Diffuse Interstellar Bands:
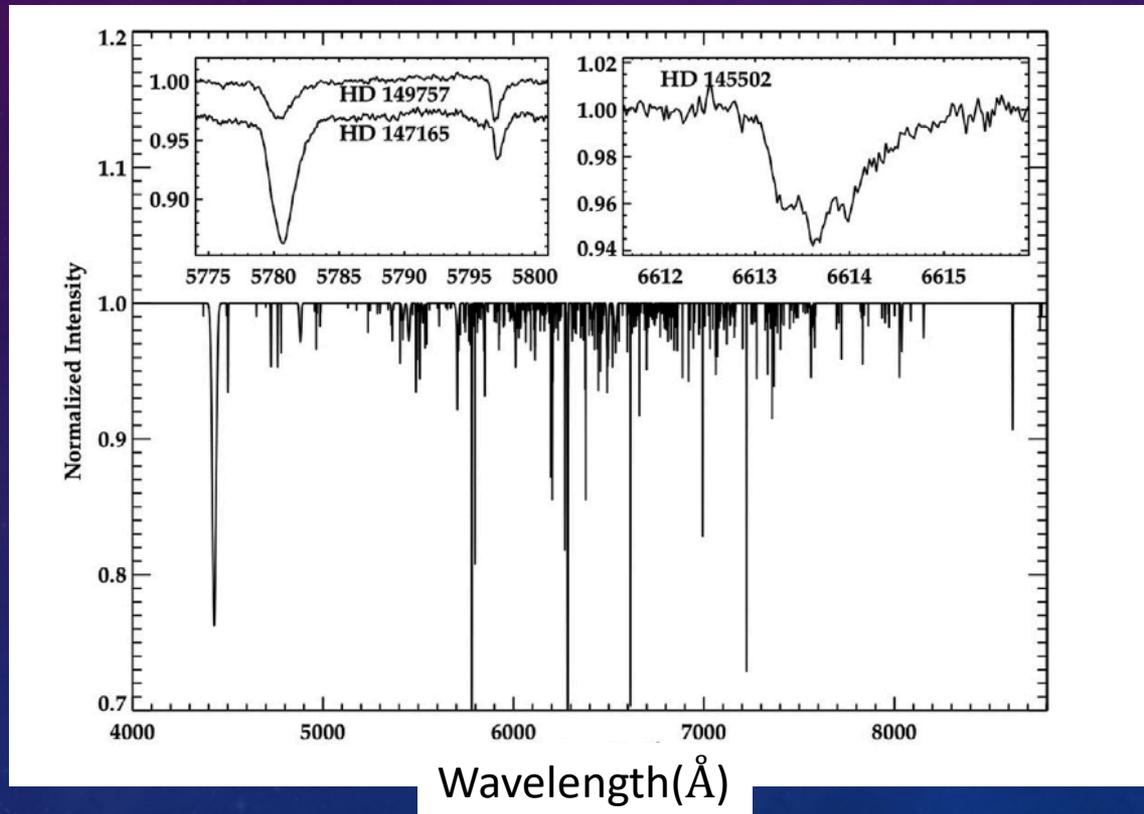## Cosmic Shadow
of Interstellar Molecules

Satoshi Hamano
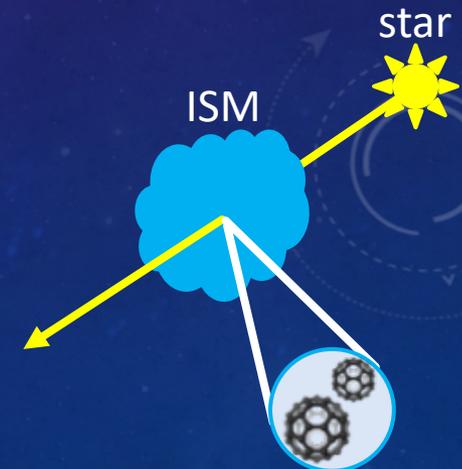
Kyoto Sangyo University

Diffuse interstellar bands (DIBs)

◆DIBs: Absorption features from interstellar medium detected in the spectra of background stars. DIBs are considered to originate from gas-phase carbonaceous molecules.

