UNIVERSITEIT VAN AMSTERDAM

New Insights into the Carbonaceous Nature of Diffuse Interstellar Bands

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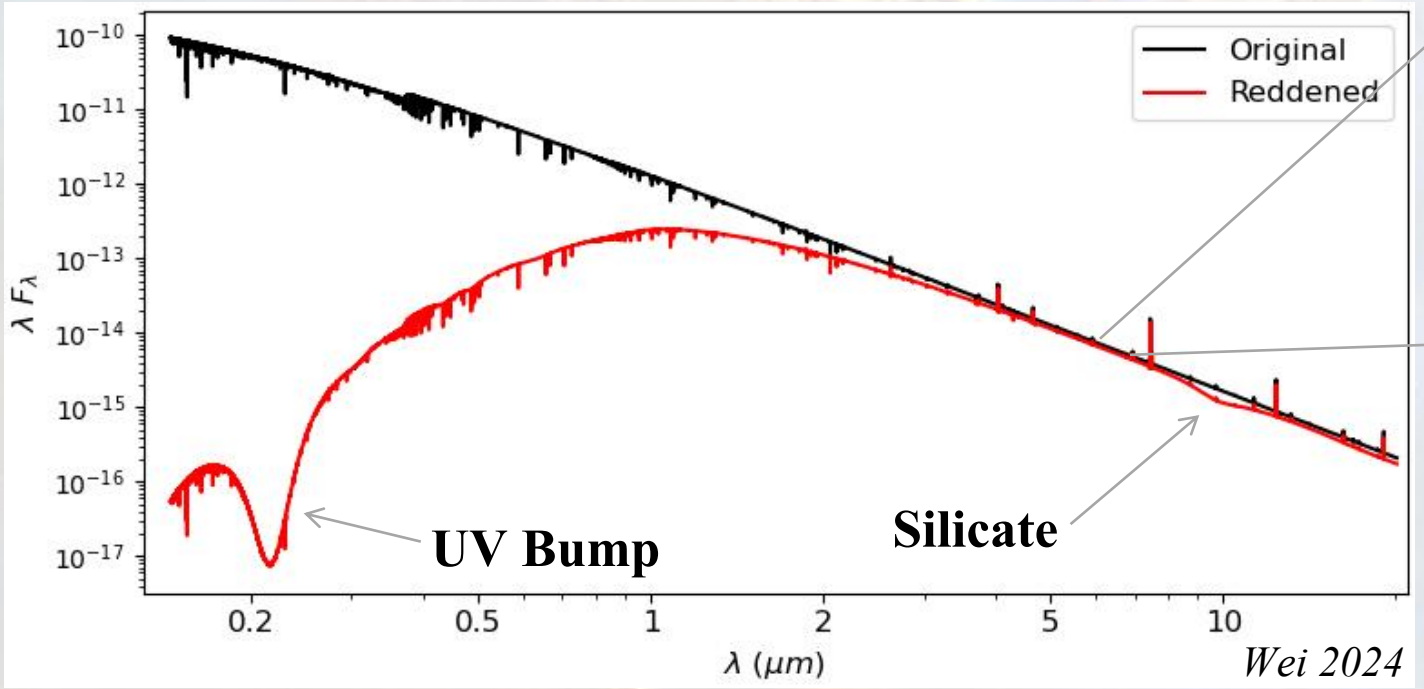
and **WISCI** (Webb Investigation of Silicates, Carbons and Ices) Team

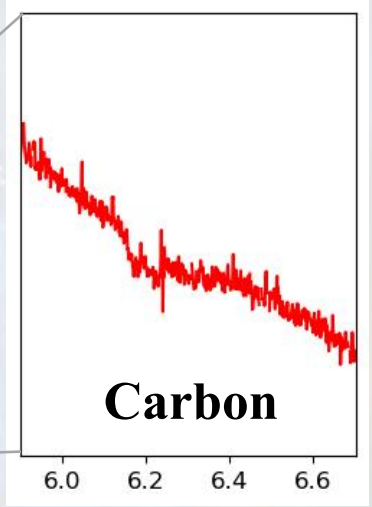
University of Arizona, Tucson

November 10th, 2025

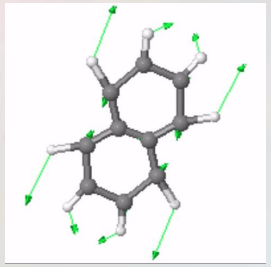
Origins Center

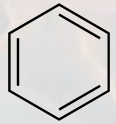
Extinction curve and features

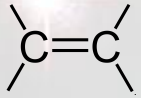


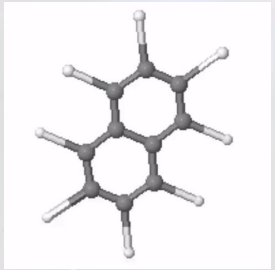


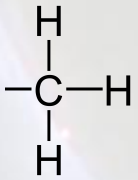
- **UV Bump**: Carrier unknown, but likely carbonaceous
- **Silicate** 9.7 μm: Caused by Si-O stretch
- **Carbon** 6.2/3.4 μm: Caused by C-C stretch (Aromatic/Olefinic), C-H stretch (Aliphatic)



