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Search for water outgassing of (1) Ceres near its perihelion

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Abstract

(1) Ceres is the largest body in the main asteroid belt and one of the most intriguing object since the discovery of water outgassing in the infrared by the Herschel space observatory in 2014. Ceres is the current target of NASA's Dawn spacecraft. Recently, the possible influence of the local flux of solar energetic particles (SEP) on the production of a cerean exosphere and water vapor has been suggested. On the other hand the Herschel, IUE and ground-based observations seem to show a correlation between water vapor emission and Ceres heliocentric distance. We used the opportunity of both the perihelion passage of (1) Ceres in 2018 and the presence of Dawn in its vicinity (for measuring the SEP flux in real time) to check the influence of heliocentric distance on water outgassing. We searched for OH emission lines from the limb of Ceres in the near-UV. Despite a sensitivity level similar to the Herschel observations we did not detect any water outgassing.

1. Introduction

Among the numerous asteroids in the main belt, Ceres is one of the most interesting object. This is due to the fact that it is the largest one (average diameter of 940 km from the Dawn results, it is the only dwarf planet in the main belt) and it presents unusual physical characteristics. The most intriguing of them is the possible water outgassing. This outgassing was first marginally detected with OH emission lines in the near-UV by [1] but not confirmed by [8] with the same lines. Finally water was directly detected through absorption of the continuum from Ceres in an H_2O infrared line by the Herschel satellite [5]. HST observations also searched for the atomic oxygen emission lines but failed, nevertheless, to detect water outgassing [7]. Because the sensitivity of the observations of these different works was similar, it is clear that water outgassing is a transient phenomenon on the surface of Ceres. The possible influence of the local flux of SEP on the apparition of a cerean exosphere and water vapor has also been suggested [10].

Water outgassing is consistent with the expected internal structure of Ceres. This body is differentiated into a silicate core and an icy mantle [4], while hydrated minerals have been found ubiquitous on its surface [6][3] and water ice has also been detected [2]. Its low density, 2.162 ± 0.003 g.cm^{-3} [9], suggests a high content of ice up to 30%, if its porosity is low.

The physical mechanism responsible for water outgassing being unclear, it was the objective of this work to get new observational constraints during the perihelion passage of Ceres in 2018.

2. Observations

Ceres was observed on February 16, 2018 at the European Southern Observatory (ESO) using the 8.2-m UT2/Kueyen telescope of the Very Large Telescope (VLT) with the Ultraviolet and Visual Echelle Spectrograph (UVES) instrument. This instrument is a cross-dispersed echelle spectrograph designed to operate with high efficiency from the atmospheric cut-off at 300 nm to the long wavelength limit of the CCD detectors (about 1100 nm). To this aim, the light beam

from the telescope is split in two arms (UV to Blue, and Visual to Red) within the instrument. Ceres was observed with the Blue arm centered at 346 nm, with a resolving power $\lambda/\Delta\lambda \simeq 15,000$.

The slit was oriented perpendicular to Ceres spin axis, above the northern hemisphere, Ceres being positioned outside the slit with an offset of 6 arcsec with respect to the slit center. The slit width was 3 arcsec. Two spectra were obtained with a similar exposure time of 4815 s. At that time Ceres heliocentric distance was 2.566 au and geocentric distance 1.63 au (Ceres heliocentric distance varying from 2.556 to 2.978 au).

Simultaneously to these VLT observations, the GRaND experiment, onboard the Dawn spacecraft orbiting around Ceres, measured the energetic proton flux near Ceres. Despite a SEP event detected around Earth on February 12 by the NASA Advanced Composition Explorer satellite, GRaND did not measure a significant increase of energetic proton flux near Ceres at the time of our observations. So, if water outgassing on Ceres is due to a SEP event, such an event was not occurring during our observations.

3. Data analysis

The two spectra obtained have been processed in a standard manner (i.e. wavelength and flux calibrated). The two 2D spectra were converted in 1D spectra by co-adding the 38 different lines corresponding to the slit length (38×0.25=9.5 arcsec). We computed a synthetic OH spectrum for the heliocentric distance and velocity of Ceres at the time of observations and searched for these lines in the observational spectra.

No OH lines could be detected directly. We also co-added all the parts of the observational spectra where OH lines were expected, in order to improve the signal-to-noise ratio as much as possible. Once again no OH could be detected.

A first estimate of the upper limit for the OH production rate lead to $Q_{max} \simeq 10^{26}$ molecules.s^{-1}, i.e. the same order of magnitude that the production rate measured by Herschel.

4. Conclusions

From previous observations, water outgassing on Ceres seems to be a transient phenomenon that could be due either to solar heating - as for comets - or to the influence of SEP events. Because of the lack of positive detection during our observations, performed both near perihelion and with no energetic particles hitting the surface of Ceres, this work adds support to the influence of SEP activity for triggering water outgassing. Nevertheless, complementary observations, ideally conducted during such an event, are necessary to reach a definitive conclusion.

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