Cosmic Dust:

What are the Carriers of the Diffuse Interstellar Bands & 'Unidentified' IR bands?

Peter Sarre

The University of Nottingham, UK

January 2007

Diffuse Interstellar Bands and UIR Bands

Key questions:

What are they?

Why are they important?

How can the problems be solved?

What are the wider practical implications?

European Groups:

France, Italy, Latvia, Poland, The Netherlands, UK.....

Diffuse Interstellar Bands – what are they?

History.....

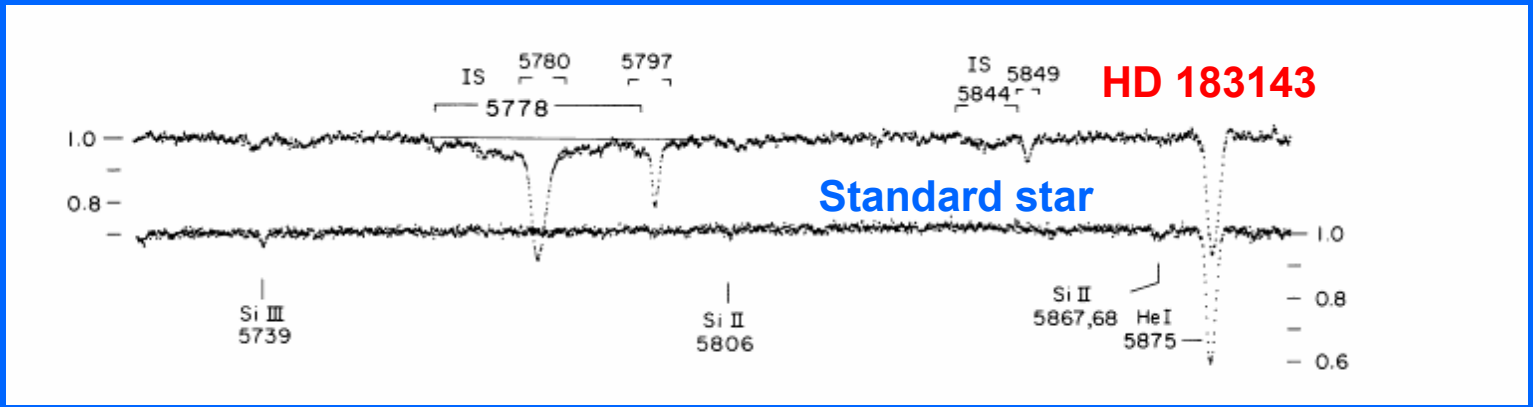
Mary Lea Heger at Lick Observatory USA (1919)

Paul W Merrill (1935)

‘Recent observations.....have disclosed four lines whose approximate wave-lengths are 5780.4, 5796.9, 6283.9, and 6613.9 Å.

