The source of H$_2$O in Jupiter's stratosphere: comet Shoemaker-Levy 9

In July 1994, the Shoemaker-Levy 9 (SL9) comet « String of Pearls » hit Jupiter at 44°S. These impacts deposited material in the atmosphere of the planet (Lellouch et al. 1995). The detection of H$_2$O by ISO by Feuchtgruber et al. (1997) in the Jovian stratosphere raised the question whether this H$_2$O originated from SL9.

With Herschel and its unprecedented spectral resolution (HIFI) and spatial resolution (PACS), ISO, SWAS and Odin observations have only brought tentative clues regarding a cometary origin of H$_2$O in Jupiter's stratosphere (Cavalié et al. 2008, 2012).

The « pre-Herschel » picture at Jupiter and Saturn

What is observed today is a remnant of the oxygen delivery by the SL9 comet at 44°S in July 1994.

H$_2$O at Titan: interplanetary dust particles or Enceladus geysers?

Moreno et al. (2012) have used a combination observations of three unresolved H$_2$O rotational lines at 66.4, 75.4 and 108.0 µm with PACS, and two spectrally-resolved transitions at 557 GHz (538 µm) and 1097 GHz (273 µm) with HIFI, to infer the vertical profile of H$_2$O over the Titan stratosphere.

H$_2$O is in the stratosphere above the tropospheric cold trap (H$_2$O seen in emission)

ISO, SWAS and Odin observations have only brought tentative clues regarding a cometary origin of H$_2$O in Jupiter's stratosphere (Lellouch et al. 2002; Cavalié et al. 2008, 2012).

The origin of external oxygen in Jupiter and Saturn's environments

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With Herschel and its unprecedented spectral resolution (HIFI) and spatial resolution (PACS) at H$_2$O rotational frequencies, Cavalié et al. (2013) have demonstrated that the spatial distribution of water in Jupiter's stratosphere is clear evidence that a recent comet, i.e., the Shoemaker-Levy 9 comet, is the principal source of water in Jupiter's stratosphere (Lellouch et al. 2002; Cavalié et al. 2008, 2012).

The measured H$_2$O column density of ~4x10$^{15}$ cm$^{-2}$ in the equatorial plane, along with estimations made on the H$_2$O flux from the torus to Saturn's atmosphere, indicate that Enceladus is thus the likely source of Saturn's external H$_2$O (Hartogh et al. 2011). An additional confirmation could be provided by the latitudinal distribution of H$_2$O on Saturn.

References


The origin of external oxygen in Jupiter and Saturn's environments

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Detection of the Enceladus torus at Saturn

Cryovolcanic activity at the south pole of Enceladus produces spectacular geysers, mainly composed of H$_2$O vapor and ice particles. The emitted molecules form a torus around Saturn, at Enceladus orbital distance. Hartogh et al. (2011) have detected this H$_2$O vapor torus with Herschel, by observing the 557, 987, 1113 and 1670 GHz H$_2$O lines with HIFI.

The H$_2$O geysers of Enceladus

The H$_2$O torus of Enceladus, located between Saturn and Herschel, is observed in absorption on Saturn’s emission spectrum!

The measured H$_2$O column density of ~4x10$^{15}$ cm$^{-2}$ in the equatorial plane, along with estimations made on the H$_2$O flux from the torus to Saturn's atmosphere, indicate that Enceladus is thus the likely source of Saturn's external H$_2$O (Hartogh et al. 2011). An additional confirmation could be provided by the latitudinal distribution of H$_2$O on Saturn.

Conclusion

The current picture at Jupiter and Saturn + Titan

Both interplanetary dust particles and Enceladus’ activity appear to provide sufficient supply for the current Titan H$_2$O. Enceladus is tentatively favored as potentially more prone to time variability (Moreno et al. 2012).