Sarre et al. 08

Wavelength(Å)

Over 500 DIBs mainly in optical wavelength range.
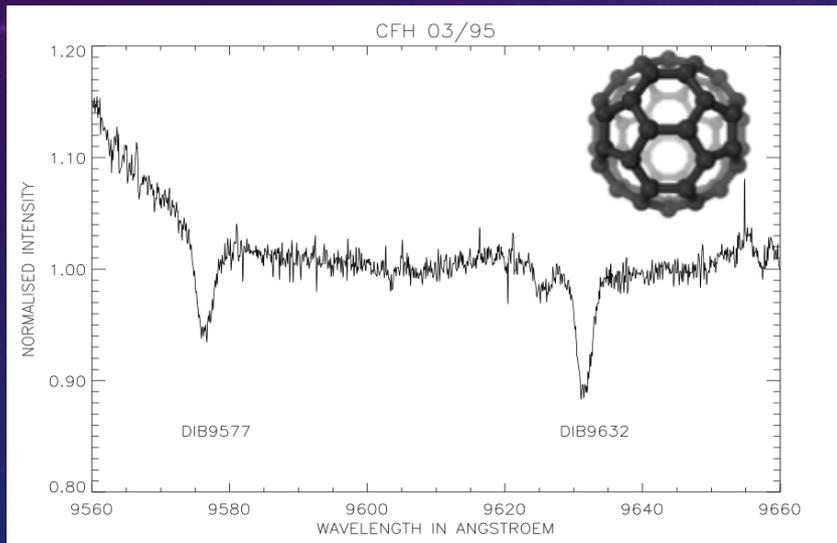
Hobbs et al. 08, 09

star

ISM

Tielens 2014

Cosmic fullerenes
- The largest ISM molecule -

◆ C_{60}^+ DIBs

- Two main bands at λ=9577, 9632Å
- Only DIBs whose carrier is identified. (Identified in 2015.)

◆ Fullerene MIR emission

- C_{60}, C_{70}, C_{60}^+
- Detected in various type objects (PNe, YSO, post-AGB, ISM)

Foing et al. 94, 97
Campbell et al. 15
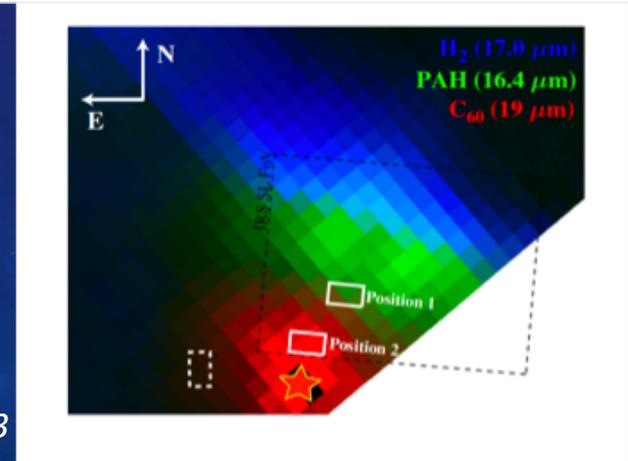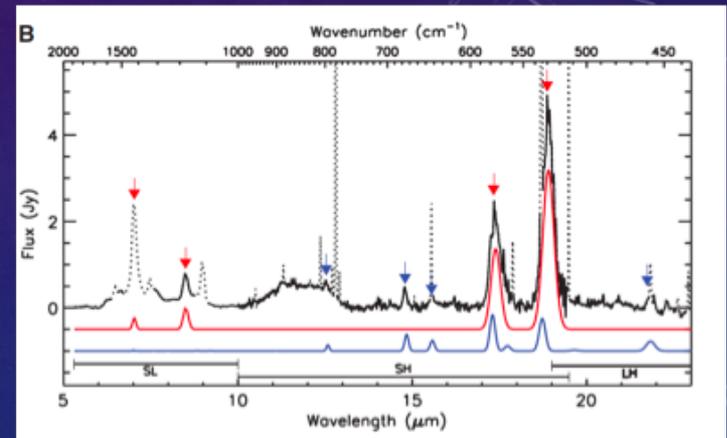
Cami et al. 10
Berne et al. 13

Cosmic Shadow 2018

NIR DIB survey with WINERED

Advantages of WINERED for DIB study

◆ **High sensitivity** → Weak DIBs can be detected.

