Pin-pointing water in space

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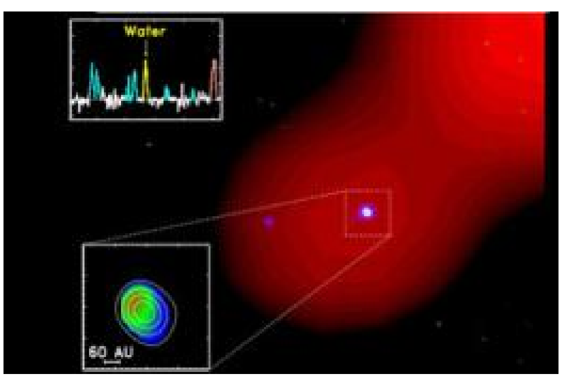
Artist's impression of the young Star NGC 1333 IRAS4B. Scientists assume that planets form in the surrounding disk. For the first time they were now able to detect large amounts of water in this disk. Image: NASA/JPL-Caltech/R. Hurt (SSC)

(PhysOrg.com) -- Water is regarded as a key ingredient for life - and water exists plenty in the universe. Now scientists have found the precious element in a disk around a young star, similar to our Sun. This disk, supposedly the birth place for future planets, contains a hundred times more water than all oceans on Earth. The astronomical observations obtained with the IRAM interferometer appear very promising with regard to solving the mystery around the origin of water in our solar system (*The Astrophysical Journal*, February 10, 2010).

Most of the water in the Earth's oceans likely originated in a tenuous cloud between the stars, which collapsed to form our solar system. Exactly where the water was produced and how the molecules made their way from this giant cloud to a tiny planet like Earth some 4.5 billion years ago is one of the key questions in the study of our origins.

While astronomers cannot turn back the clock to observe our own young solar system, they can study planetary systems in formation around other nearby young stars. The IRAM Interferometer on the Plateau de Bure in the French Alps has pinpointed for the first time the location of the bulk of the hot water vapour in the rotating disk around a very young star, analogue to our Sun.

Because of obscuration by the large amounts of water in our own atmosphere, astronomical observations of normal water ($H_2{}^{16}O$) require satellites such as the recently launched Herschel Space Observatory. However, about 1 in 500 water molecules in space contain the heavier ^{18}O isotope. Some signatures from this heavier water ($H_2{}^{18}O$) are able to penetrate the Earth's atmosphere and reach the IRAM telescopes. Since telescopes on Earth are much larger and see a hundred times sharper than any existing satellites, this allows astronomers to zoom in on the forming stars and determine the location of water.



Radio image obtained with the IRAM interferometer: Top left the spectral fingerprint of water can be clearly discerned. Bottom left, the distribution of water in the disk around the young star NGC 1333 IRAS4B is shown. Image: Ewine van Dishoeck/Jes Jørgensen

The astronomers Ewine van Dishoeck from the Max Planck Institute for Extraterrestrial Physics in Garching and Leiden Observatory, and Jes Jørgensen from the University of Bonn and the Centre for Star and Planet Formation in Copenhagen, used the IRAM Plateau de Bure interferometer to look for heavy water ($H_2{}^{18}O$) around a young star, NGC 1333 IRAS4B that formed only 10,000 - 50,000 years ago. The astronomers found that most of the steam around the young star is located within the inner 25 Astronomical Units of the rotating disk. This distance corresponds approximately to the orbit of Neptune in our own solar system (1 AU is the distance Earth-Sun, about 150 million kilometres).

Previous observations of this protostar had suggested that water vapour is pouring down from the cloud and accretes onto the disk. The IRAM data show that the amount of water actually in the disk is a factor of hundred larger than in any such shocks - about 100 times more than the content of Earth's oceans.

'The water is likely located in a hot layer just above the disk midplane, where most of the available oxygen is driven into water by chemical reactions,' says Ewine van Dishoeck. 'We now know that most water enters the disk in the form of ice around dust grains from the cold collapsing cloud, and that these "icy mantles" evaporate in the higher temperatures close to the young star.'

'These observations of water vapour have opened up a whole new avenue to study water in young solar systems, complementary to that possible with satellites,' explains Jes Jørgensen, lead author of the paper. 'Only the IRAM Plateau de Bure Interferometer is currently able to catch and image these very weak signals of the water isotopologue. Moreover, the long wavelengths at which the Plateau operates allow us to see much deeper into the disk and we can thereby study the physical and chemical processes that control the early evolution of these disks that may set the stages for the eventual formation of planets.'

Over the next three years, the Herschel Space Observatory will survey normal water in many star-forming clouds in our own and other galaxies. Combined with similar ground-based observations, astronomers will be able to determine exactly how much water is located where and at which stage of the evolution of a young star. "The combined access to the powerful IRAM telescopes and the Herschel-PACS instrument makes the Max Planck Institute for Extraterrestrial Physics a unique environment to carry out such comprehensive studies of water in young solar systems", says Ewine van Dishoeck.

More information: Jes K. Jorgensen, Ewine F. van Dishoeck, Water Vapor in the Inner 25 AU of a Young Disk around a Low-Mass Protostar, The Astrophysical Journal, February 10, 2010. arxiv.org/abs/1001.1532

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