Use of Neural Networks in calculating the abundance of different species in exoplanet atmospheres

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Dataset (using VULCAN)

- VULCAN (Tsai et al. 2017) is a chemical kinetics code to estimate the chemical abundances in the exoplanet atmosphere in terms of mixing ratios.

- Validated for hot-Jupiter atmospheres from 500 K to 2500 K

- The parameters shown are configured keeping other parameters in VULCAN configurations constant to generate the dataset.

Parameters

- Planet's Mass within the range [0.5, 20] M_J

- Orbit Radius within the range [0.01, 0.5] AU

- Stellar Radius within the range [1, 1.5] $R_{\odot}$

- Planet Radius

- Temperature-Pressure Profile

- Stellar Flux

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Input (Properties)

- Initial mixing ratios (the mising ratios for 69 species are defined for the 150 height layers of the exoplanet atmosphere)

- Temperature Profile

- Pressure Profile

- Gravitational Profile

- Stellar Flux

- Stellar Wavelength Component (the corresponding wavelength for the stellar flux from the stellar spectrum)

Autoencoders

- Used for dimensionality reduction, eventually decreasing training time.

- Grassi et al. (2022) have shown that autoencoders can be successfully used for this purpose.

- There is an autoencoder for each of the six input properties.

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Core Network

- LSTM-like neural network that maps the input properties to the output mixing ratios from VULCAN.

- The latent representation from the encoders are the input this core network.

- Output of the core network is passed through decoders to interpret the results.
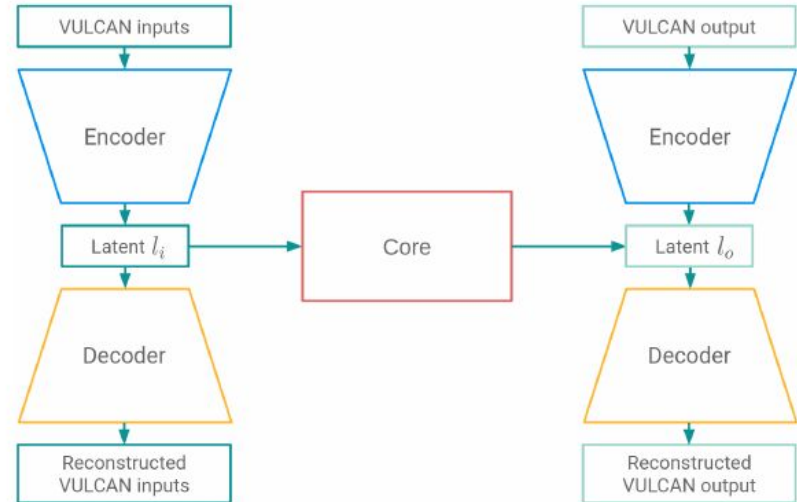
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Future Plans

- Investigate the use of this idea to implement the neural network method on a single exoplanet.

- Modified the input properties by changing the elemental abundances, diffusion coefficient.