◆ Covering 0.9-1.35 μm range
  → Many ISM features: all C_{60}^+ bands, the strongest NIR DIB, many DIBs, C_2 and CN bands

◆ High resolution (R=28,000 or 68,000)

Ikeda et al. 16

Araki 1.3m → NTT 3.58m → Magellan 6.5m

2012   2017   2019

Cosmic Shadow 2018

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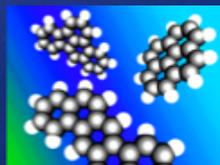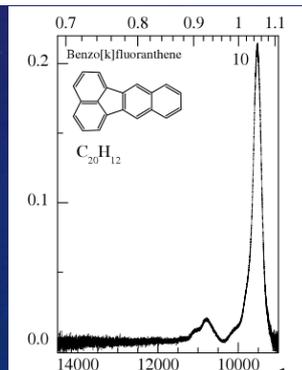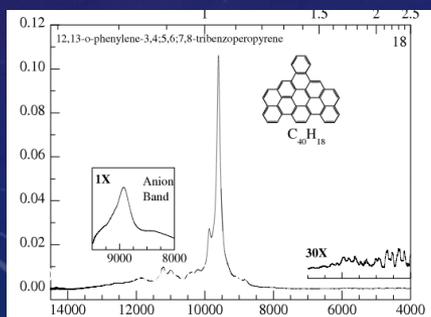
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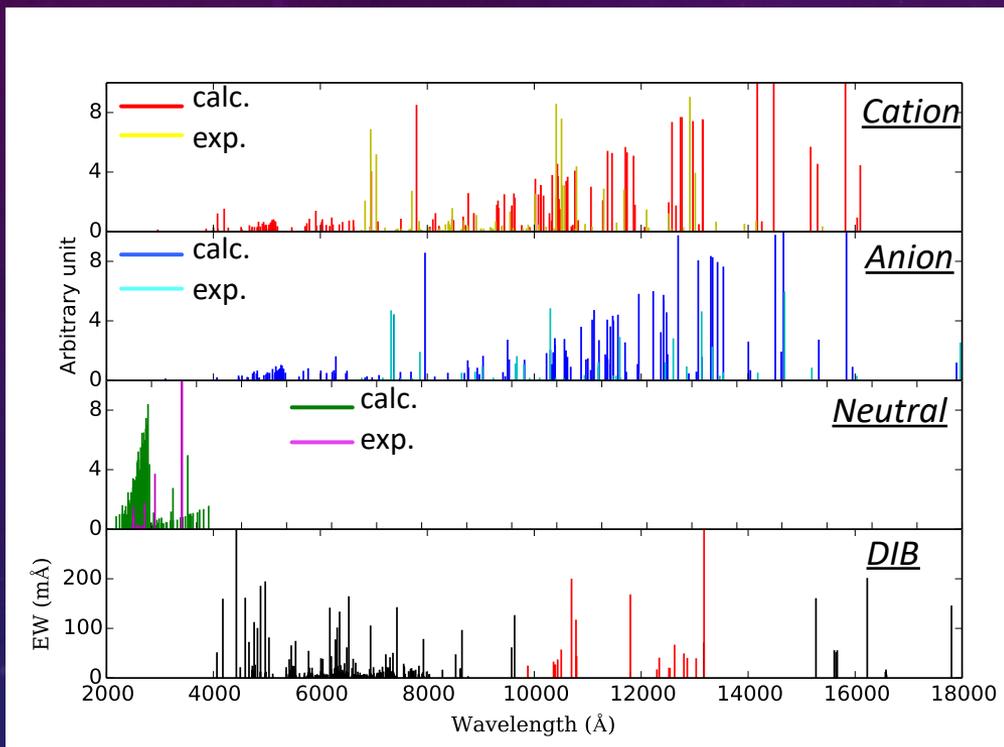2012   2017   2019