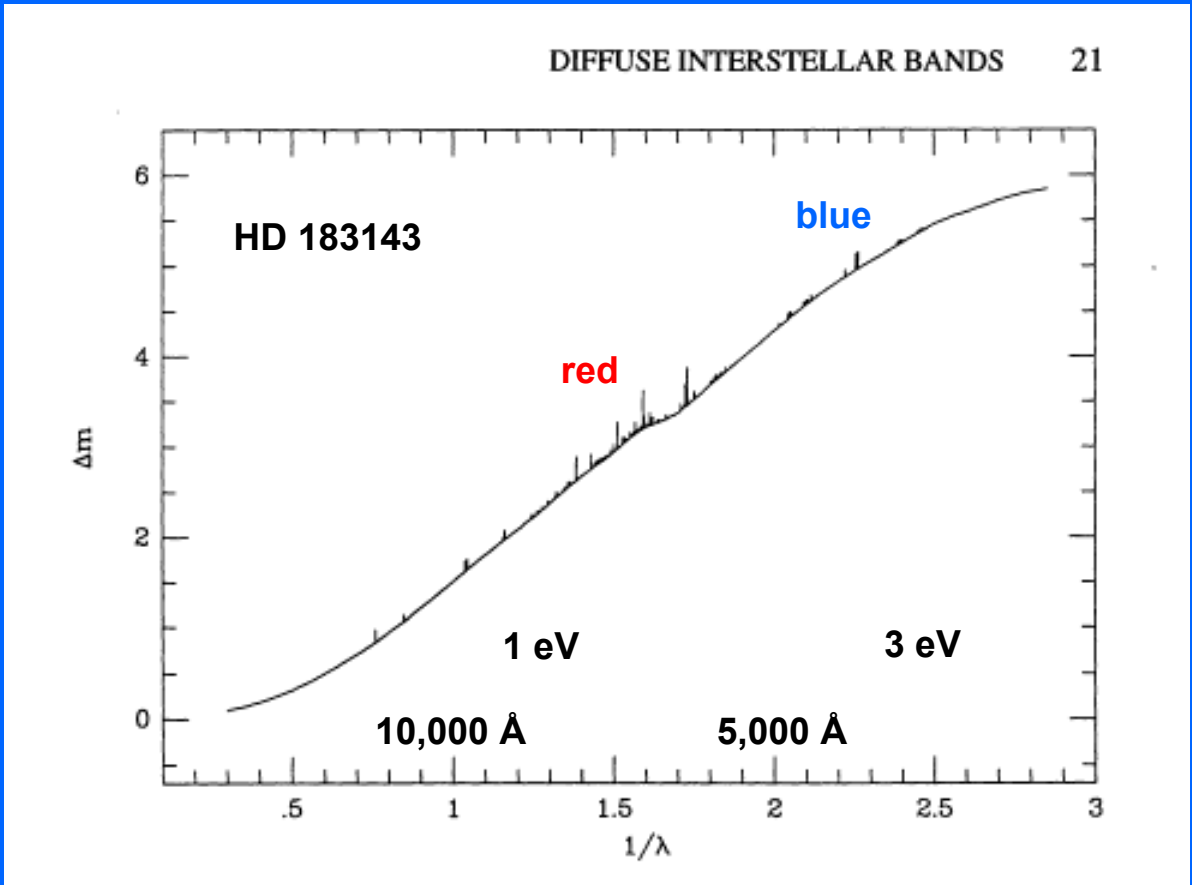
The chemical identification of these lines has not yet been made.’ (!)

George H. Herbig (1975)



Astrophysical Journal, vol. 196, Feb. 15, 1975, pt. 1, p. 129-160.

George H. Herbig (1995)



Annual Review of Astronomy and Astrophysics, 33, 1995, pp. 19-74.

