Localized sources of water vapour on the dwarf planet (1) Ceres

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We report the detection of water vapour on (1) Ceres, the first unambiguous discovery of water on an object in the asteroid main belt. Most of the water vapour stems from localized regions at low latitude, possibly from surface features known from adaptive-optics observations. We suggest either cometary-type sublimation from the near surface or cryovolcanism as the origin of the waver vapour [1].

The snowline conventionally divides Solar System objects into dry bodies, ranging out to the main asteroid belt, and icy bodies beyond the belt. Recently, the detection of dust emission from "main-belt comets" [2] and of hydration features and possible water ice absorption on some main-belt asteroids [3], together with theories of migration of small bodies in the solar system [4], cast some doubts on the classical picture.

Ceres is thought to be differentiated into an icy core and a silicate mantle [5] and hydrated minerals were found on infrared spectra of its surface [6]. A marginal detection of OH, a photodissociation product of water was reported in 1991 [7], but questioned by later, more sensitive observations [8]. We observed Ceres with the Heterodyne Instrument for the Far Infrared (HIFI) [9] on the Herschel Space Observatory [10] in the context of the MACH 11 guaranteed time program and with a follow-up DDT program. The observations took place in Nov. 2011, Oct. 2012, and March 2013. We searched for the signature of water in the ground state line of ortho-water at 556.936 GHz. After a non- detection in the first observation, an absorption line is clearly visible in all other observations. In March 2013, water is detected in emission as well (at 3 sigma level). The production rate of water on Ceres is a few times 10^{26} s^{-1}.

The signal from the water vapour from Ceres was found to be linearly polarized during some of the observations, with the absorption being stronger in the horizontal branch. The measured line-area ratio of up to 2.5 between H and V polarizations is so far unexplained.

The water signal varies on timescales of hours. We interpret this variation as localized sources on Ceres surface rotating into and out of the hemisphere visible for Herschel. The time variability is consistent with those sources being dark features known from ground-based adaptive-optics observations [11].

The water vapour on Ceres may be either produced by near-surface ice heated by sunlight (cometary activity) or by cryovolcanoes or geysers getting their energy from the Ceres interior. In the first case, the production rate is expected to peak around perihelion, while for volcanic activity the time variations are expected to be more stochastic. The existing observations appear consistent with the cometary hypothesis, but do not allow to clearly distinguish between those possibilities. Upon its arrival at Ceres in 2015, the Dawn spacecraft [12] may provide insight into the sources and mechanisms of water production at Ceres.

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