Cosmic Shadow 2018

Today's talk

Comparison with laboratory spectra

◆ **PAHs**

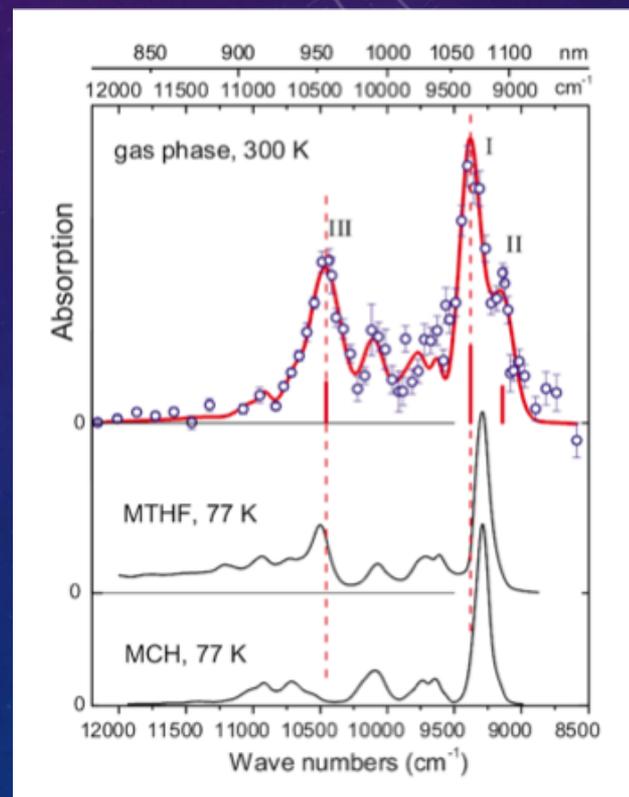*calc.: Ruiterkamp et al. 05*
exp.: Gredel et al. 11, Salama et al. 11, Mattioda et al. 05
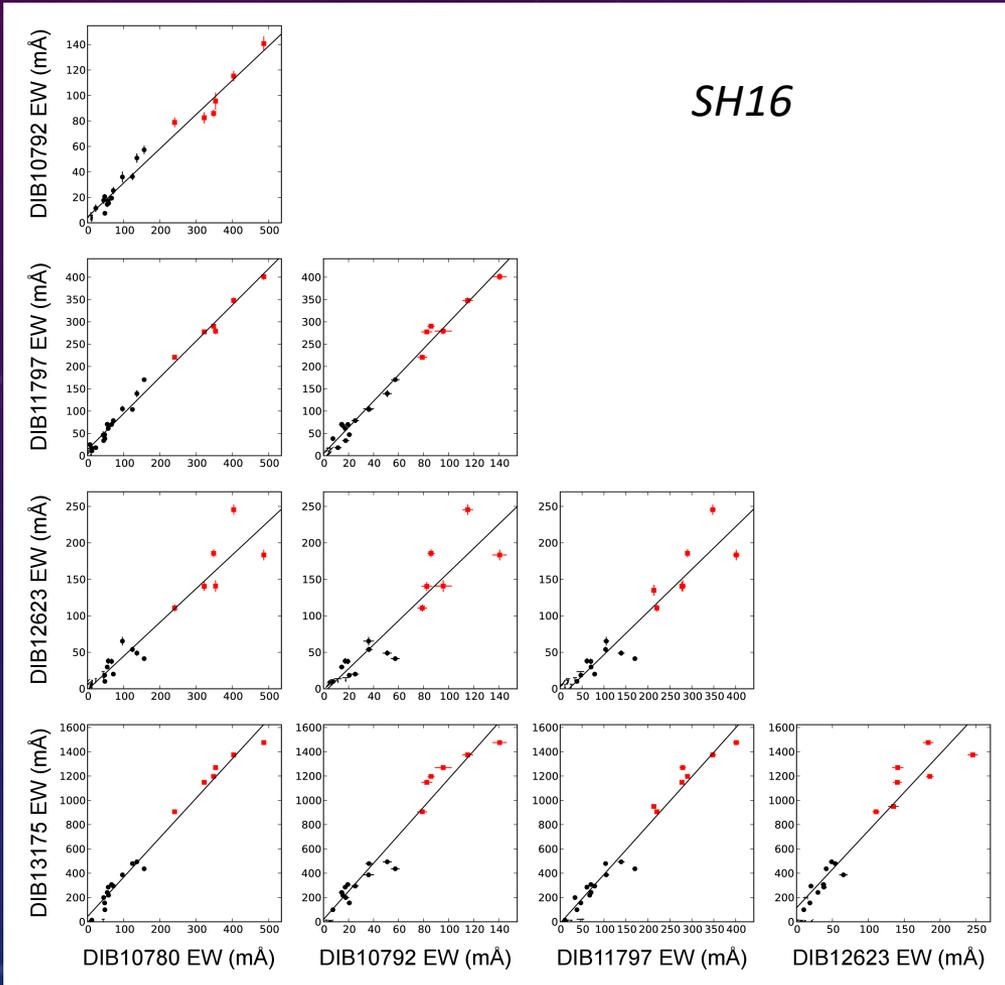
◆ **Fullerenes**

