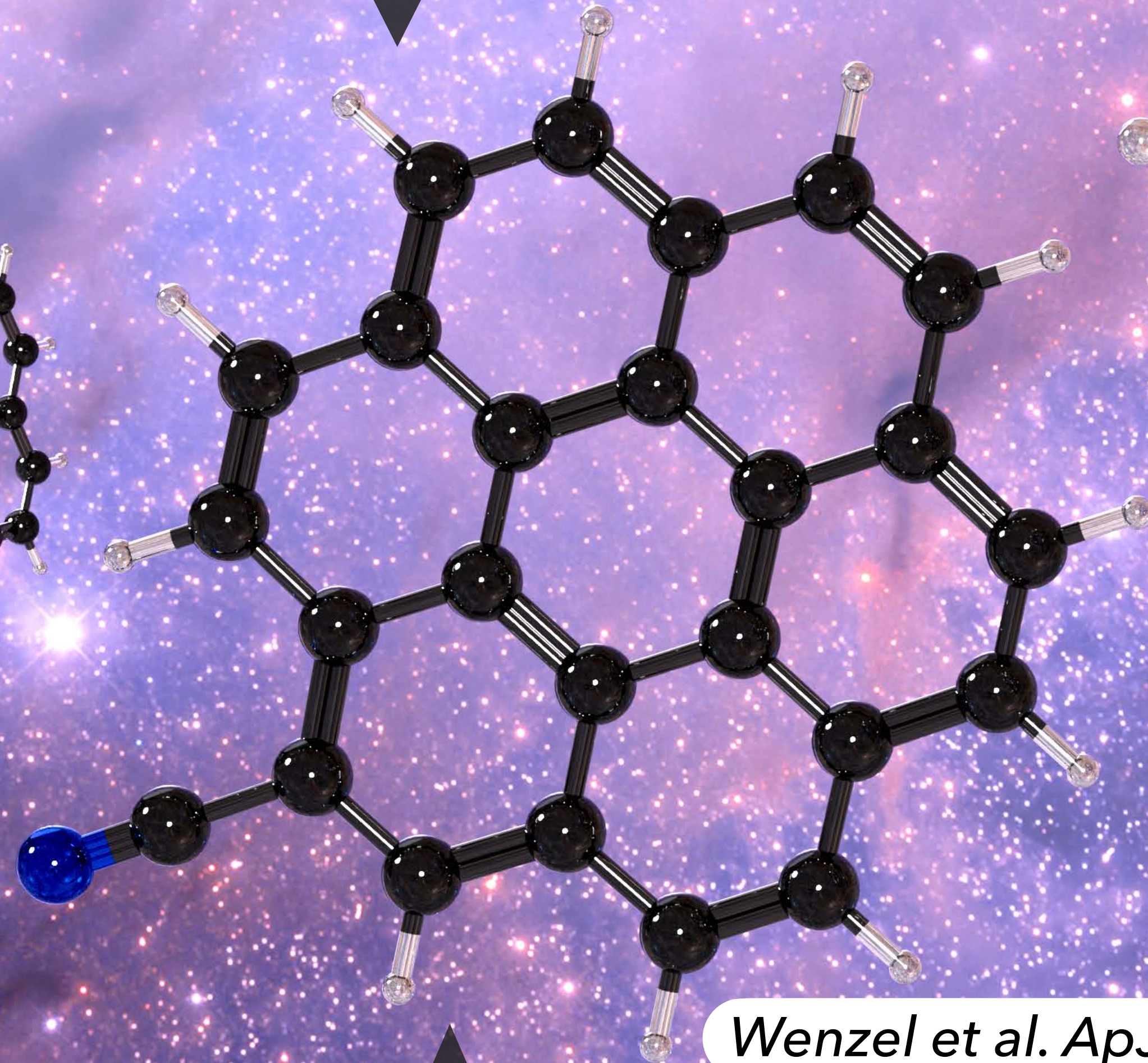


IF YOU LIKE IT PUT MORE RINGS ON IT

DISCOVERY OF INTERSTELLAR CYANOCORONENE

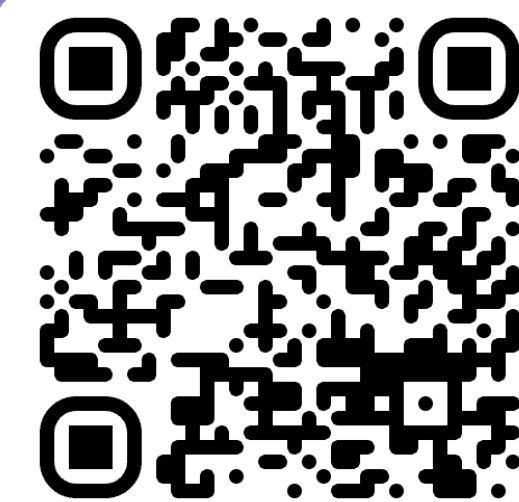


Wenzel et al. ApJL 984, L36, 2025

GABI WENZEL

Massachusetts Institute of Technology
Center for Astrophysics | Harvard & Smithsonian

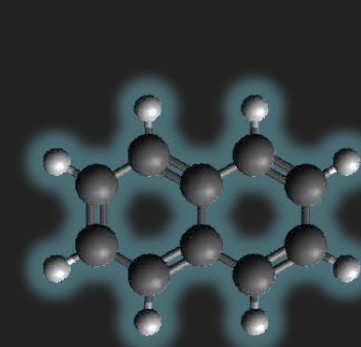
Collaborators: GOTHAM Team including Edwin A. Bergin (UMich), Ilsa R. Cooke (UBC), Michael C. McCarthy (CfA/SAO), Anthony J. Remijan (NRAO), Brett A. McGuire (MIT)



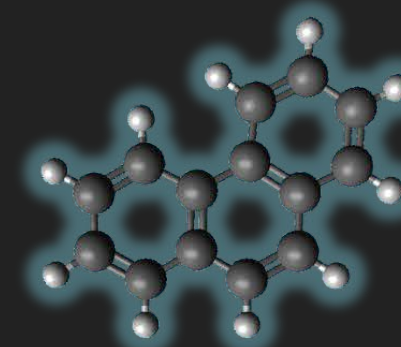
THE ROLE OF POLYCYCLIC AROMATIC HYDROCARBONS



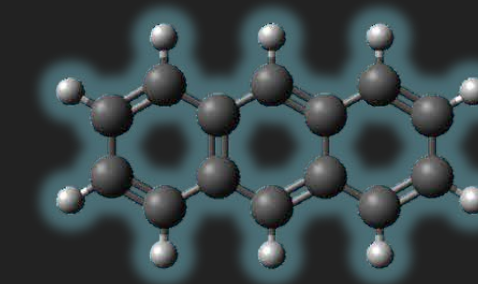
South Jersey, 2024



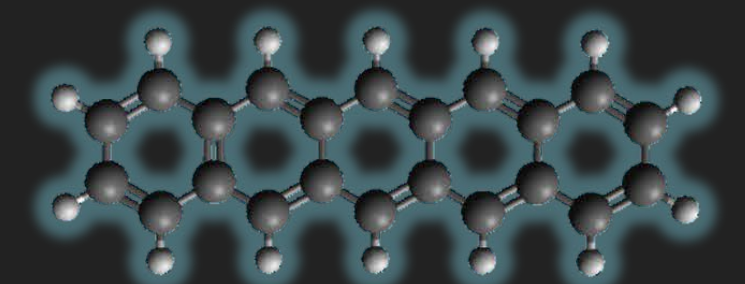
Naphthalene
(C₁₀H₈)



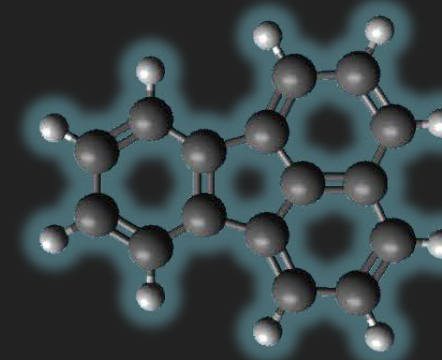
Phenanthrene
(C₁₄H₁₀)



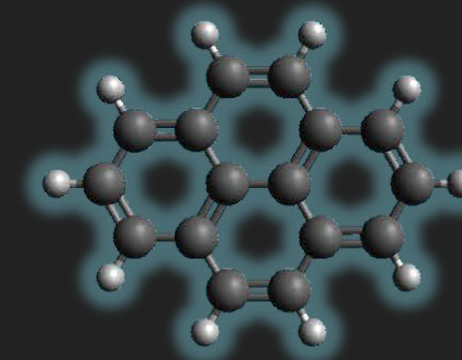
Anthracene
(C₁₄H₁₀)



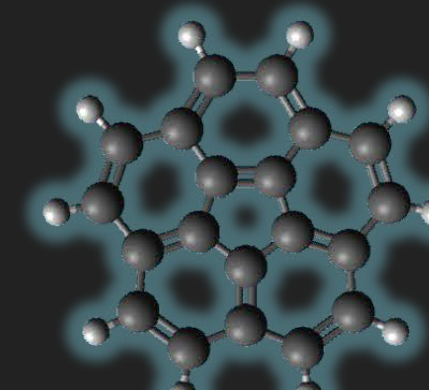
Pentacene
(C₂₂H₁₄)



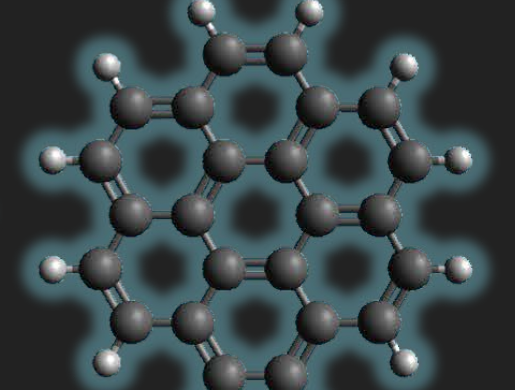
Fluoranthene
(C₁₆H₁₀)



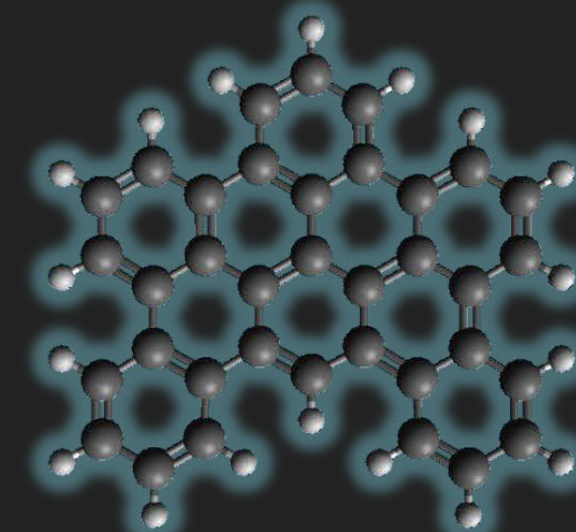
Pyrene
(C₁₆H₁₀)



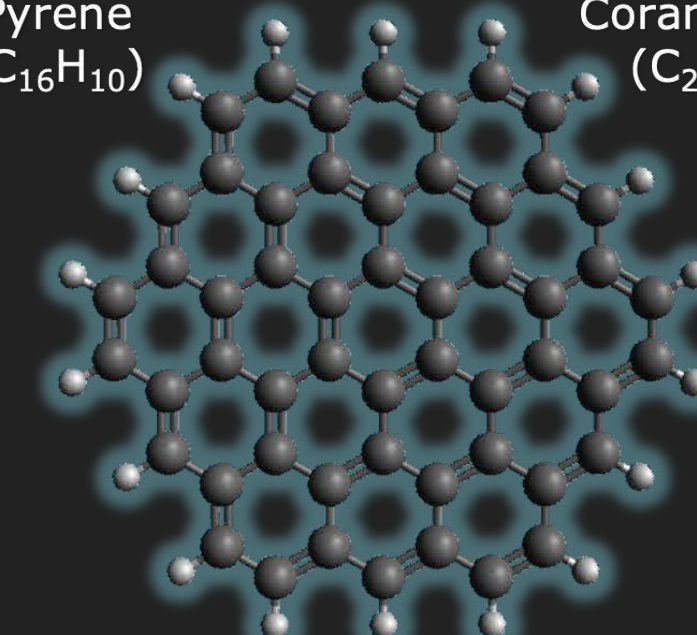
Corannulene
(C₂₀H₁₀)



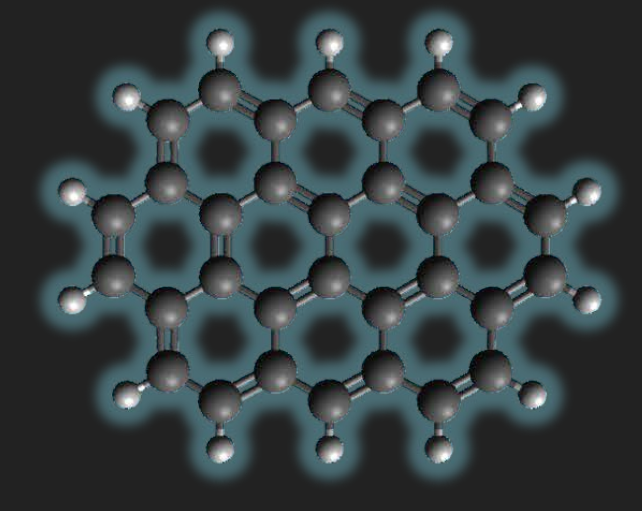
Coronene
(C₂₄H₁₂)



Dibenzophenanthropentaphene
(C₃₆H₁₈)



Circumcoronene
(C₅₄H₁₈)



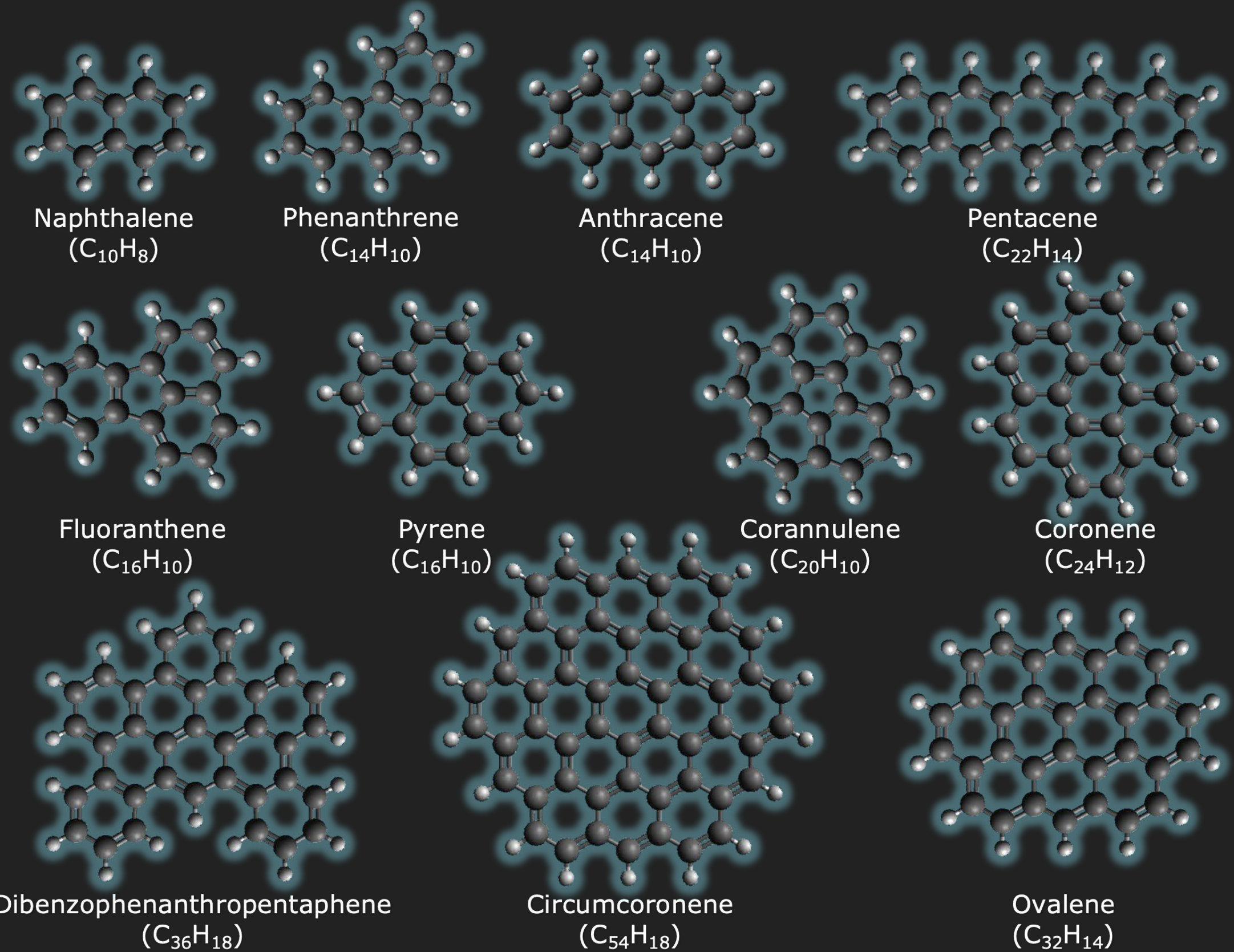
Ovalene
(C₃₂H₁₄)

THE ROLE OF POLYCYCLIC AROMATIC HYDROCARBONS

- **On Earth**
 - Pollutants
 - Wildfires, smoke, car exhaust - Combustion processes
 - Toxic: carcinogenic, mutagenic, teratogenic



South Jersey, 2024



THE ROLE OF POLYCYCLIC AROMATIC HYDROCARBONS

- **On Earth**

- Pollutants

- Wildfires, smoke, car exhaust -
Combustion processes

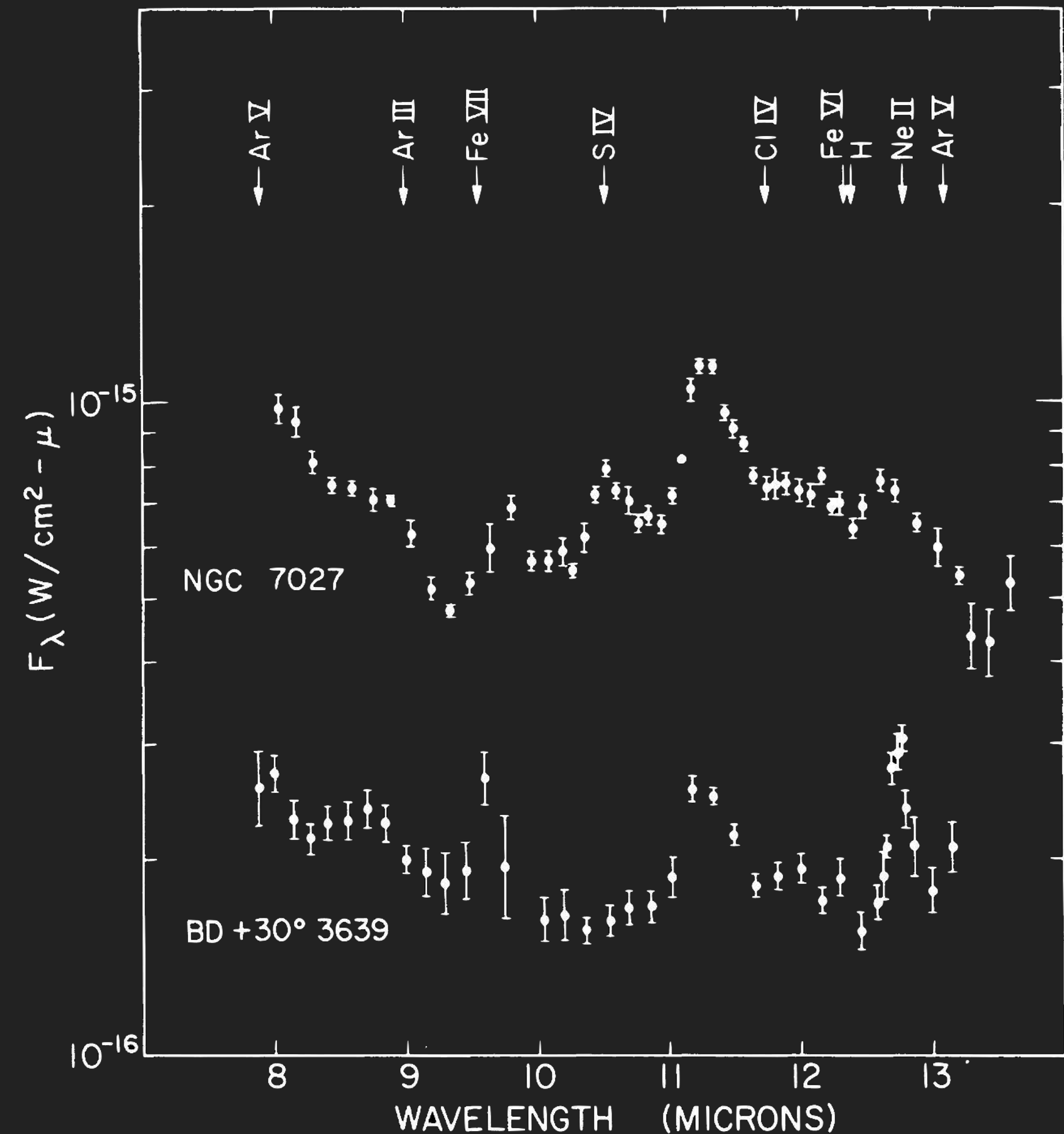
- Toxic: carcinogenic, mutagenic, teratogenic

- **In space**

- Part of interstellar dust

- Catalysts (e.g. for molecular hydrogen formation), cause neutral gas heating, among other things

- Presence inferred from infrared observations toward photon-dominated regions



THE ROLE OF POLYCYCLIC AROMATIC HYDROCARBONS

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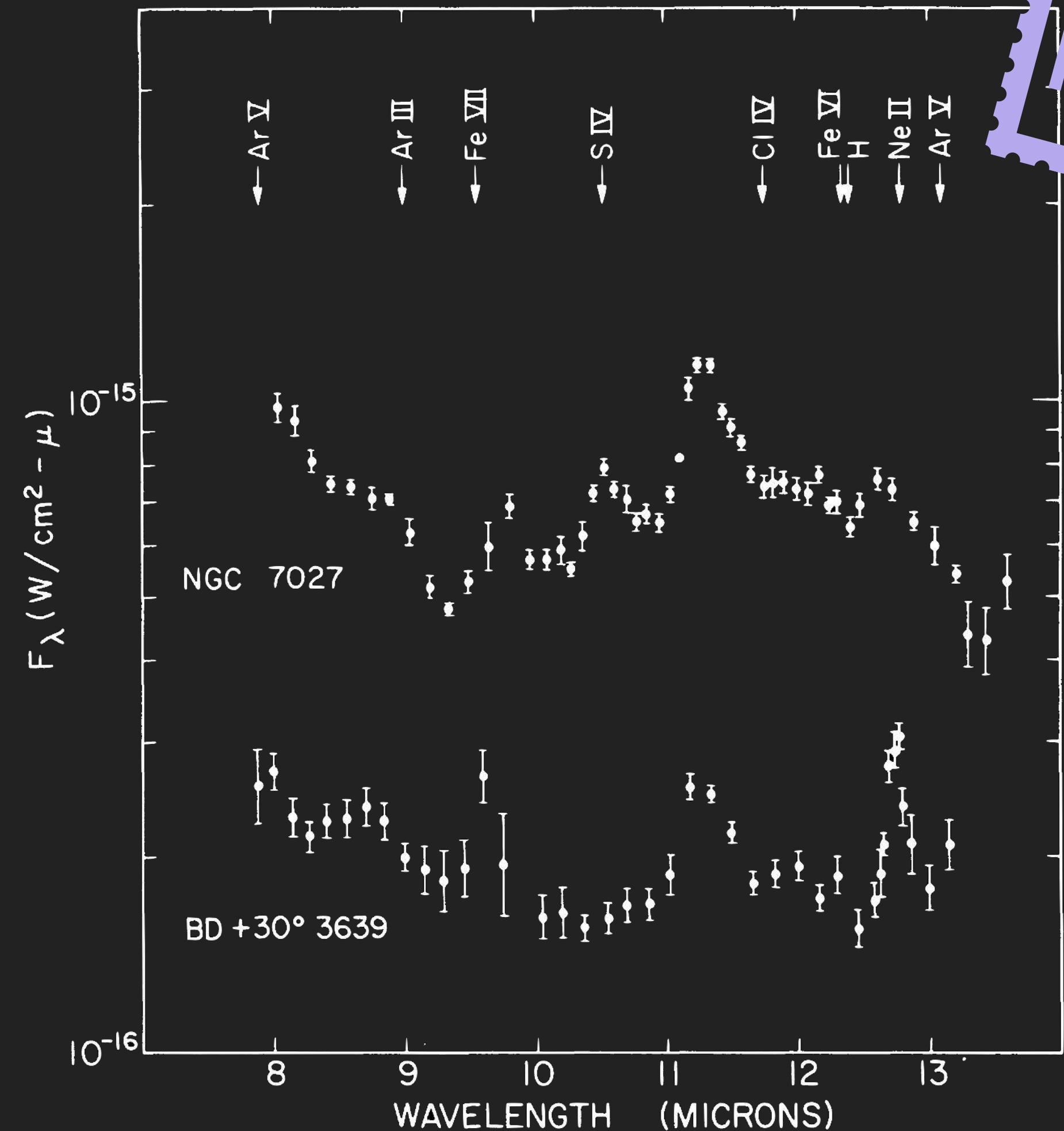
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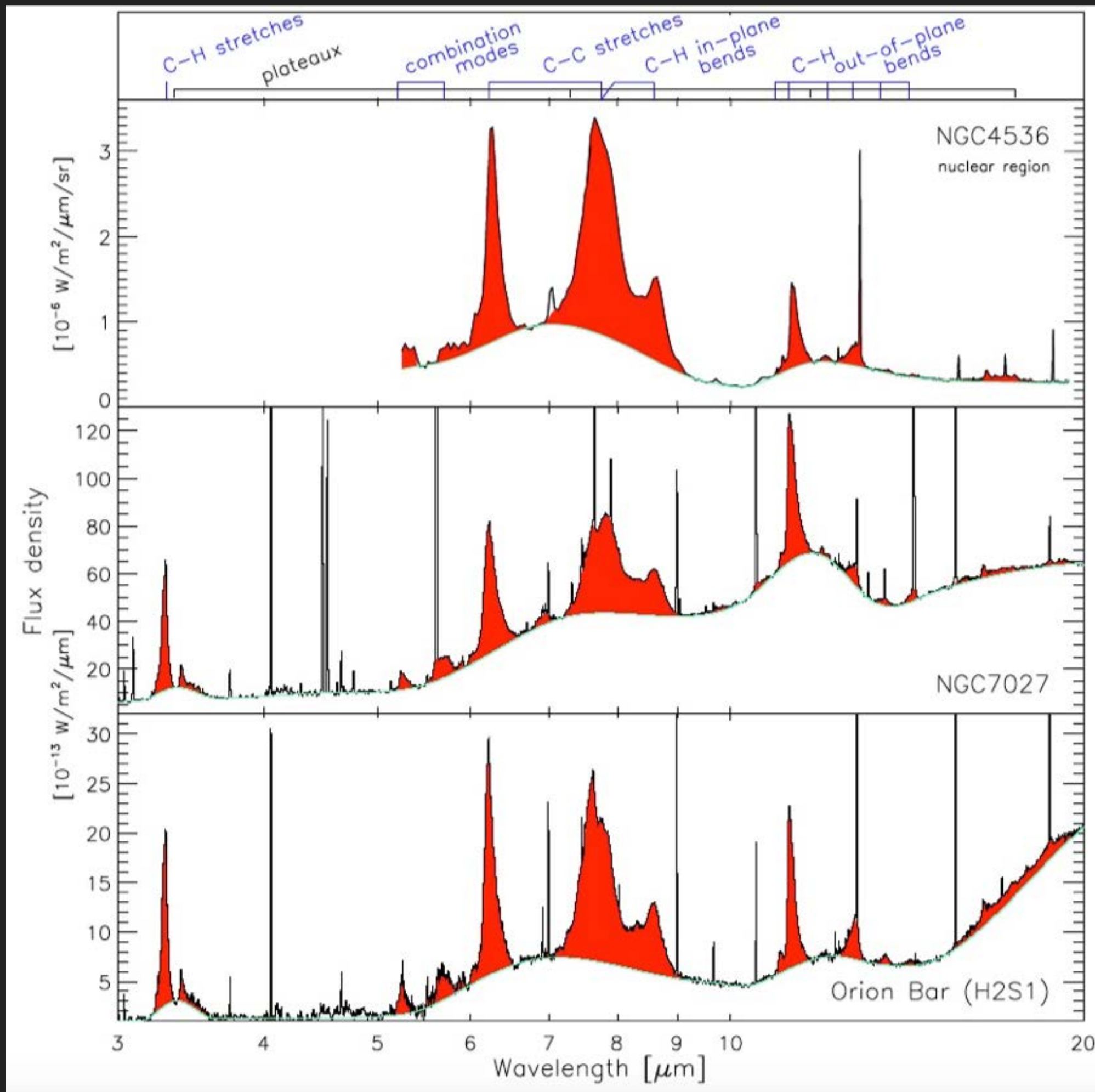


