The diffuse interstellar medium and interstellar bands observed with HARMONI

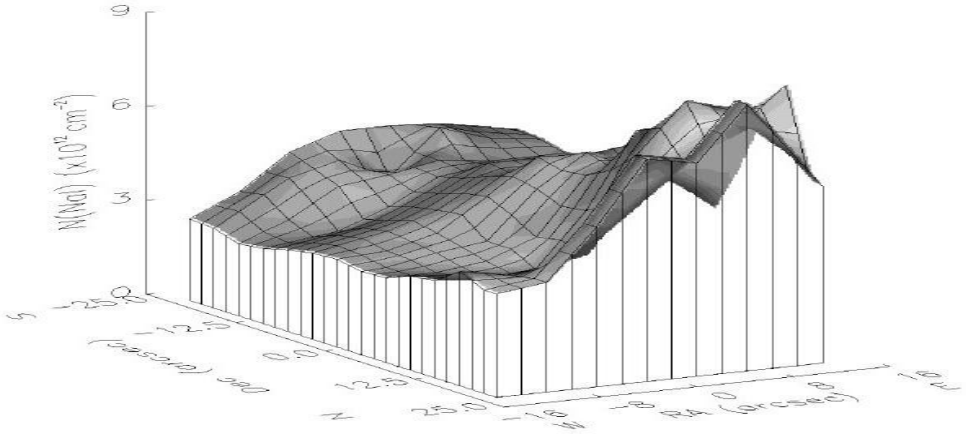
(J. Smoker[1], N. Cox[2], K. Smith[3])

([1]ESO, [2]INAP/CNRS, [3]Science Magazine)

- Variations in the absorption-line strength at small scales in the ISM tell us about the geometry of the absorbers, and how they are affected by changes in local conditions such as temperature and density.
- For this work we need high spatial resolution & closely spaced targets.
- HARMONI will have spatial resolution of 30x60 mas per pixel in the “wide-field” mode, ideal for revealing small-scale structure in some interstellar lines.

Previous work on small-scale structure

- Optical observations of the cores of open and globular clusters have been performed by Meyer & Laurouch (1999) and Smoker et al. (2015) amongst others, using either IFUs or multi-fibre spectrographs and using early-type stars as the probes.
- Variations of 10% over a few pc in NaI and CaII can be explained by a model of ISM cloudlets with filling factor 0.3, although other geometries are not ruled out.
- Recent work has used late-type stars with modelling used to remove the' many stellar features. This increases markedly the number of targets available.
- Velocity resolution > 10,000 is preferred for CaII, NaI or KI as intrinsic lines narrow, hence HARMONI will not be the ideal instrument for these studies.



M15 Meyer & Laurouesh (1999), NaI IFU, also Smoker et al. (2003) CaII, longslit.

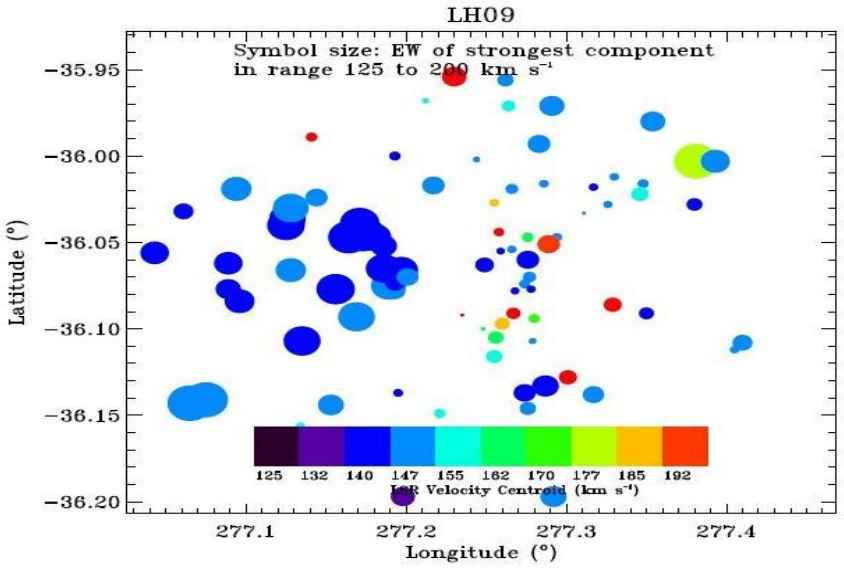


Figure A10. NGC 1761 equivalent width and peak velocity between +125 and +200 km s^{-1}.