C_{60}^-: *Tomita et al. 2005*

DIBs correlations

SH16

◆ NIR DIB "family"

- 10780, 10792, 11797, 12623, 13175

- r > 0.95

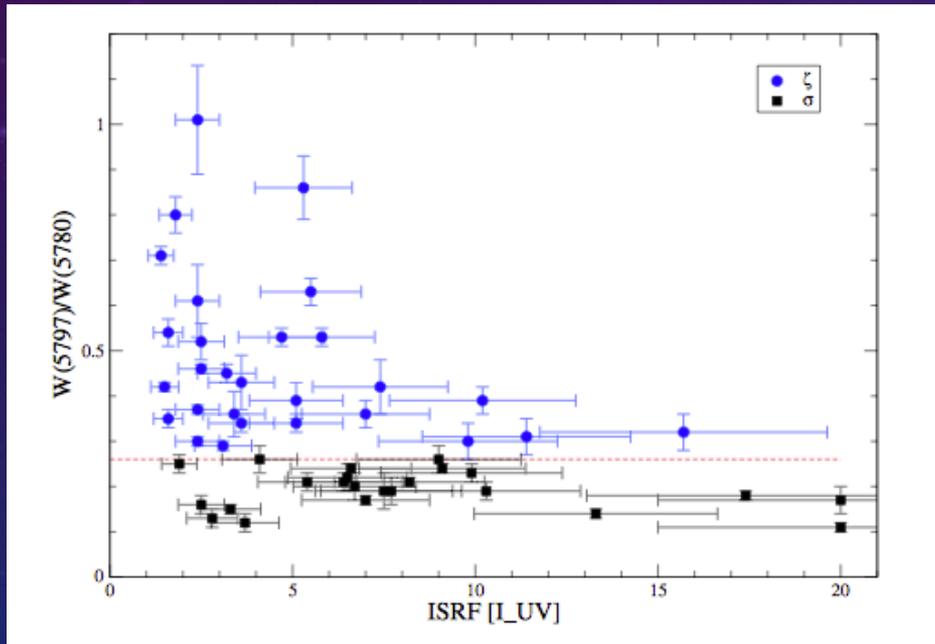→ Similar molecules? (Perhaps, same?)

DIB correlations

◆ Correlation of NIR DIBs with DIBs 5780, 5797

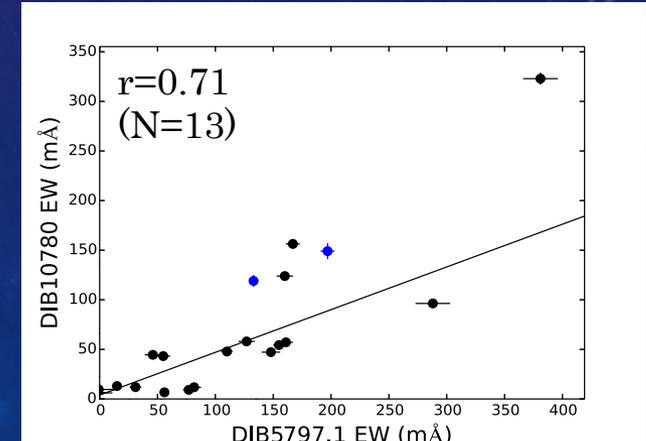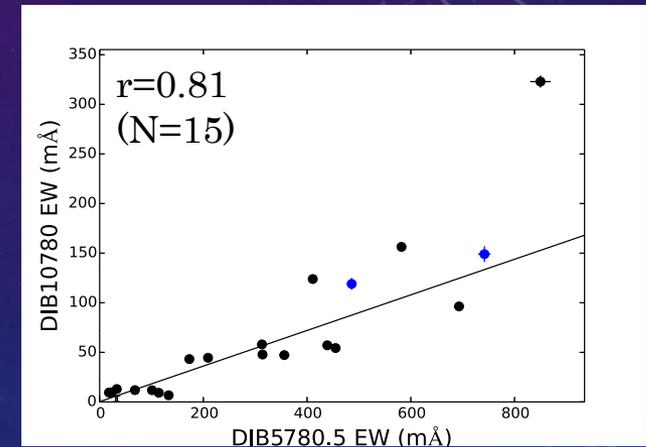- NIR DIB family correlates well with 5780.

