ESP Open-source Opacity Database

S. Grimm, **A. Guzmán Mesa**, K. Heng
Center for Space and Habitability, University of Bern
@Astroandrea
andrea.guzmanmesa@space.unibe.ch

Why an Opacity Database?

We need **opacities** (cross-sections per unit mass) **of atoms** and **molecules** in all sort of (exo)planetary atmospheric calculations!
But computing opacities is a **very difficult task** that starts with **line lists** that have **very large number of transitions.** It takes an incredible amount of **computing time** to do so**!** We do not want to *"reinvent the wheel"* for this tedious step of transforming line list data into opacities for **multiple points** in **T** and **P** every time, therefore we are creating a **publicly available opacity database** for the exoplanet community.

New Open Opacity Database for Exoplanetary atmospheres! Coming Soon!

Take a picture to **download the papers**

How do we calculate them?

Molecular and atomic opacities are calculated using **HELIOS-K** (Grimm & Heng 2015). We use line lists from different databases like **HITRAN, HITEMP, ExoMol, Kurucz** and **NIST.** It calculates the molecular absorption of each line's strength and resamples the line-by-line data into a manageable ***k-distribution*** format. ***We use GPU's to accelerate the calculations.**

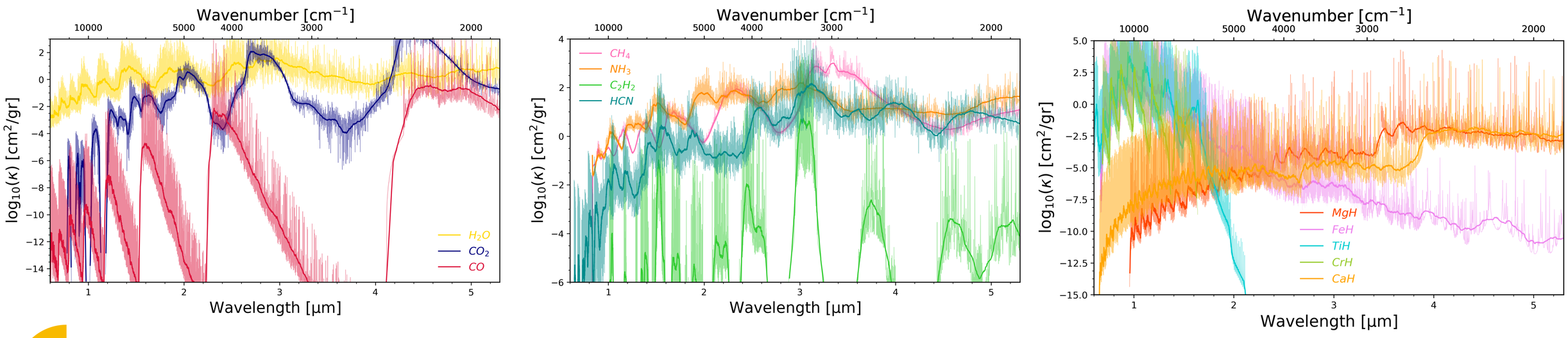


Figure 1. Examples of opacities. They were calculated using **T**= 1500 K and **P** = 10^{-3} bars

$\kappa = S \cdot \Phi$ **Opacity Function** = Intensity * Line Shape

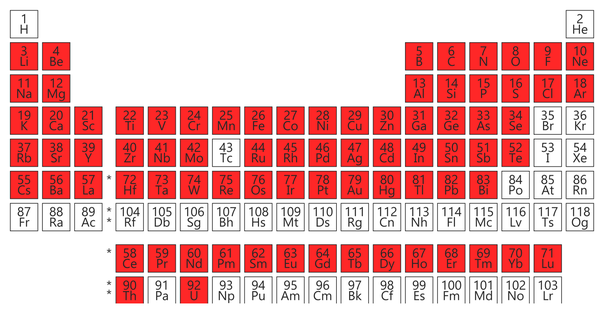
$$\Phi = \left(\frac{\ln 2}{\pi}\right)^{\frac{1}{2}} \cdot \frac{H_v}{\Gamma_D}$$ **Line Shape** = The Voigt-Profile

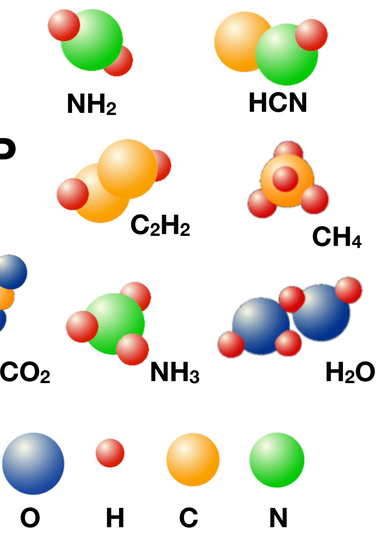
$$H_v = \frac{a}{\pi} \cdot \int_{-\infty}^{\infty} \frac{exp\left(u'^2\right)}{\left(u-u'\right)^2 + a^2} du'$$ **Must be solved numerically! Computationally Expensive***

H_v : Voigt H-function Γ_D : Doppler profile a : Damping parameter

What does it have?

- **~ 150** molecules (**isotopologues**)
- **~ 60** Atoms and Ions
- **Grid** of opacity functions in **T** and **P**





Challenges

- **Long time** to calculate
- **Large amounts** of data
- Wavenumber **resolution** (**10^{-2} cm^{-1})**
- **No theory for** *cutting length* and *pressure broadening* for large amount of lines.

References

- Grimm, S.L., & Heng, K., 2015, Astrophysical Journal, 808,182
- Grimm, S.L., **Guzmán Mesa, A.**, et al 2019, *In prep*
- https://github.com/exoclime/HELIOS-K

UNIVERSITÄT BERN
CSH CENTER FOR SPACE AND HABITABILITY
EXO PLANETS EXOCLIMES GROUP
EXOCLIMES SIMULATION PLATFORM
PlanetS