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# Observing Transneptunian Objects with JWST/NIRSpec

Aurélie Guilbert-Lepoutre (1), Robin Métayer (1), Pierre Ferruit (2), Frédéric Merlin (3), Bryan Holler (4), Nahuel Cabral (5)
(1) LGLTPE, UMR 5276 / CNRS, Universit Claude Bernard Lyon 1, ENS, Villeurbanne, France
(2) ESA, ESTEC, Noordwijk, Netherlands
(3) LESIA-Observatoire de Paris, UMR 8109 / CNRS, UPMC Univ Paris 06, Univ. Denis Diderot, Sorbonne Paris Cite, Meudon, France
(4) STScI, Baltimore, MD, United States
(5) UTINAM, UMR 6213 / CNRS, UBFC, Besancon, France

## 1. Introduction

The transneptunian region has proven to be a valuable probe to test models of the formation and evolution of the solar system. To further advance our current knowledge of these early stages requires an increased knowledge of the physical properties of Transneptunian Objects (TNOs). Colors and albedos have been the best way so far to classify and study the surface properties of a large number TNOs. However, they only provide a limited fraction of the compositional information, required for understanding the physical and chemical processes to which these objects have been exposed since their formation. This can be better achieved by near-infrared (NIR) spectroscopy, since water ice, hydrocarbons, and nitrile compounds display diagnostic absorption bands in this wavelength range. The largest TNOs are bright and thus allow for detailed and reliable spectroscopy: they exhibit complex surface compositions, including water ice, methane, ammonia, and nitrogen. Smaller objects are more difficult to observe even from the largest telescopes in the world. In order to further constrain the inventory of volatiles and organics in the solar system, and understand the physical and chemical evolution of these bodies, high-quality NIR spectra of a larger sample of TNOs need to be observed.

## 2. Prospective observations

In this work we simulate JWST/NIRSpec observations of TNOs using ice mixtures relevant to these objects. From the ground, the variety of chemical compounds present at the surface of TNOs have been detected through the overtones and combination bands of O-H, C-H and N-H bounds up to 2.5 microns. NIRSpec is expected to open a new window into our understanding of TNO surface composition through the identification of their fundamental absorption bands in the 3-5 micron region. We show that for an object with a J-magnitude similar to Orcus' and relatively small exposures, the SNRs achieved for most TNOs' brightness will be sufficient to detect shallow absorption bands corresponding to 5-10% of ice at the surface. We argue that the key aspect to advance our understanding of TNO surface composition will be related to the spectral resolution, which will address the unexpected: molecules we may not anticipate, dilution and ice phases, as well as a detailed investigation of the surface temperature.

## 3. Efficient use of NIRSpec

High-resolution observations will be expensive in time though, even for bright objects like Orcus. We see that the efficiency of NIRSpec observations of solar system moving targets is typically 50-60%. Therefore, achieving a high SNR as well as a high spectral resolution may lead to very long observing programs that may prove difficult to get through a time allocation committee. Alternatives include the use of medium resolution, or slits instead of the IFU. From our simulations, we anticipate that an efficient strategy may be to systematically observe the objects with the PRISM mode in order to get the full spectral coverage in one shot and with a good SNR. This will already allow the disentanglement of most species expected at the surface of TNOs. Then, instead of adding high-spectral resolution observations for the complete wavelength range, observations could be limited to the G395M or G395H gratings (medium- or high-spectral resolution) that cover the key 3-5 micron wavelength range. This combination of spectral configurations appears very promising on paper, for detailed investigations of the physical nature of components present at the surface of TNOs. The NIRSpec GTO program on Orcus and 2003 AZ84 will provide an early, real-life test of this strategy.