Diffuse interstellar bands (DIBs)

- DIBS were discovered in 1922.

  Broad lines, hence “Diffuse”. Not atomic transitions but could be related to dust. More recently the possibility raised of the carriers being Polycyclic Aromatic Hydrocarbons (PAHs) e.g. $C_{mm}H+_{nn}$

- More than ~500 DIBs known according to recent papers. Easy to get a fit in wavelength to one transition, but matching all the bands for a particular PAH has proved impossible so far.

- DIBs are an important constituent of the ISM in MW and other Galaxies.

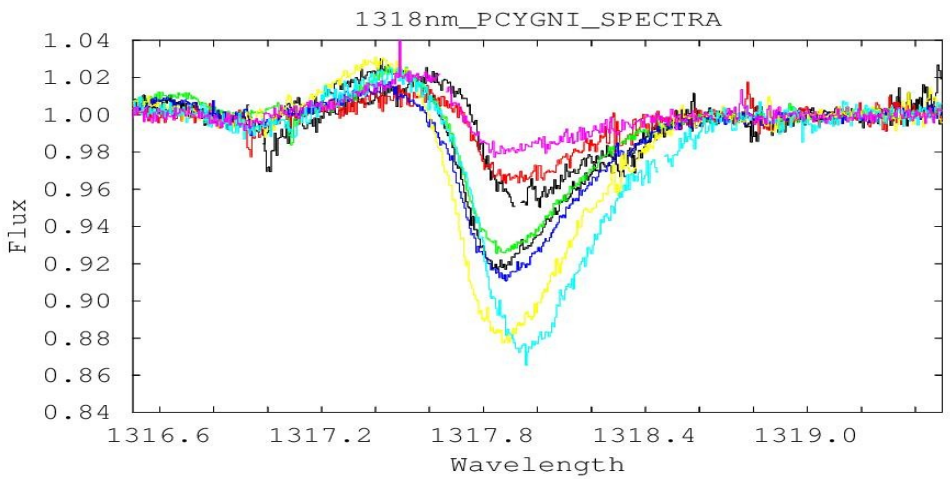
- Most work to date has been done on optical DIBs. However, discoveries from the 1990s and onwards Joblin et al., Rawlings et al. and Geballe et al. in the NIR have given this field a push, especially with new IR instrumentation.

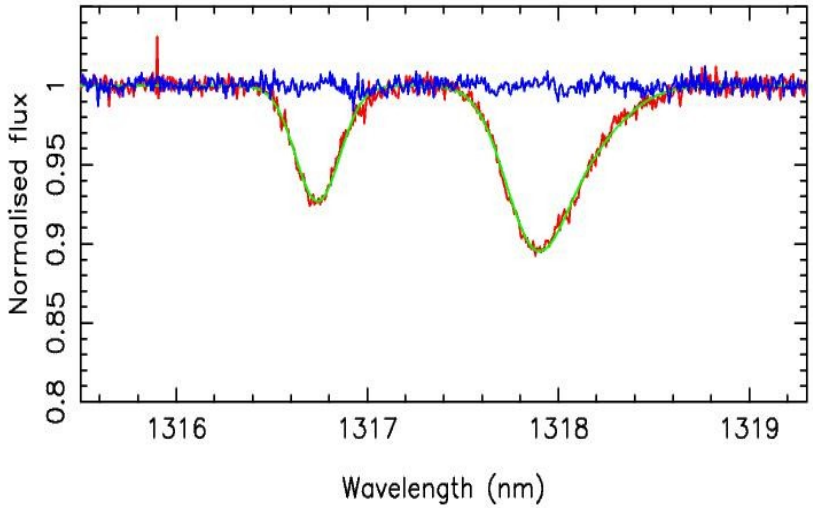
- The basic idea is that PAHs with more than about 20 C atoms have main transitions in the NIR range, compared with neutral and small charged PAHs where the UV/optical is the place to look (Tielens, Cox).

