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Towards the observation of prebiotic molecules in Titan's atmosphere

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Titan, Saturn's largest moon, hosts a dense nitrogen-methane atmosphere where complex organic chemistry produces molecules of potential prebiotic significance. Photochemical models predict the presence of reactive radical intermediates, such as CH, C₂, and CN, that play crucial roles in forming more complex organic compounds, yet these species remain undetected. Here we present ultra-high-resolution visible spectroscopic observations of Titan obtained with VLT-ESPRESSO during December 2024, targeting these elusive photochemical intermediates. We developed a comprehensive data reduction pipeline to distinguish Titan's intrinsic absorption features and successfully validated the detection of multiple CH₄ absorption bands. We then generated synthetic transmittance spectra for CH, C₂, and CN and performed χ^2 minimisation analyses across varying atmospheric parameters. While we identified spectral regions potentially consistent with absorption of these molecules, the features lacked coherent alignment with modelled band structures and fell within regions dominated by solar and telluric contamination and methane absorption, preventing unambiguous attribution. We conclude that visible wavelengths, though accessible to ESPRESSO's exceptional resolution, are not optimal for detecting these radicals on Titan. Future observations should target infrared wavelengths where rovibrational transitions of most molecular species of atmospheric interest are stronger, less blended with solar features, and more amenable to detection.

Field of Research/Work

Beyond Physics

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