AROMATIC INFRARED BANDS (AIBs)

Emission features
3.3, 6.2, 7.7, 8.6, 11.2, 12.7 μm



Vibrational modes
of PAHs



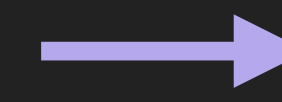
Orion Bar

JWST © NASA / ESA / CSA
PDRs4All team
S. Fuenmayer

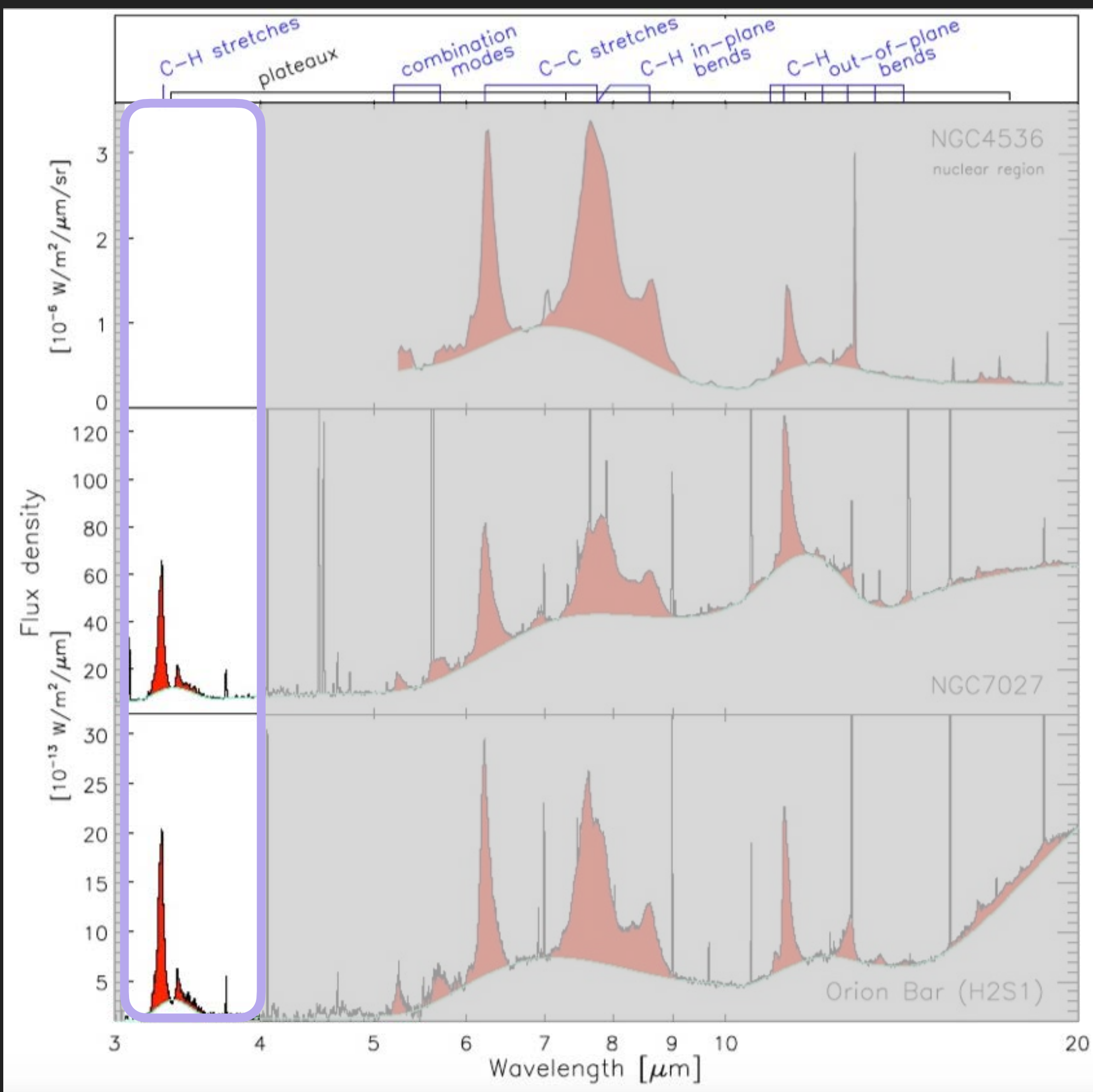
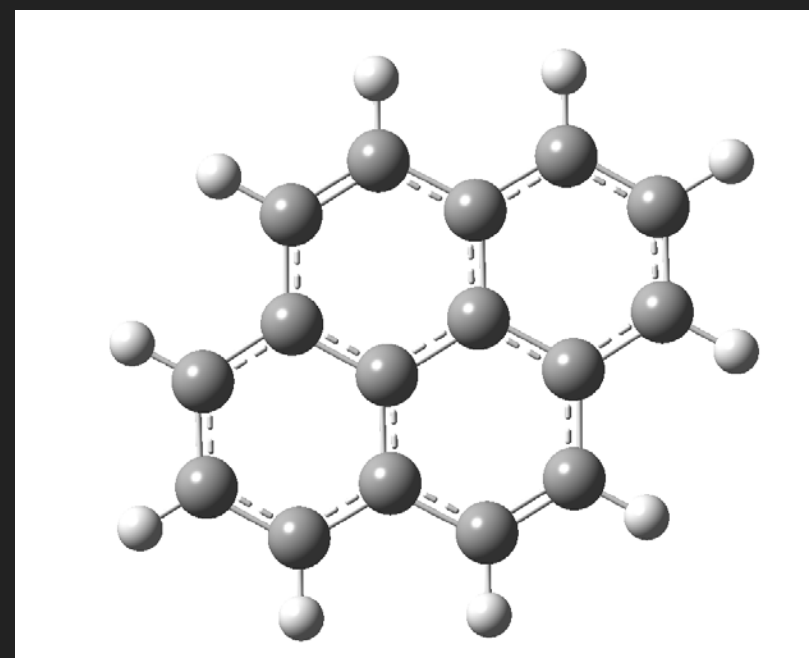
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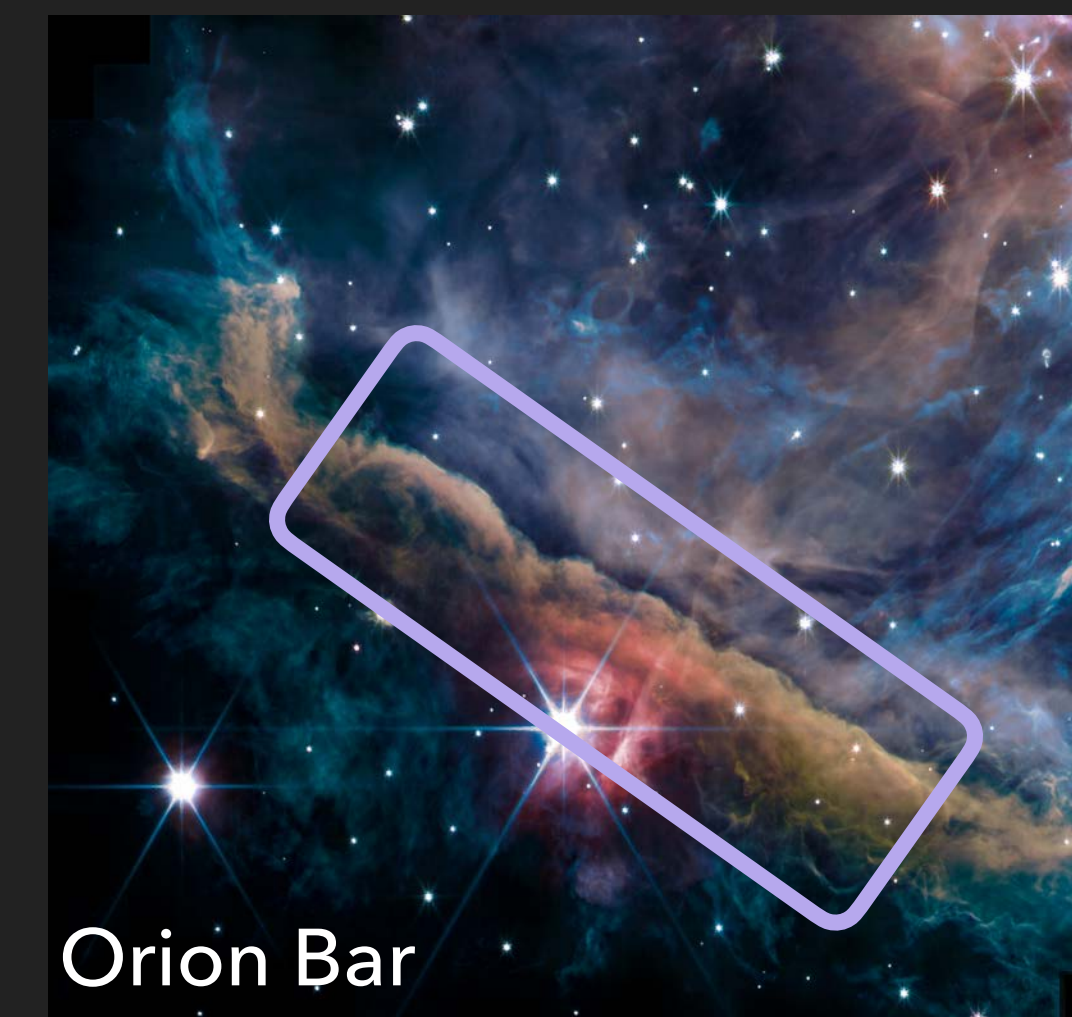
Vibrational modes
of PAHs



C-H STRETCHES



© Shubhadip Chakraborty



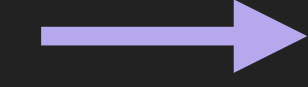
Orion Bar

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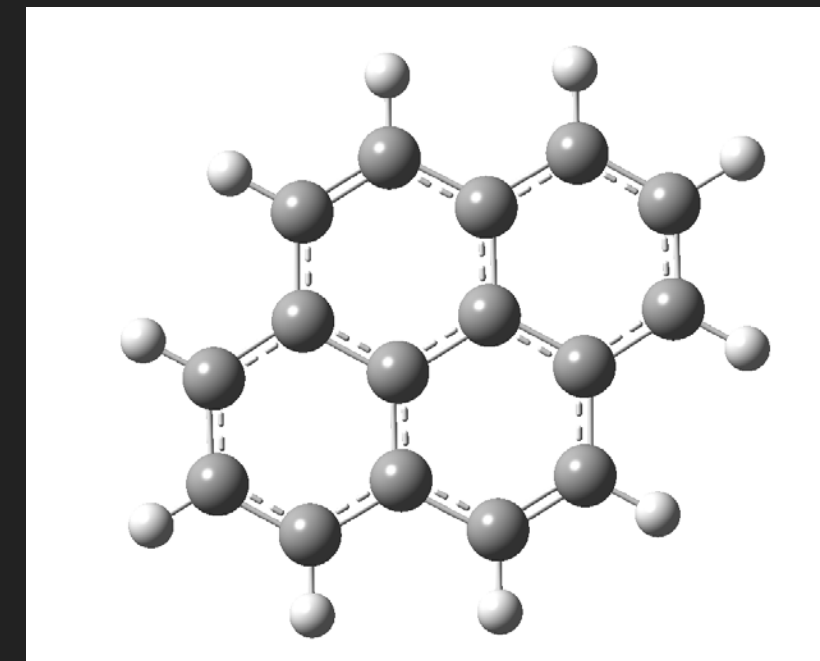
AROMATIC INFRARED BANDS (AIBs)

Emission features
3.3, 6.2, 7.7, 8.6, 11.2, 12.7 μm

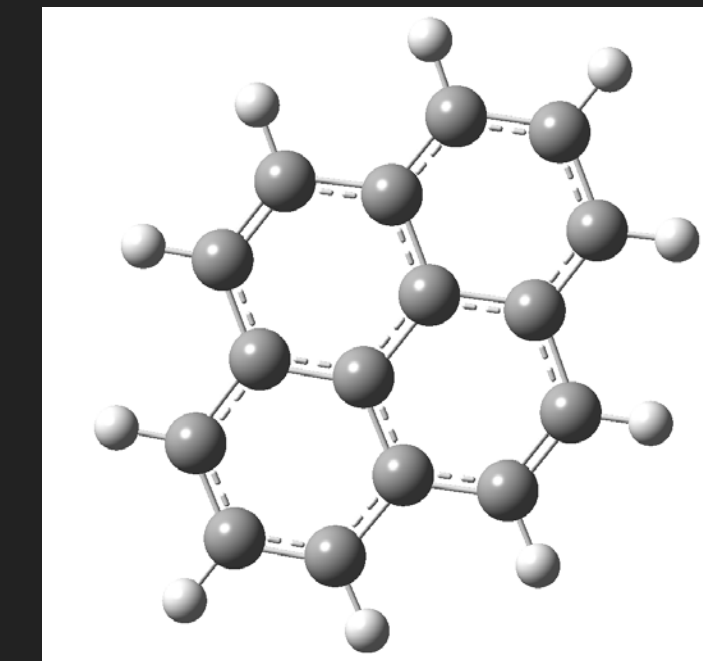
Vibrational modes
of PAHs



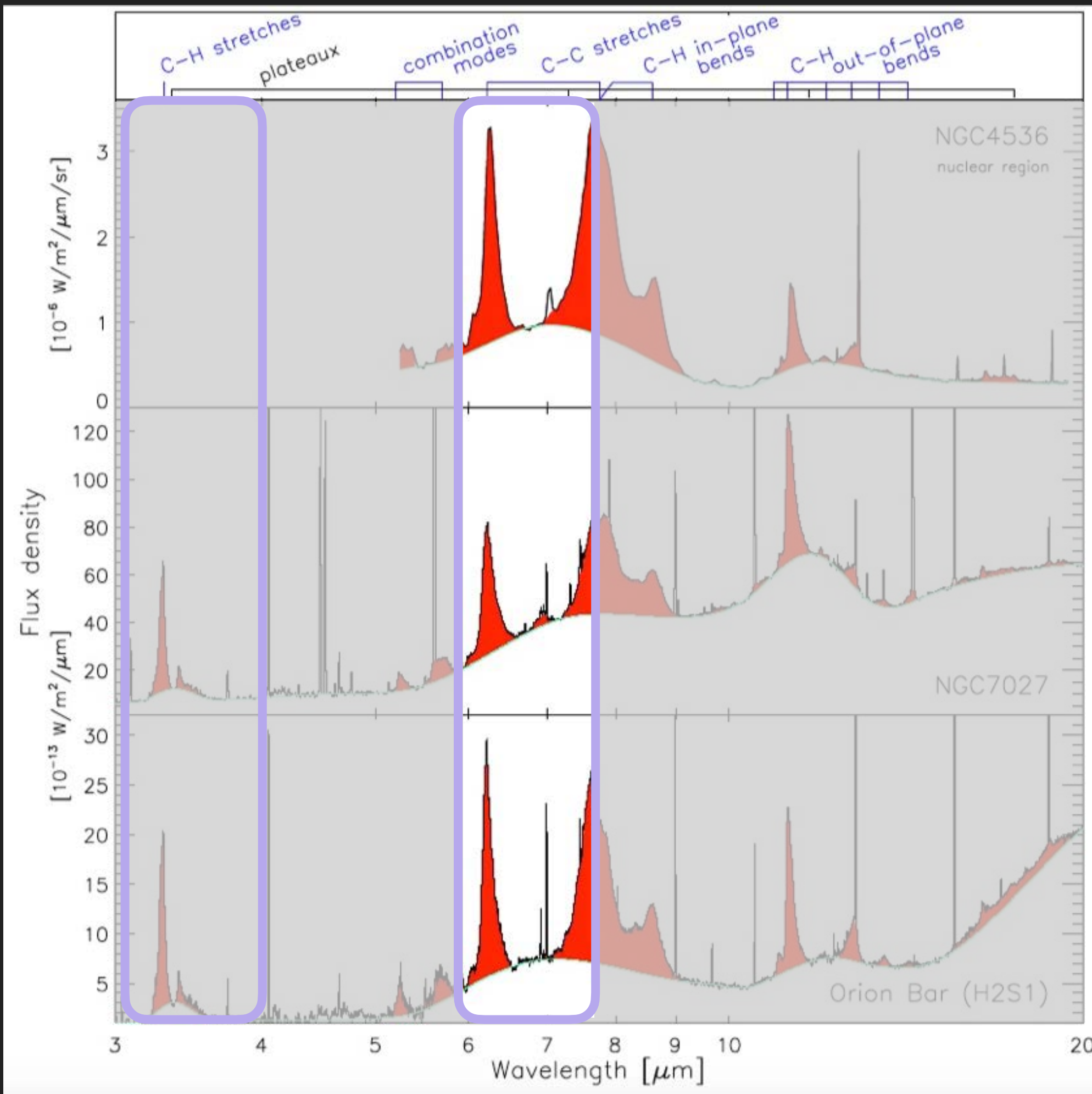
C-H STRETCHES



C-C STRETCHES



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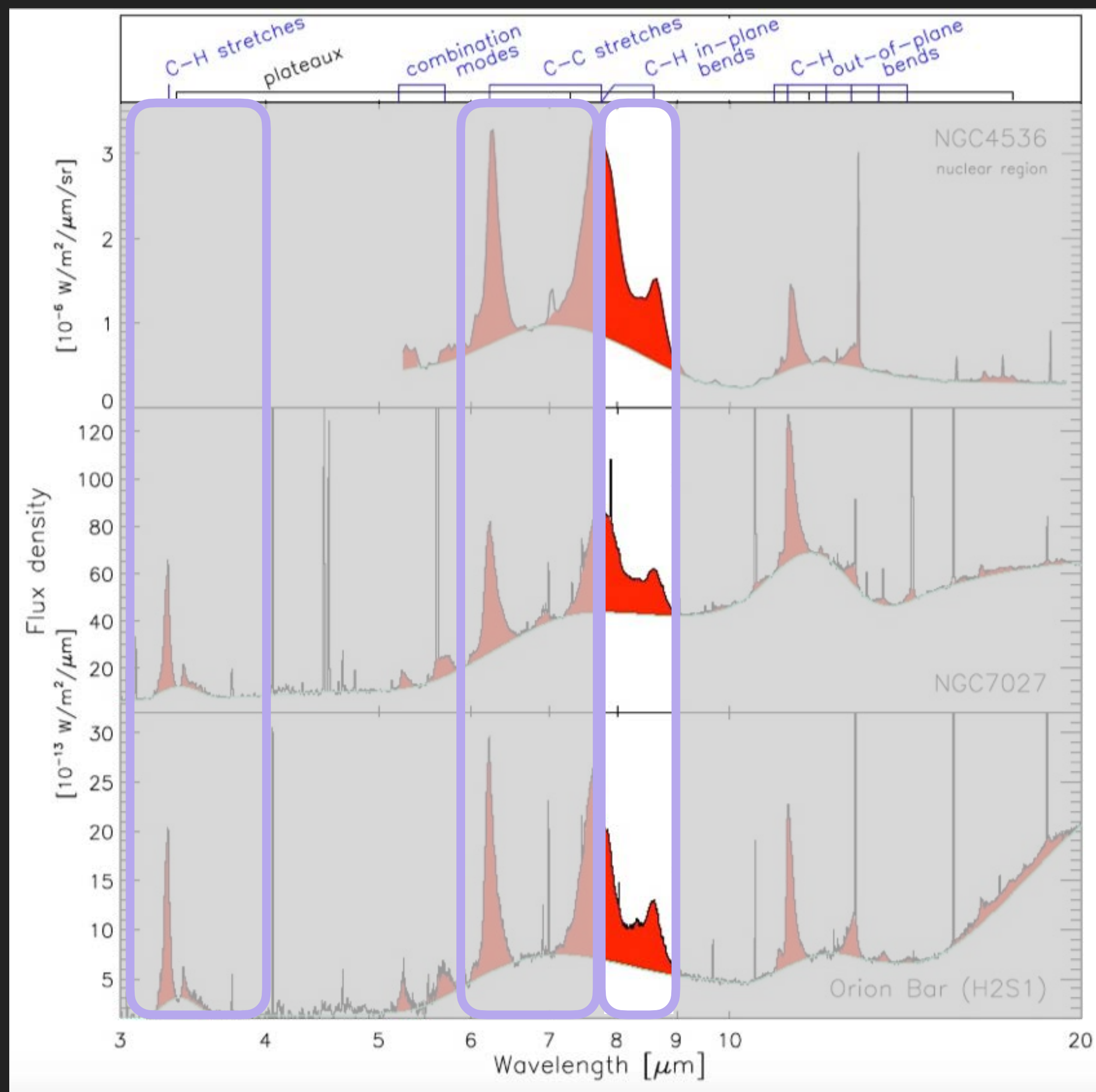
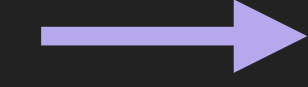
Orion Bar

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S. Fuenmayer

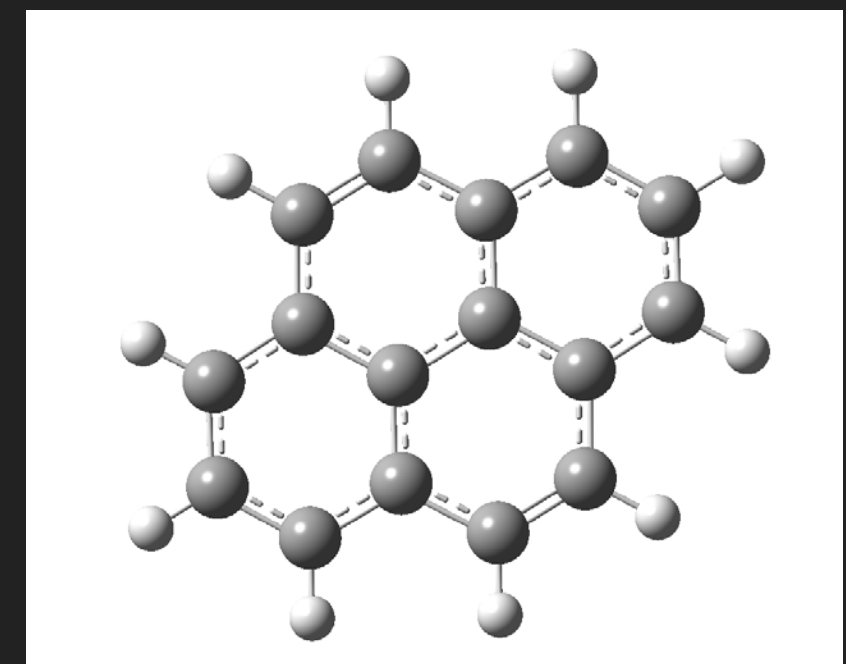
AROMATIC INFRARED BANDS (AIBs)

