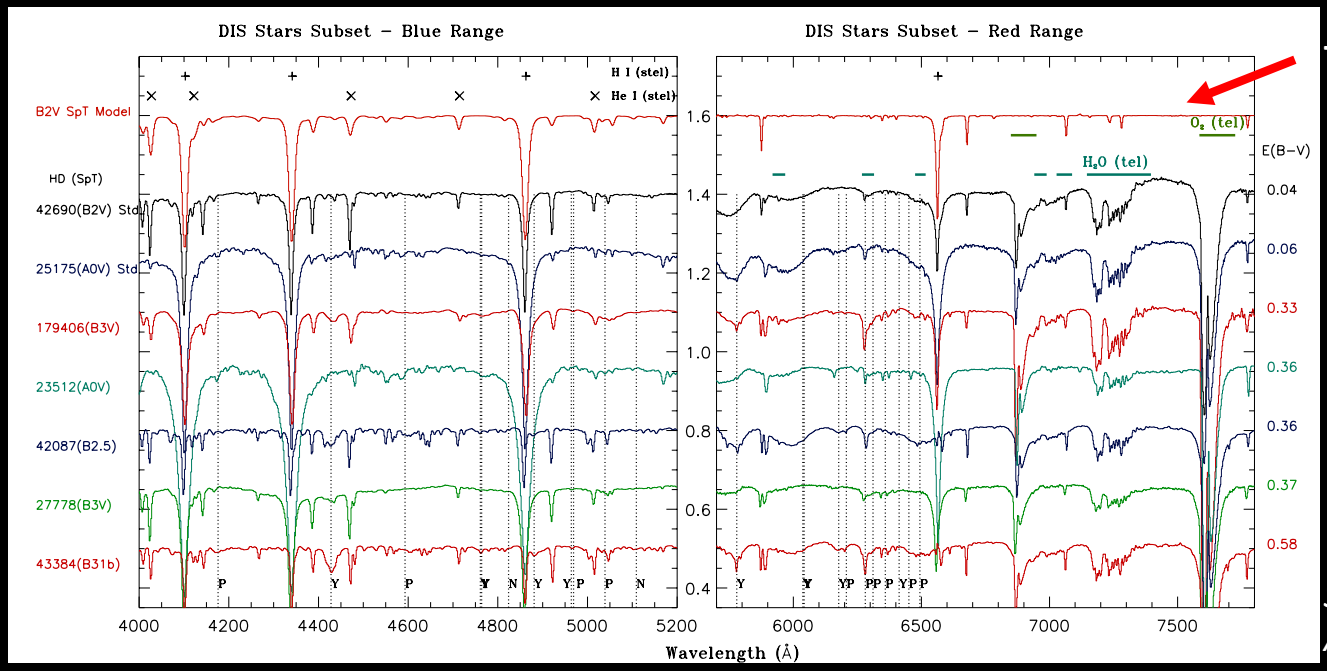
Most DIB carriers seem favored in the atomic phase of the ISM traced by H I. *(Friedman et al. 2011)*

The DIB Database Project (cont.)

A few highlights

The Broad DIB (FWHM> 6Å) Survey

- **34 features in literature => investigated 22 features toward 21 stars**
- **DIB distribution:**
  - ⇒ **10 features confirmed as DIBs**
  - ⇒ **10 features are probable DIBs**
  - ⇒ **2 features are rejected as DIBs**



TLUSTY stellar model

R ~1000 data

"blend Challenge"

- Stellar blends
- Telluric
- Narrow DIBs
- ISM lines

Sonnentrucker et al. (2017, ApJ submitted)

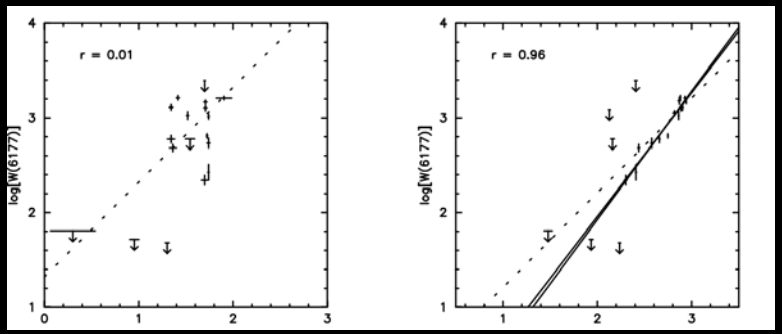
The DIB Database Project (cont.)

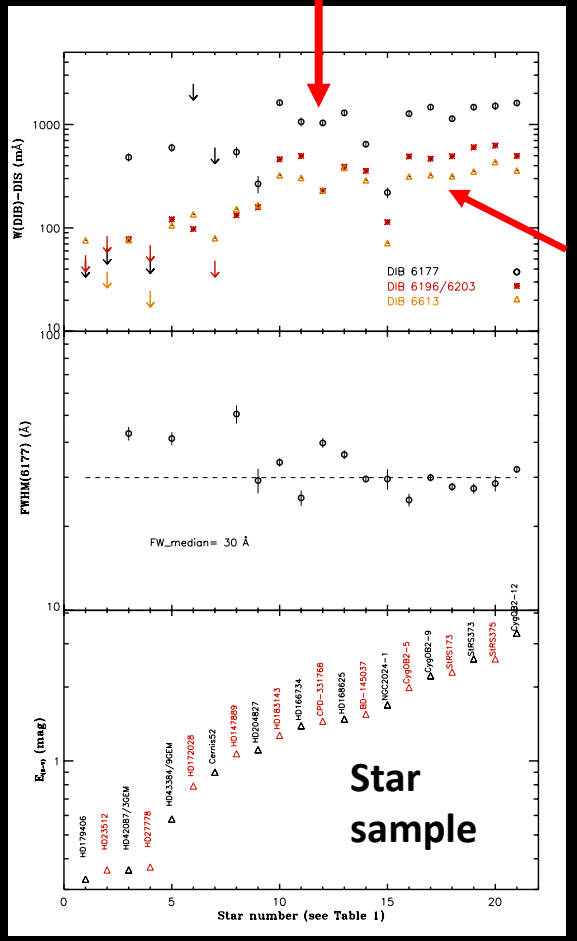
A few highlights

The Broad 6177 Å DIB Characteristics:

- FWHM(6177) = 30 +/- 5Å
- Steady increase of band strength W(6177)
  => no saturation
- Correlation with 5780 DIB: Yes
- Correlation with C_2 DIB: No
  => 6177 Å DIB carrier favored in H I-dominated phase of ISM

W(6177 DIB)





DIB tracers of H I gas

Summary

- **MISSION ACCOMPLISHED!!**

First Database Release: Oct 2017 (Fan et al. 2017)

http://dib.uchicago.edu/

- **Detected 150 additional narrow, weak DIBs**
  => ~550 narrow DIBs and counting…
- **2 distinct classes of DIB carriers:**
  => C_2 DIBs: tracers of denser gas (minority in number)
  => Classical DIBs: tracer of H I (majority in number)
- **Confirmed 10 broad DIBs; rejected 2 features; still 10 probable cases**
- **Measured characteristics of broad 6177Å DIB: part of the "classical" DIB group**

Thank you!

Acknowledgments:

- The Definitely Interacting Bunch DIB collaboration:

D.G. York, D.E. Welty S.D. Friedman T.P Snow,
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