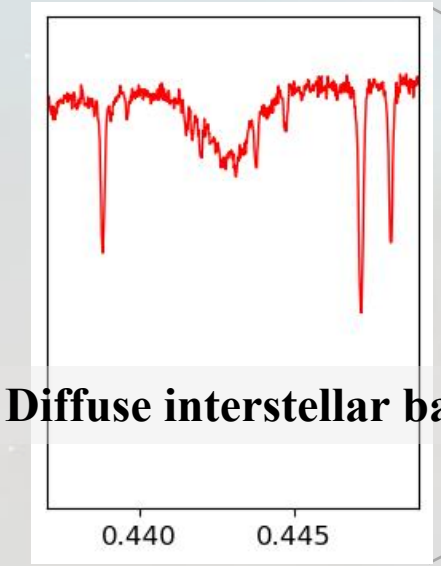




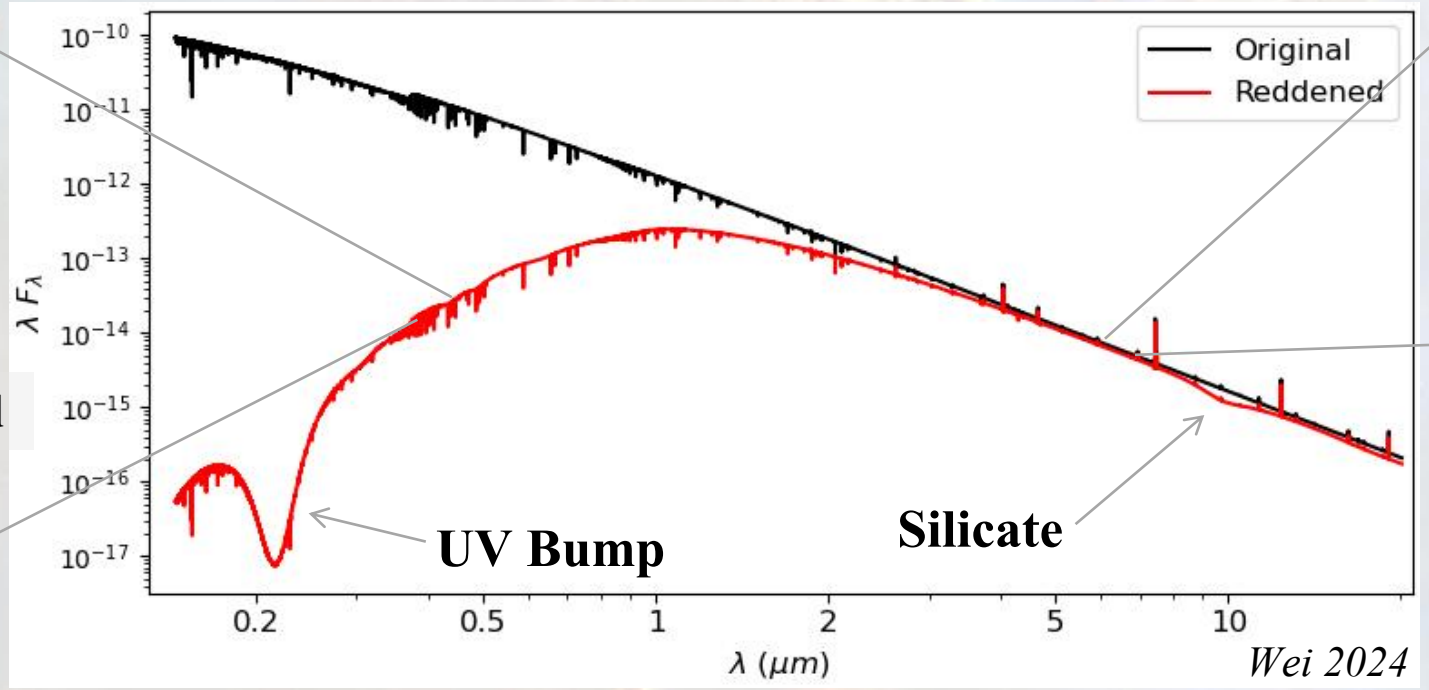


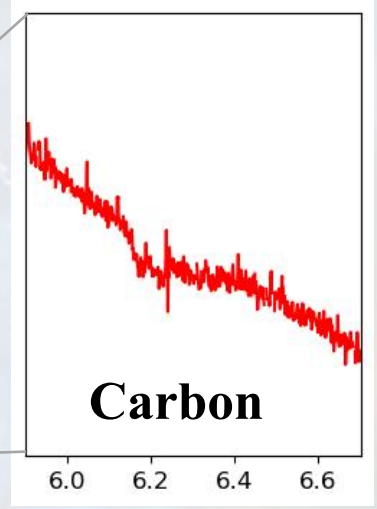


Extinction curve and features



Diffuse interstellar band





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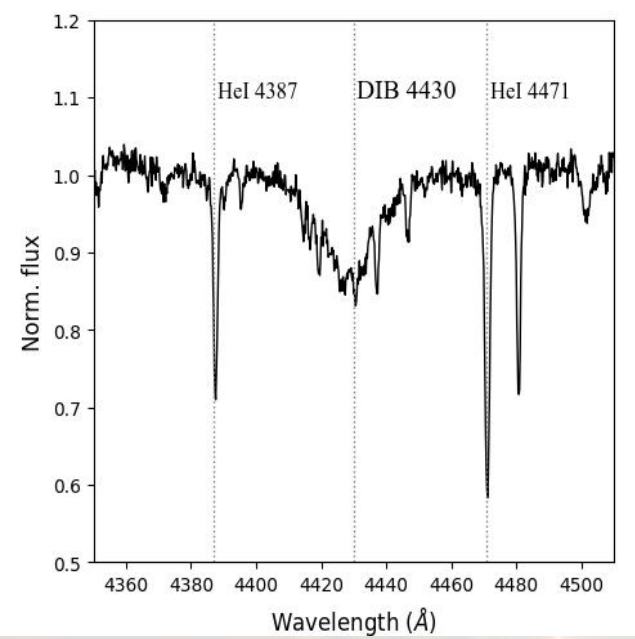
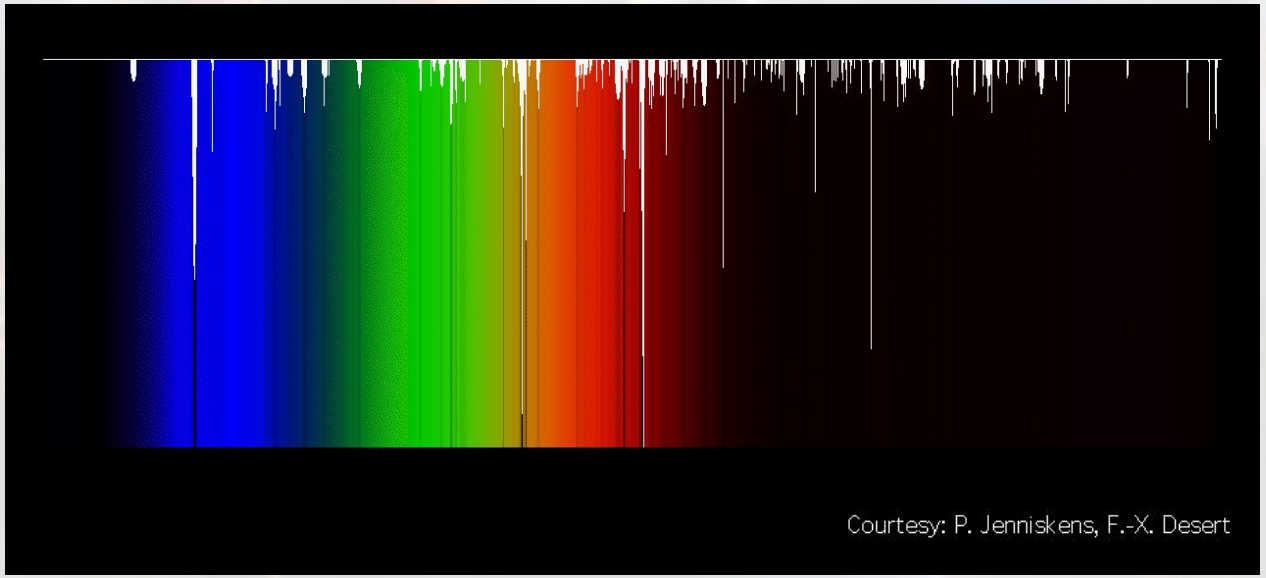
- **Diffuse Interstellar Bands**

Diffuse Interstellar Bands (DIBs)

- Much broader than typical stellar lines
- Over 500 DIBs in optical and near-infrared
- Carriers remain a mystery for over 100 years
- Candidates: Fullerenes (e.g. C_{60}^{+}), Polycyclic Aromatic Hydrocarbons



Wei 2024



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- **Lab experiment**

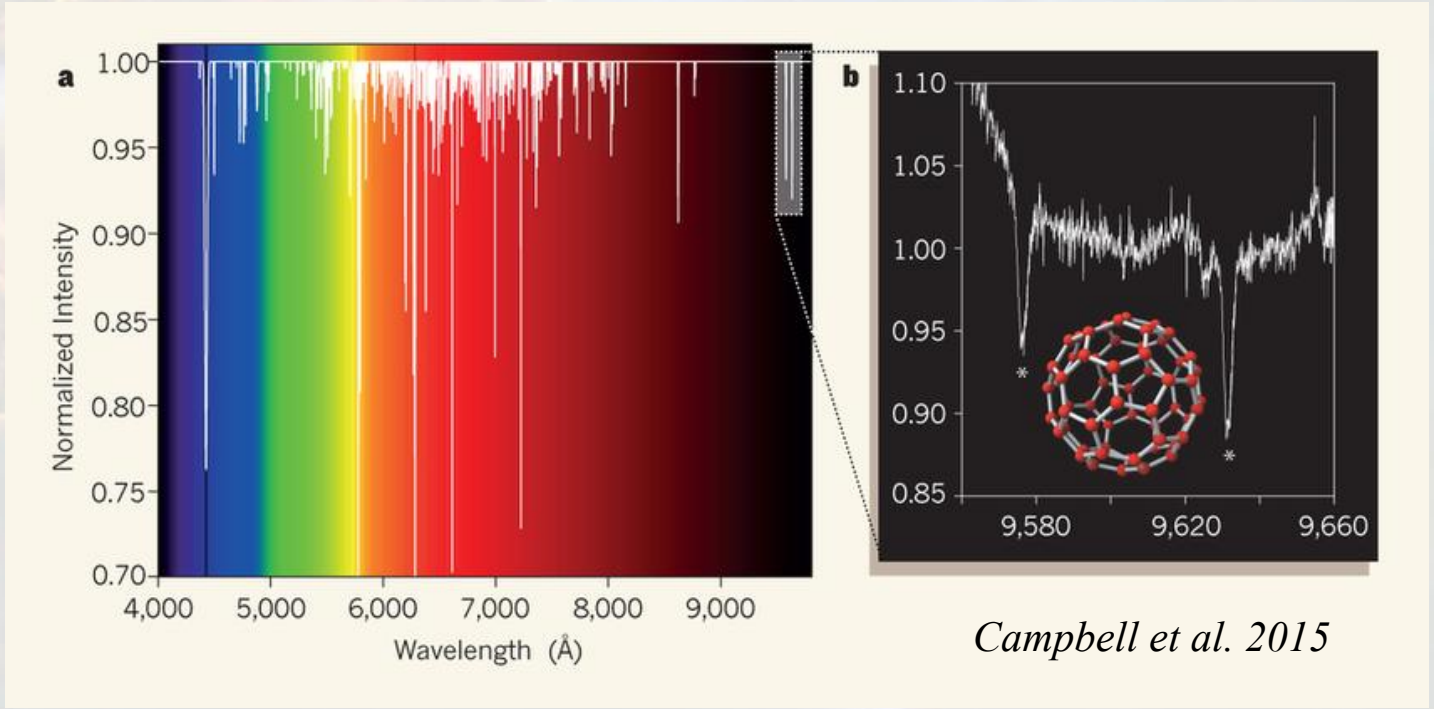
→ Challenging (Isomers)

- **Correlation with other features**

→ Weak IR carbon features

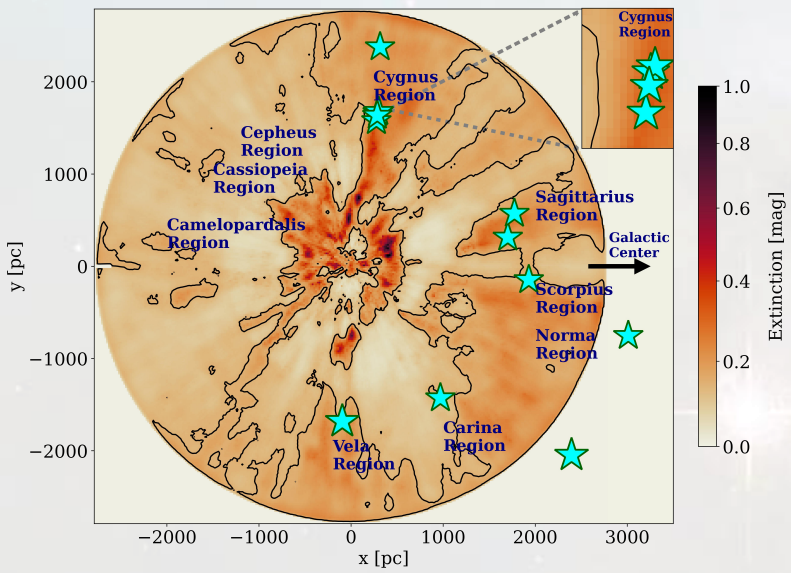
→ Only observed in highly reddened sightlines

