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Titan's seas observed in polarized light

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Titan, the enigmatic large moon of Saturn, is the unique satellite of the solar system surrounded by a dense atmosphere. Although a thick and global layers of aerosols is present, with *Cassini* instruments the surface has been observed at some microwave (radar) and infrared wavelengths. These observations have allowed the detection, and the study, of lakes and seas of hydrocarbons, located in polar regions. Up to now, all the published investigations have been based on either radar or infrared (unpolarized) data. In the *Planetary Data System* we have identified pictures of Titan's seas, taken by the *Imaging Science Subsystem* (ISS) camera through polarizing filters. The number of such images is rather limited, but they bring a new type of constrains on surface properties of Titan's seas. In this work, we discuss preliminary results concerning polarized infrared observations of Titan's north seas.

Context

After decades of speculations, and tentative detections with Earth based radiotelescopes, cryogenic seas of liquid hydrocarbons have been discovered in Titan's polar regions [12] by the radar which was aboard the *Cassini* spacecraft. Since then, numerous observations were made in both radar and infrared wavelength domains [see for instance: 13, 11, 1, 2]. For the largest, comparable in size to the Great Lakes of North America, these liquid bodies represents an exciting and unique case of "exo-oceanography". Among other exotic features, some of surface properties may be considered surprising: the occurrence of radar overbrightness event [8, 7, 5] or the mm-level smoothness of this surface [14, 15, 6]. Recently, the existence of a possible floating layer of organic material has been proposed [4].
Beside this, while *Cassini* radar and unpolarized infrared data were extensively investigated, some observations, made with *Imaging Science Subsystem* (ISS) [10] camera with polarizing filters were still untouched. For more than a century, light polarization has been used to characterized the nature of extraterrestrial surfaces: for instance the french astronomer François Arago demonstrated that the Moon has a solid surface and that the Sun is gaseous, employing polarizers. For the solar system small bodies, polarimetric technique is commonly used [9, 3]. Then, data from ISS cameras, combined with polarizers, offer a new opportunity to learn more about the Titan's ocean-atmosphere interface.

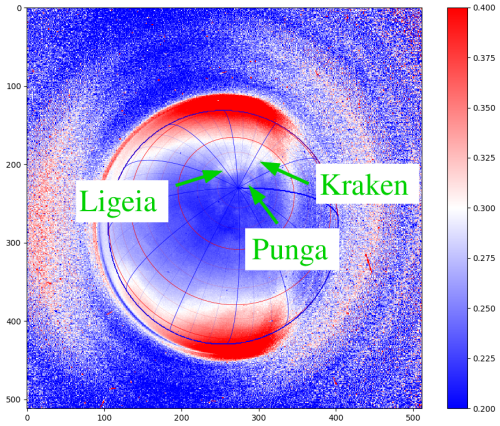

Figure 1: *A map of the degree of linear polarization* $(I_{0^\circ} - I_{90^\circ})/(I_{0^\circ} + I_{90^\circ})$ *derived from ISS data acquired with the wide-angle camera (WAC) using CB3 filter, for which the surface can be seen through the haze. The parallels and meridians were displayed to insure geographic readability. The seas maria Kraken, Ligeia and Punga are clearly distinguishable in the north polar region.*

Observations and interpretation

At the near-infrared wavelength $\lambda = 939$ nm, the atmosphere of Titan is slightly transparent. Then, with the filter `CB3` placed in the optical path of the ISS wide-angle camera (WAC) the surface is visible. In addition, polarizers, corresponding to two different orientations (0° and 90°) are also available (respectively `IRP0` and `IRP90`). Our Fig. 1 is based on two ISS images, each one taken using the `CB3` filter (939 nm) and a polarizer. This figure is a map of the degree of

linear polarization

$$p = \frac{I_{0^\circ} - I_{90^\circ}}{I_{0^\circ} + I_{90^\circ}} \quad (1)$$

as it can be seen, the radiation reflected by Titan's seas appears more polarized than infrared light reflected by surrounding terrains.

In this work, we have developed a model dedicated to the optical properties of Titan's surface, and we try to interpret the difference in degree of linear polarization between seas and nearby dry lands.

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