- Cation molecules?

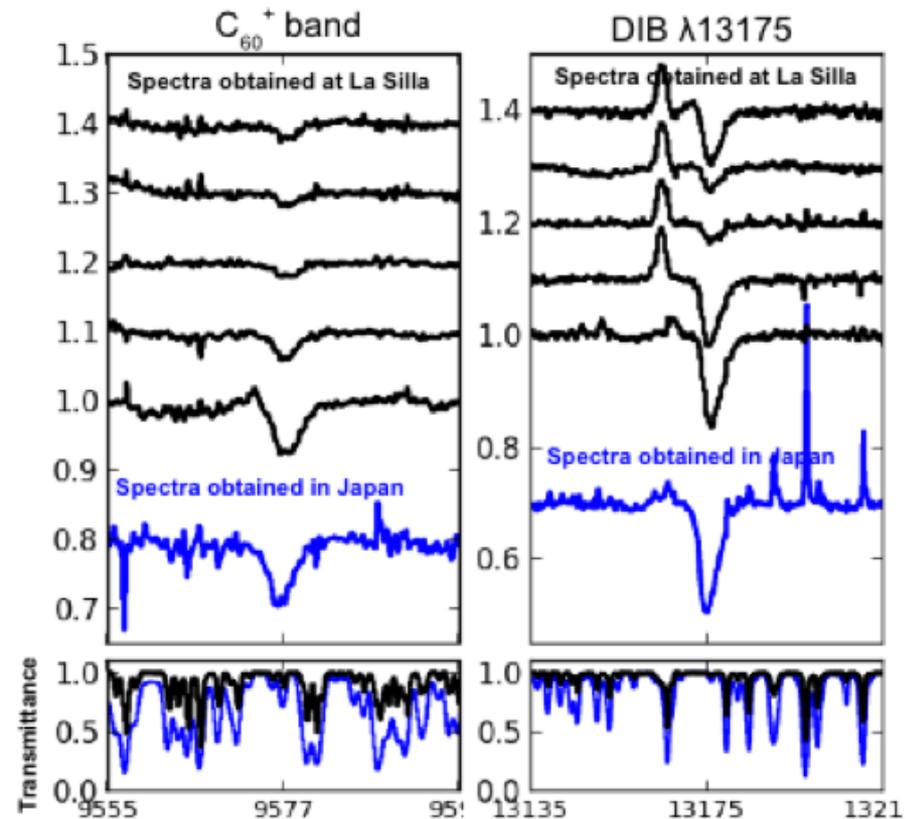*SH15*

5797/5780

UV
Vos et al. 11

C_{60}^+ DIBs

◆ **C_{60}^+ DIBs in 0.92-0.96 µm**

- λ9577: Strong

- λ9633: Strong, but overlapped by a stellar MgII absorption line.