Diffuse Interstellar Bands – characteristics

> 300 diffuse bands

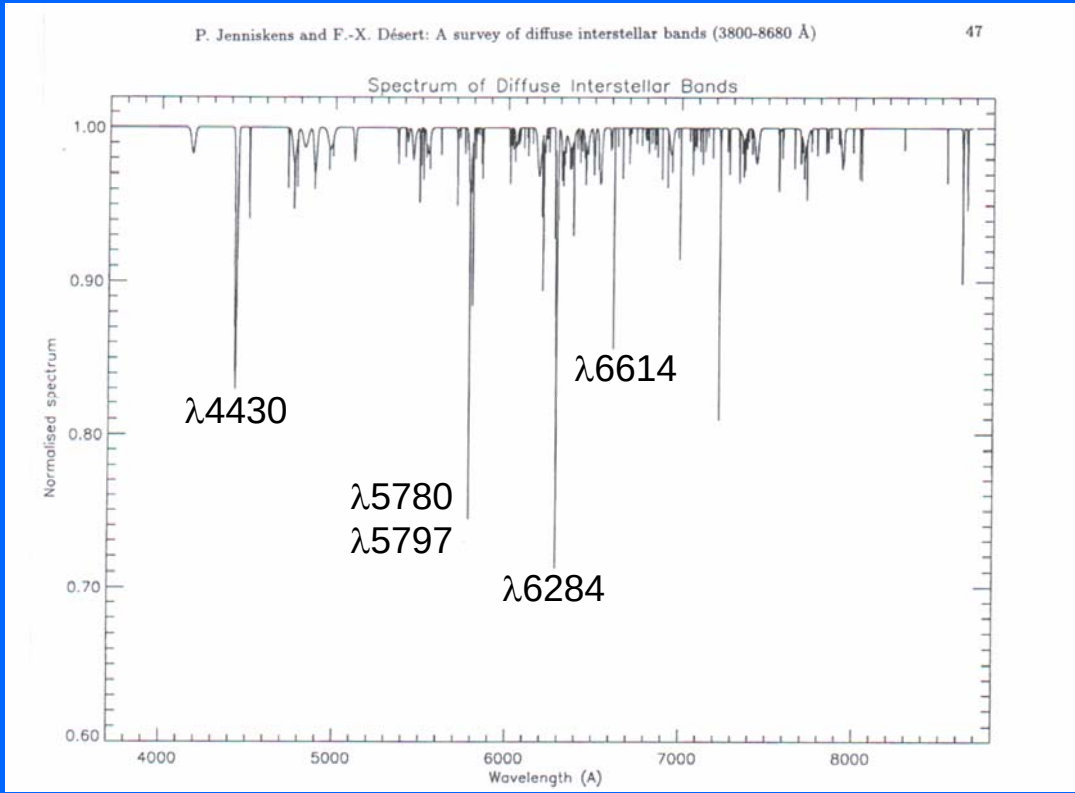
Widths ~ 0.5 – 30 Å

Good correlation with E(B-V) and N(H I)

No regularity in spectrum

Galactic &
Extragalactic (LMC, starburst galaxies, z ~ 0.5)

Overview of diffuse band data



From: Astron. Astrophys. Suppl. 106, 39-78 (1994)

Diffuse Interstellar Bands – why are they important?

- High-precision *spectroscopic* tracer of dust
- Exploit dust as a diagnostic of processes
- Carriers probably organic molecules - PAHs?
- Templates for prebiotic molecules?

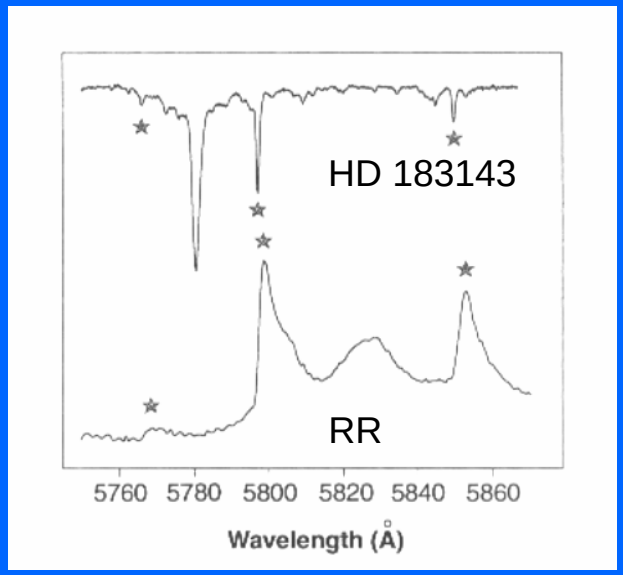
Diffuse Interstellar Bands – solving the problem

- Observations to define and constrain the problem
- Laboratory astrophysics guided by observations
- Theoretical modelling, DFT etc.

