A Study of Very High-Resolution Visible Spectra of Titan: Line Characterisation in Visible CH4 Bands and the Search for C3

Rafael Rianco-Silva (1,2,3), Pedro Machado (1,2), Zita Martins (4), Emmanuel Lellouch (5), Jean-Christophe Loison (6), Michel Dobrijevic (7), Joao A. Dias (1,2) and Jose Ribeiro (1,2)

(1) Instituto de Astrofisica e Ciencias do Espaco, Lisbon, Portugal
(2) Faculty of Sciences of the University of Lisbon, Lisbon, Portugal
(3) University College London, London, United Kingdom
(4) Centro de Quimica Estrutural, Institute of Molecular Sciences and Department of Chemical Engineering, Instituto Superior Tecnico, Universidade de Lisboa, Lisbon, Portugal
(5) LESIA, Observatoire de Paris, PSL Research University, CNRS, Sorbonne Universites, Universite de Paris, France;
(6) Institut des Sciences Moleculaires, CNRS, U.Bordeaux, France
(7) Laboratoire d'Astrophysique de Bordeaux, U.Bordeaux, CNRS, France

The atmosphere of Titan is a unique natural laboratory for the study of atmospheric evolution and photochemistry akin to that of the primitive Earth, with a wide array of complex molecules discovered through infrared and sub-mm spectroscopy. Here, we present the results of the exploration of original, ground-based, very high-resolution visible spectra of Titan, obtained with VLT-UVES. We have developed a new, Doppler-based line detection method which allowed to retrieve an empirical, high resolution (R = 100.000) list of methane absorption lines between 525nm and 618nm, for which no similar line lists are yet available, identifying and characterising more than 90 new high energy CH4 lines.

Furthermore, we searched for the predicted, but previously undetected carbon trimer molecule, C3, on the atmosphere of Titan, at its 405.1 nm band, by comparing VLT-UVES Titan spectra with a line-by-line model spectrum of Titan's atmosphere with C3. Our results are consistent with the presence of C3 at the upper atmosphere of Titan, with a column density of 10^13 cm-2. This study of Titan's atmosphere with very high-resolution visible spectroscopy presents a unique opportunity to observe a planetary target with a CH4-rich atmosphere, from which CH4 optical proprieties can be studied. It also showcases the use of a close planetary target to test new methods for chemical retrieval of minor atmospheric compounds, in preparation for upcoming studies of temperate small exoplanets.