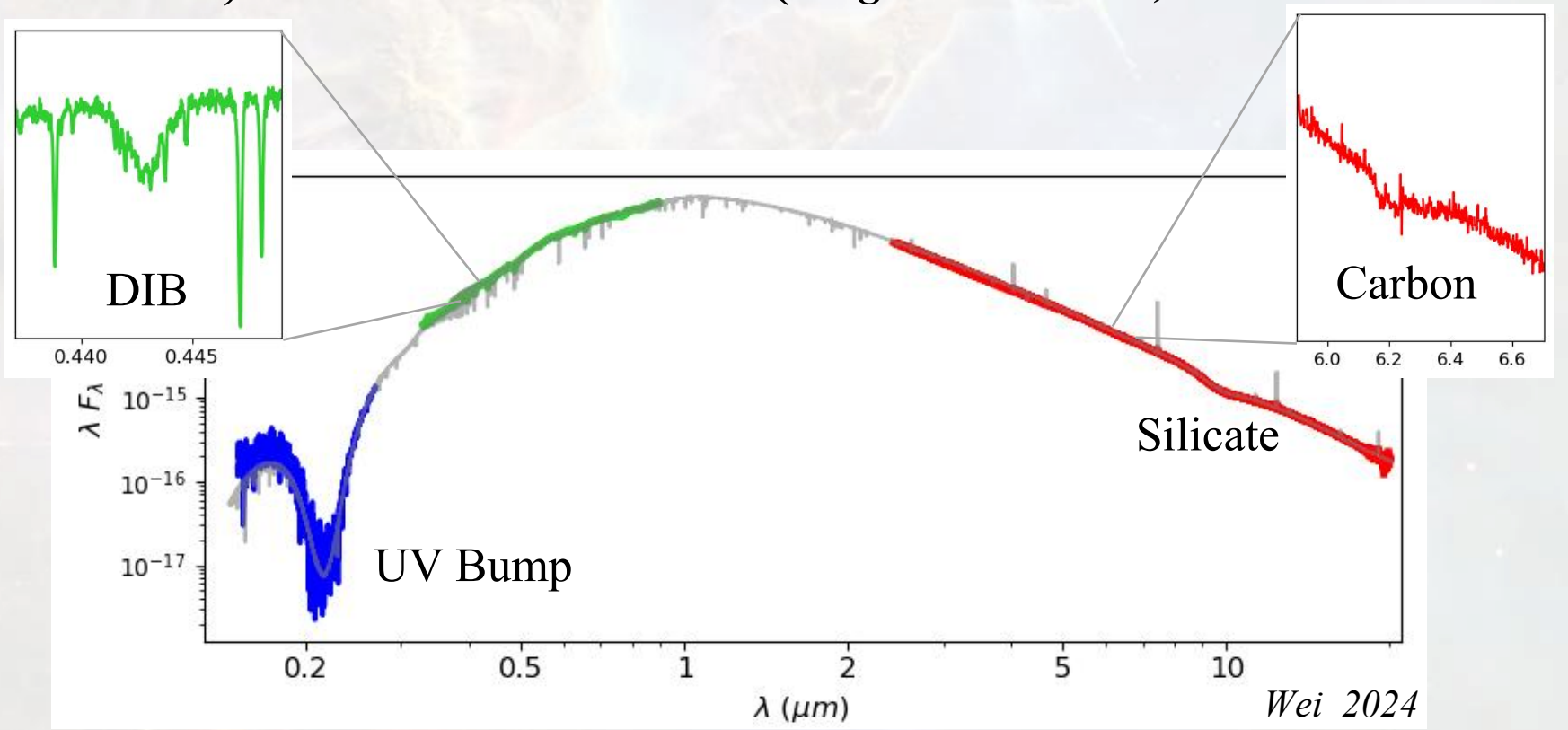
→ Severe extinction in the UV and optical



Campbell et al. 2015

Webb Investigation of Silicates, Carbons and Ices (*Zeegers et al. 2025*)



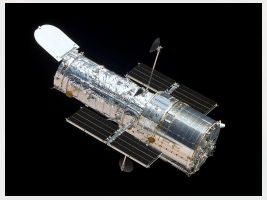


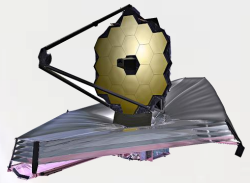
Targets: 12 OB stars

Extinction: $4 < A_V < 7$ (moderate)

Single Cloud sightlines

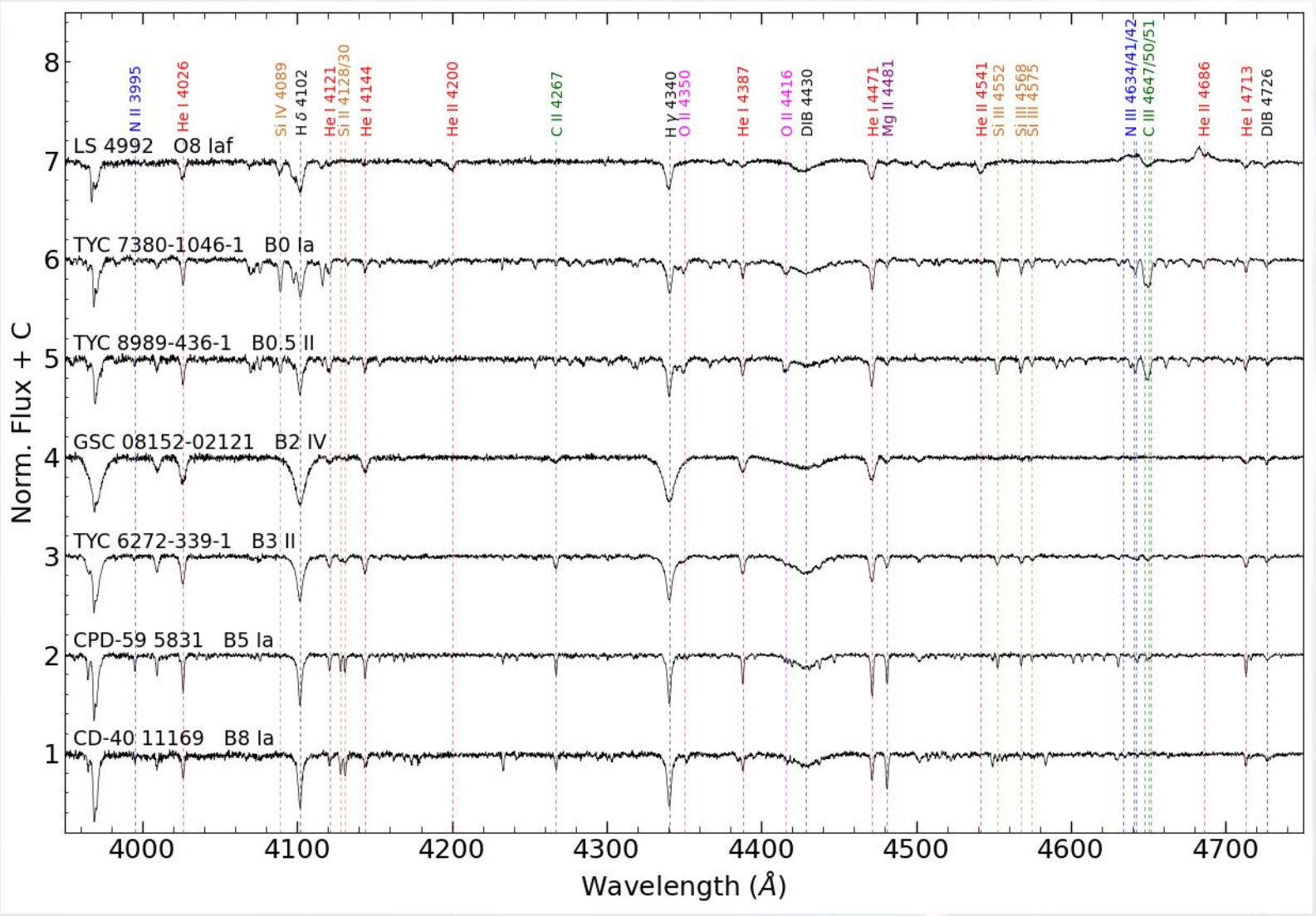
HST / STIS, **VLT** / Xshooter, **JWST** / NIRCam, MIRI





First time to measure these features in the same sightlines!

Spectral classification



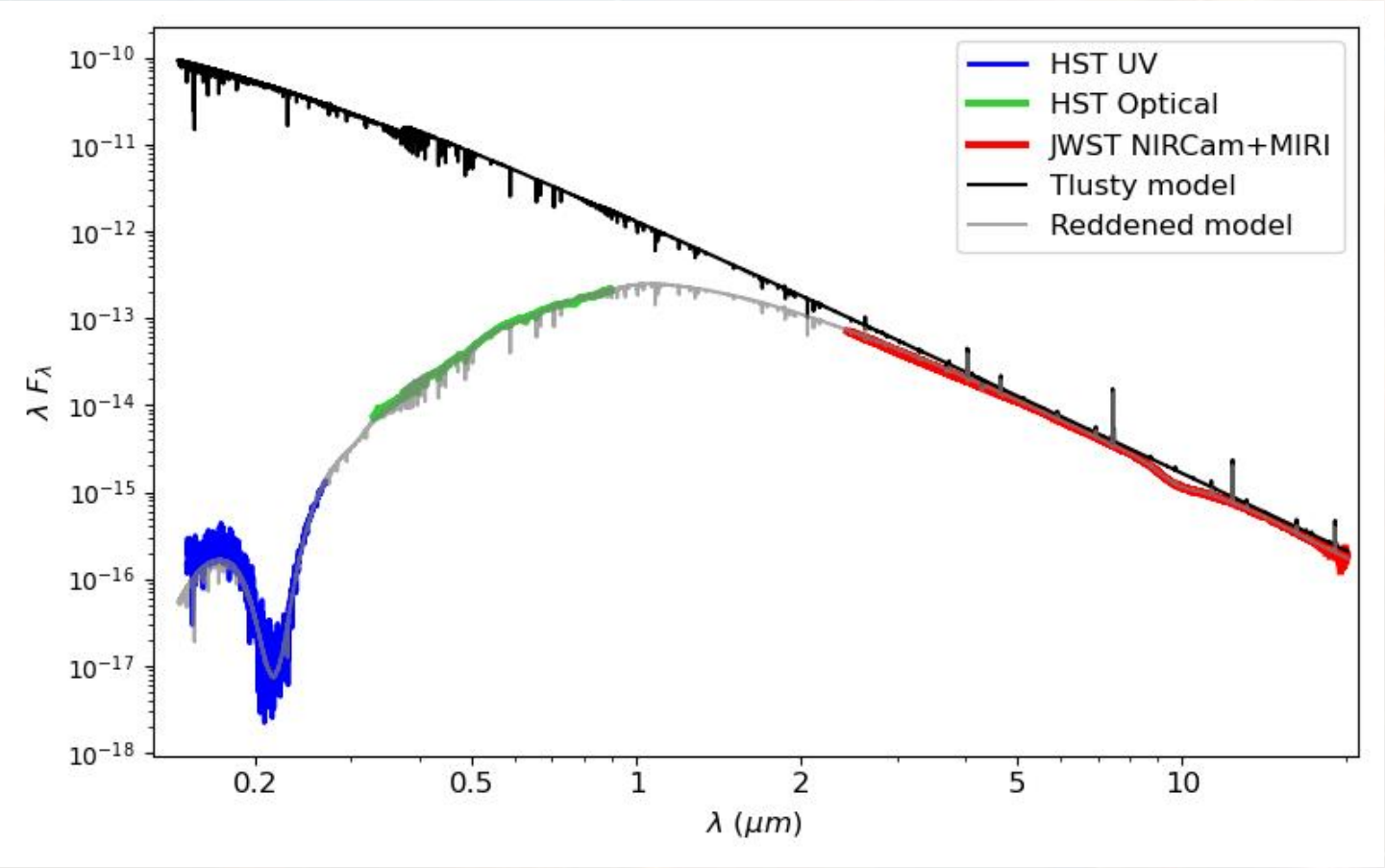
Strengths and shapes of **H, He, and metal lines**