Emission features
3.3, 6.2, 7.7, 8.6, 11.2, 12.7 μm

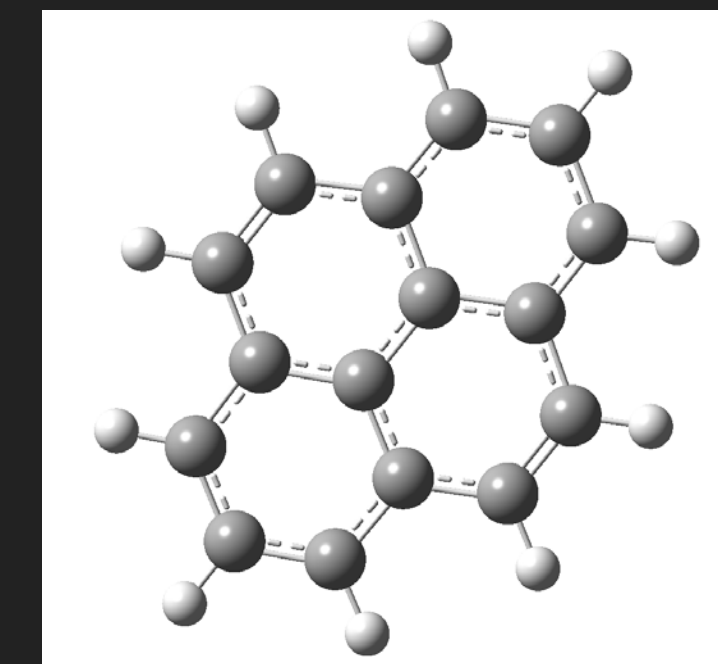
Vibrational modes
of PAHs



C-H STRETCHES

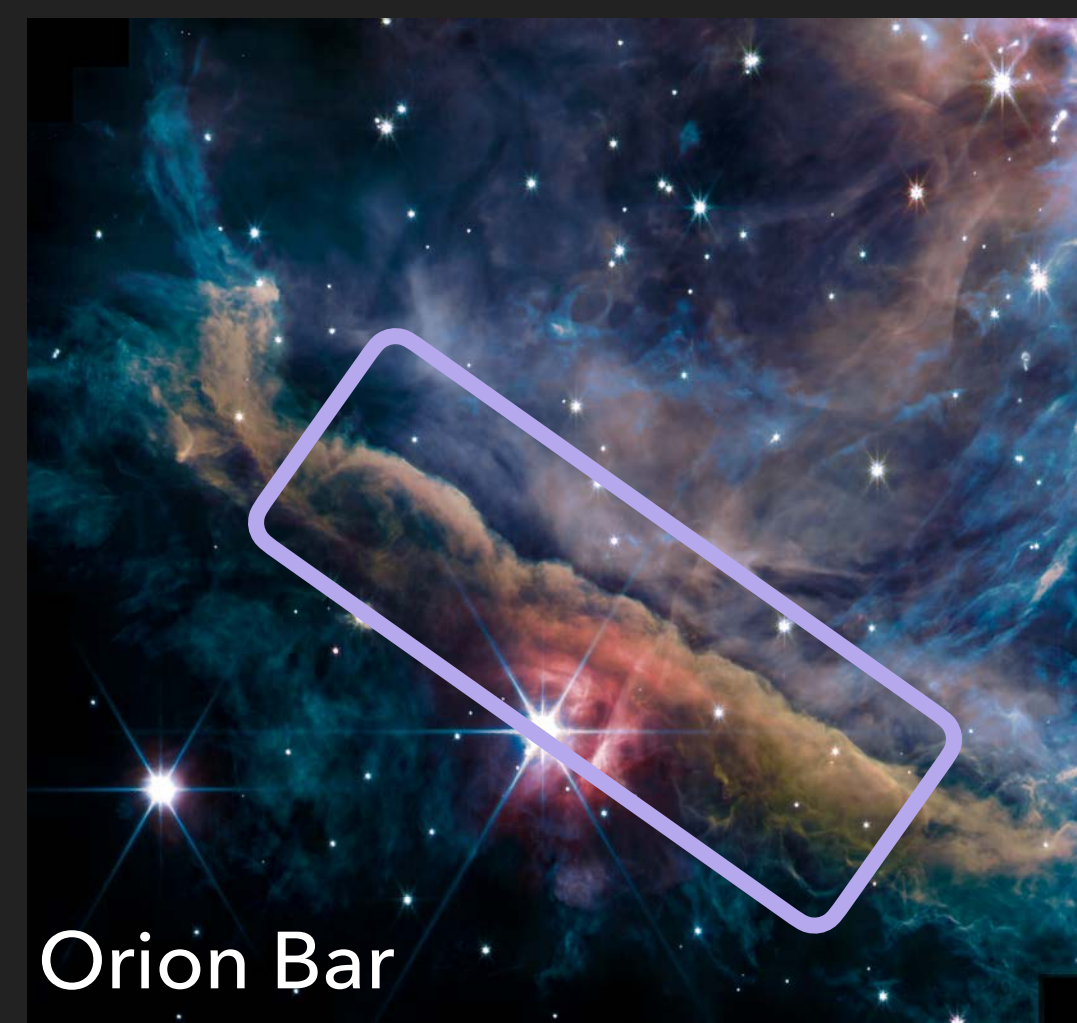
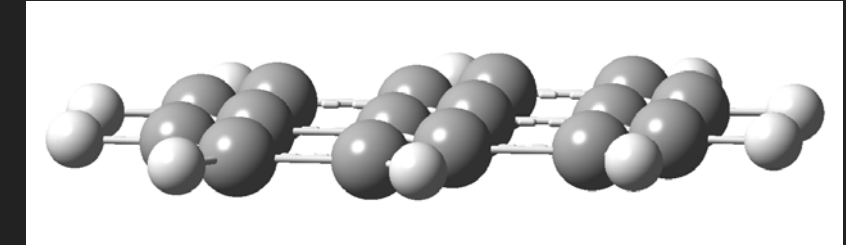
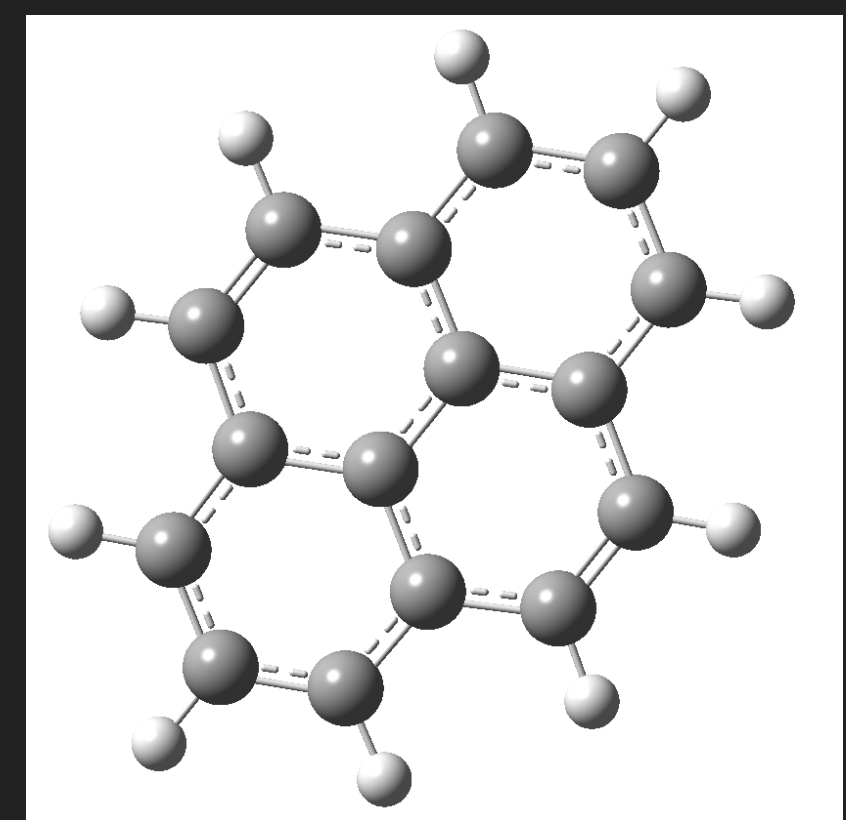


C-C STRETCHES



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C-H IN-PLANE BENDS



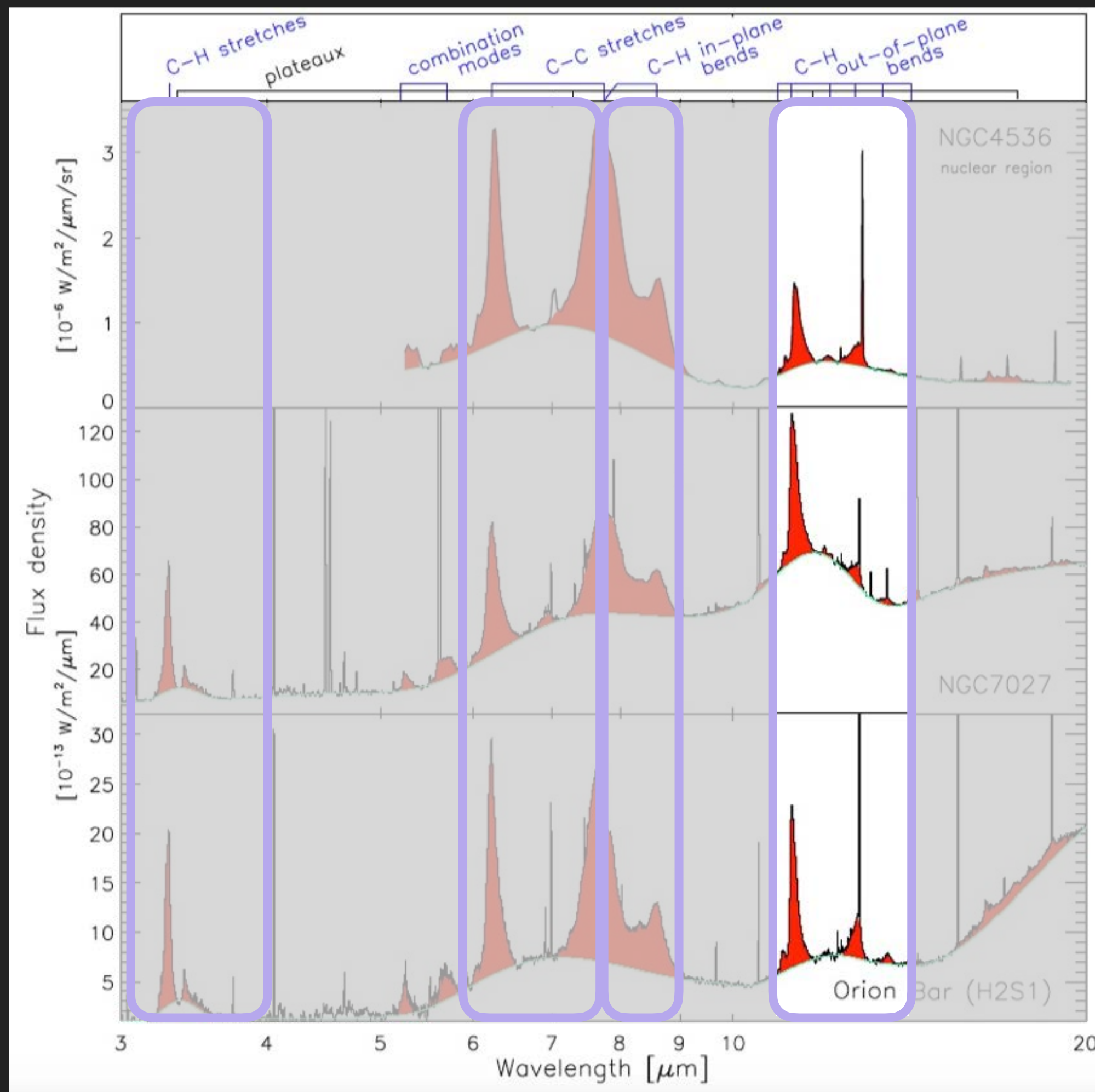
Orion Bar

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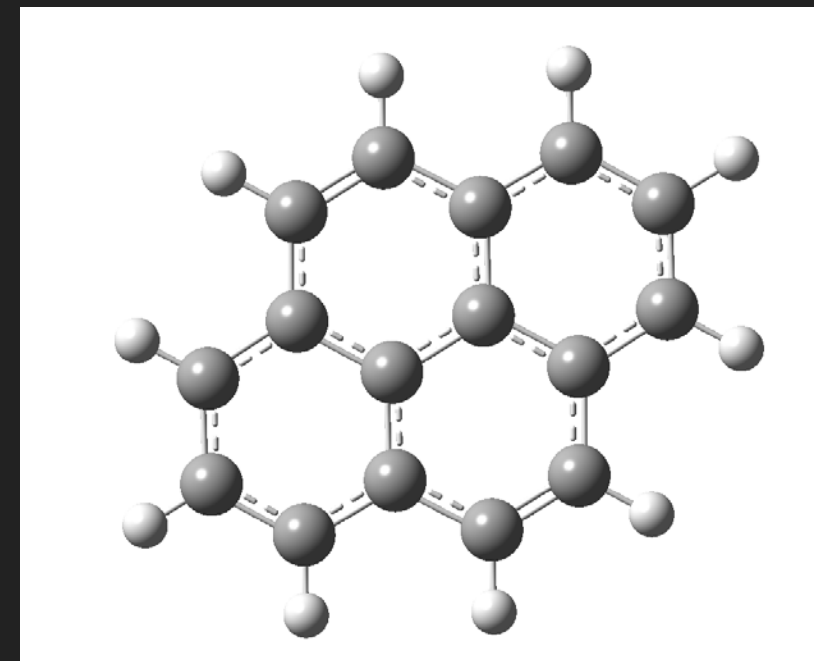
AROMATIC INFRARED BANDS (AIBs)

Emission features
3.3, 6.2, 7.7, 8.6, 11.2, 12.7 μm

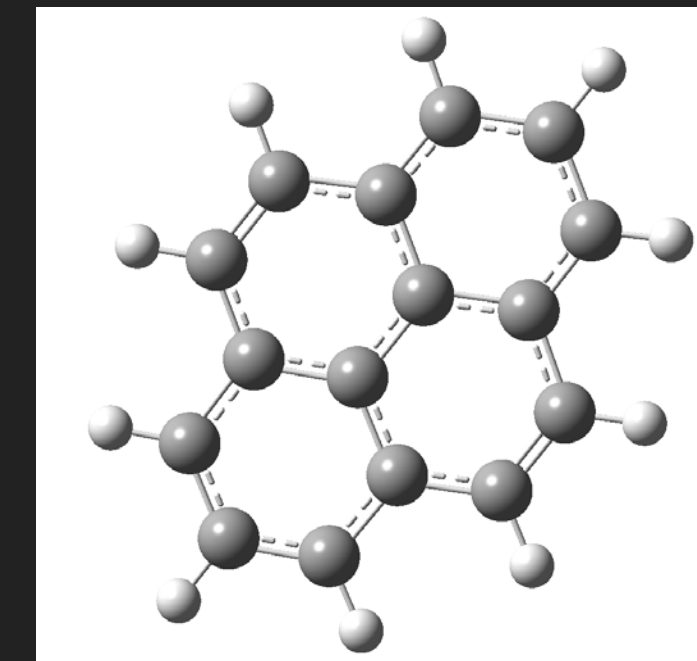
Vibrational modes
of PAHs



C-H STRETCHES

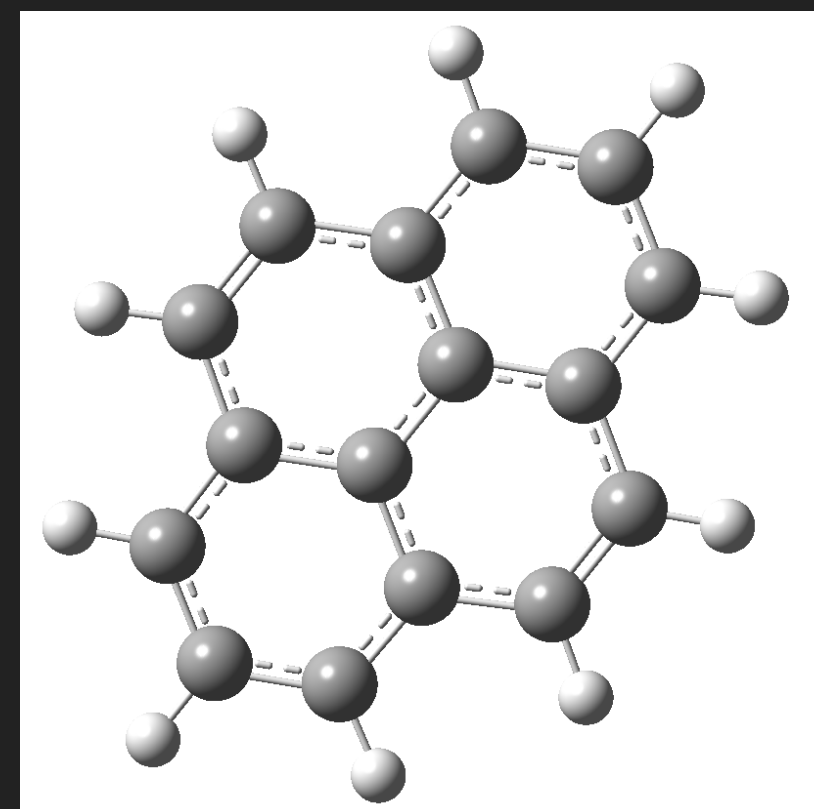


C-C STRETCHES

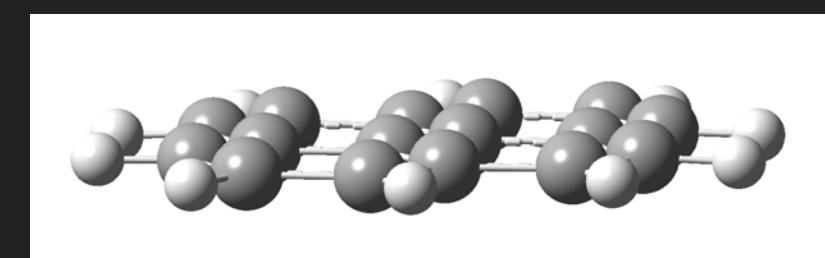
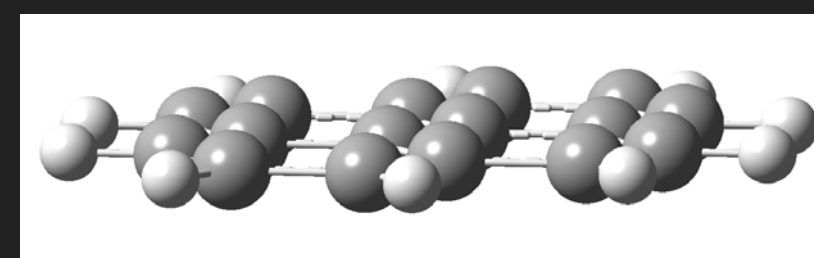
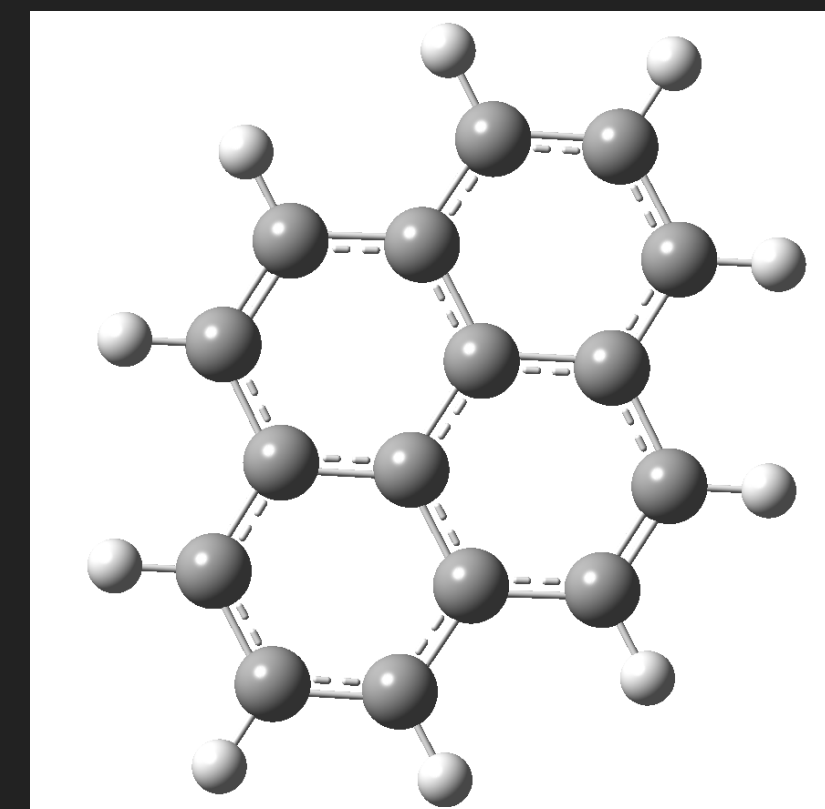


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C-H IN-PLANE BENDS



C-H OUT-OF-PLANE BENDS



Orion Bar

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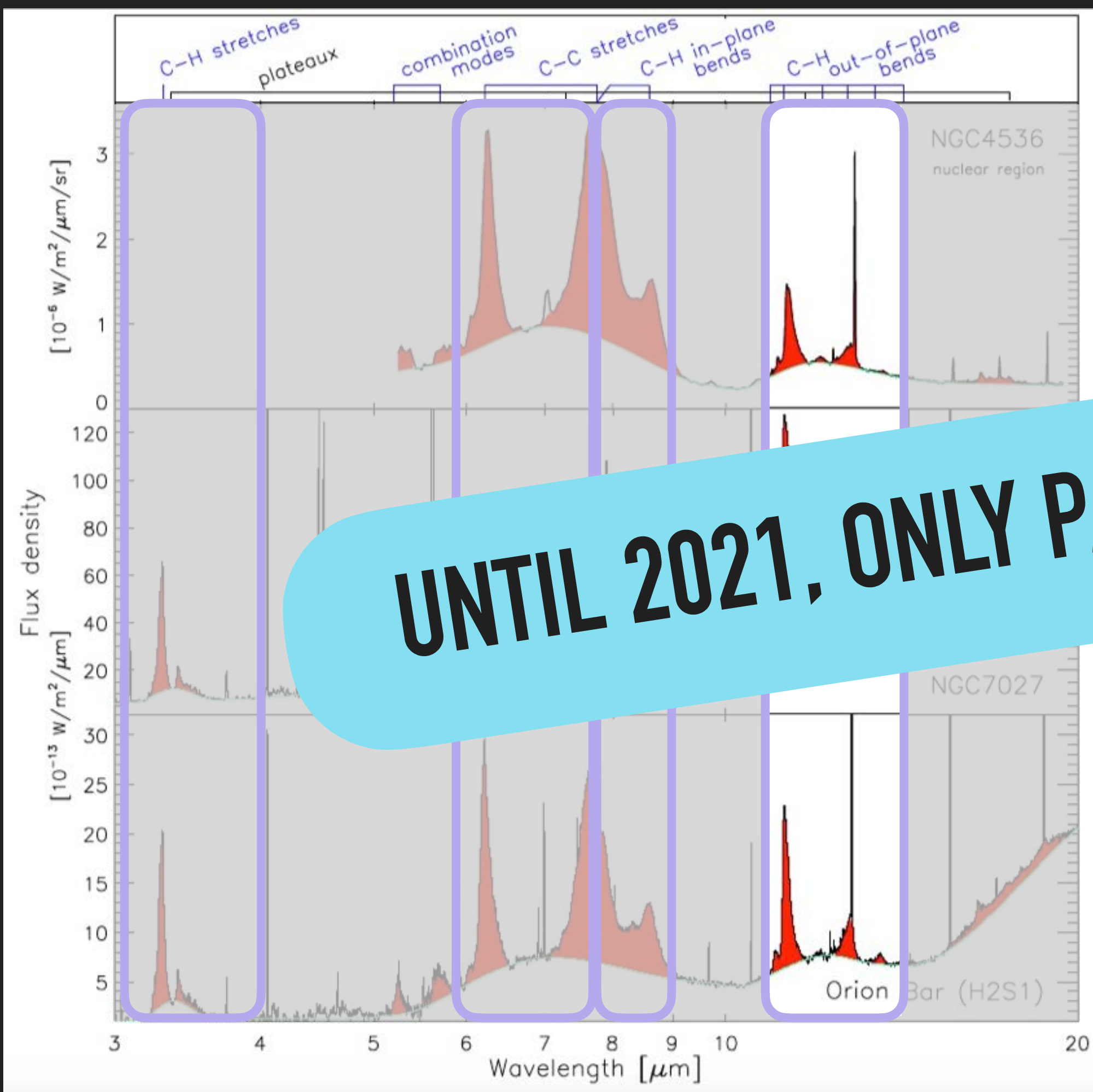
AROMATIC INFRARED BANDS (AIBs)