Reward:

- ...a new tool in ISM diagnostics

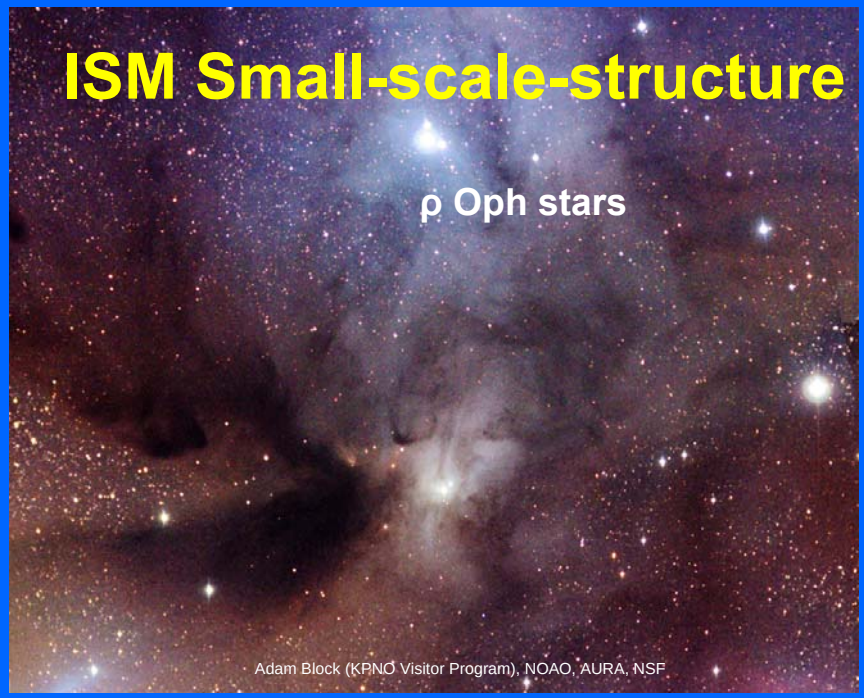
Red Rectangle Optical Emission – astro to lab

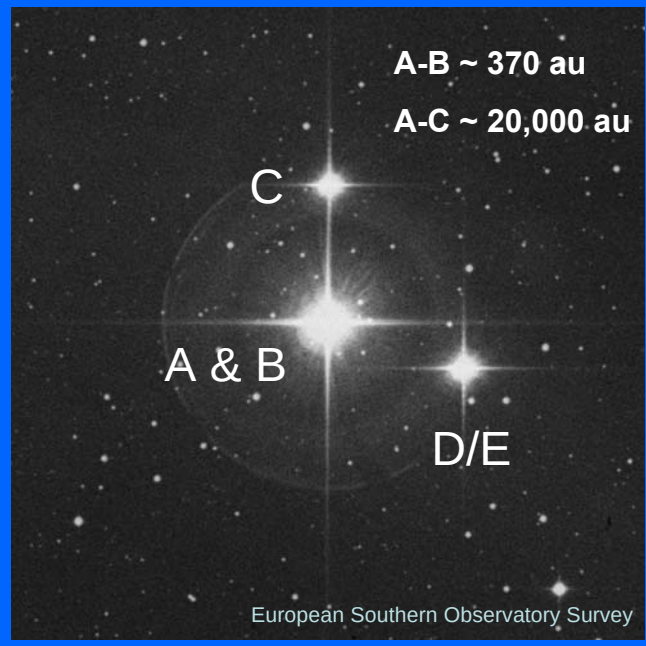


...led to new lab experiments

HST image 2004, NASA, ESA & H. Van Winckel and M. Cohen

Sarre et al. Science 269, 674 (1995)