↓

Spectral type (Teff, logg)

Wei 2024, criteria from *Gray & Corbally (2009)*

SED Fitting → Extinction



Wei 2024, Extinction model from *Gordon et al. 2023*

Spectral type (Teff, logg)

↓

Stellar model (*Tlusty model*)

↓

Fit with observed spectrum

Extinction parameters A_V, $E(B-V)$

DIB selection & measurement

DIB families: response to changing environment / relation to certain molecule

σ : 4430, 5780, 6196, 6284, 6614, 7224, 8620

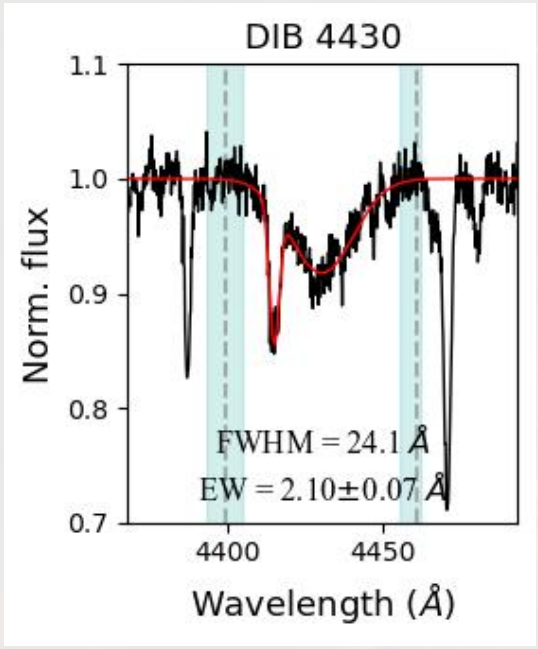
Intermediate: 4501, 4762

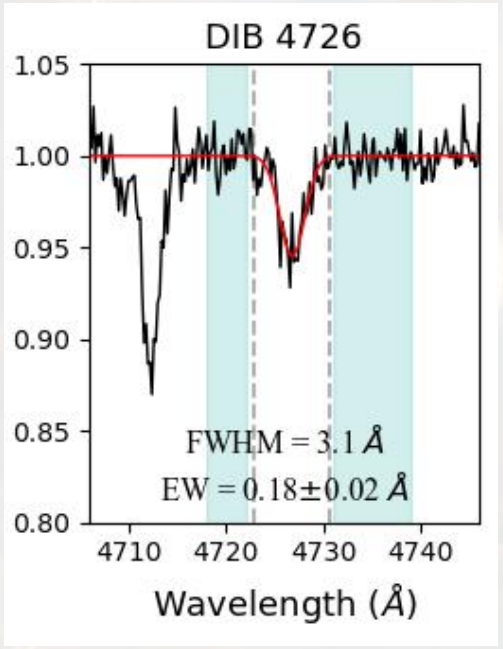
ζ : 5797, 5849, 6379

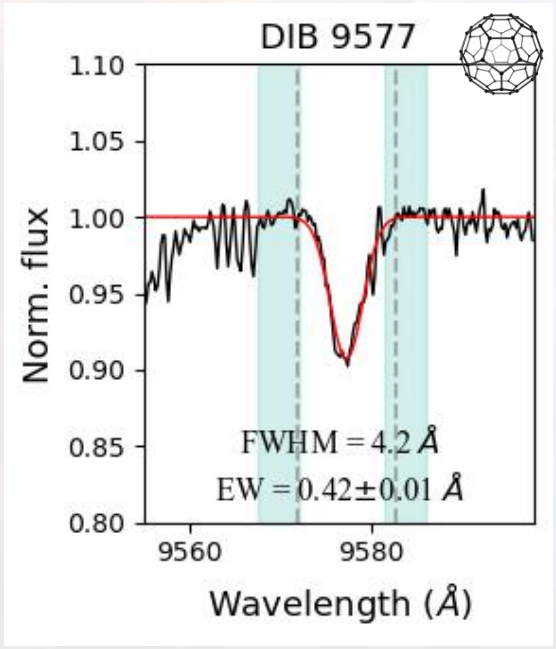
C_2 : 4726, 4964

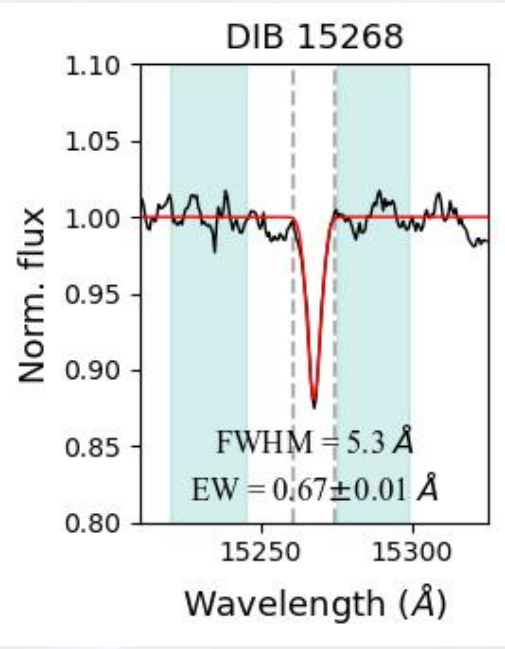
C_{60}^+ : 9577, 9632

NIR : 13176, 15268





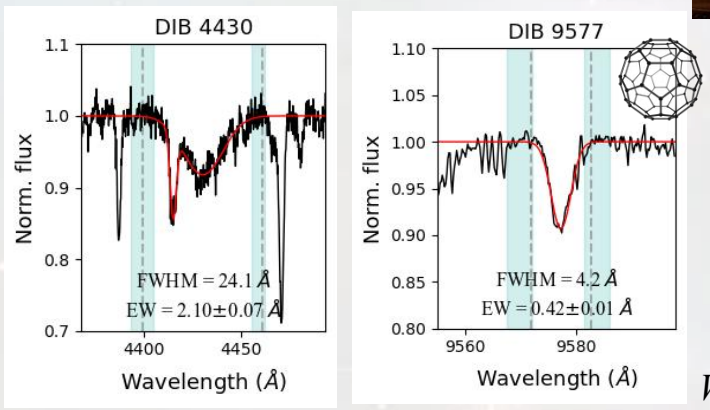




Wei 2024

Measuring different features

1. Diffuse interstellar bands



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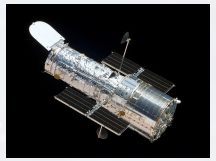
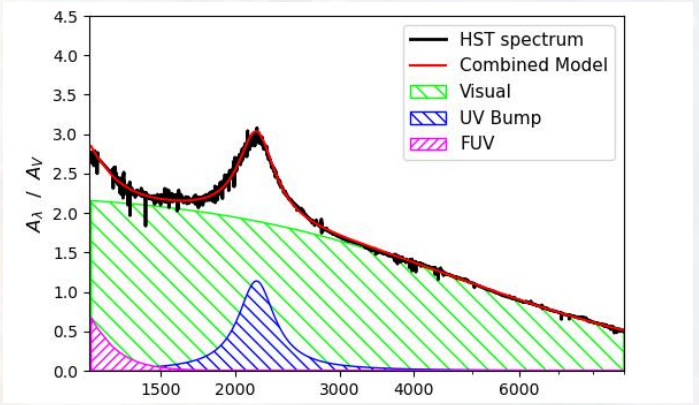
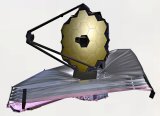
2. UV Bump (Drude profile)

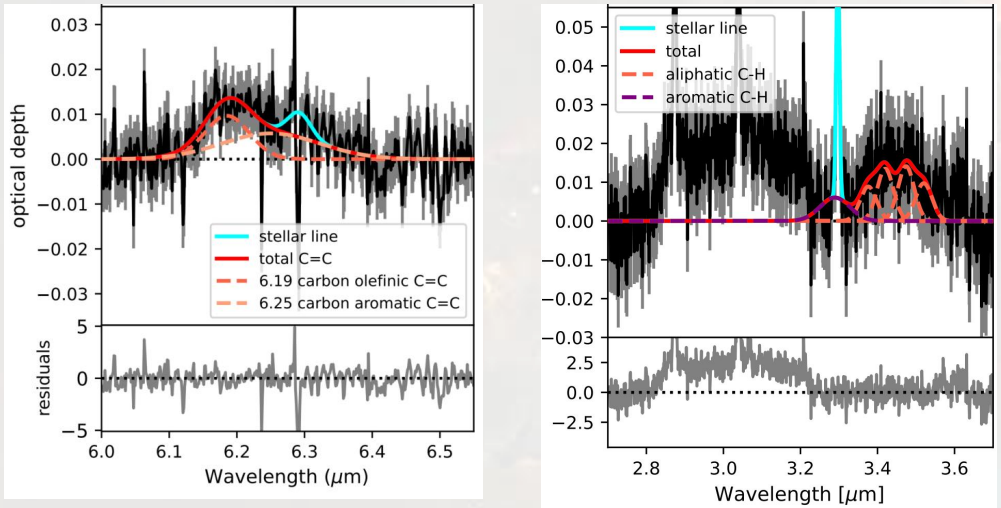




Wei 2024

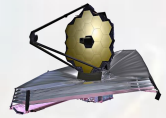
3. Carbon (Multiple Gaussians)