Emission features

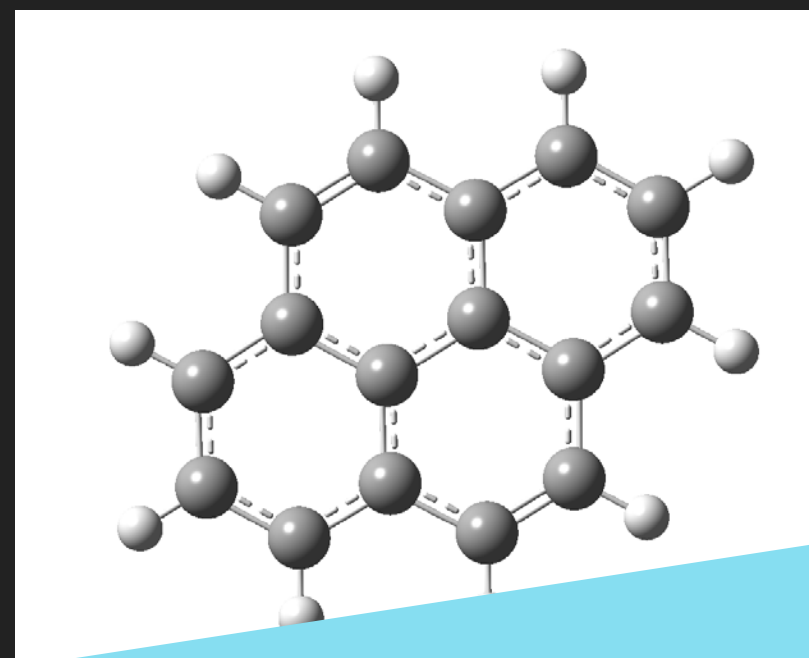
3.3, 6.2, 7.7, 8.6, 11.2, 12.7 μm

Vibrational modes

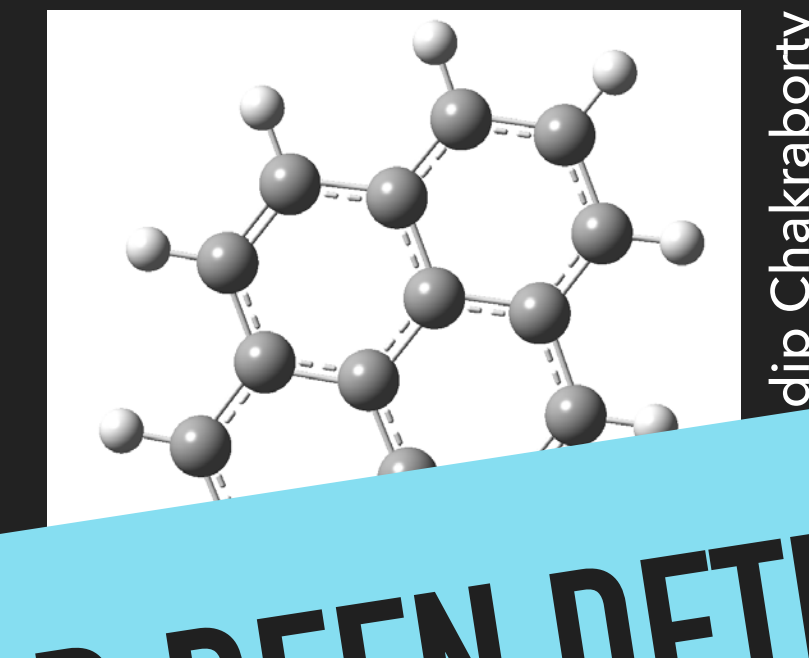
of PAHs



C-H STRETCHES

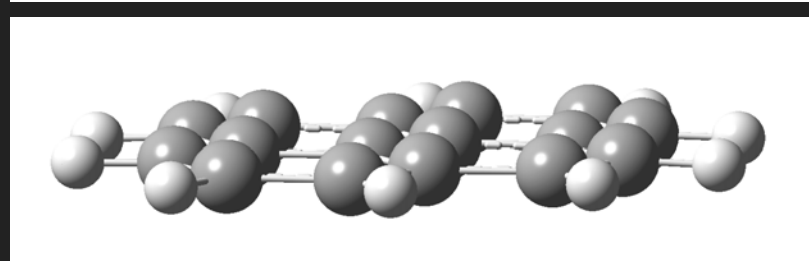
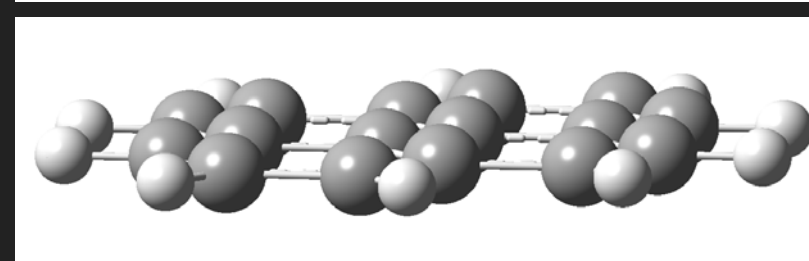
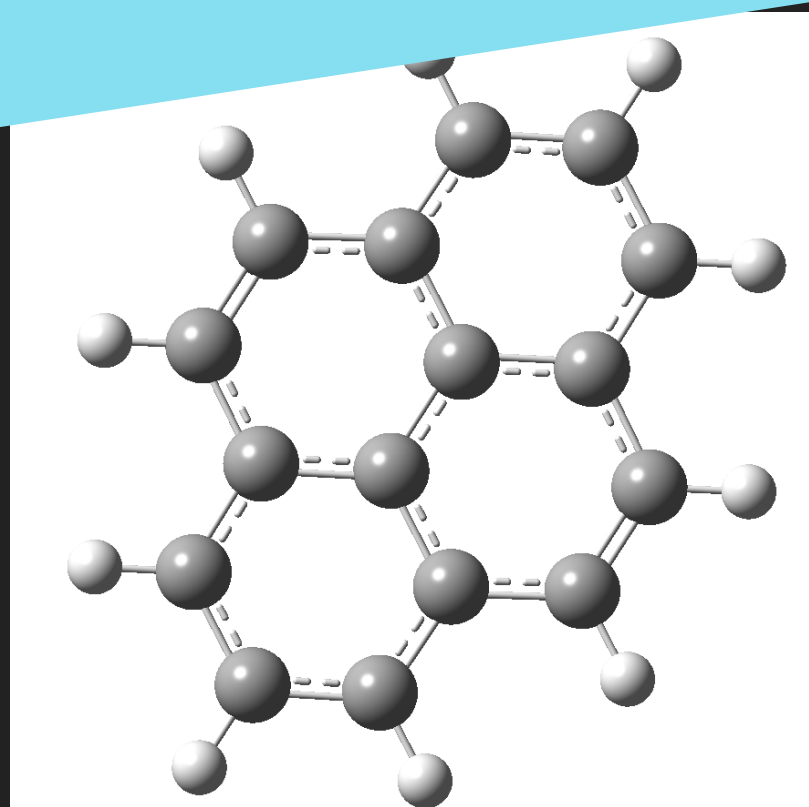
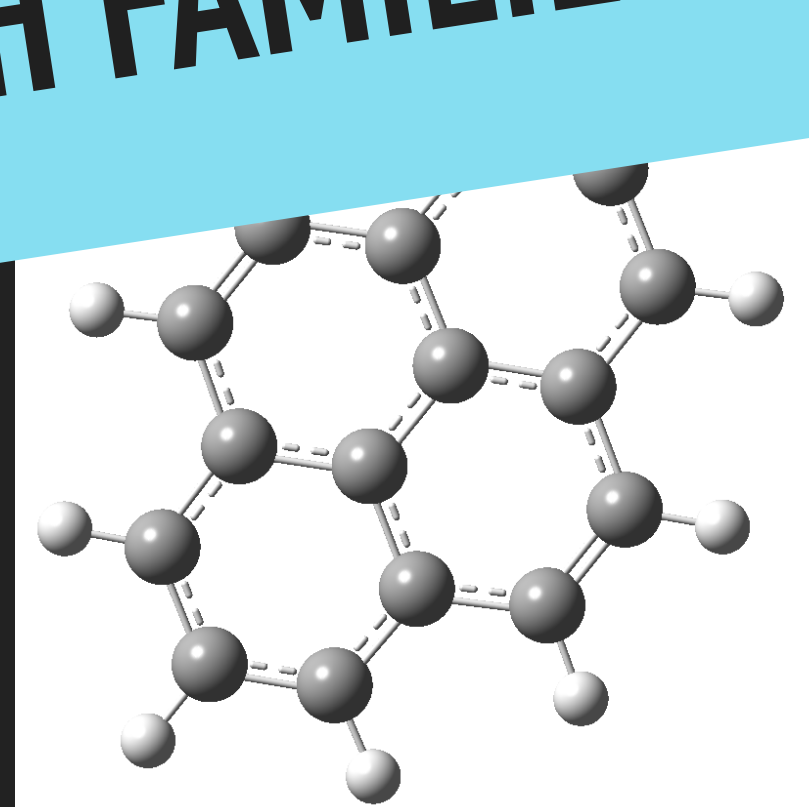


C-C STRETCHES



dip Chakraborty

UNTIL 2021, ONLY PAH FAMILIES HAD BEEN DETECTED



Orion Bar

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AROMATIC CHEMISTRY IN A DARK MOLECULAR CLOUD

AROMATIC CHEMISTRY IN A DARK MOLECULAR CLOUD



Taurus Molecular Cloud
450 ly, 5-10 K

AROMATIC CHEMISTRY IN A DARK MOLECULAR CLOUD



Taurus Molecular Cloud
450 ly, 5-10 K



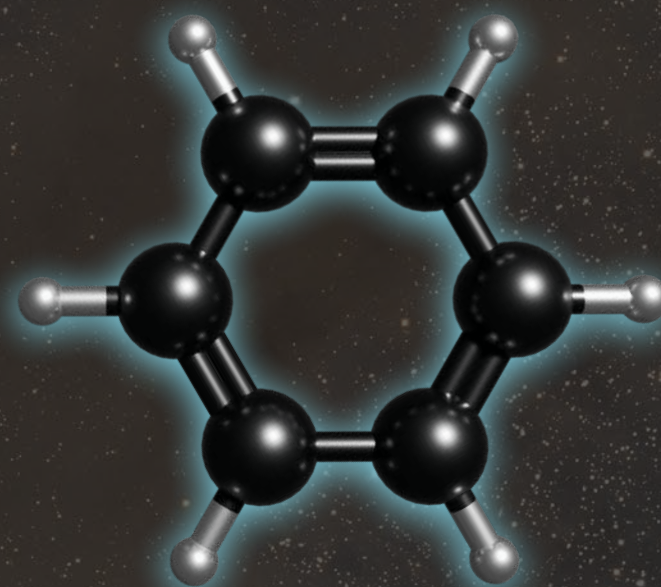
100 m Green Bank Telescope

GOTHAM

AROMATIC CHEMISTRY IN A DARK MOLECULAR CLOUD



Taurus Molecular Cloud
450 ly, 5-10 K



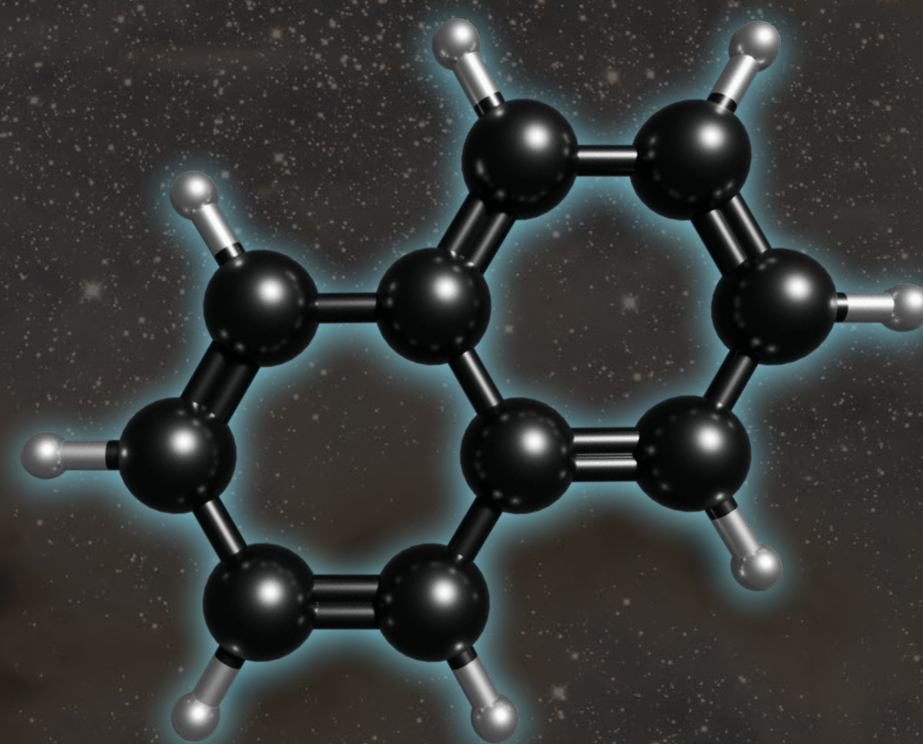
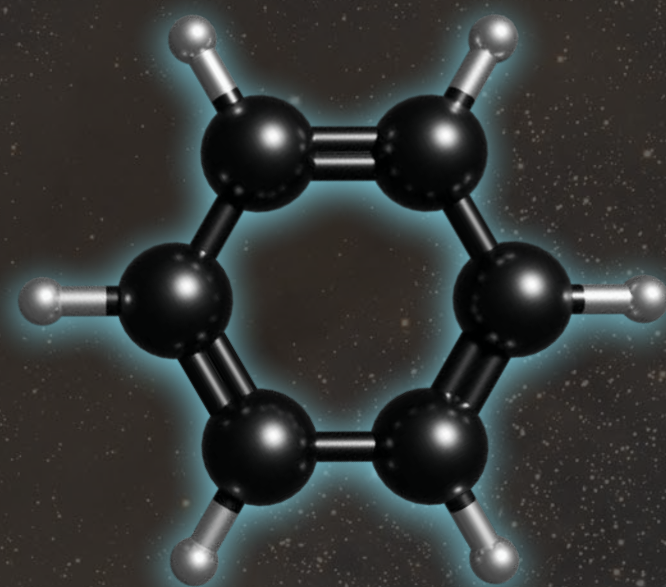
GOTHAM

100 m Green Bank Telescope

AROMATIC CHEMISTRY IN A DARK MOLECULAR CLOUD



Taurus Molecular Cloud
450 ly, 5-10 K



GO THAM

100 m Green Bank Telescope

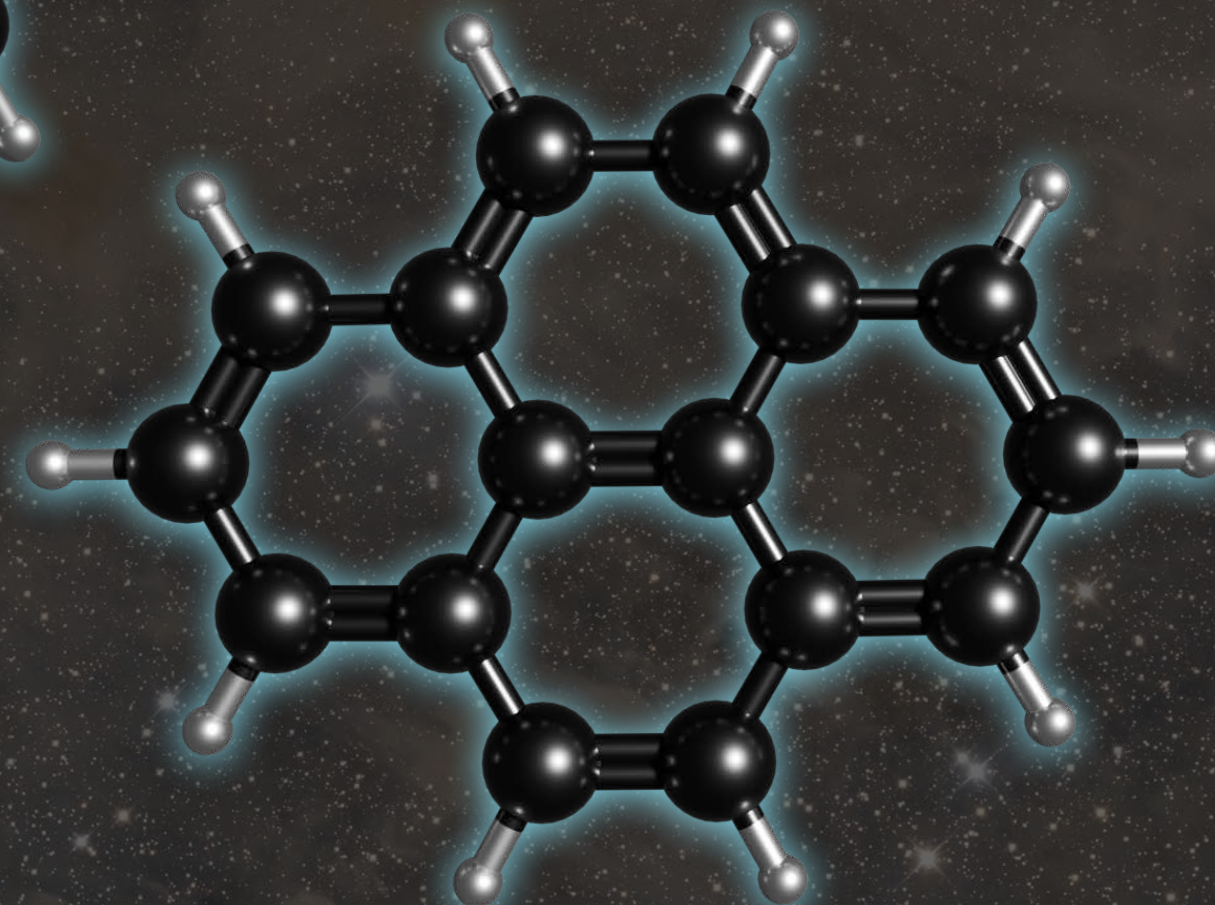
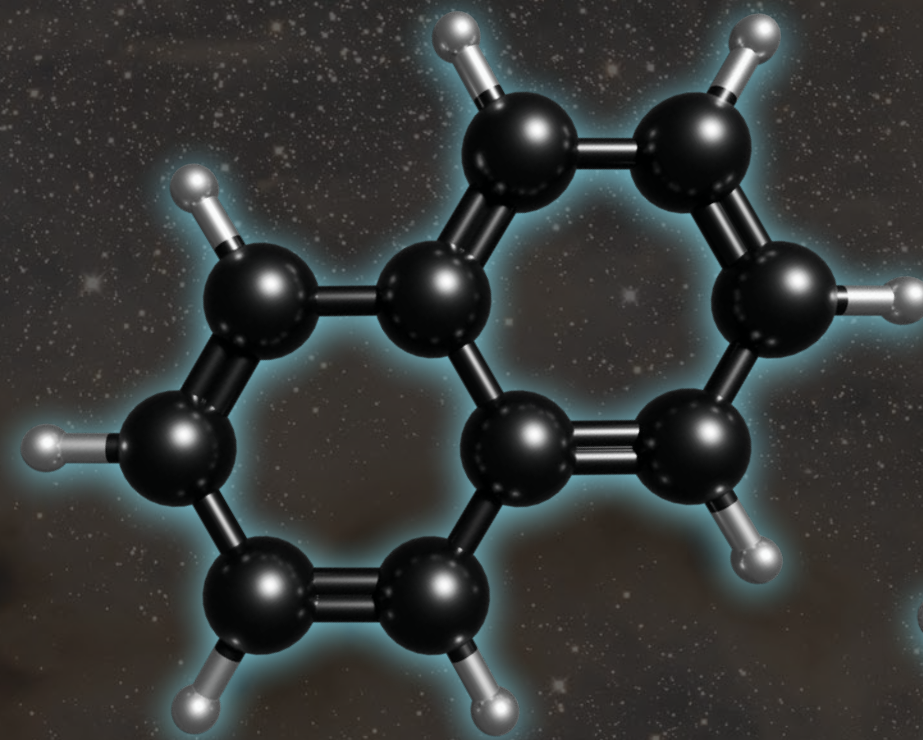
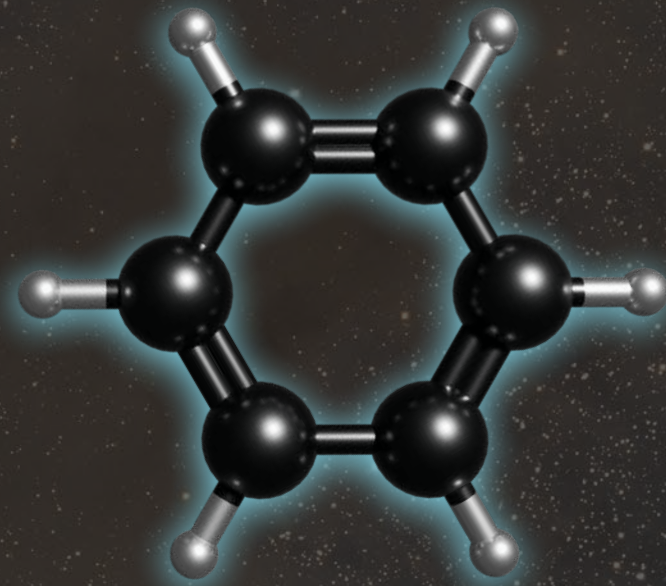
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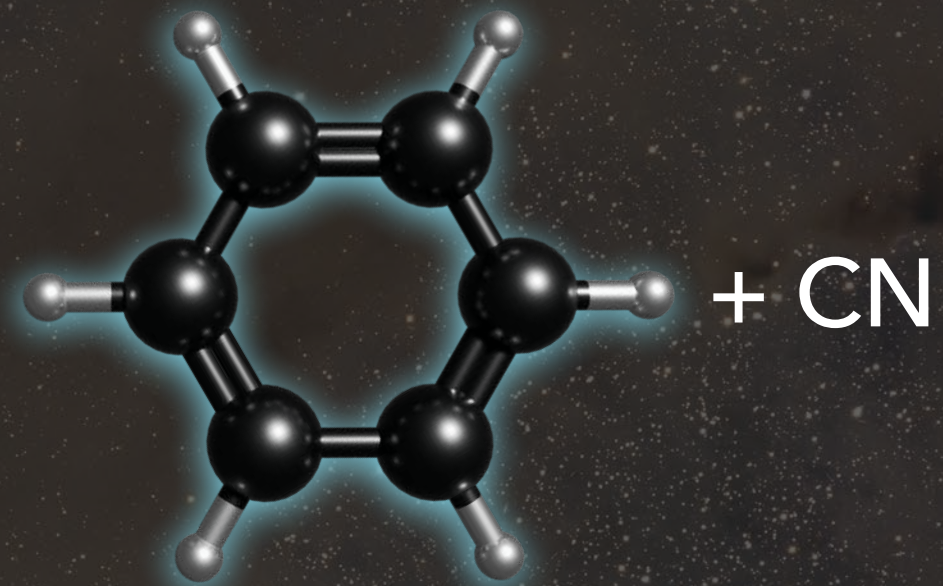
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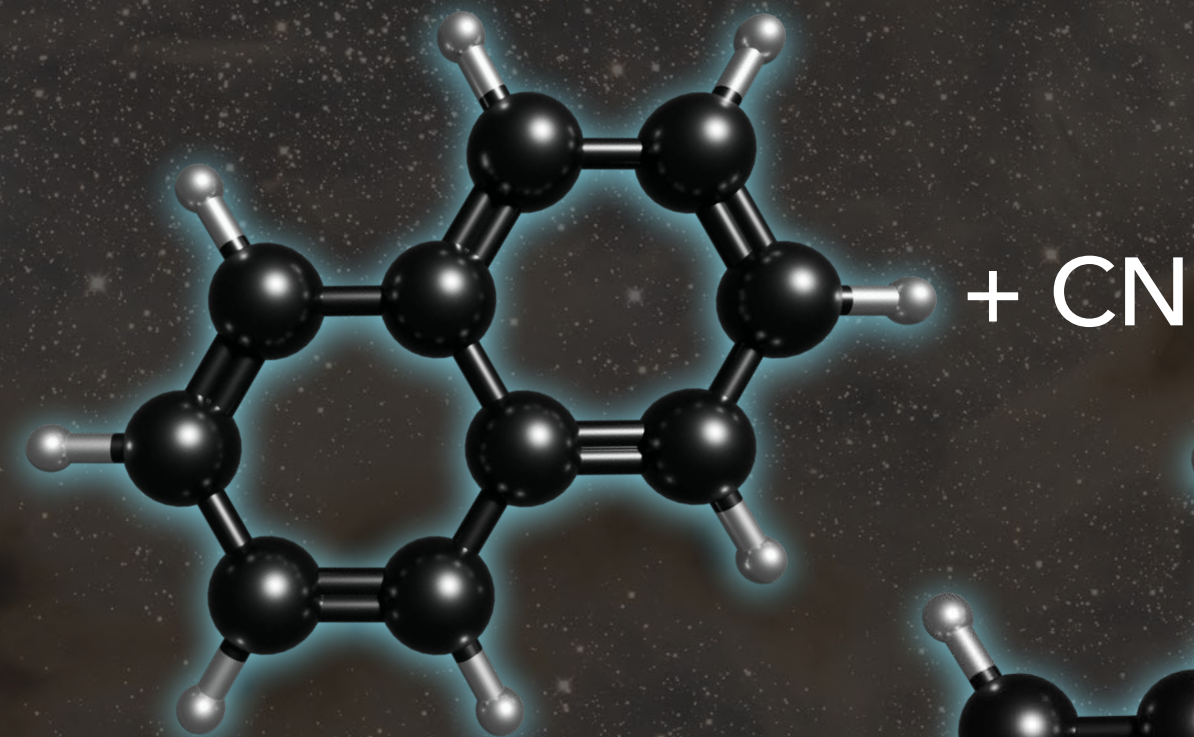
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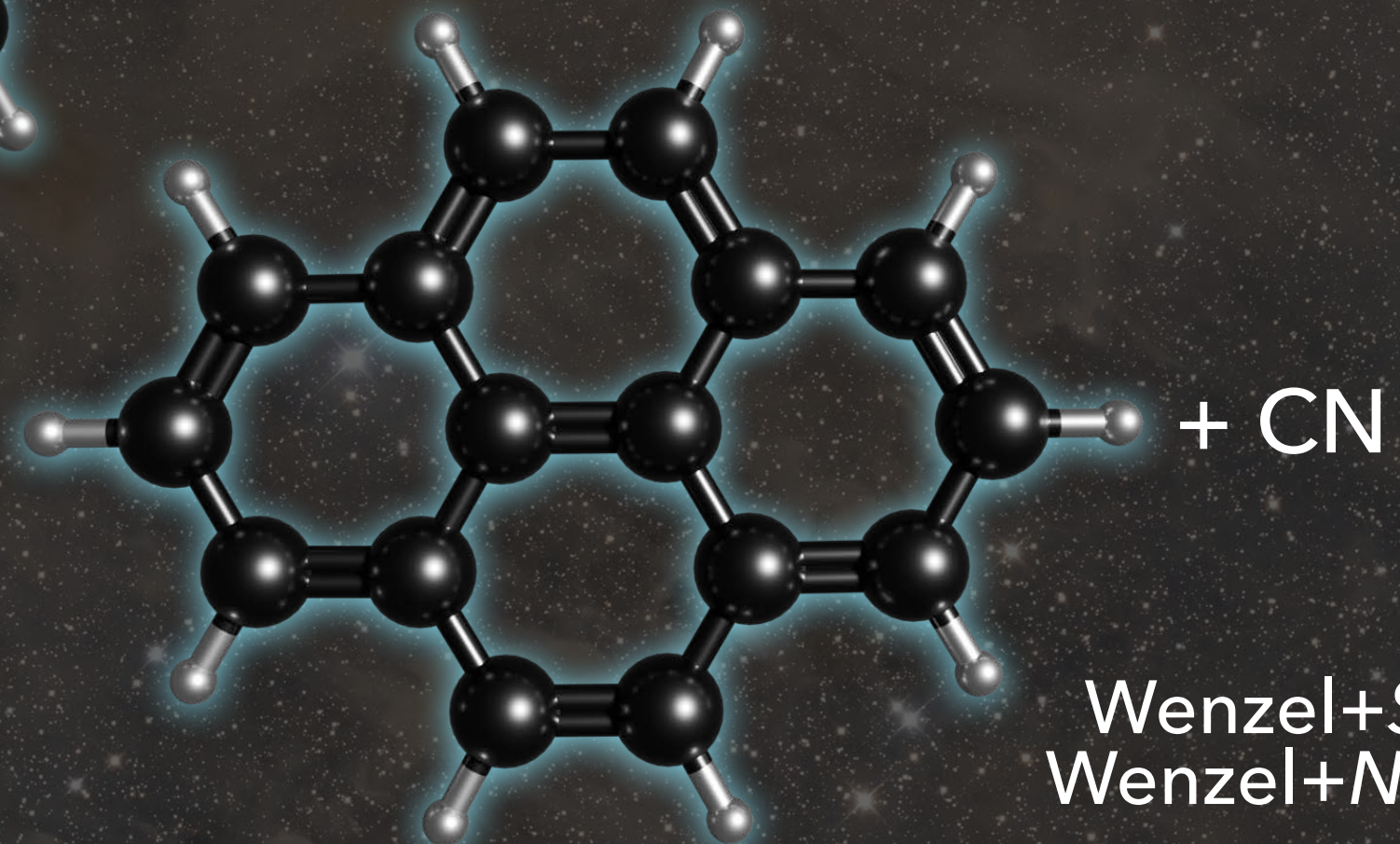
100 m Green Bank Telescope