- Around 15 NIR DIBs have been discovered so far, none redder than 1.8 microns.

NIR DIBs observed with CRIRES

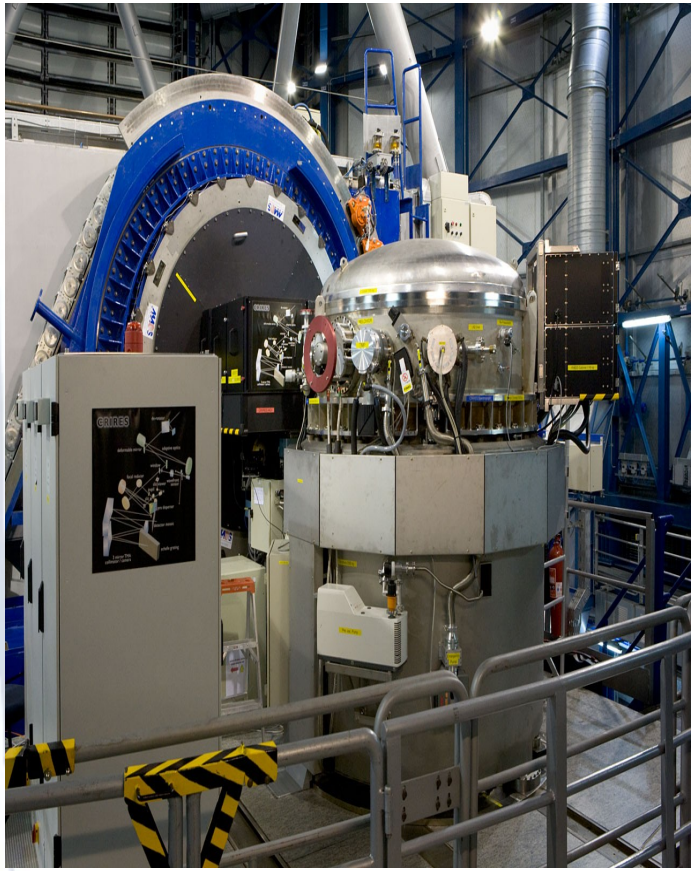
- Recently we have observed ~80 sightlines with CRIRES at 1318, 1527, 1568 and 1624-nm at a spectral resolution of *R*~50,000 and S/N=300 with sightlines having H-band magnitudes ~6-8 mag. E(B-V) were typically 0-1 magnitudes.
- Detection rates were ~85% in the 1318-nm DIB. FWHM values were around 60-100 kms^{-1} in the 1318-nm feature (often twin components).
- Velocity structure is observed in the DIBs. To be confirmed if the emission-line feature and bluewards DIB are stellar or circumstellar in nature.