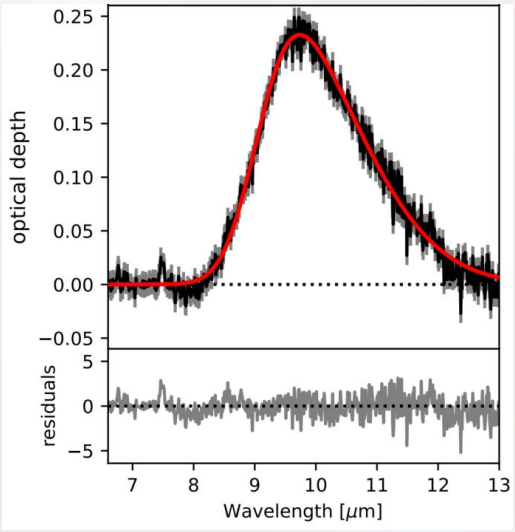




Zeegers et al. 2025

4. Silicate (Skewed Gaussian)

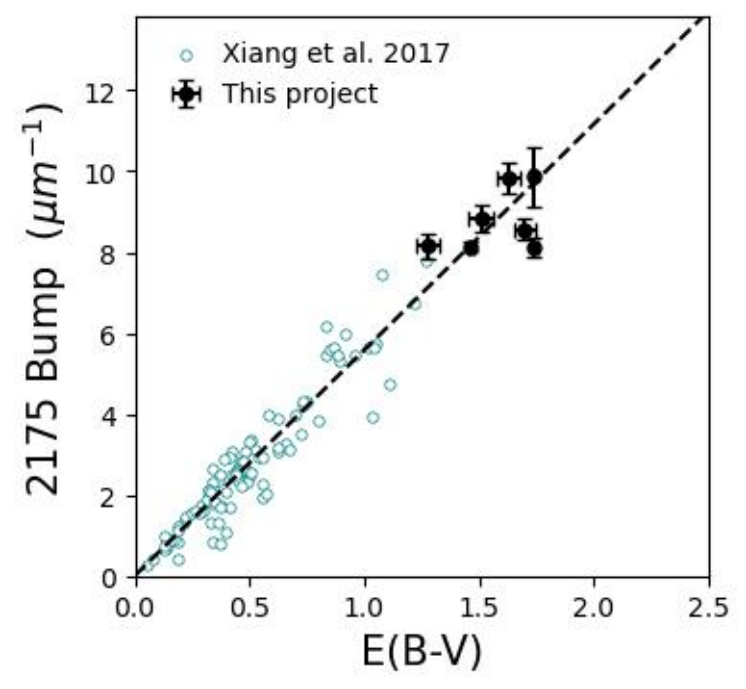




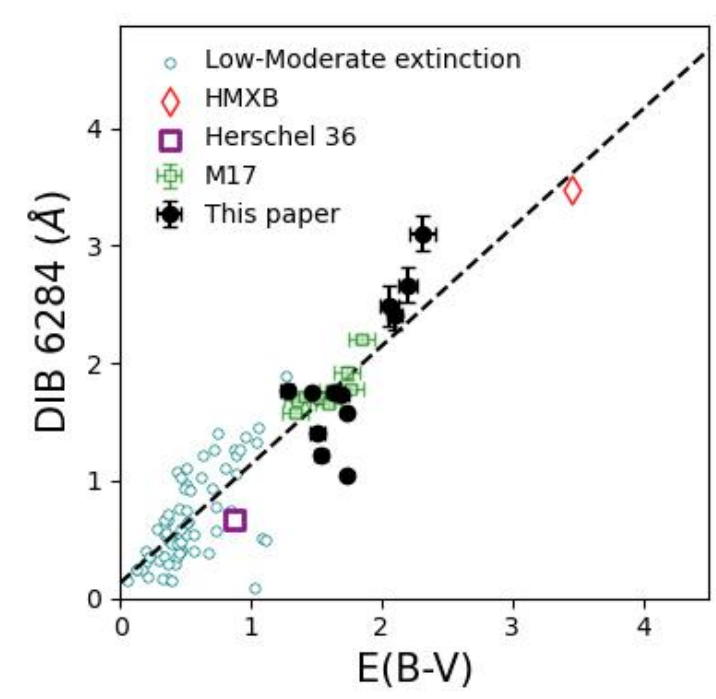
Zeegers et al. 2025

Strength vs $E(B-V)$

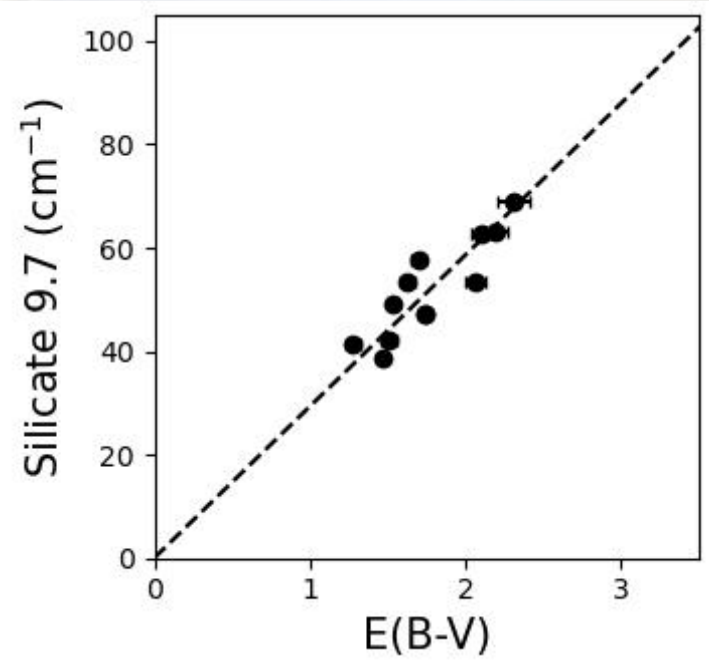
UV Bump



DIB



Silicate

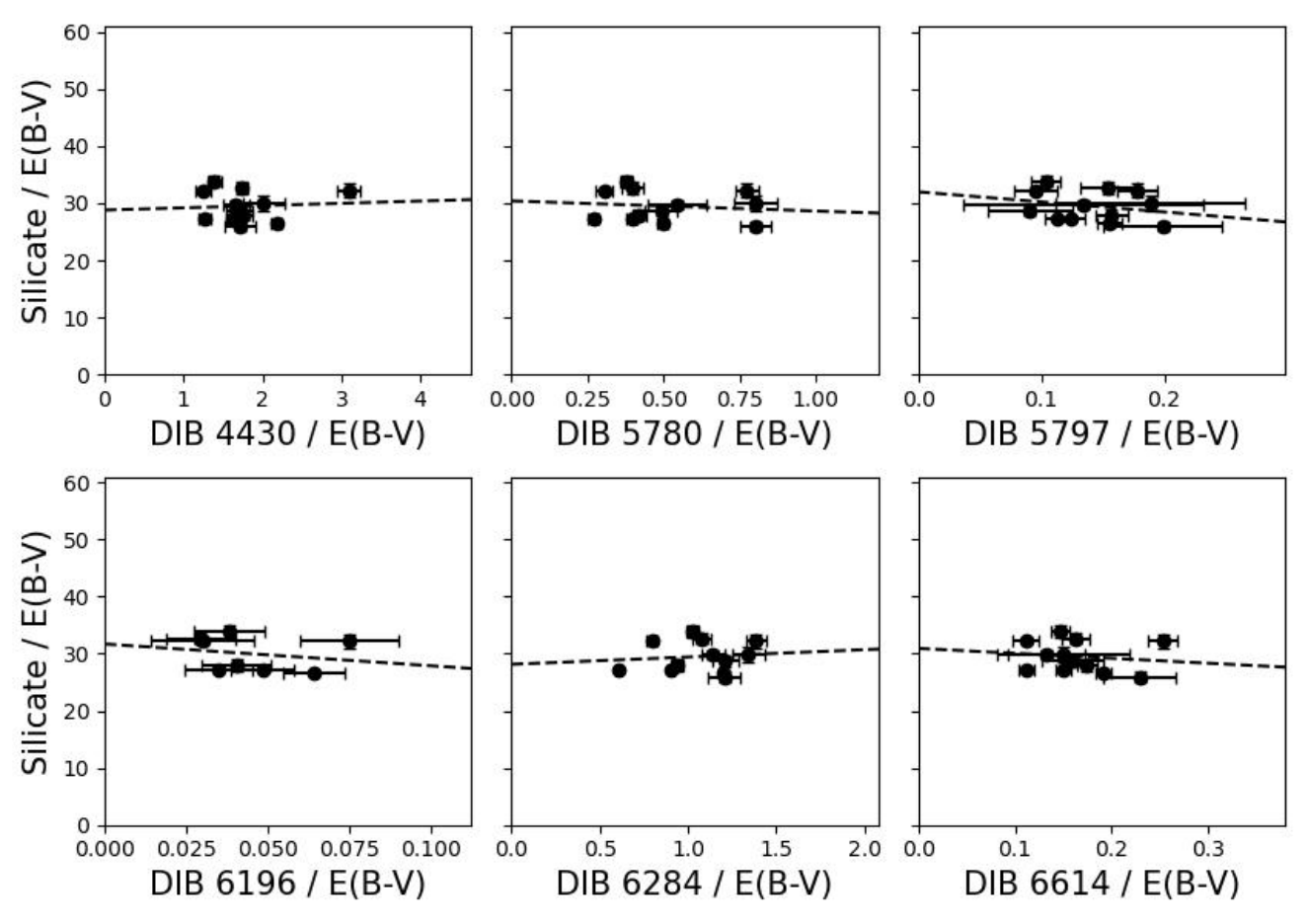


Wei 2024

- Strengths scale with $E(B-V)$ (Dust column)