McGuire+Science2018



McGuire+Science2021



Wenzel+Science2024
Wenzel+NatAstron2025

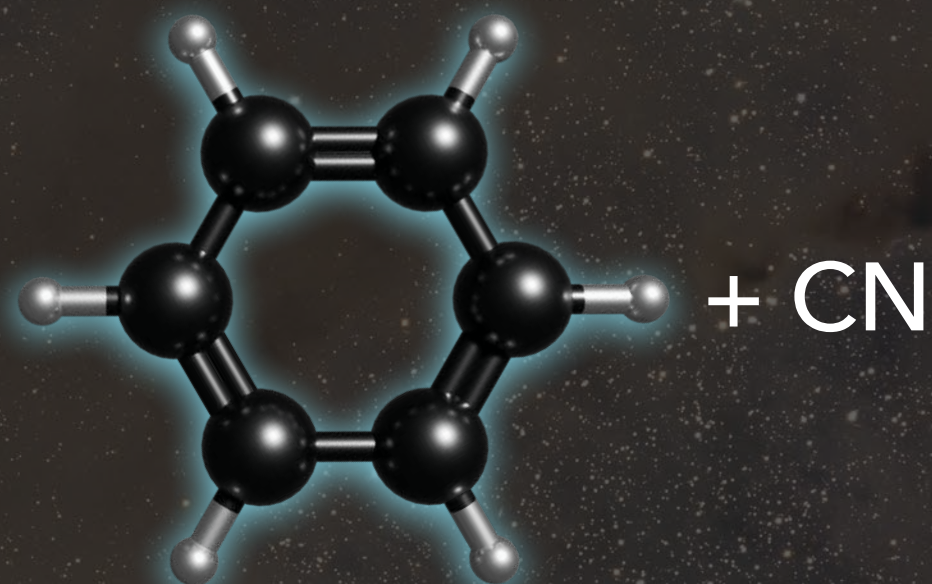
AROMATIC CHEMISTRY IN A DARK MOLECULAR CLOUD



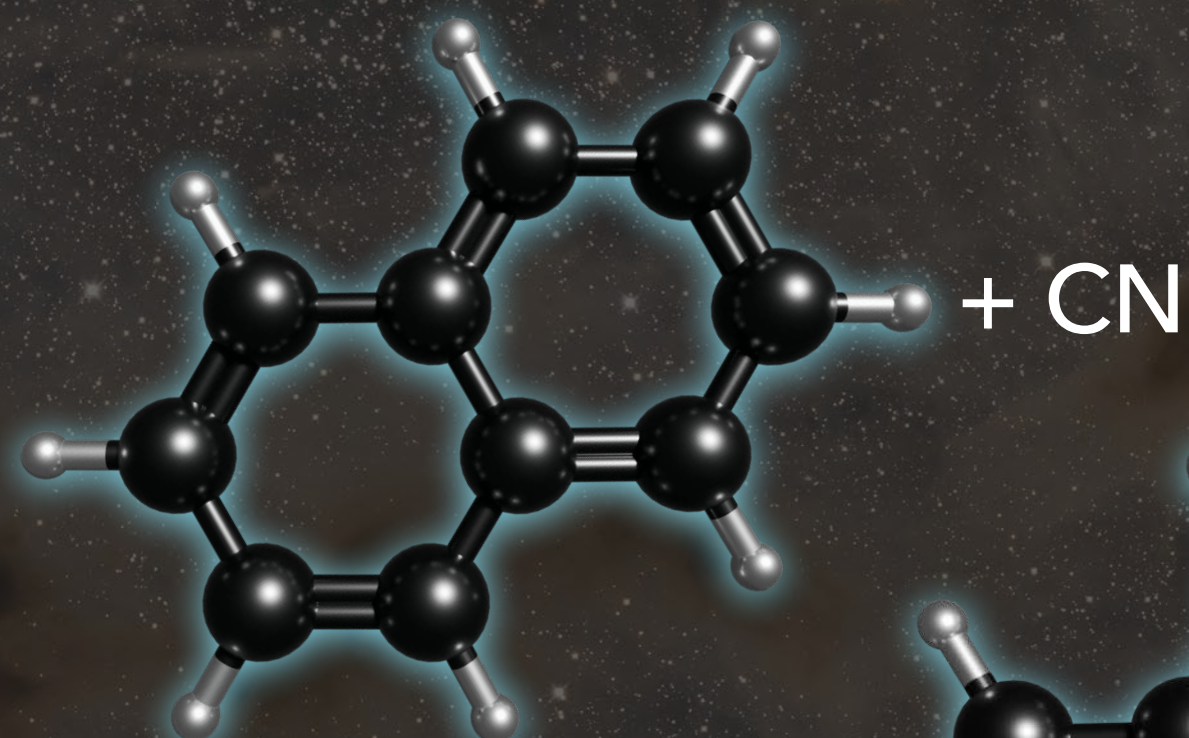
Taurus Molecular Cloud
450 ly, 5-10 K



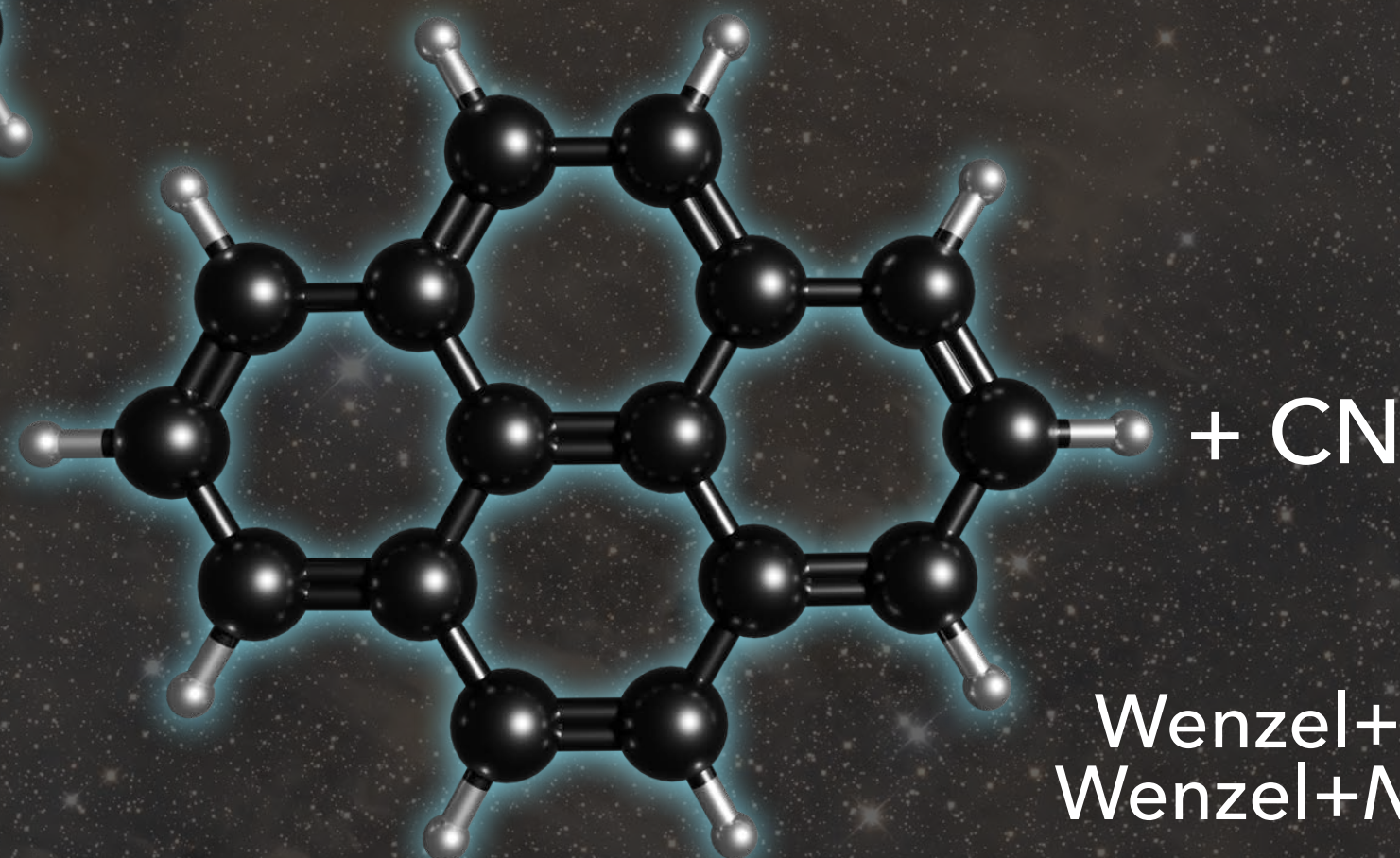
100 m Green Bank Telescope



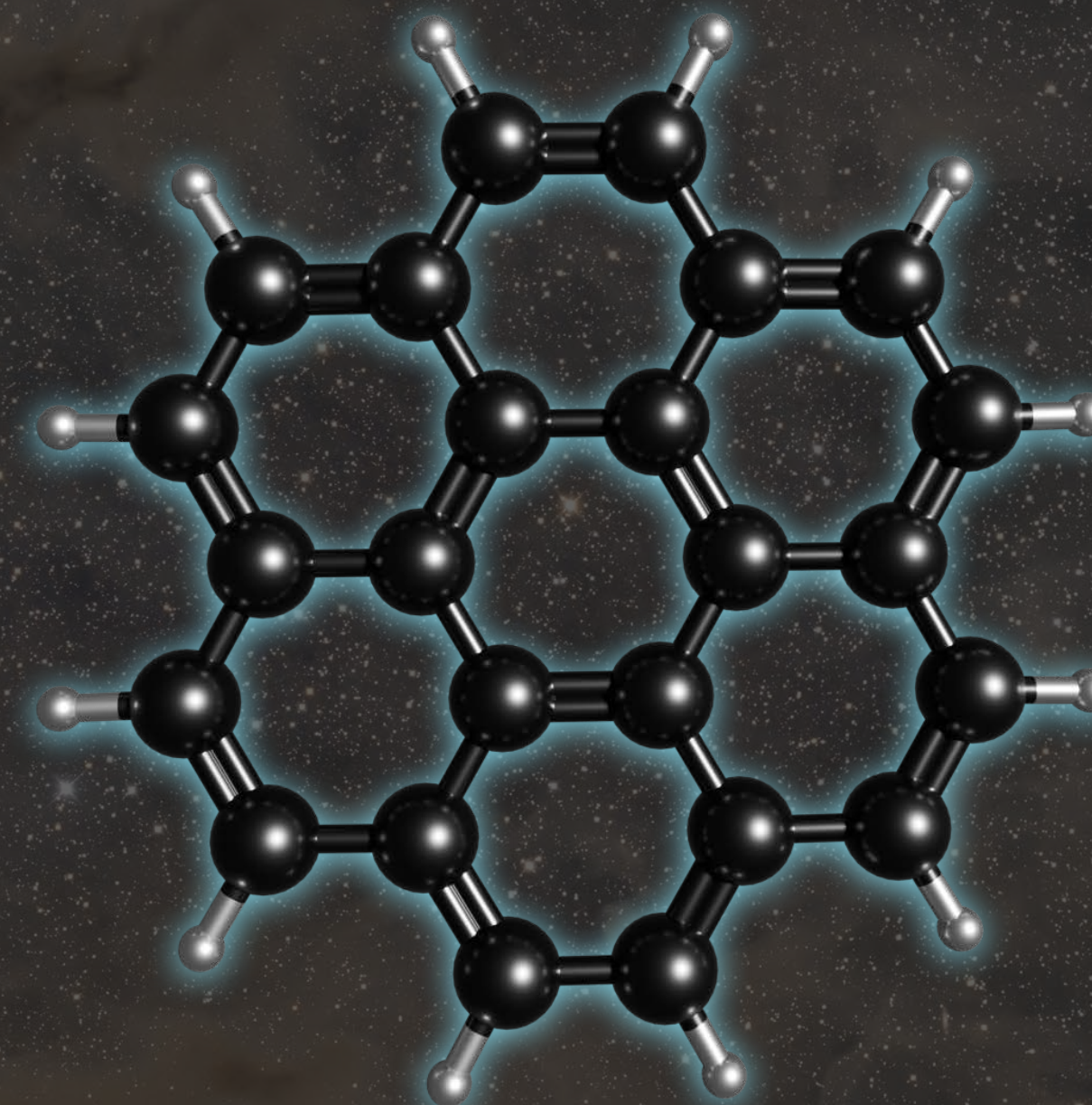
McGuire+Science2018



McGuire+Science2021



Wenzel+Science2024
Wenzel+NatAstron2025



Coronene, C₂₄H₁₂

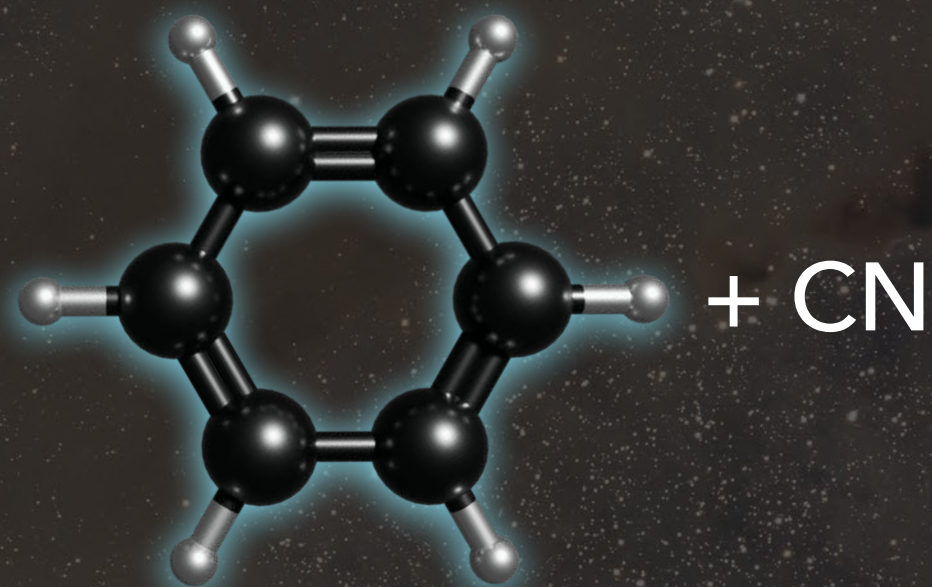
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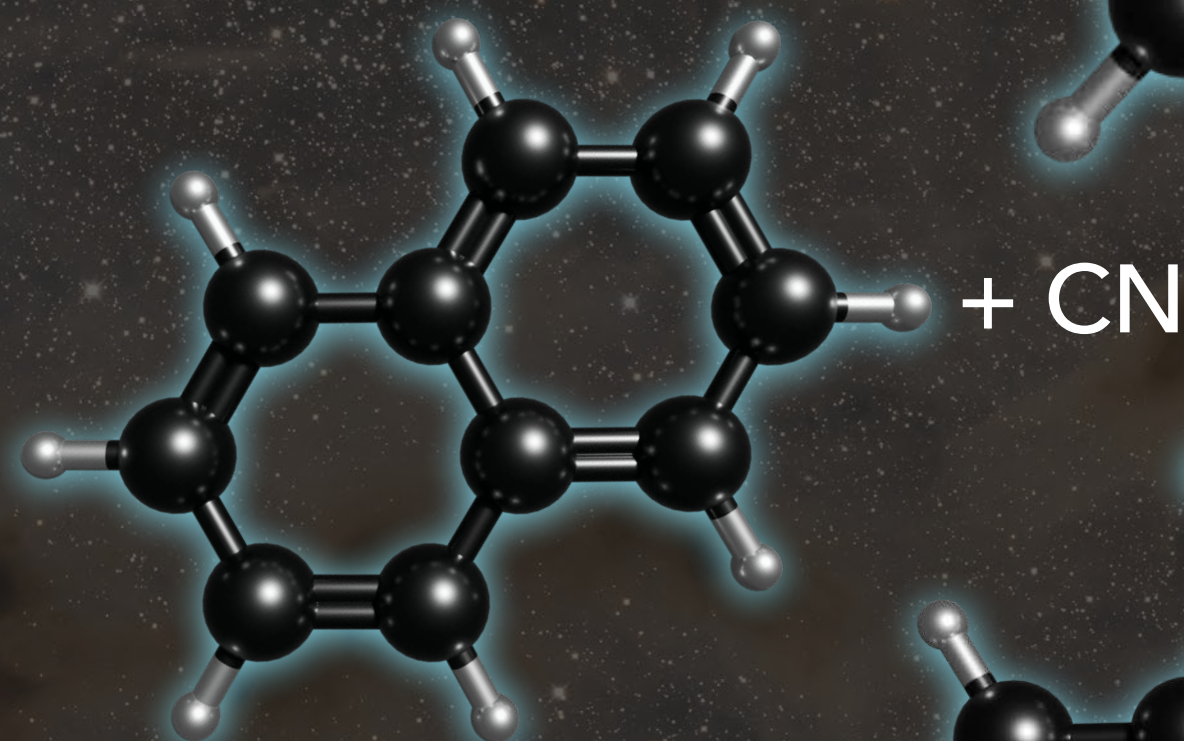
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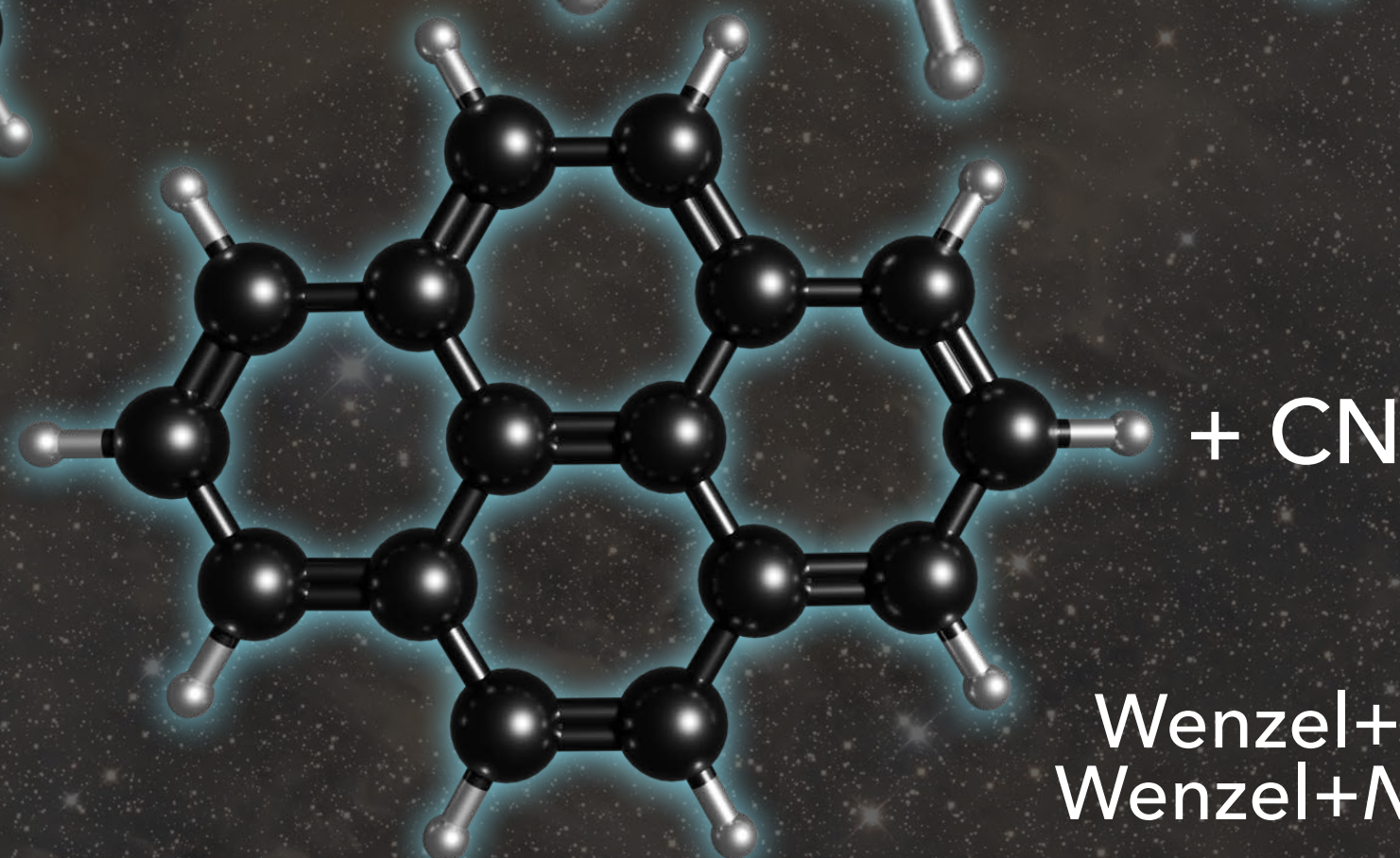
100 m Green Bank Telescope



