EPSC Abstracts
Vol. 13, EPSC-DPS2019-273-1, 2019
EPSC-DPS Joint Meeting 2019

EPSC
EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

Photoelectrons produced by Far-UV radiation on Titan's aerosols

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Abstract

Titan, the largest moon of Saturn, is surrounded by a permanent thick photochemically-produced haze made of solid organic particles. These nanometer-sized particles spend about one year in suspension, undergoing further physical evolution during their atmospheric journey towards Titan's surface. In the present work we have simulated in the laboratory the emission of photoelectrons by submitting Titan's aerosols analogues to realistic EUV radiations. The aerosols are found to be easily ionized producing photoelectrons close to Titan's surface.

1. Introduction

Since the recent Cassini-Huygens space mission, the organic particles composing Titan's haze are known to be produced at about 1000 km of altitude [1]. Before reaching the surface, the nanometer-sized particles sediment slowly, spending about one year in the atmosphere of Titan [2]. VUV solar radiations are progressively filtered by the atmospheric layers, but the highest wavelengths penetrate atmospheric layers until low altitudes. During their slow descent, particles are therefore permanently exposed to VUV photons. No instrument onboard Cassini-Huygens could inform us on a possible aging of Titan's aerosols under VUV solar irradiation. Such a process was simulated at SOLEIL-synchrotron, submitting analogues of Titan's aerosols to the VUV photons from the DESIRS beamline. We studied the flux of secondary photoelectrons produced by photoionization [3].

2. Methods

Analogues of Titan's aerosols were produced at LATMOS with a plasma reactor simulating the ion-neutral chemistry occurring in Titan's upper atmosphere. The contribution of aerosols to the budget of photoelectrons in Titan's atmosphere was simulated at SOLEIL synchrotron on the DESIRS beamline. A free jet of organic nanoparticles with a mean size of 60 nm was photoionized in the 9 to 11 eV range. Photoelectrons were collected and analyzed in energy by a Velocity Map Imaging spectrometer.

3. Results

Photoelectron spectra of aerosols analogs are shown on Figure 1. The ionization onset appears at a photon energy of 6.0±0.1 eV, well below any free molecules ionization energy. This ionization threshold is consistent with the data of the Permittivity, Waves and Altimetry instrument on board Huygens between 160 and 80 km in Titan's atmosphere [4] [5].

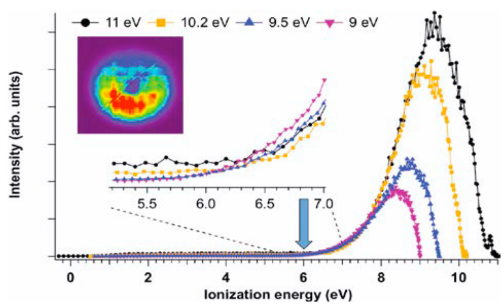

Figure 1: Photoelectron spectra of Titan's aerosol analogs recorded at different photon energies (from 9 to 11 eV). The insert shows a raw photoelectron image exhibiting an asymmetry due to the finite photon penetration length and electron escape depth.

Measured absolute photoionization cross sections increase from $2.4x10^5$ Mb at 9 eV to $1.2x10^6$ Mb at 11 eV, orders of magnitude higher than the ones of standard gas phase molecules. This result combined with a very low ionization threshold make VUV photoionization of aerosols an important phenomenon in the atmosphere of Titan, down the surface where 6 eV radiation can penetrate.

4. Summary and Conclusions

Nanometric haze grains are formed in Titan's upper atmosphere, then slowly dive into deeper layers of the atmosphere. We have shown that they produce a significant amount of photoelectrons even at low altitudes. Since the Titan's haze is abundant, the impact of the photochemical processing into Titan's climate should be taken into account.

Acknowledgements

S.T. is grateful to the Paris Saclay IDEX for providing a thesis grant under the IDI program. N.C. thanks the European Research Council for funding via the ERC PrimChem project (grant agreement No. 636829). We thank J. F. Gil for his technical help around the SAPHIRS platform and to the general technical staff of Synchrotron SOLEIL for running smoothly the facility under projects 99150054 and 99150112.

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