→ Normalize by $E(B-V)$

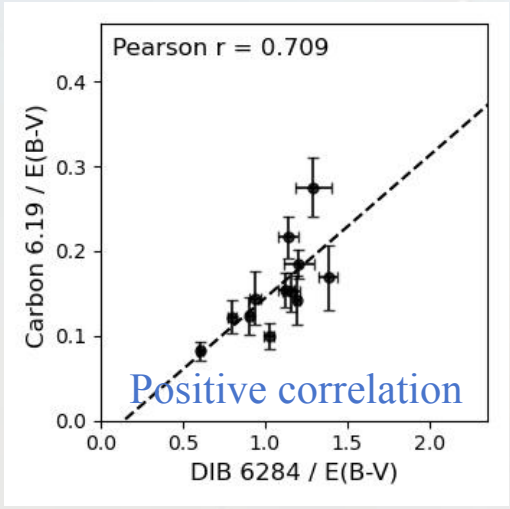
DIBs vs Silicate

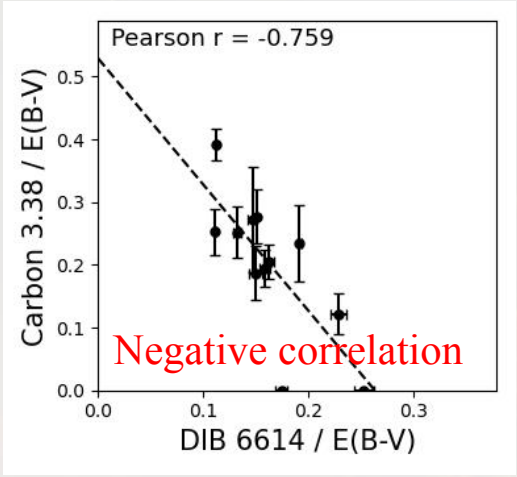


Wei et al. (to be submitted)

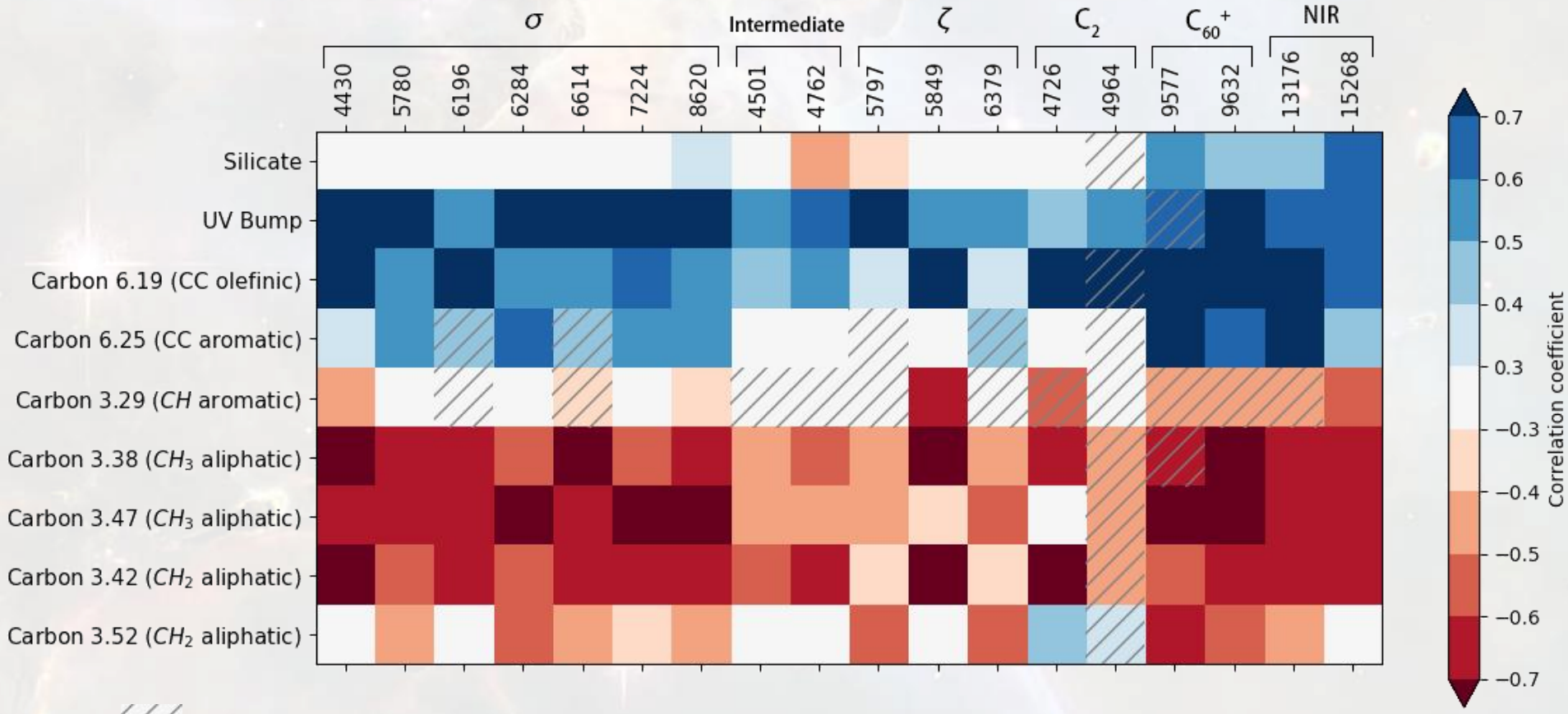
No correlation → DIB carriers are not related to silicate dust

DIBs vs Carbon (UV Bump + Infrared vibrational modes)





Diffuse interstellar bands

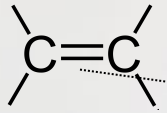


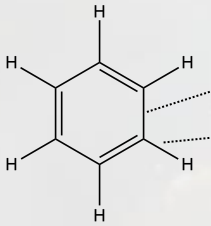
(Hatching): Less than 6 data points
or more than half data points have error > 20%

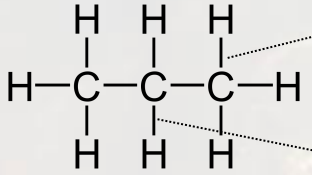
Wei et al. (to be submitted)

DIBs vs Carbon (UV Bump + Infrared vibrational modes)

?







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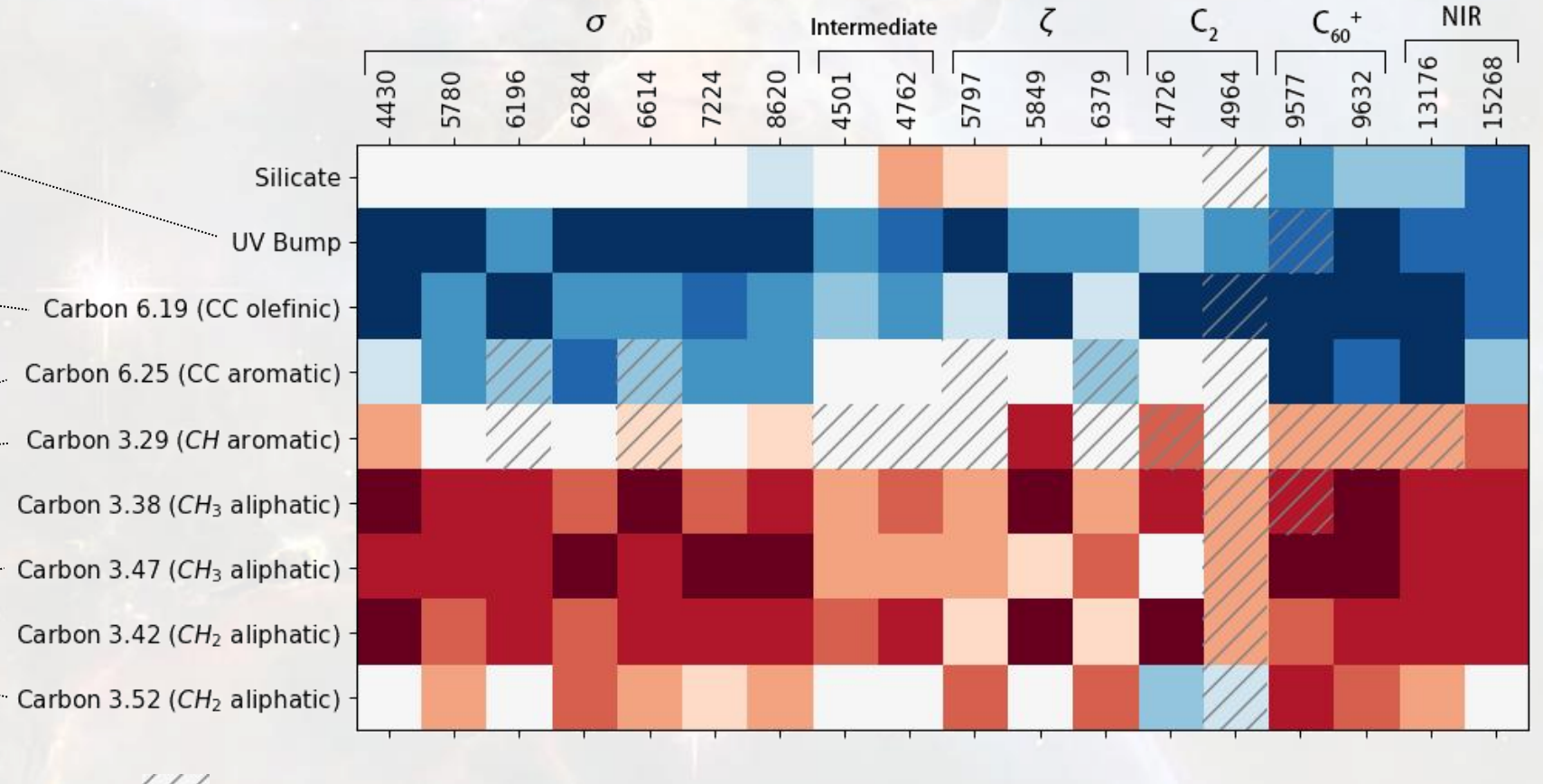