McGuire+Science2018



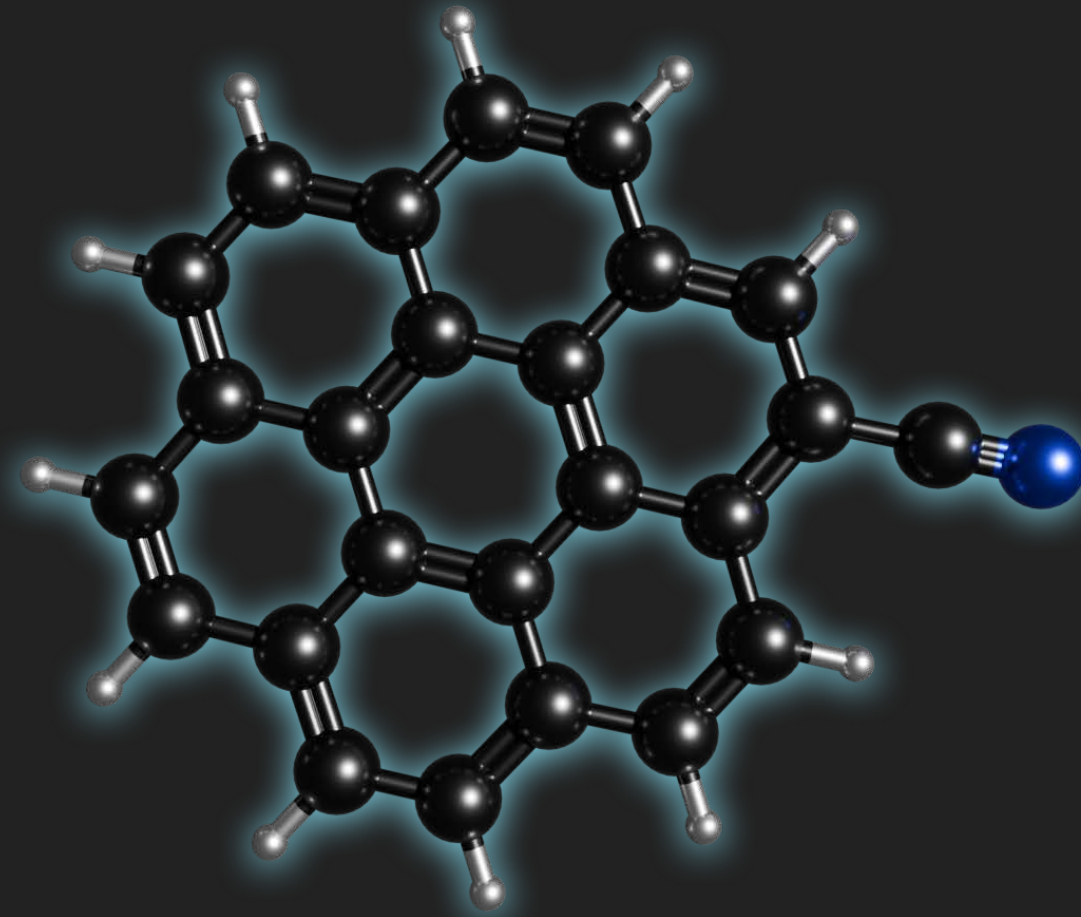
McGuire+Science2021



Wenzel+Science2024
Wenzel+NatAstron2025

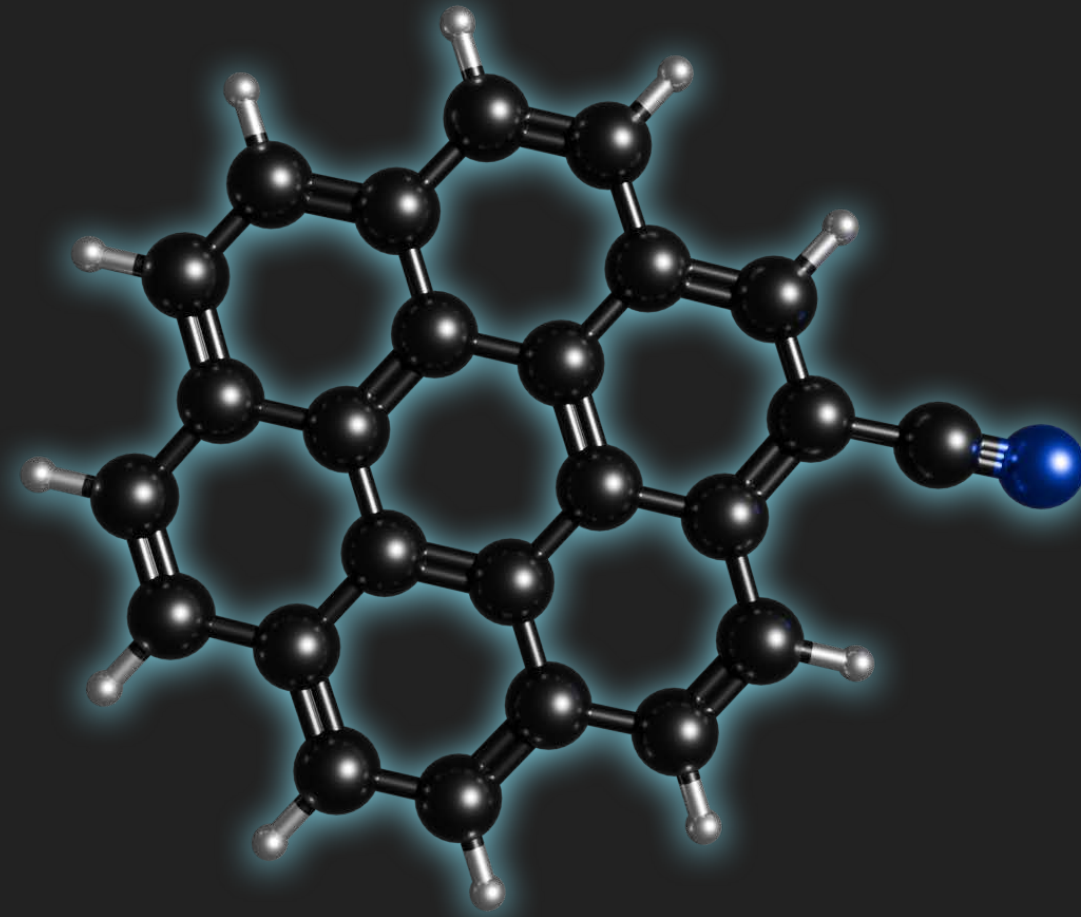
Cyanocoronene
 $C_{24}H_{11}CN$

CYANOCORONENE IN TMC-1



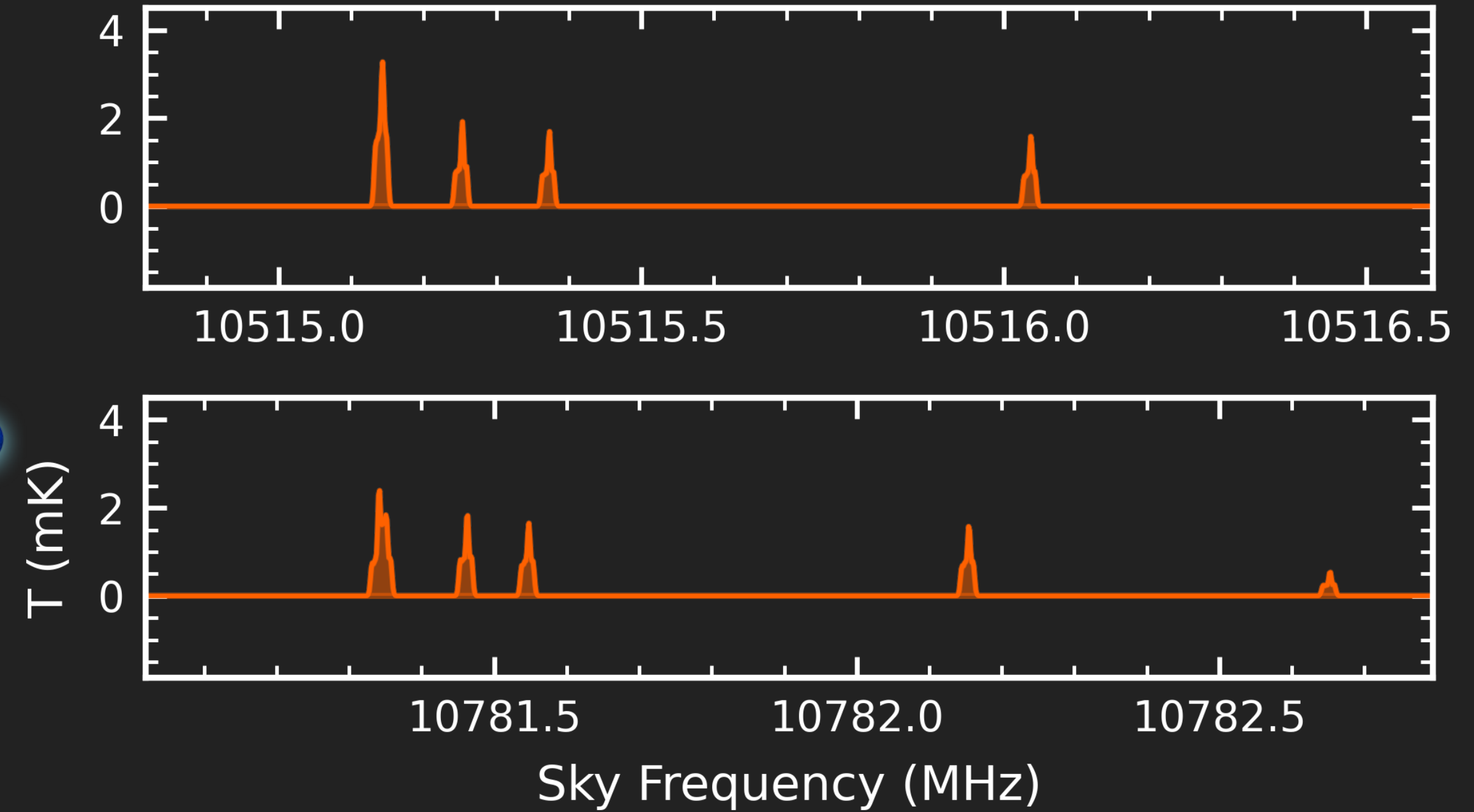
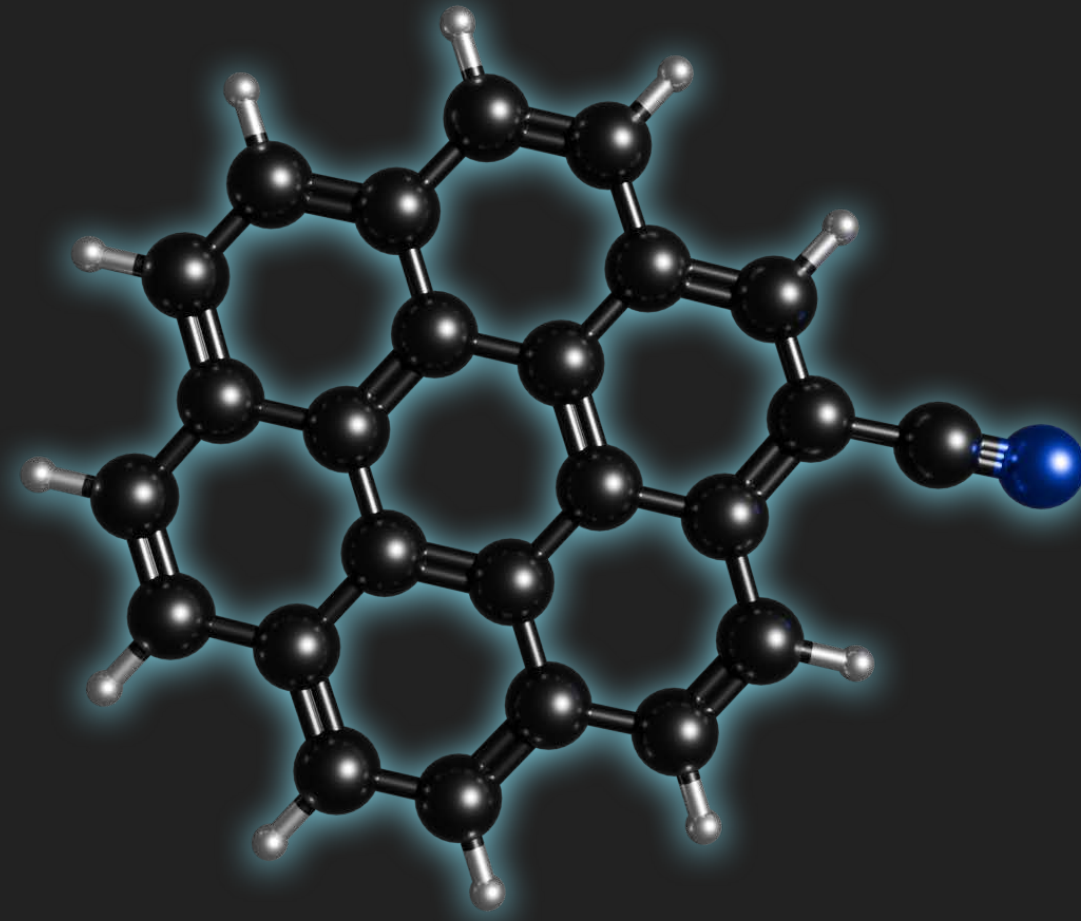
CYANOCORONENE IN TMC-1

- Laboratory rotational spectrum measured using high-resolution Fourier Transform microwave spectroscopy



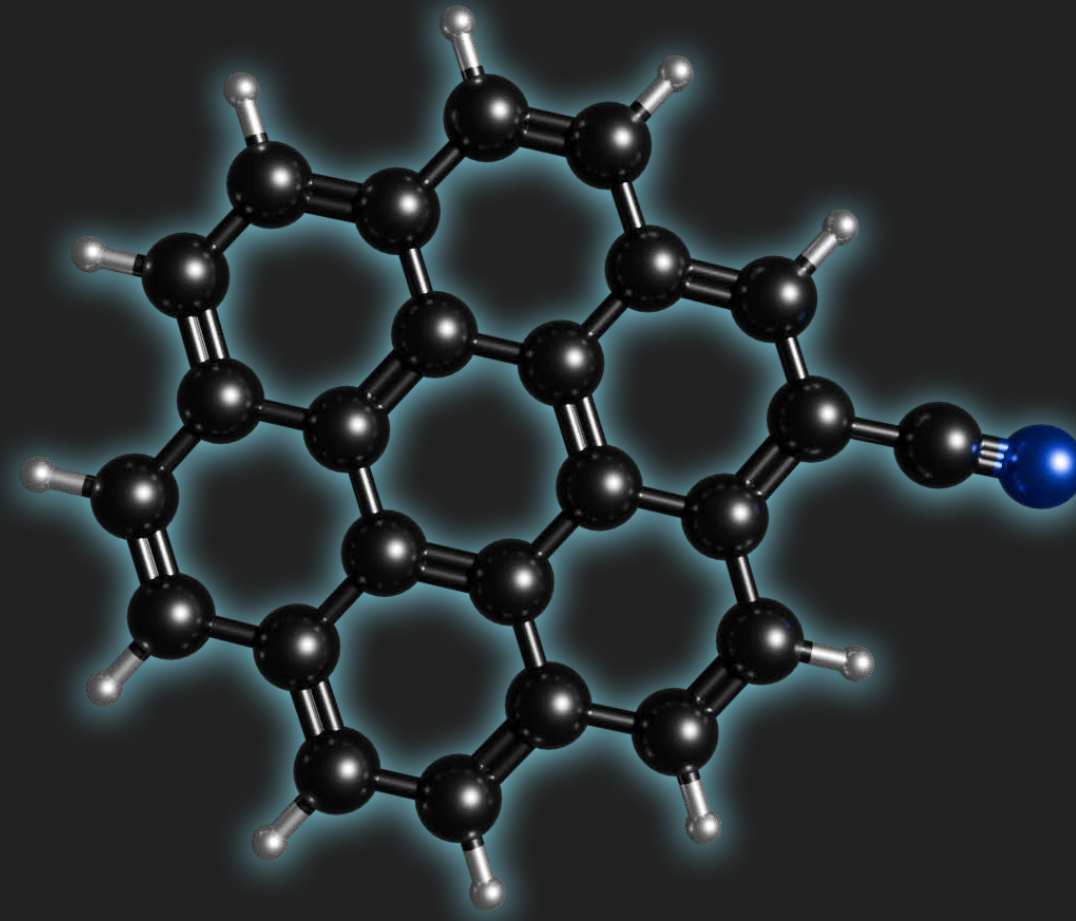
CYANOCORONENE IN TMC-1

- Laboratory rotational spectrum measured using high-resolution Fourier Transform microwave spectroscopy
- Simulating rotational spectrum using physical conditions present in TMC-1 (~ 6 K, 5.8 km s $^{-1}$)

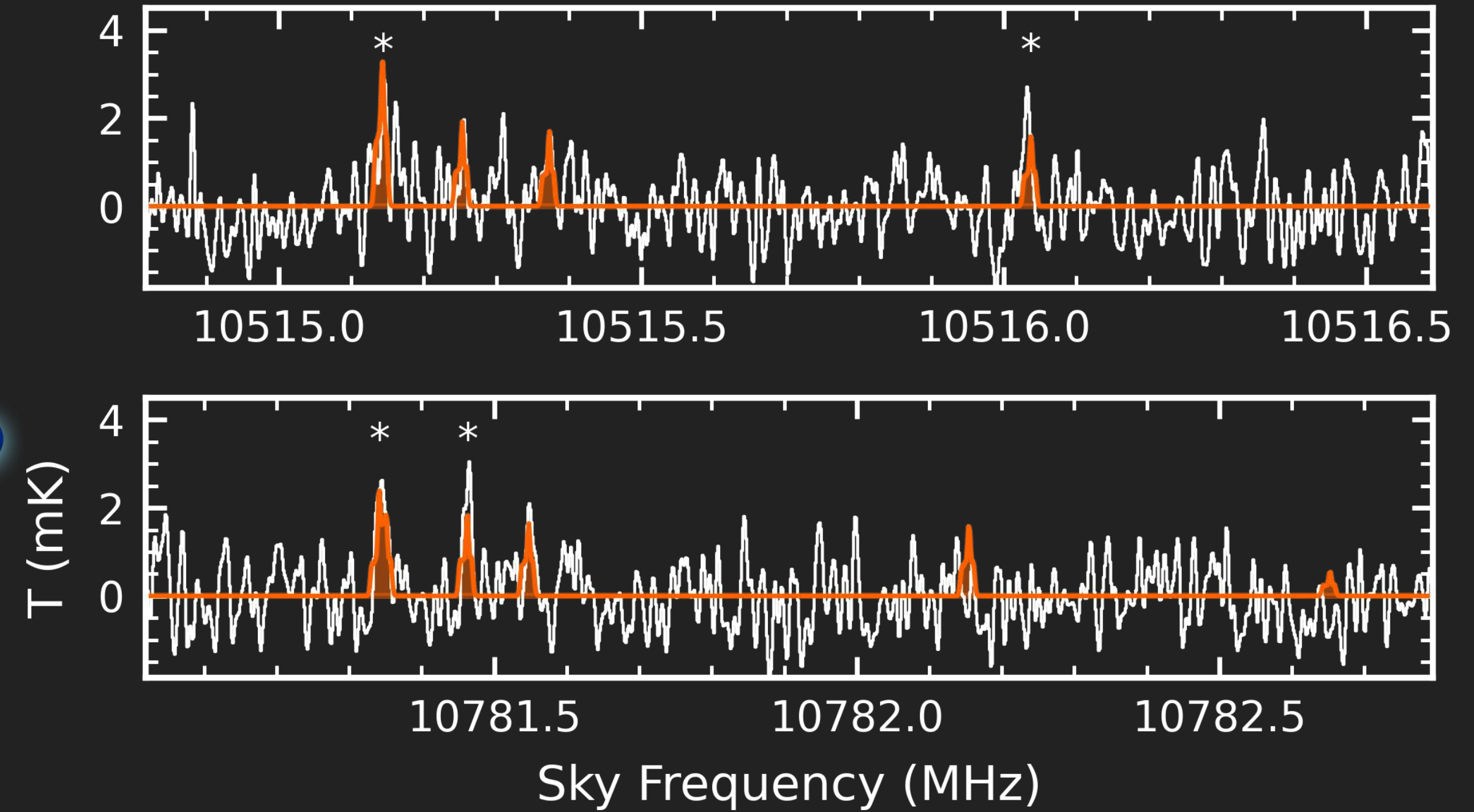


CYANOCORONENE IN TMC-1

- Laboratory rotational spectrum measured using high-resolution Fourier Transform microwave spectroscopy
- Simulating rotational spectrum using physical conditions present in TMC-1 (~ 6 K, 5.8 km s $^{-1}$)
- Comparison to radio astronomical observations of TMC-1

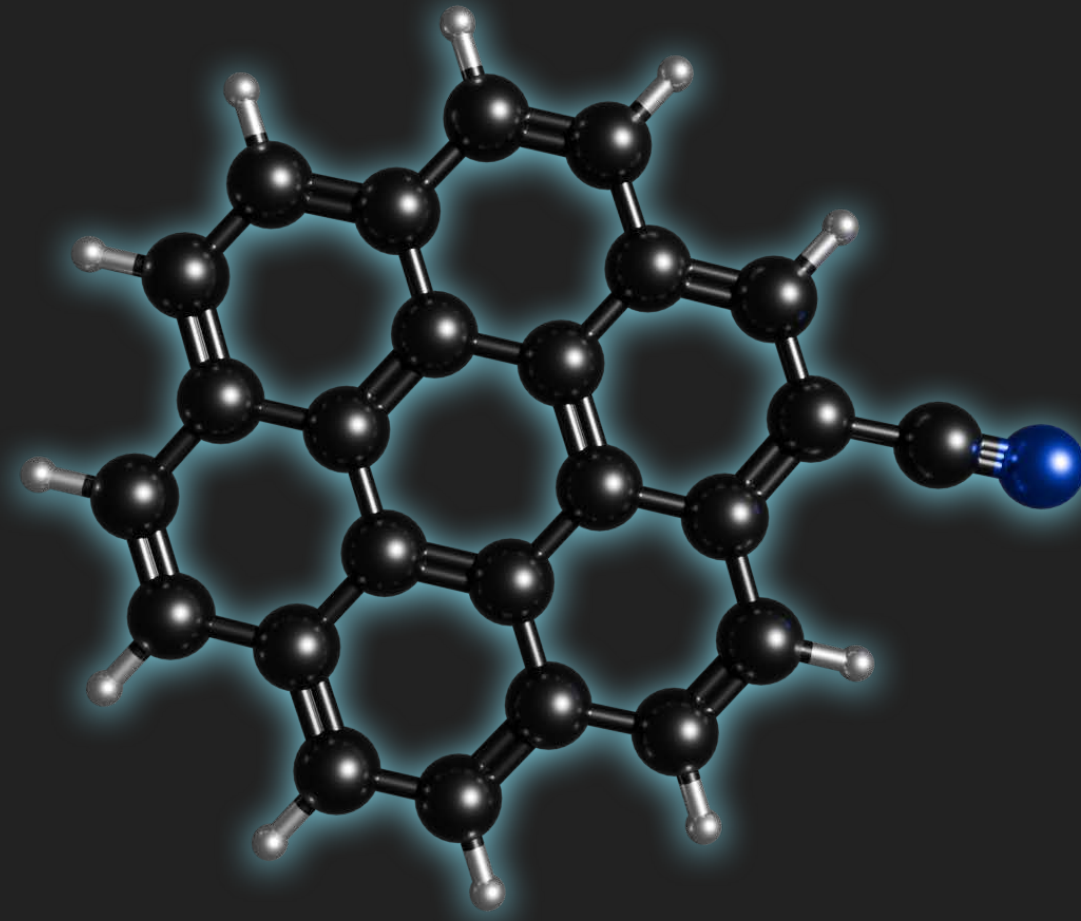
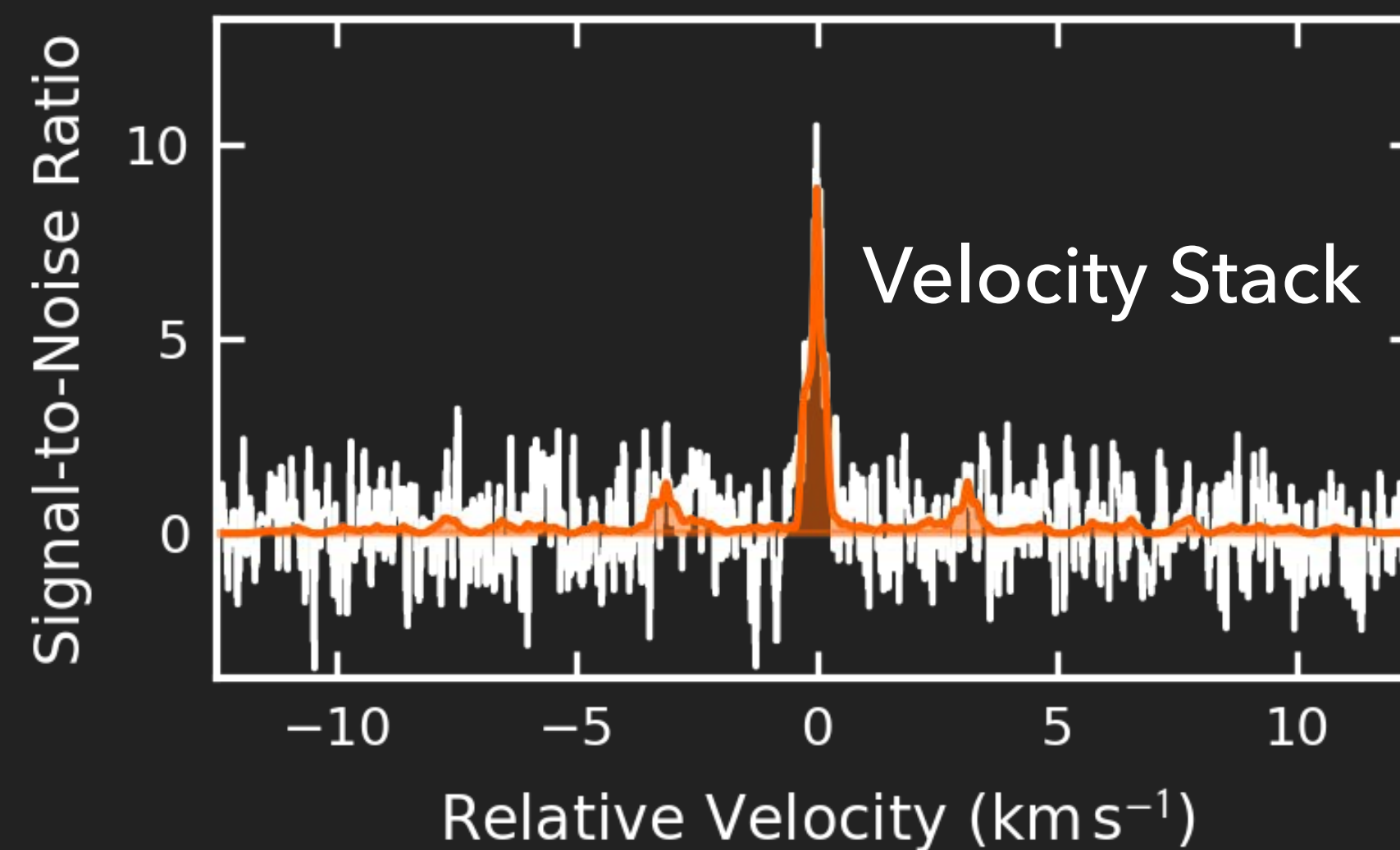
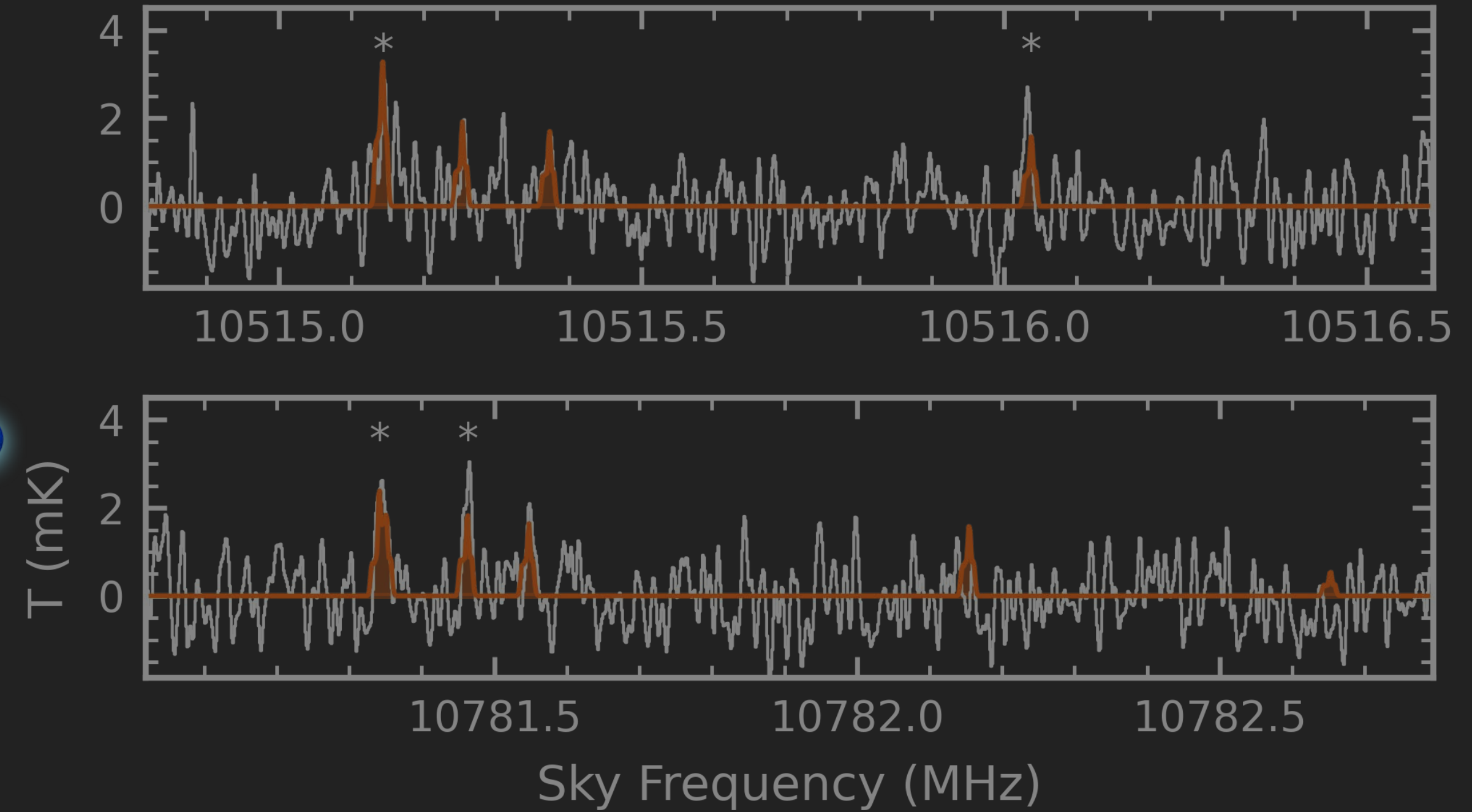


