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Mapping the surface of the dwarf planet Makemake

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Abstract

Makemake is the third largest dwarf planet (and trans-neptunian object) so far discovered in the Solar System, after Eris and Pluto. However, despite of its large dimensions, previous observations of Makemake have been scarce and sometimes not satisfactory (e.g., due to low S/N), thus it is by far the less investigated object among the largest TNOs. Hence we used the TNG telescope to carry out, for the first time, high S/N visible and near infrared spectroscopy at different rotational phases, in order to assess the surface composition of this body, as well as the presence of the hypothesized inhomogeneities. The obtained data are also important to put constraints on processes like space weathering, cryovolcanism, atmospheric escape, etc..

1. Introduction

The dwarf planet (136472) Makemake (formerly labeled as 2005 FY9) has been discovered in 2005 on an orbit typical for “classical” TNOs, with a semi-major axis of 46 AU. Its diameter has been found to be 1360 < D < 1480 km [1], i.e. it is the third largest trans-neptunian object so far discovered, after Eris and Pluto. The rotational period of Makemake is 7.771 ± 0.003 hr [2]. The surface of Makemake is dominated by methane ice [3, 4]. Interestingly, a shift of the wavelengths of the CH_4 visible bands has been found [5], suggesting a dilution of methane in nitrogen [6]. Ethane and tholins or other organics have been also suggested as components of the surface [7]. The thermal modeling of Makemake, based on data obtained with the Herschel Space Observatory, requires the presence of a two-terrain surface: a limited, low-albedo terrain and an extensive, high-albedo terrain [1]. The former could result from the sublimation of nitrogen and methane in areas of high-insolation, exposing the underlying non-volatile materials.

2. Observations and discussion

We used the TNG telescope to carry out, for the first time ever, high S/N visible/NIR spectroscopy of Makemake at different rotational phases, using the DOLORES instrument (with the LR-R grism) in the visible and the NICS instrument (with the Amici prism) in the near-infrared. We obtained 10 rotationally resolved spectra in the visible and 3 rotationally resolved spectra in the NIR. The data obtained in four different observing nights can be easily related through the known rotational period. All of the data have been reduced and are currently under analysis. Radiative transfer models are used to interpret the complete spectra (0.45 – 2.5 μm), as our group already did for other TNOs based on ESO-VLT data [e.g., 8, 9]. This way, the ice compounds present on the surface, as well as organics like tholins, kerogen, carbons can be firmly detected and quantified. We look for wavelengths shifts in the methane absorptions that would indicate a dilution of CH_4 ice in nitrogen. Since the weaker CH_4 bands are formed on average more deeply within the surface than the cores of the stronger bands are [10], this will allow us to possibly identify different degrees of dilution and/or stratification of methane on Makemake, thereby helping to sort out the processes that could take place on its surface (e.g., cryovolcanic activity or atmospheric freezeout). The high S/N we reached could give us better knowledge and constraints on the space weathering processes occuring on the surface of Makemake. Indeed, the main products from irradiated methane ice, such as ethane and ethylene, could be found. Ethane seems to be present on Pluto for instance [e.g., 11], and its origin is still unknown. Detection of these compounds on Makemake would inform us on its formation processes (formed in a thin and transient atmosphere and/or on the surface?) and give us better constraints on the implication of the space weathering on the surface evolution of this and other atmosphereless bodies.

3. References

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