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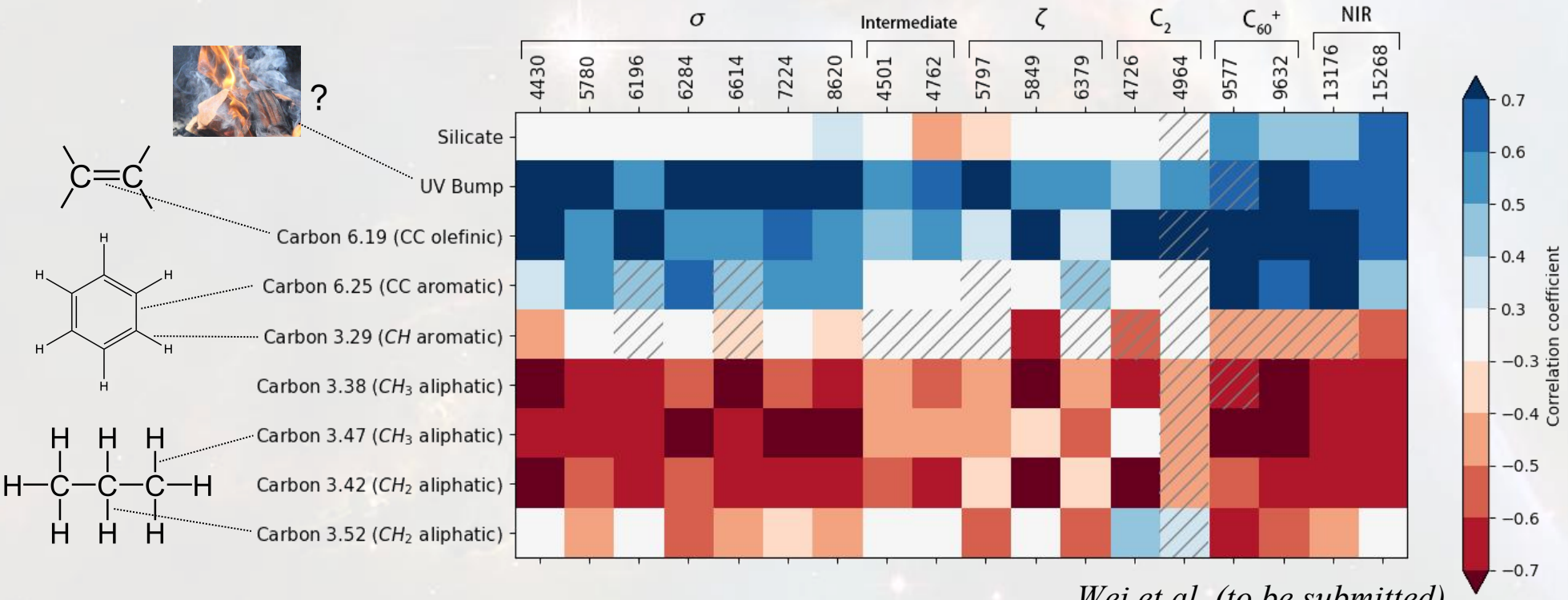
Wei et al. (to be submitted)

Correlation analysis

- No correlation between DIBs and Silicate
- Correlation between DIBs and Carbon

} **Carbonaceous** nature of DIBs

- Constrain the structure of DIB carriers
- Negative correlation with C-H → Removal of H in UV radiation
- Indenpent of DIB family properties

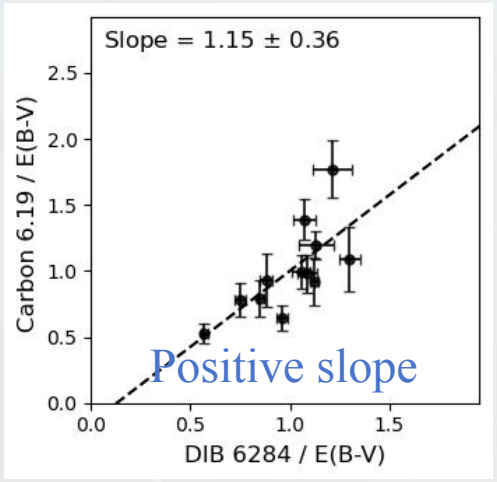


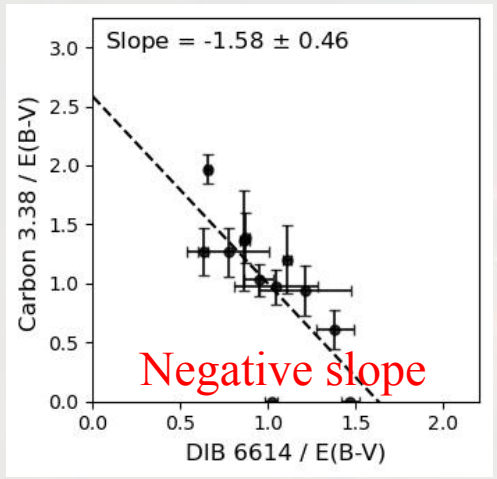
Wei et al. (to be submitted)

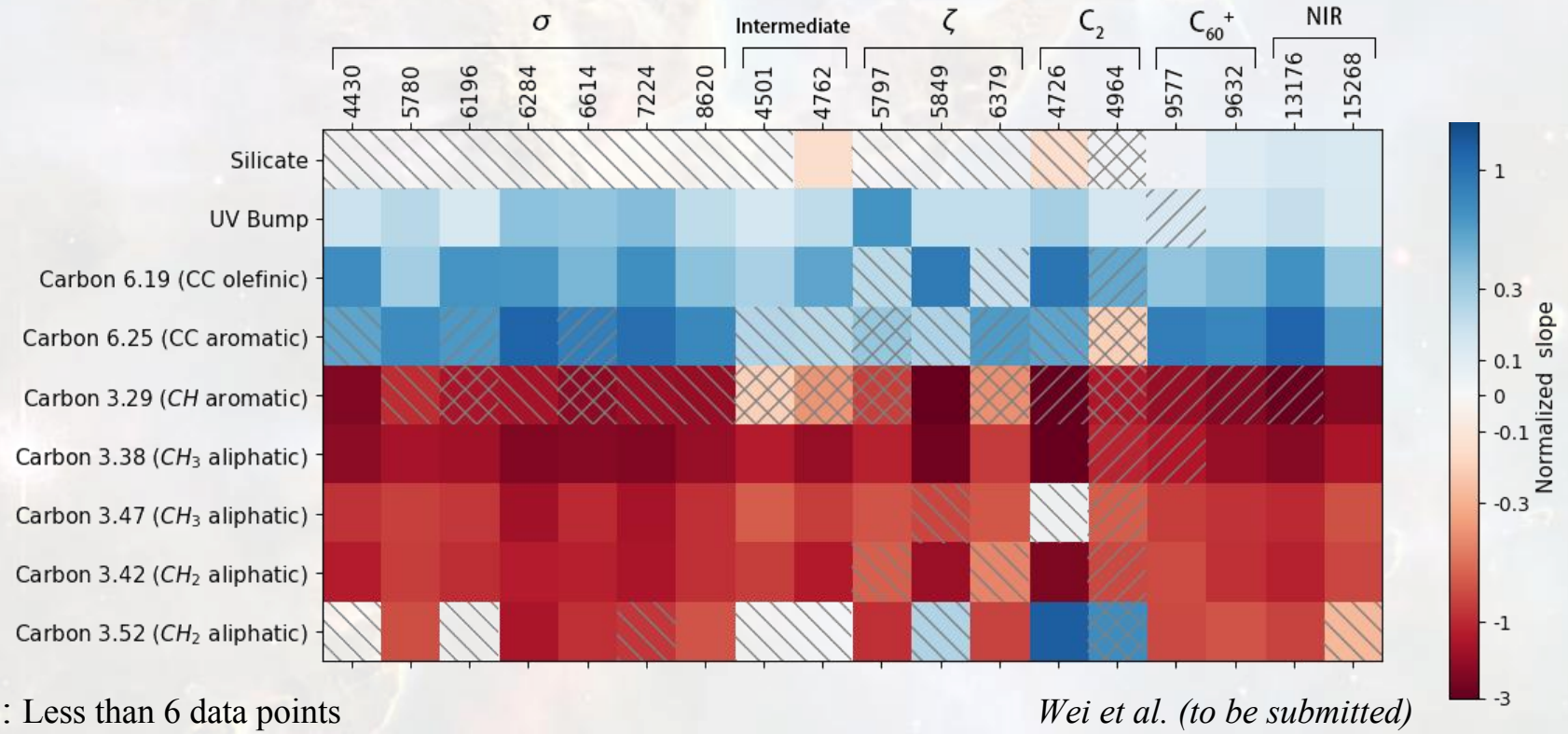
If the relation exists (qualitative)

How are they related ?