GBT X-band, ~ 200 hours



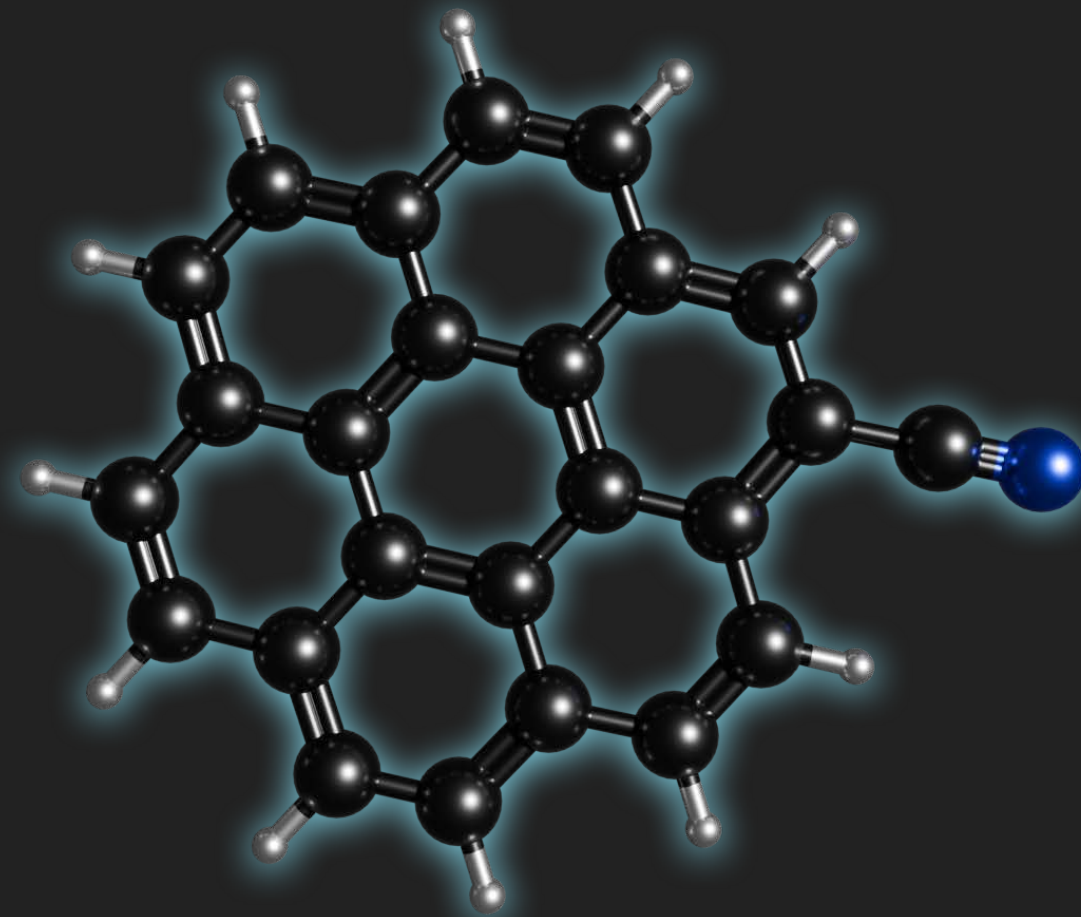
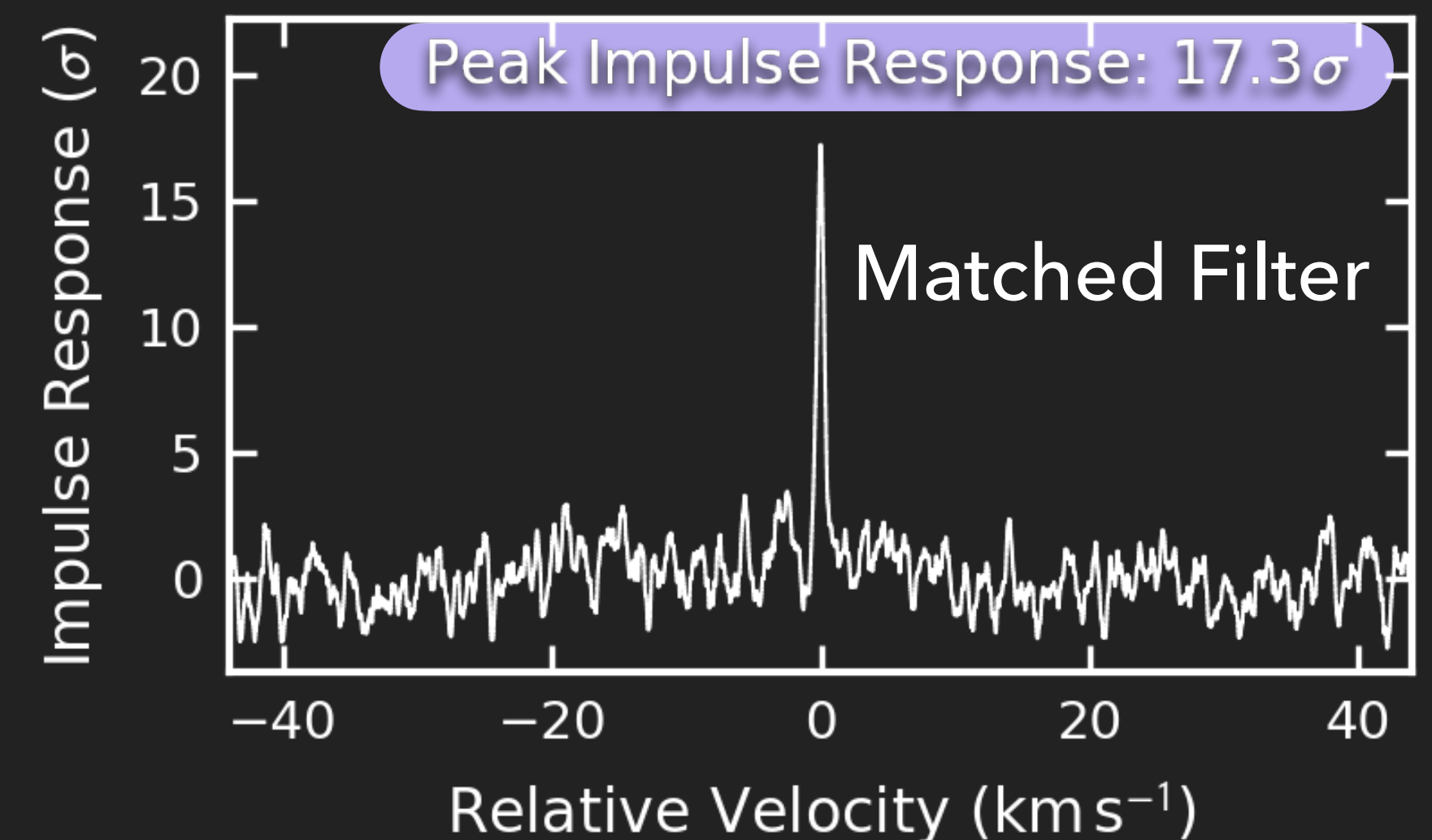
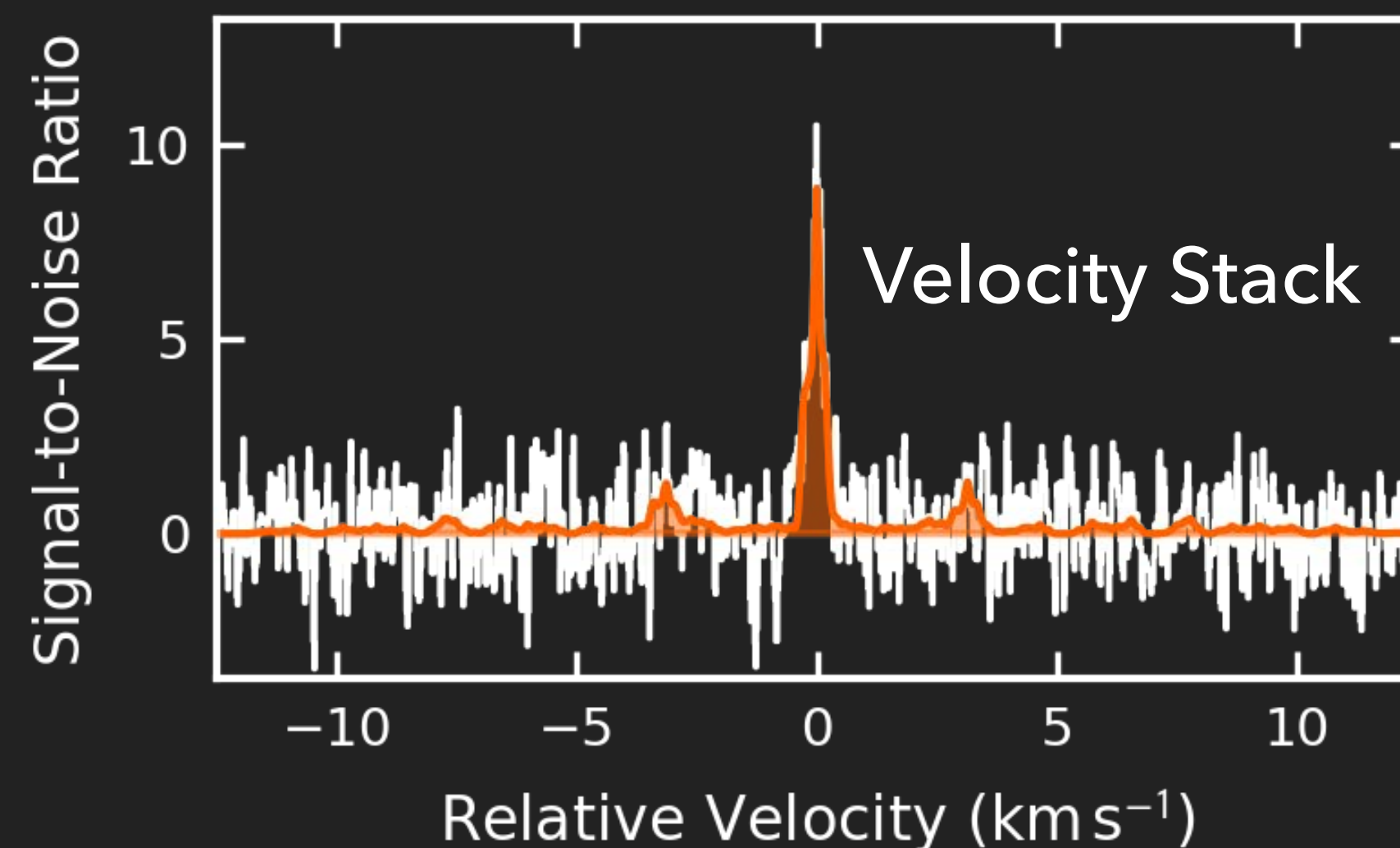
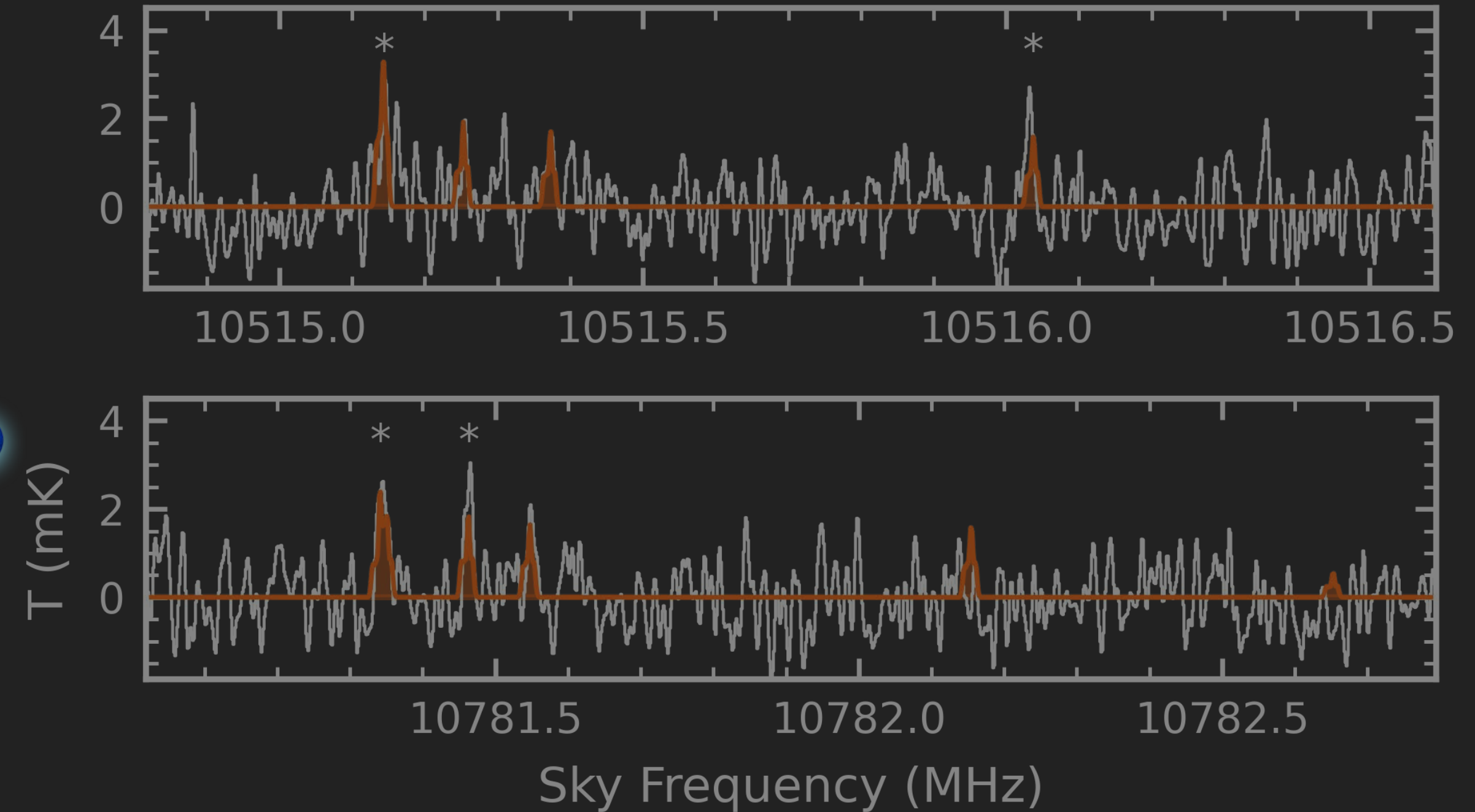
CYANOCORONENE IN TMC-1

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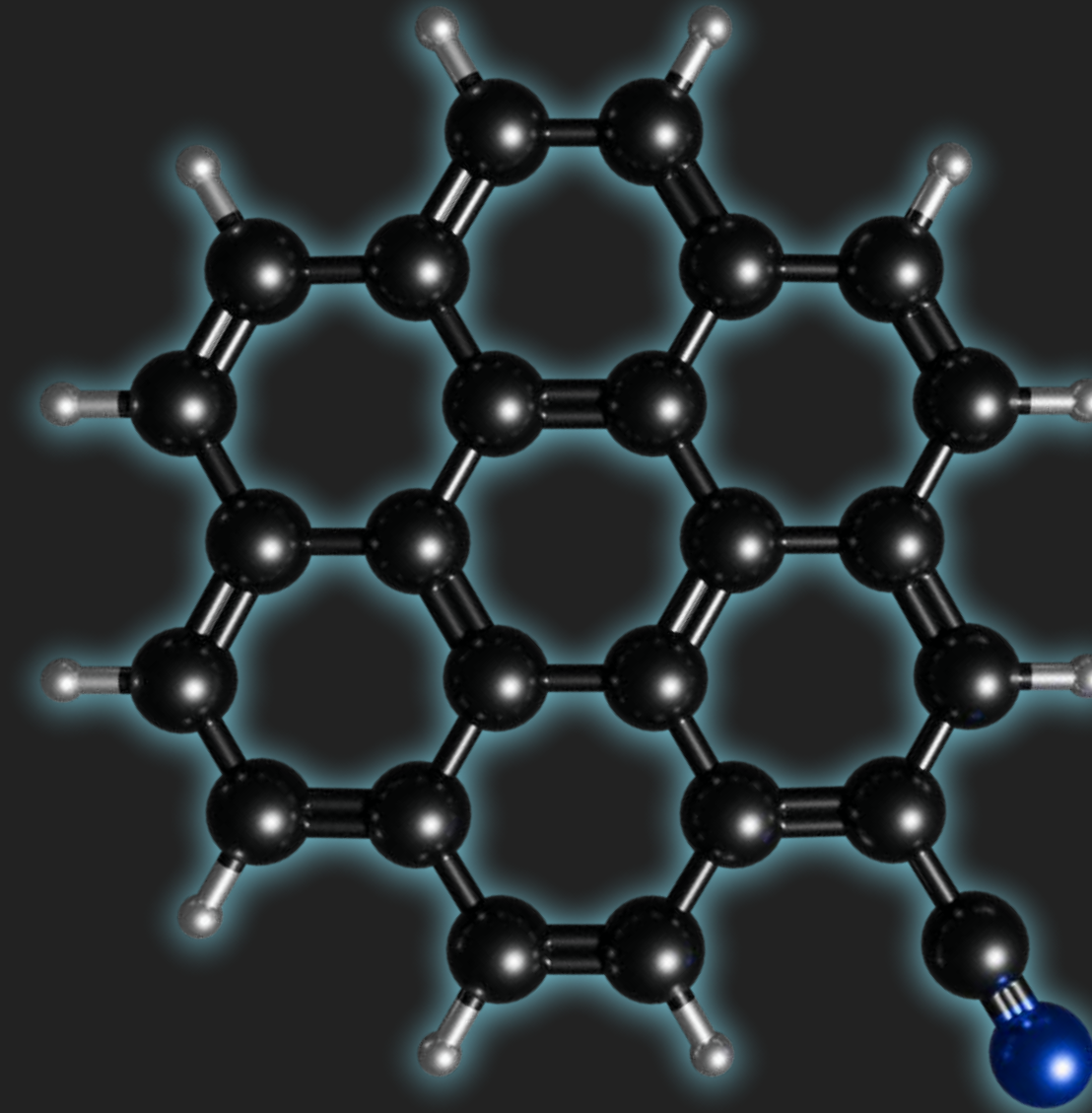
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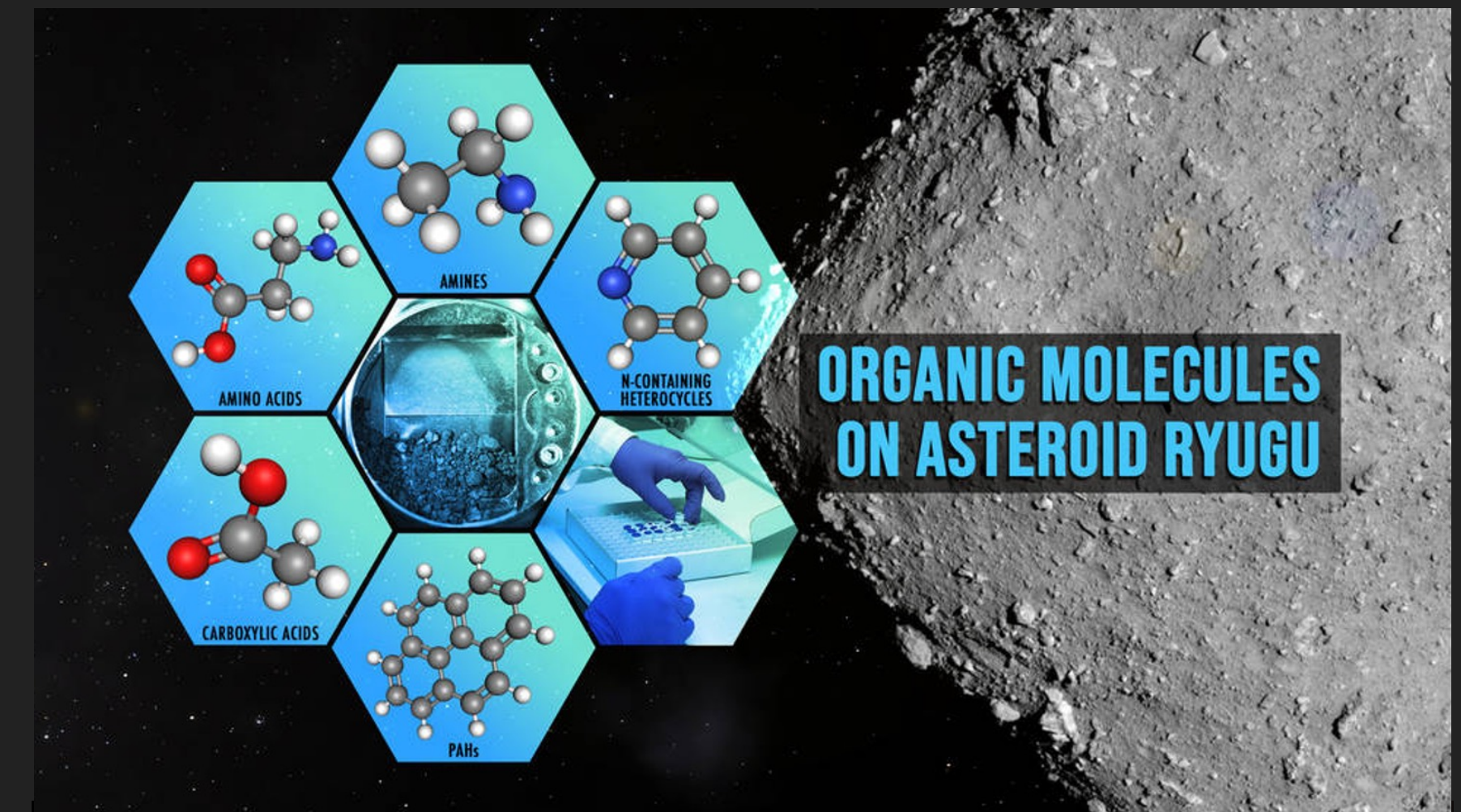
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PAH EMISSION OBSERVED

- Protoplanetary disks
- Extragalactic PAHs (even at high z)



MOLECULAR CLOUD

PROTOSTAR

PROTOPLANETARY DISK

PLANETARY SYSTEM

Image credit: Bill Saxton, NSF/AUI/NRAO

Image credit: JAXA, U. Tokyo, Kochi U., Rikkyo U., Nagoya U., CIT, Meiji U., U. Aizu, AIST

