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Polarimetric study of Titan's aerosols during its early northern summer

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1 Introduction

Titan's aerosols result from a complex photochemistry, where the photodissociation of N_2 and CH_4 mostly by solar UV and EUV photons [1, 2] generate photochemical species which react further together until their condensation or the formation of large organic molecules (hazes). Aerosols represent a key ingredient in Titan's atmospheric processes. They have an important radiative effect as they generate an anti-greenhouse effect by absorbing most of the solar flux, while letting the infrared radiation from the surface escape towards space [3]. Their effect on Titan's radiative balance also affects indirectly its atmospheric dynamics, which in return can change the aerosols spatial distribution [4]. Aerosols also affects the production and destruction rates of photochemical species, by absorbing the UV photons involved in the photolysis of these gases [5]. Besides, Titan undergoes seasonal variations of insolation (because of its 26.7° obliquity), which affect significantly the complex balance between radiative, dynamical and chemical processes (e.g. [6, 7]). As aerosols interact with each component of this balance, the characterization of their properties and their spatial distribution at different seasons is a very important step to model and understand Titan's atmosphere.

In this study, we present the first VLT/SPHERE (Spectro-Polarimetric High-contrast Exoplanet REsearch [8]) polarimetric observations of Titan's aerosols in early northern summer, in order to infer their meridional distribution and get insight on their physical and chemical properties.

2 Observations and goals

In August 2018, we performed three half-nights of observations with VLT/SPHERE. As aerosols polarize the light they scatter, polarimetry is particularly sensitive to their presence, and to their geometric (size, shape) and optical properties (refraction index, opacity). That is why we used the polarimetric imaging modes of SPHERE (ZIMPOL and IRDIS) to observe Titan. We imaged Titan, using several broad and narrow-band filters in visible (ZIMPOL) and near-infrared (IRDIS) wavelengths (see fig. 1) in order to study the evolution of the aerosols properties with wavelength. We also take advantage of the spatial resolution offered by VLT/SPHERE (5° in latitude on Titan) to infer meridional variations in the properties and distribution of the aerosols from the variations of polarimetric variables such as the polarized flux (see fig. 2).

As our VLT/SPHERE observations were realised during Titan's northern summer, they can be compared to previous polarimetric measurements, especially those from the Cassini mission which cover northern winter to summer solstice. This will allow us to study the seasonal evolution of the aerosols distribution and properties. These observations will thus bring unique constraints for the radiative, chemical and dynamical models of Titan's atmosphere, and improve our knowledge of its climate.

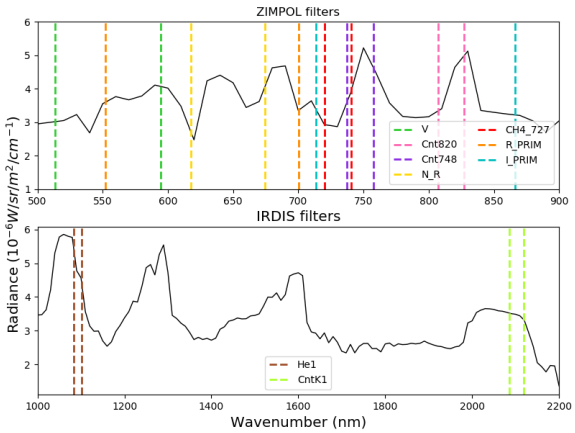

Figure 1: Titan's spectrum (from NASA Planetary Spectrum Generator) and filters used in our VLT/SPHERE observations in visible (ZIMPOL mode) and infrared wavelengths (IRDIS mode).

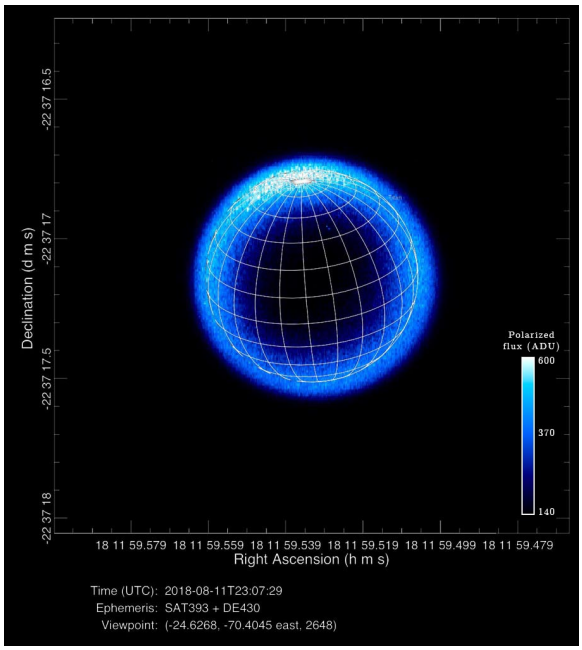

Figure 2: Polarized flux (in ADU) of Titan in the N_R filter (617.5-674.2 nm).

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