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Session 6) Isotopes in Mars and Venus

Towards Understanding Isotopic Fractionation of Chemical Processes in the Venusian Atmosphere

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Venus has a thick atmosphere with many of its chemical and photochemical processes yet to be fully understood. While it mainly consists of relatively inert CO_2 and N_2, the trace gases which include chlorine and sulfur compounds are responsible for Venus rich and diverse chemistry and photochemistry. Given that chlorine has two stable isotopes and sulfur has four, there are plenty of opportunities of naturally occurring isotopic effects in Venusian atmospheric chemistry. Oxygen, carbon and hydrogen are also typically participating in Venusian chlorine and sulfur chemistry providing further diversity in isotopes to study.

With high-level computational chemistry methods we model temperature dependent rate constants for reactions involving different isotopologues. I will present recent work involving the chlorine catalytic cycle on Venus and how measurement of isotopic signals can inform us how CO is oxidized to CO_2. Furthermore, we explore the intricate chemistry of sulfur oxides on Venus which will provide spectroscopic signatures for infrared and microwave study of the atmosphereas well as mass spectrometry signatures allowing for detection of novel sulfur species.

Our work provides quantitative numbers for isotopic fractionation which is needed to interpret which chemical processes dominates on Venus. Fractionation of naturally occurring isotopes on Venus provides detectable signatures for future missions through either spectroscopy (IR or microwave) or mass spectrometry. Notably, NASA's DAVINCI mission launching in 2031 will include a mass spectrometer in its payload.

Our results are useful to understanding the isotopic fractionation of the atmosphere of Archean Earth (pre-oxygen era). This because the atmospheres of the Archean and Venus has similar oxidation states and are likely to have the same atmospheric chemical processes happening, given that Venus and Earth as a whole consist of the same elements in similar ratios.