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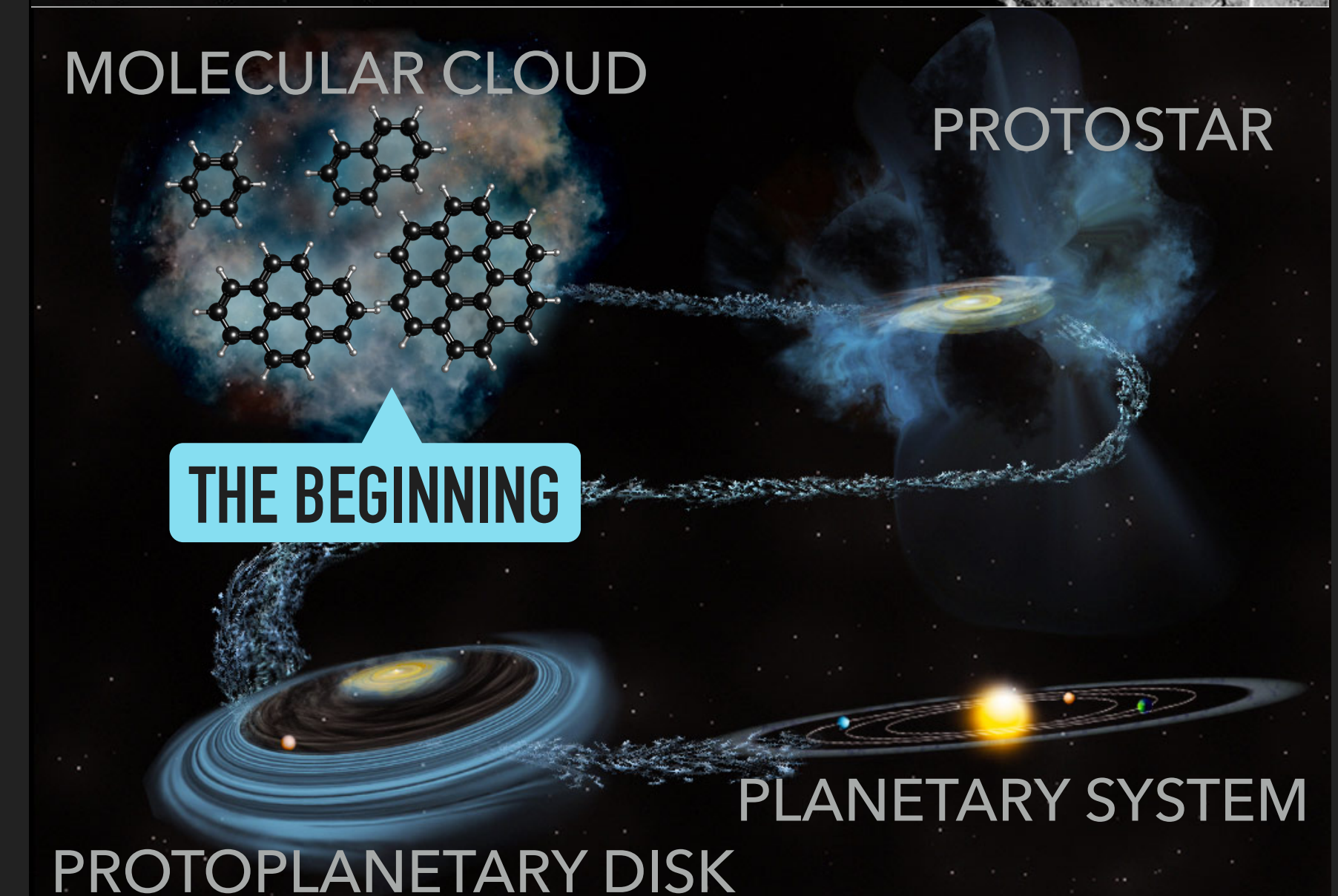
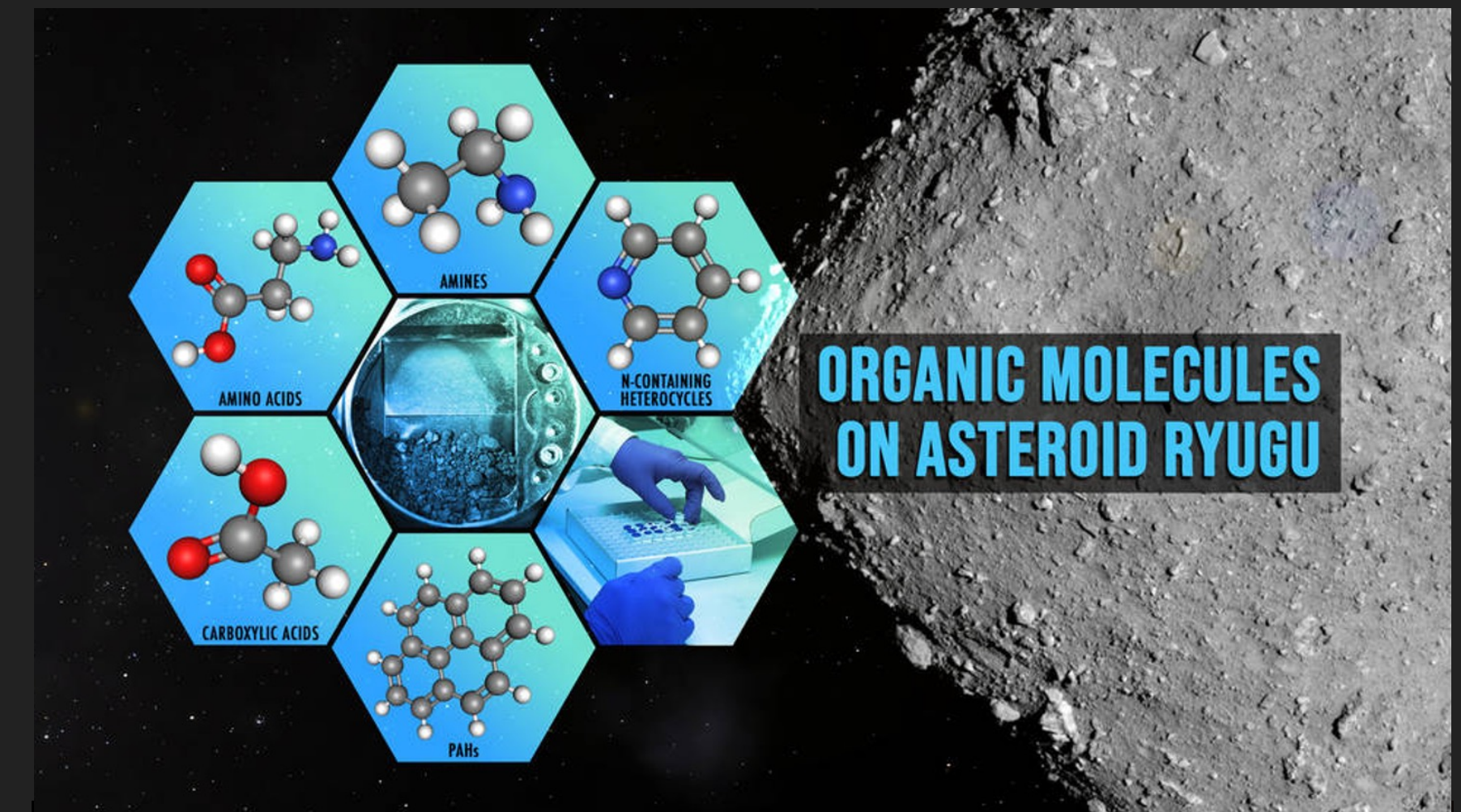


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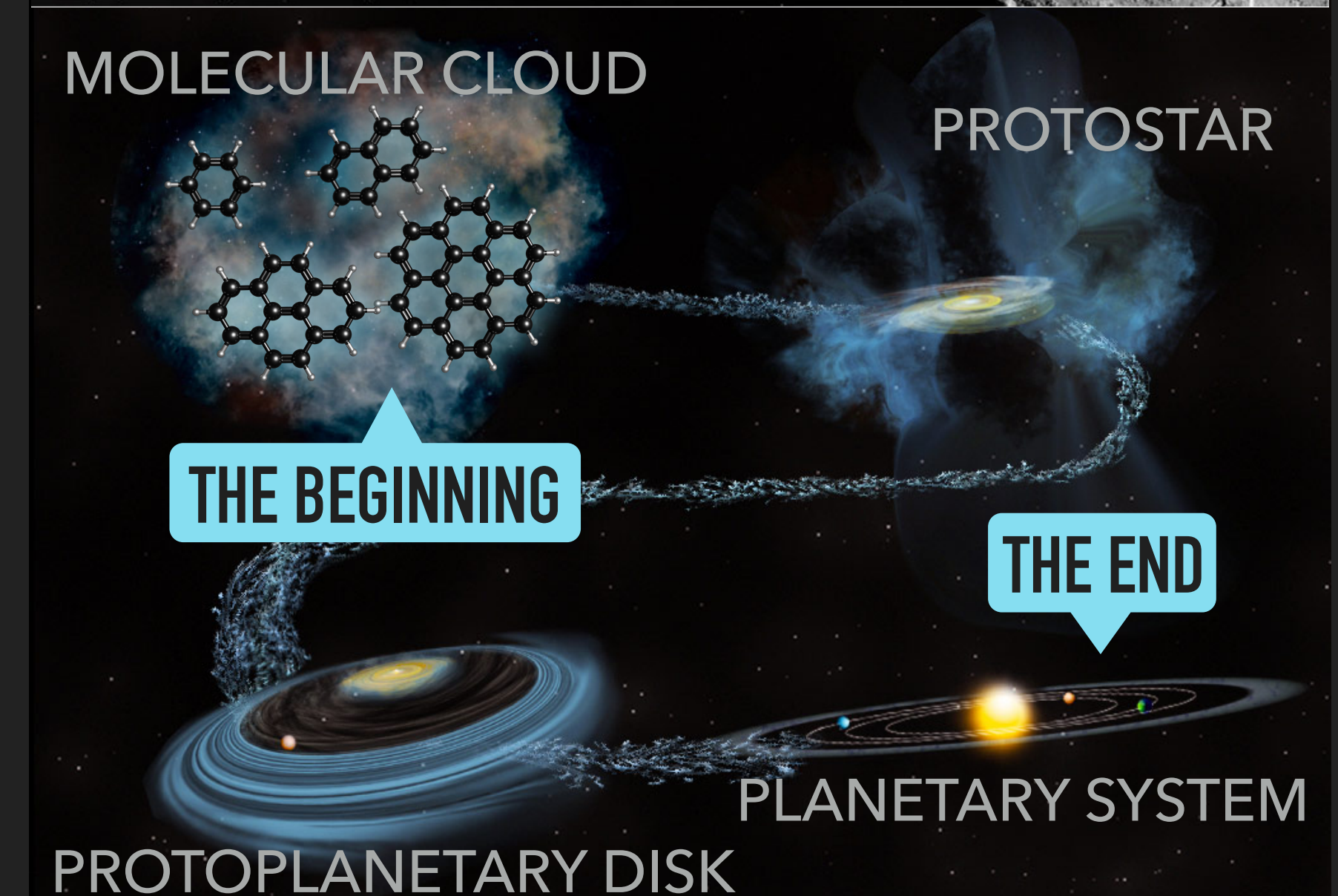
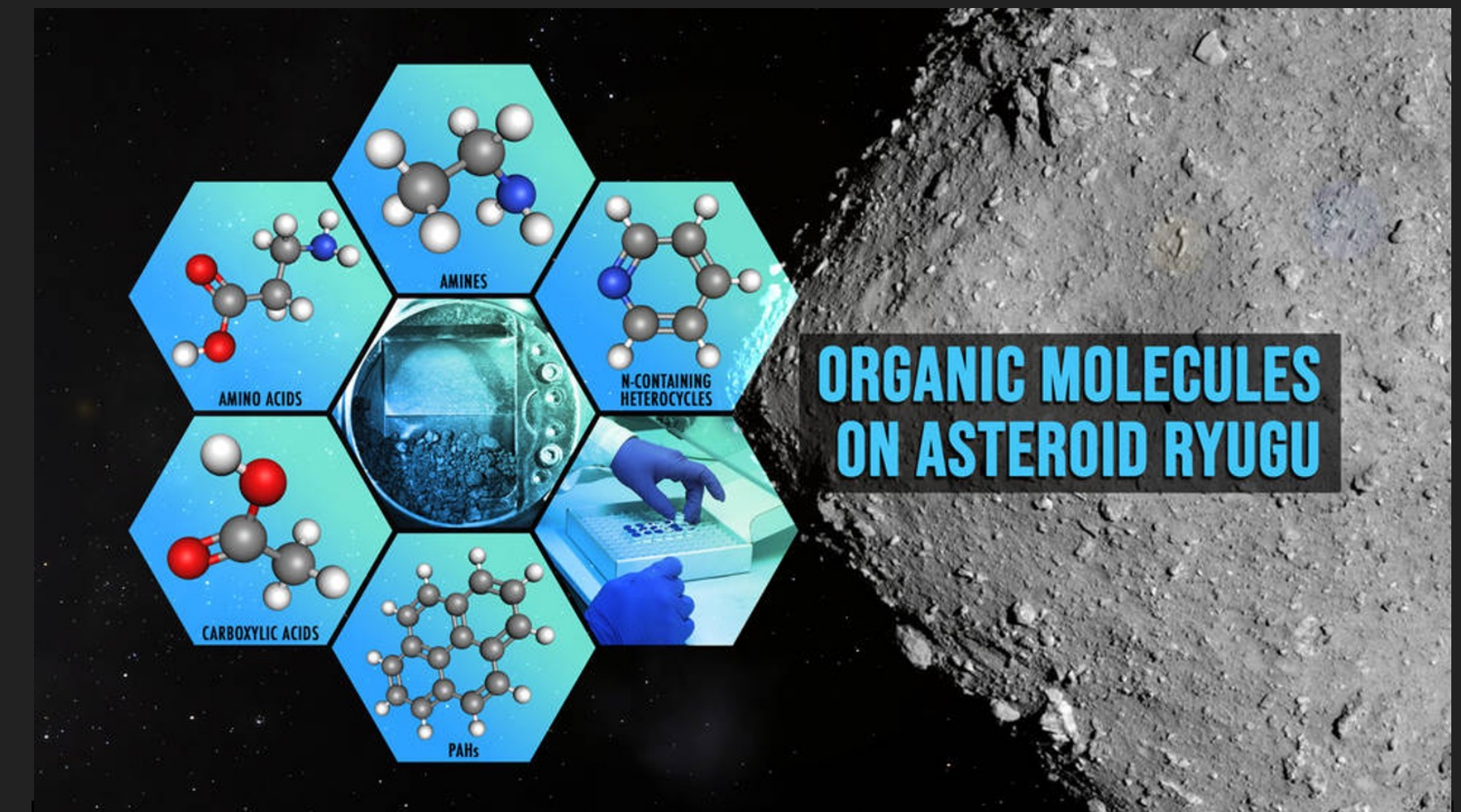


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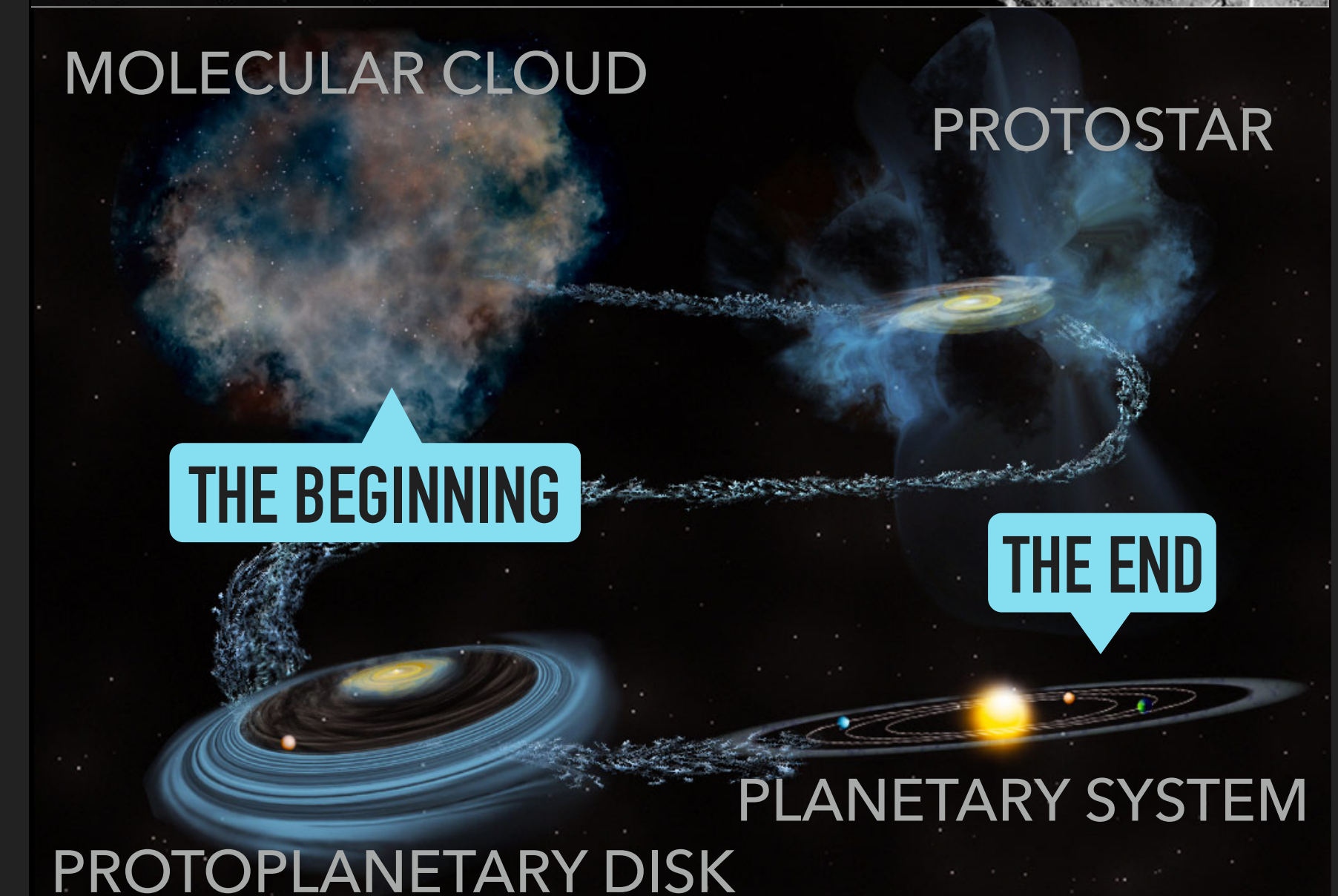
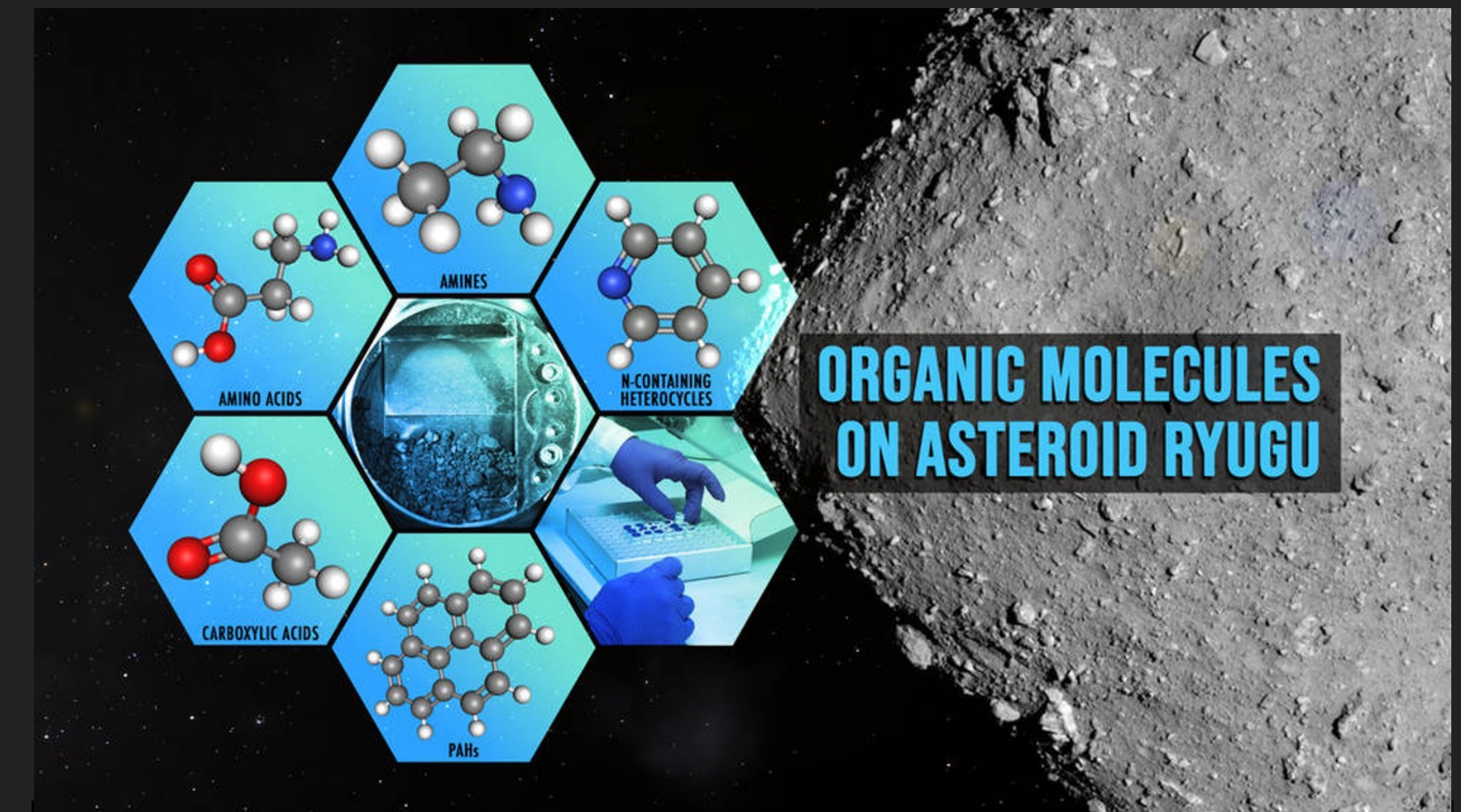


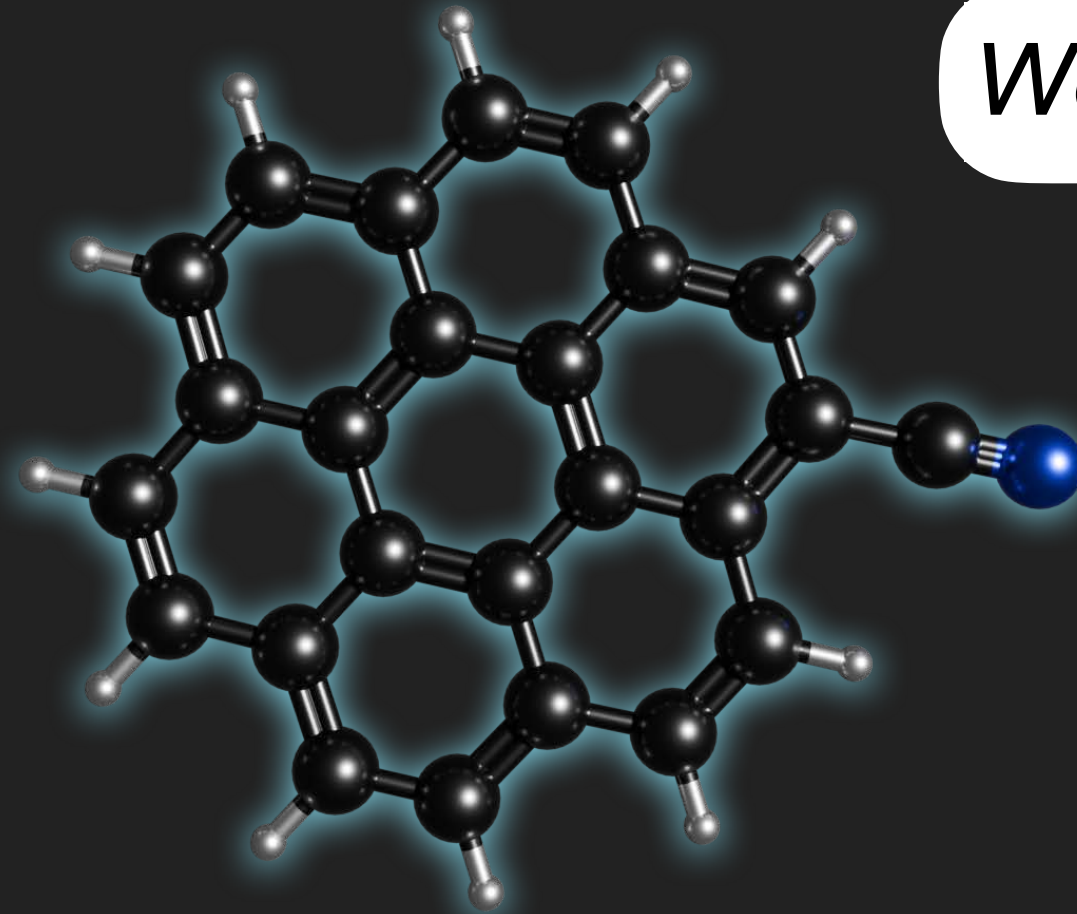
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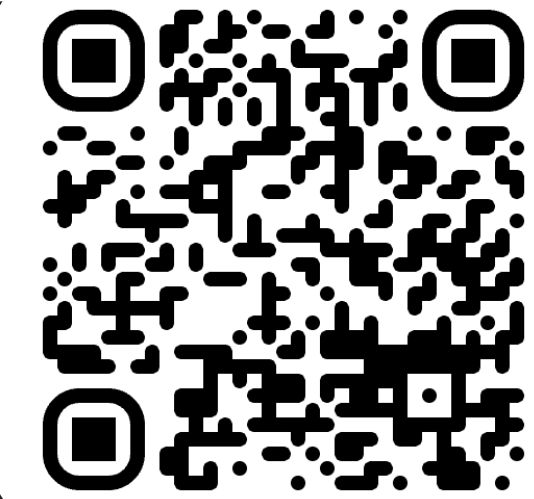
SUMMARY & IMPLICATIONS

- Using high-resolution laboratory rotational spectroscopy of CN-PAHs and the Green Bank Telescope (GBT), we detected **cyanocoronene** toward the cold dark cloud TMC-1
- **Largest molecule** detected with radio astronomy to date
- Carbon reservoir and potentially supply carbon to planets
- Origin and fate of PAHs remain mysterious
 - Formation *in situ* vs. inheritance

Cyanocoronene, $C_{24}H_{11}CN$



Wenzel et al. *ApJL* 984, L36, 2025



gwenzel@mit.edu

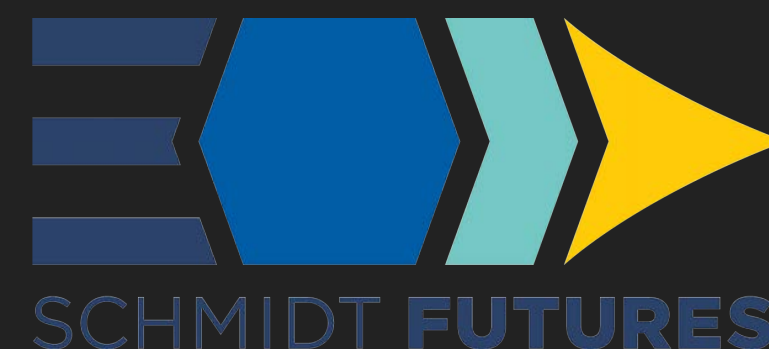


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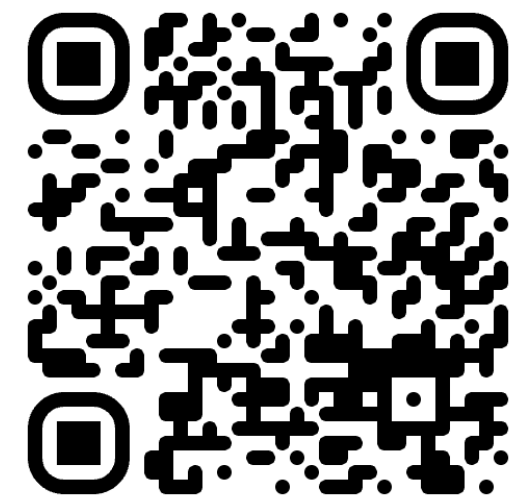
Gabi Wenzel, Siyuan Gong, Ci Xue, P. Bryan Changala, Martin S. Holdren, Thomas Speak, D. Archie Stewart, Zachary T. P. Fried, Reace H. J. Willis, Edwin A. Bergin, Andrew M. Burkhardt, Alex N. Byrne, Steven B. Charnley, Andrew Lipnicky, Ryan A. Loomis, Christopher N. Shingledecker, Ilsa R. Cooke, Michael C. McCarthy, Anthony J. Remijan, Alison E. Wendlandt, Brett A. McGuire

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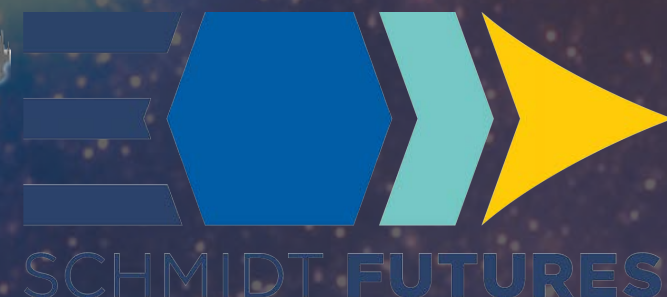


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