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Search for Water Vapour Emission from DAWN target (1) Ceres with HERSCHEL

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Abstract

Asteroid (1) Ceres may contain substantial amounts of water ice in its crust. Even a small fraction of water ice on Ceres' surface would produce measurable amount of water vapour. Past searches for a water exosphere through observations of the dissociation product OH led to inconclusive results. We are using the Heterodyne Instrument for the Far Infrared (HIFI) onboard Herschel to search for water vapour emission and absorption. A first observation close to Ceres' aphelion did not result in water detection, leading to an upper limit of about 10^{26} s^{-1}. A second observation closer to perihelion will be performed end of 2012 or early 2013. In addition, we will report on the search for absorption features from water vapour and organic molecules in spectra taken with Herschel's Photodetector Array Camera and Spectrometer (PACS).

1. Introduction

Dwarf planet (1) Ceres is a C-type asteroid [1], associated with the primitive hydrated carbonaceous chondrite CI and CM types. Thermo-physical-chemical models of the evolution of its interior have predicted the possible presence of an ice-rich crust and even liquid water in its interior, with possible polar ice caps [2-5].

Disk-resolved imaging and spectroscopy of Ceres have revealed a surface covered by albedo markings [6-8]. Because water ice is not stable at Ceres' heliocentric distance (2.55 – 2.98 AU), the most sensitive measurement of the presence of (sub-)surface water ice is the search for water vapour or its dissociation products around the asteroid.

In the early 1990s, a marginal (3 sigma) detection of near-ultraviolet OH emission band at 308 nm was indeed reported [9], but could not be confirmed by a later, more sensitive search for the same line [10]. We will present new observations constraining the water production rate of Ceres.

2. Observations

Ceres was observed with the Heterodyne Instrument for the Far Infrared (HIFI) on-board Herschel on 23 Nov. 2011 in the context of the Herschel Asteroid and Comet Observation guaranteed time program "MACH 11". The heliocentric and observer distance were 2.94 AU and 2.51 AU, respectively. The water ground state line at 557 GHz was searched for in a 1.1 hour integration. While the thermal continuum from Ceres was detected, no line emission or absorption was found. Additional upper limits of water absorption will be derived from a far infrared spectral range scan of Ceres with the Photodetector Array Camera and Spectrometer (PACS) on Herschel that took place in July 2011 and from further PACS observations taken for Herschel calibration. In addition, the PACS spectra are searched for absorptions by silicates and organic molecules.

3. Results and Discussion

We model the water line with a "standard" cometary sublimation and radiative transfer model [11], but extending it to include the absorption of the continuum and Ceres' gravity (the escape velocity of Ceres of 0.52 km/s is of the same order as the expansion velocity of cometary water). The corresponding upper limit on the water production rate is about 10^{26} s^{-1} using conservative assumptions about the source distribution and the expansion velocity. This implies that the surface fraction covered by water ice is limited to a maximum of order 10^{-7}, consistent with the non-detection by [6-8].

If Ceres crust indeed contains large amounts of water ice, it must be covered by a thick dust layer.
A deeper search for water vapour on Ceres will be performed by Herschel in winter 2012/2013, closer to perihelion. Notably, both the measurements in [10] and the present observations were performed at larger heliocentric distance than the tentative detection by [9]. If the different measurements are indicative of a strongly varying activity of Ceres, there is a good chance of detection in the upcoming observation. The question of the presence of water ice on Ceres may by finally answered in 2015 when it will be encountered by the DAWN spacecraft.

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