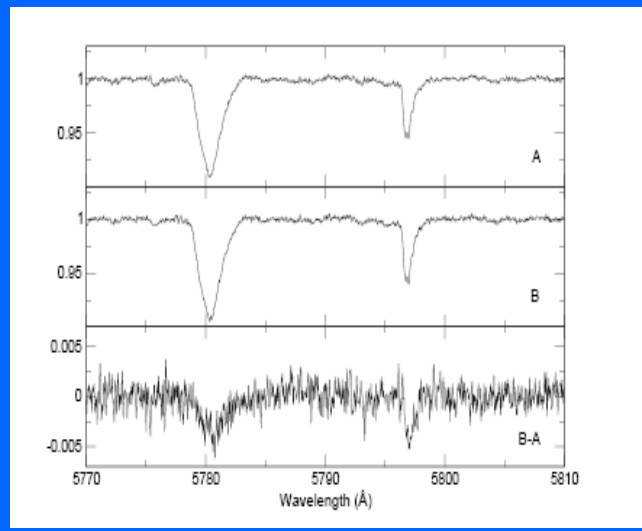


ρ Oph A and B separated by 370 au

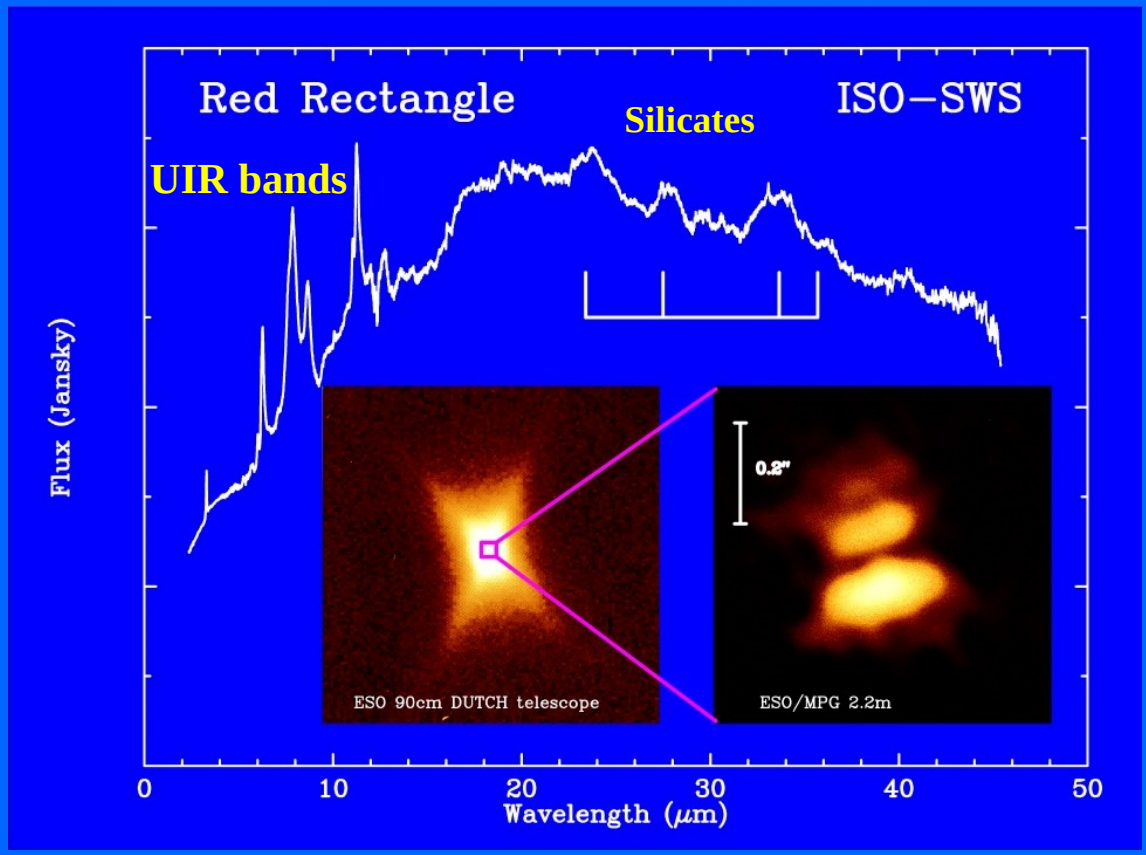
λ5780 and λ5797

B > A by ~ 5 %

Early stages of SF

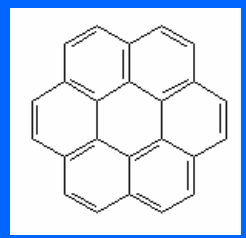


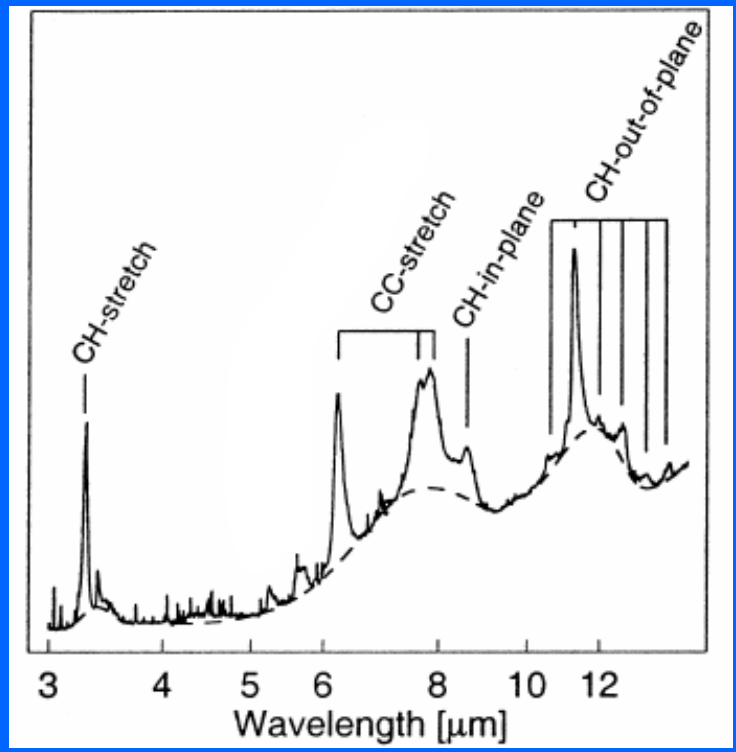
ISO spectrum + ESO images of Red Rectangle



UIR bands - ubiquitous

- Young stars
- Up to 20% of IR luminosity from galaxies with intense SF is in UIR bands
- Used for red-shift determination
- Usually attributed to polycyclic aromatic hydrocarbons (PAHs)