- Three other DIBs: weak

◆ **These DIBs are contaminated with many strong telluric absorption lines.**

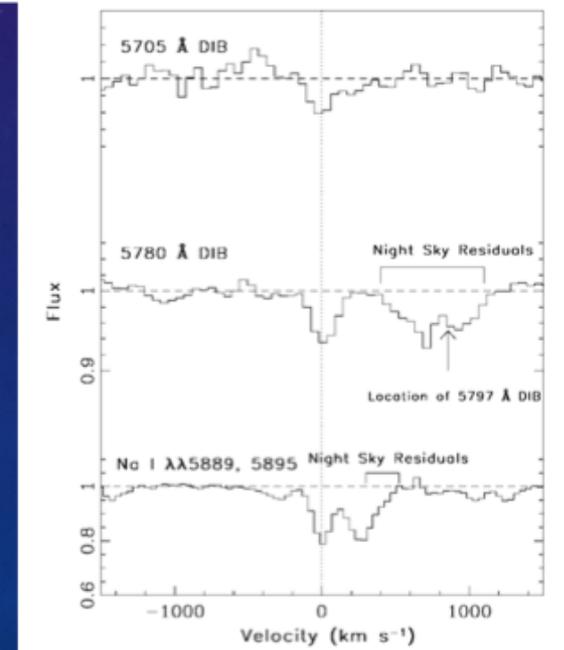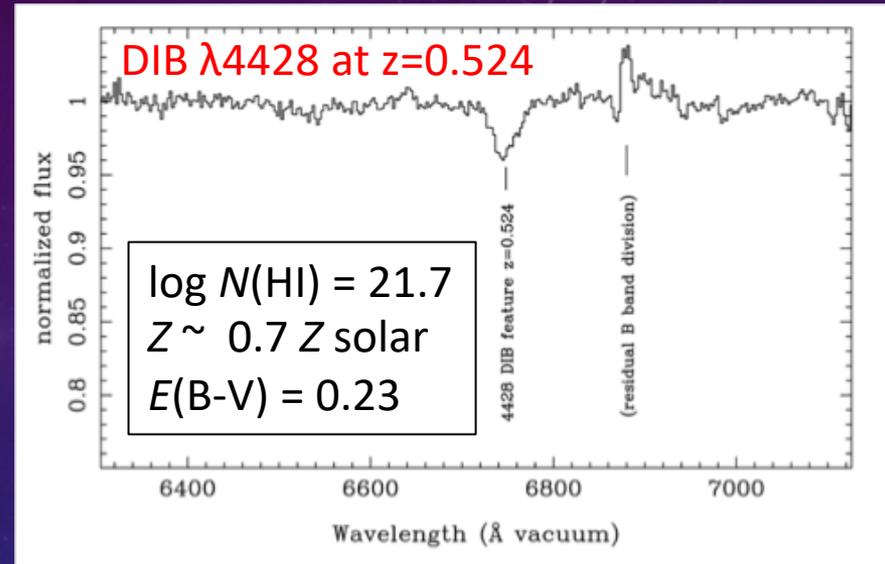- Low humidity and precise telluric correction are crucial.

(a) NTT/WINERED spectra from P99 run

C_{60}^+ band — DIB λ13175

DIBs in QSOALS

◆DIBs have been detected in
two QSOALSs
(z = 0.524 and 0.1556).

◆Evolution of
organic molecules
in a cosmological time scale.

◆Test for DIB "families".

◆DIBs diagnostics
(e.g. 5797/5780).

