Water vapor in space

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An image of the Orion nebula in the infrared as seen by the IRAC camera on the Spitzer Space Telescope (taken during the extended, warm mission). Credit: NASA and Spitzer

(PhysOrg.com) -- Water is a critical molecule for human life, and,

because it is abundant in the interstellar medium, it also plays an important role in the life of molecular clouds and the stars and planets that form in them.

Radiation from water vapor helps to cool a collapsing cloud of material, allowing it to dissipate heat and thereby shrink until a new star can develop. Water ice acts as a glue on dust grains, helping them coagulate into planetesimals and then, it is thought, into planets. Liquid water transports molecules on planetary surfaces where they can facilitate complex chemistry.

For all these reasons, astronomers are actively looking for water in the cosmos. However, water vapor in the Earth's atmosphere blocks most of the radiation from cosmic water from reaching ground-based observatories; space missions offer much more powerful platforms for investigation. In 1998, a NASA team led by CfA astronomers launched a space mission to study water in space -- the Submillimeter Wave Astronomy Satellite (SWAS). SWAS found water nearly everywhere it looked, but also found a puzzle: there was less of it (in relation to other molecules) than had been expected. In a series of papers over the past decade, the SWAS scientists analyzed and probed the data, concluding that considerable amounts of water are frozen out onto the surfaces of cold grains of dust.

Writing in this month's Astrophysical Journal, CfA astronomers and SWAS team leaders Gary Melnick and Volker Tolls, along with two previous members of the CfA SWAS community and four colleagues, published their summary conclusions from a study of water over a very large area of the sky. They mapped water vapor along a ridge of warm material in the Orion nebula nearly eighteen light-years in length. The Orion ridge is associated with the closest region of massive star formation to the Earth, a complex that has long been a key site for astronomers investigating how stars form, which physical processes are

at work, and what chemistry takes place in the cloud. The Orion ridge also offers the advantage of being viewed from Earth face-on, with the side facing us illuminated by bright young stars.

The astronomers report in this comprehensive and detailed study that most of the water vapor originates near the surface of the cloud, and that it does not extend into the cloud by more than about one hundredth of a light-year, probably because it turns into ice. This result is in conspicuous disagreement with theoretical predictions from the last decade, but is consistent with the team's earlier conclusions. It explains why the total abundance estimates of water had been too low. The analysis also helps to resolve what happens when radiation from hot stars impinges on the surface of a molecular cloud.

Provided by Harvard-Smithsonian Center for Astrophysics

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