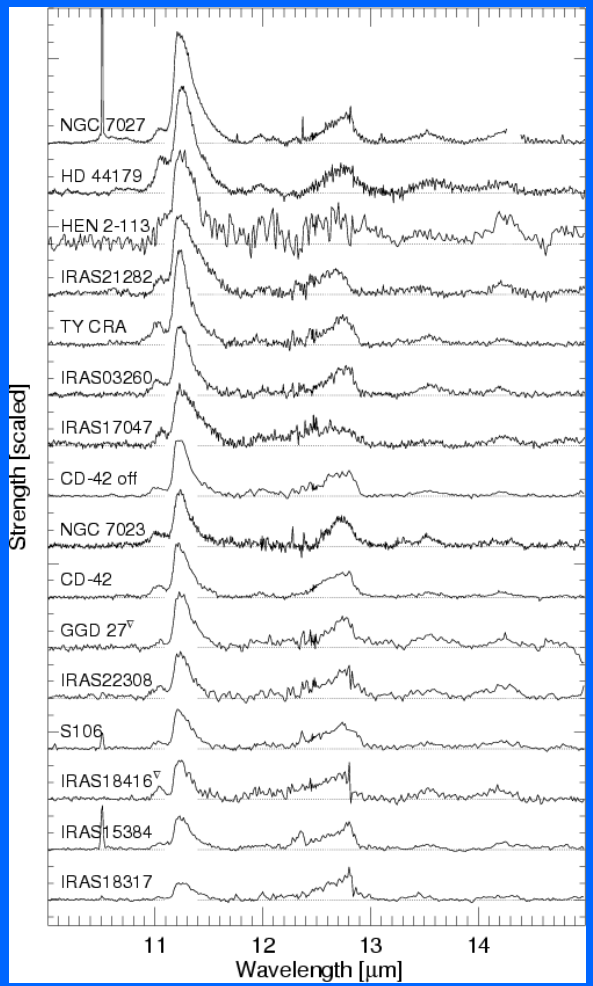




Typical spectrum

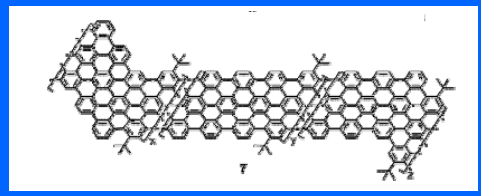
UIR bands: e.g. 11 - 13 μm region

RR

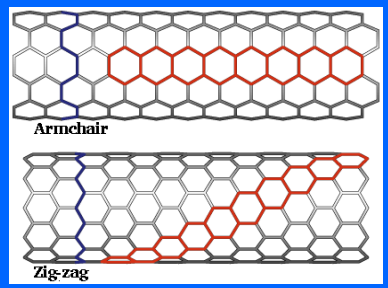


Hony et al. (2001)

Flat PAHs?

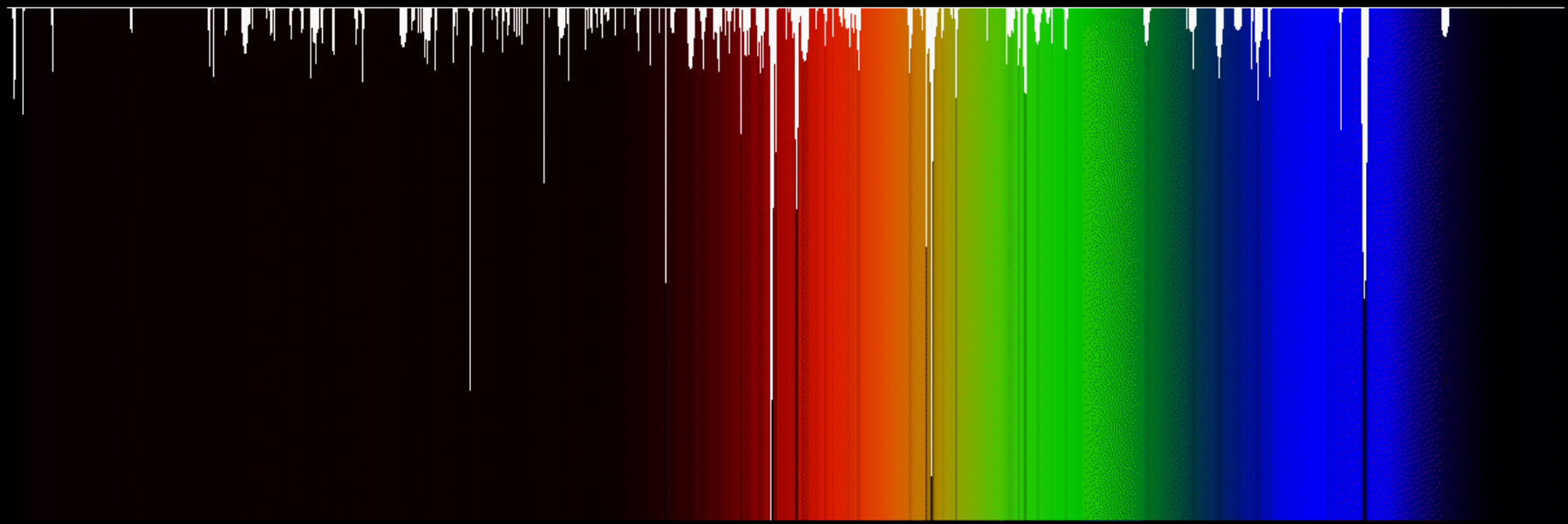


Nanotubes?



Major potential applications e.g. in SWNT diagnostics

The Diffuse Interstellar Bands



Fullerene (C_{60}) discovery (leading to nanotubes) motivated by search for solution to the diffuse band problem

Courtesy: P. Jenniskens, F.-X. Desert