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Detection and Measurement of Allene on Titan

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Abstract

1. Introduction

Titan, the largest moon of Saturn, has long been known to be home to a complex suite of hydrocarbon and nitrile species. Hundreds of kilometers above the surface of Titan, Titan's two dominant species, molecular nitrogen and methane, are destroyed by solar ultraviolet photons and electrons energized by Saturn's magnetosphere. The reactive radicals and ions formed from this photodissociation then act as building blocks to form ever larger and more complex species, including several of the C3 hydrocarbons. To date, propane C3H8, propene C3H6, and methylacetylene (CH3CCH) have been detected and measured in Titan's stratosphere.

Methylacetylene has a single isomer – allene, also known as propadiene, with chemical formula CH2CCH2. Unlike the abundant methylacetylene, allene has never been definitively detected on Titan.

A tentative detection was reported in [1] using mid-infrared spectra from the Texas Echelon cross Echelle Spectrograph (TEXES) at the NASA Infrared Telescope Facility (IRTF). At the time of this previous analysis, a spectral line list was not available to properly model the high resolution TEXES observations, which was briefly discussed in the conference proceedings of [1]. A new line list for the molecule was presented in [2] and used to determine updated upper-limits of the molecule from Cassini/Composite Infrared Spectrometer (CIRS) observations.

In this presentation, we report on our recent work making use of the NEMESIS radiative transfer code to model observations of Titan acquired from TEXES at IRTF in July 2017. By using the newly updated allene line list, we have been able to definitively detect the species in Titan's stratosphere for the first time, and confirm its abundance is consistent with previously reported upper limits and model predictions [2, 4].

2. Applications

Work presented in [5] suggest that the relative abundance of allene compared to methylacetylene may act as a probe to the abundance of free hydrogen present on Titan. Constraints on the abundance of hydrogen in Titan's middle atmosphere are crucial to better understand the haze production mechanisms on Titan, and potentially pre-biotic Earth [2].

References

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