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Does Ceres have a transient exosphere? New HST observations.

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Abstract

Ceres' exosphere appears to be very elusive. While some observations from Earth-based ground and orbiting telescopes indicate the presence of a water-based exosphere, other observations with similar sensitivity provided only upper-limits. A recent study suggests that a transient exosphere might be generated by solar energetic particle events. We report new observations of Ceres obtained with the Cosmic Origin Spectrograph (COS) of the Hubble Space Telescope (HST) in October 2016 in the search for exospheric emissions near Ceres. As for our previous COS observations of Ceres from 2015, we derive upper limits for oxygen abundances in the 2016 observations and investigate the solar wind conditions at the times of both the 2015 and 2016 observations.

1. Introduction

UV spectra taken by the International Ultraviolet Explorer revealed emission features from the OH A-X (0,0) band at 3085 Å near Ceres presumably resulting from dissociation of water vapor [1]. Global water vapor production rates of 10^{26} molecules/s were estimated from the measured OH brightness. Ground-based spectra with higher sensitivity taken in 2007 did not detect OH, constraining the production to $<7\times10^{25}$ molecules/s during the time of the observations [2]. Recently, water vapor was detected around Ceres by Herschel through absorption with a production rate of at least 10^{26} molecules/s [3], similar to the rate from the IUE detection.

1.1 Dawn mission

Shortly after the arrival of the Dawn mission at Ceres, bursts of energetic electrons were measured by the Gamma Ray and Neutron Detector (GRaND) and interpreted as signs for a bow shock [4]. These events are transient and might originate from a transient exosphere, which could be generated by a high flux of protons that was measured by GRaND before the electron bursts. Based on this finding, Villareal et al. [5] investigated the solar wind proton fluxes during the previous observations of Ceres' environment and found a positive correlation of high fluxes with exosphere detections.

2. HST observations 2015 & 2016

We observed Ceres at far ultraviolet (FUV) wavelengths using COS during two five-orbit visits by the Hubble Space Telescope on 26 August 2015 and on 26 October 2016. During the first visit in 2015, COS pointed at Ceres measuring sun light reflected off the surface as well as potential emissions from an exosphere. After subtraction of the surface-reflected light, no significant exospheric emissions were detected (Figure 1). The results from the first visit provided upper limits on the oxygen emission and were related to upper limit on an atomic oxygen column density of $(8.2 \pm 13.4) \times 10^{10}$ cm^{-2} [6]. Assuming that oxygen is produced by photodissociation of H_2O, we derive a conservative upper limit for the water production rate of 4×10^{26} molecules/s.

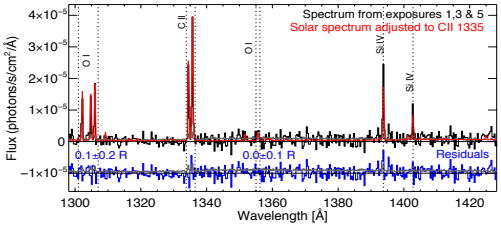

Figure 1: COS spectrum of Ceres UV emissions from 2015 providing upper limit on O abundance [6].

At the time of the first observations, the solar wind conditions indicate a very quiet period with low ion

fluxes through all energy channels of the ACE EPAM instrument (Figure 2). The non-detection of an exosphere during such quiet conditions is consistent with the presence of transient exosphere during high fluxes proposed by Villareal et al. [5].

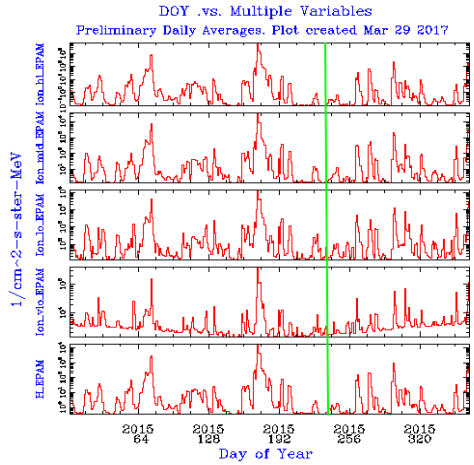

Figure 2: ACE EPAM solar wind ion and proton fluxes measured in 2015 around the HST/COS observation on 26 August (green vertical line).

During the 2016 visit, COS pointed to a region ~0.5 arcsec away from Ceres in order to search for exospheric emissions in absence of surface-reflected light. No significant emissions were measured in this region during the second HST visit either. We will compare the derived upper limits to the solar wind conditions for the 2016 observations and further investigate the consistency of our results with the theory of Villareal et al. [5].

3. Summary and Conclusions

We report HST/COS observations of Ceres taken on two occasions in 2015 and 2016, which provide independent constraints on the presence of an exosphere around the dwarf planet. No exospheric emissions were detected in the observations and upper limits on oxygen and water abundances are derived. The solar wind ion flux during the 2015 observations was particularly low and possibly insufficient for generating a detectable exosphere.

Acknowledgements

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