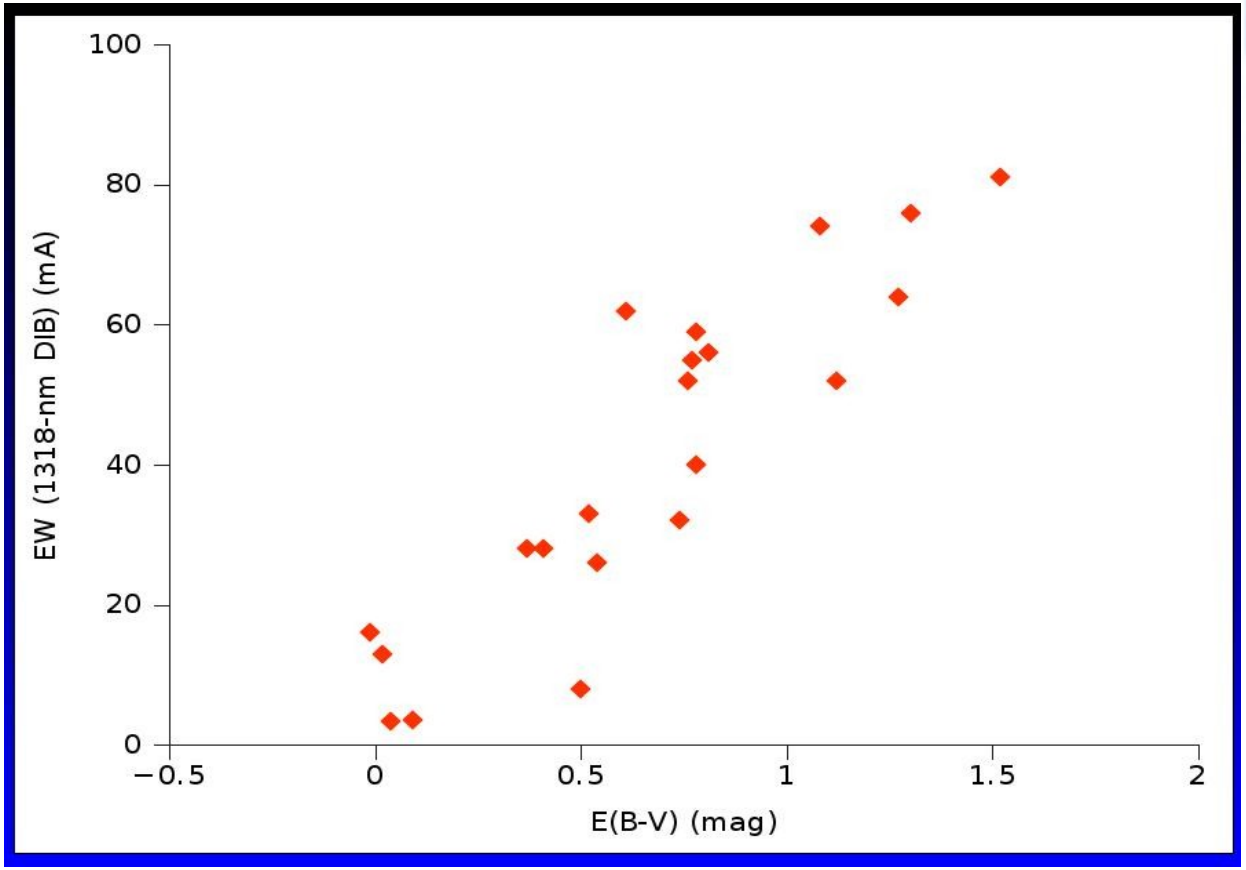




CRIRES 1318-nm DIB results

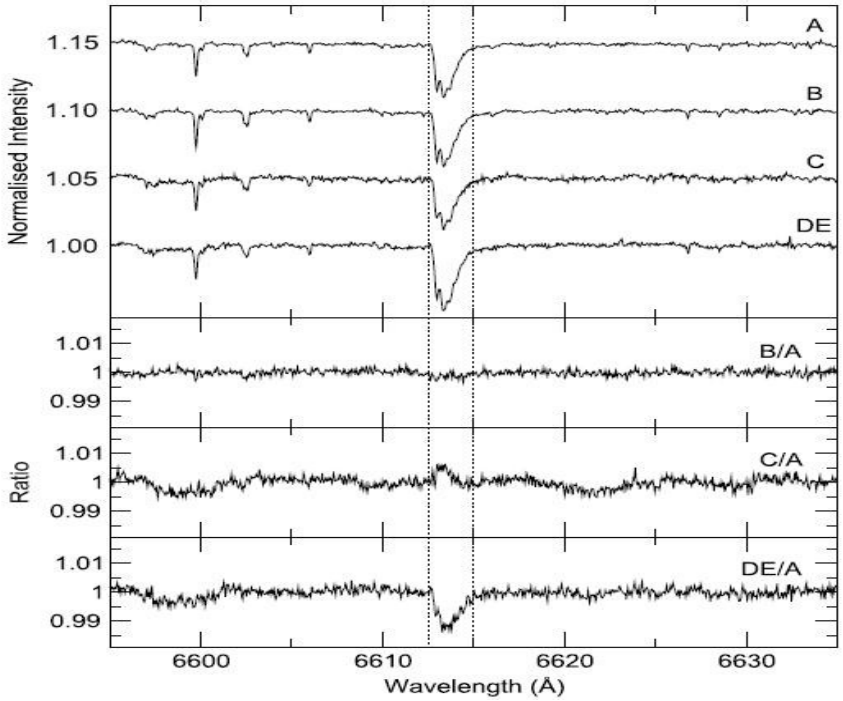
- The 1318-nm DIB is a good indicator of reddening.