Slope: Carbon variation ⟷ DIB variation







Wei et al. (to be submitted)

: Less than 6 data points or More than half data points have error > 20%

: Correlation coefficient < 0.4

Slope independent of DIB strength and families

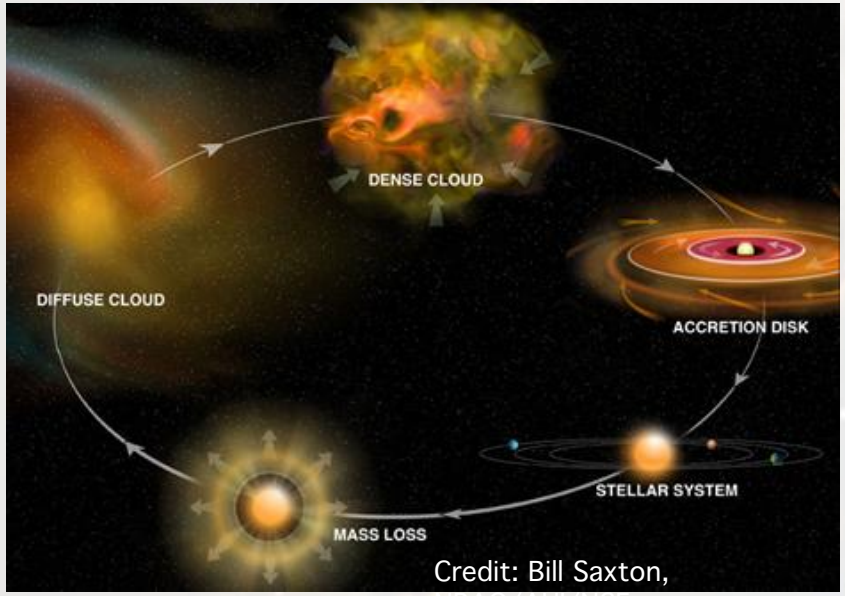
→ DIBs respond similarly to carbon variation

→ Common production / destruction mechanism

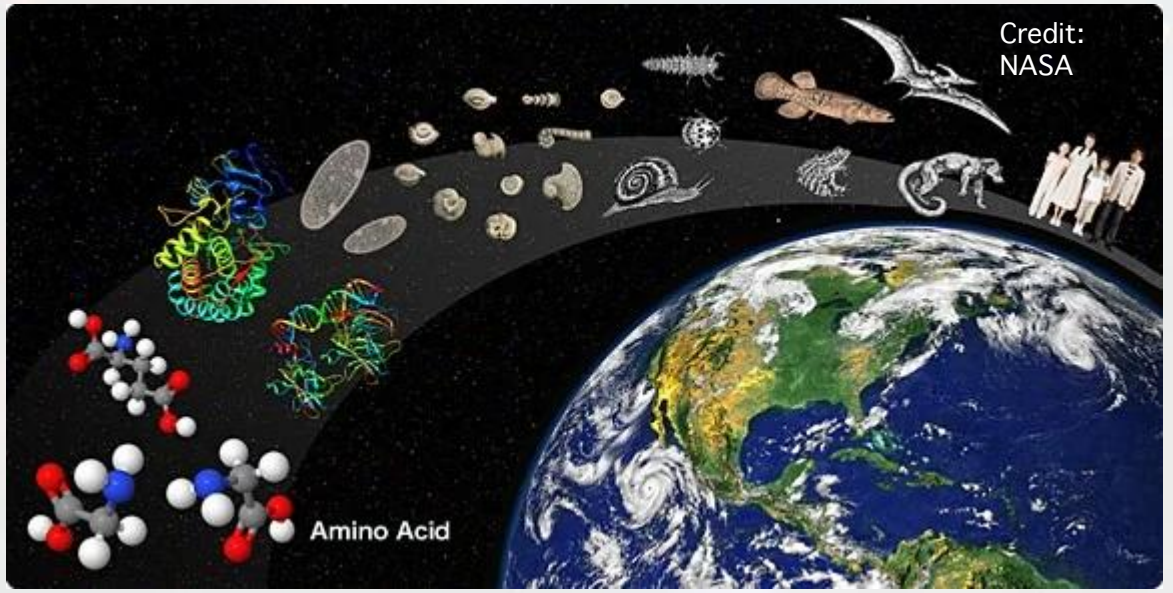
Conclusion & Implications

- Major step in solving the **century-old mystery** of DIBs
- Help understance how DIB carriers play a role in **dust evolution**
- Guide **lab experiments**
- New window for studying **carbon chemistry**
- Understand **Origin of life**

Thanks for listening !



Credit: Bill Saxton, NRAO/AUI/NSF



Back-up Slides

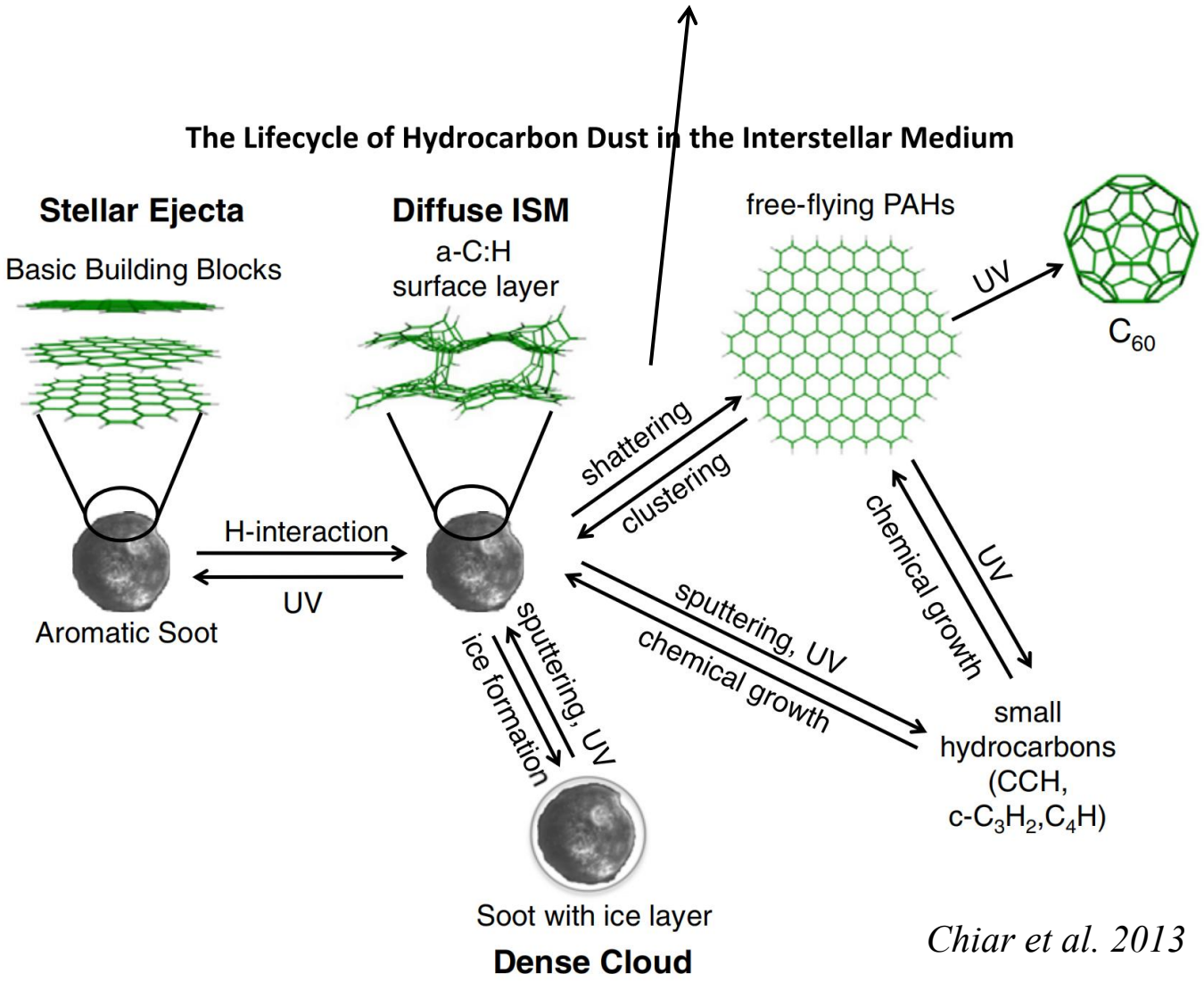
Negative corr

H removed

Aromatic carbon formed/revealed

DIB carriers produced

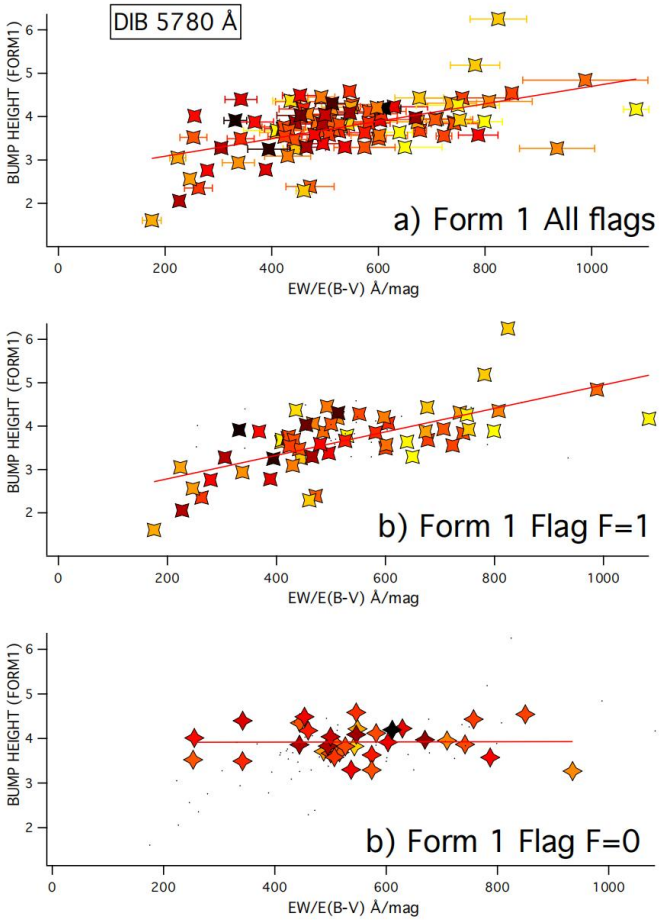
Positive corr



Chiar et al. 2013

DIB vs UV Bump

- Xiang et al. (2017): No obvious correlation
- Lallement et al. (2024): Single-cloud sight lines have stronger correlation
- Our study: Confirm results of Lallement et al. (2024)



Single cloud

Multiple clouds

Lallement et al. (2024)