DIB λ4428 at z=0.524

$\log N(HI) = 21.7$
$Z \sim 0.7 \, Z$ solar
$E(B-V) = 0.23$

Strategy for detecting DIBs in QSOALS

Ca II system statistics (SDSS)
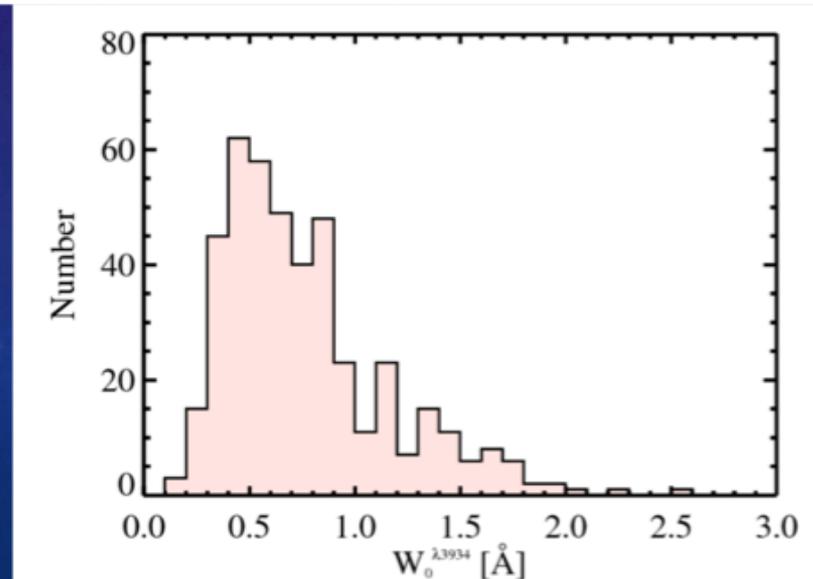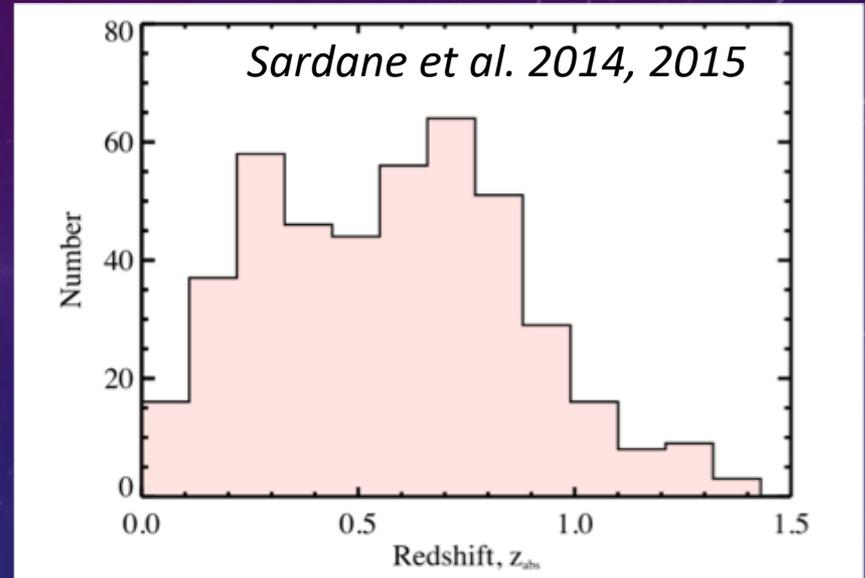
◆ DLAs with high N(HI), high Z and high E(B-V).

◆ Best tracer: CaII systems?

- Sub class of DLAs

- CaII systems trace metal-rich, dusty, neutral gas clouds.

- NaI system?

◆ Best DIB: λ4428

- Strongest DIB

- Y, J bands: 1<z<2

Cosmic Shadow 2018

Sardane et al. 2014, 2015

Fullerene evolution

◆ DIB λ5780 in z=0.524 DLA is three times weaker than that of HD183143.

◆ C_{60}^+ DIB λ9577 of HD183143:

- Depth: 9% → 3%
- EW: 0.3Å → 0.1Å

Expected in z=0.524 DLA

◆ S/N > 100 would be necessary.

- Y, J bands: 0 < z < 0.4
- H band: 0.5 < z < 0.8

Theme for 30-m class?
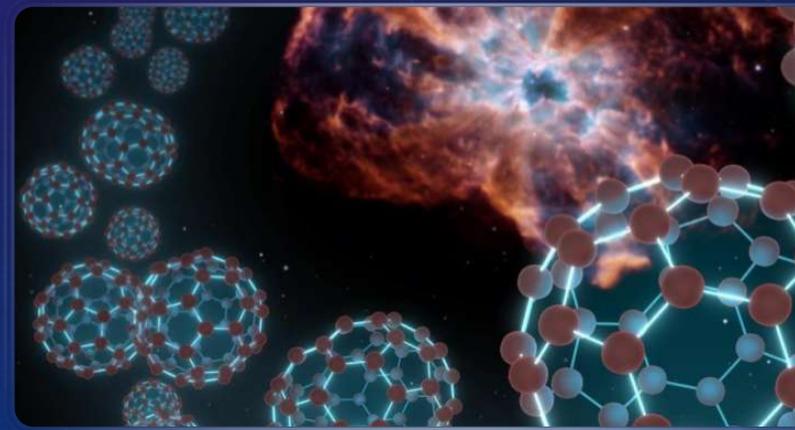
Summary

◆**DIBs: _cosmic shadow_ of interstellar molecules**

◆**NIR DIBs survey w/ WINERED**

- **Over 50 DIBs were newly detected.**

- **NIR DIB family**

- **Compared with the spectra obtained with laboratory experiments (PAHs, fullerenes)**

- **C_{60}^+ DIBs (observation is on-going)**

◆**DIBs in QSOALS**

- Evolution of organic molecules in a cosmological time scale.

- CaI systems