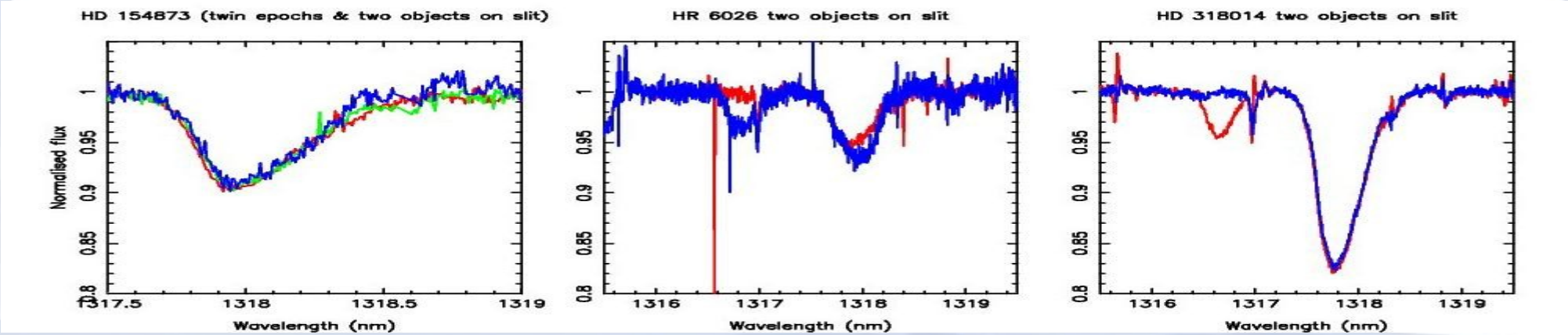




Small Scale Structure of DIBs in the optical and NIR

- Some DIBs show very good correlation with reddening, others more with HI (Cox reviews).
- Observations towards rho Oph by Cordiner et al. (right) show SSS for DIBs at 6613 Angstroms.
- Sensitivity to conditions depends on the ionisation potential of the carrier and number of C atoms for example, so in theory observations of variation or the lack of it can give clues to what the carriers are.
- Some CRIRES sightlines also show variation on arcsecond scales (figure below):





HARMONI and DIBs

- HARMONI will have a spectral resolution of 8,000 in the H-band or ~ 40 kms^{-1}, just enough to resolve velocity structure in DIBs with intrinsic widths of around 60^{-1} kms.
- Better would be a mode around 1318-nm of 20,000.
- The work would be an IR counterpart of MUSE (low resolution) studies using globular clusters at high radial velocities to determine the optical structure of DIBs.
- Combining the IR with the optical will give clues to the composition of DIBs, their structure, lifetime and survivability in different environments.

Bands	Wavelengths (μm)	R
Simultaneous V to K	0.45 to 2.45	~500*
"V+R" or "I+z+J" or "H+K"	0.45-0.8, 0.8-1.35, 1.45-2.45	~3500
"I+z" or "J" or "H" or "K"	0.8-1.0, 1.1-1.35, 1.45-1.85, 1.95-2.45	~8000
"Z" or "J_high" or "H_high" or "K_high"	0.9, 1.2, 1.65, 2.2 (TBD)	~20000

The table above shows the band, wavelength range and resolving power of the various dispersers in HARMONI. Note that the R ≈ 500 mode provides simultaneous coverage over the entire wavelength range by combining a prism disperser in the near-IR with a R≈3500 grating in the visible..

(HARMONI webpage)