Report

Water - its significance in science, in nature and culture, in world religions and in the universe

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Publication Date:
2011

Permanent Link:
https://doi.org/10.3929/ethz-a-006399956

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10. Water in the Solar System and in the Universe
10.1 Our Solar System

The Solar System - 1

Inner Planets (right: from left to right): Mercury, Venus, Earth with Moon, and Mars

Asteroid belt: Large number of small spots located between Mars and Jupiter

Outer Planets (left: from left to right): (Pluto), Neptune, Uranus, Saturn, and Jupiter
The Solar System along center row of possible zones of varying size stars. The blue zone indicates the habitable zone.

The earth is located in the habitable zone of the solar system; if it were about 5% or about 8 million kilometers closer to or further from the sun, the conditions which allow the three forms of water to be present simultaneously (liquid, solid, and gaseous) would be far less likely to exist.
10.2 Water on the Sun!

The Sun God Apollo

Head of the Sun god Apollo

Apollo, the Sun god, brings life—giving heat and light to Earth
Water vapour on the Sun spots Umbra!

Sun with sunspots: the mean temperature of the surface of the Sun is about 5'500 °C.

In the sunspots (Umbra) the temperature is “only” about 3000 to 3500 °C. In such “oasis”, water vapour can survive in a highly excited state without decomposition.

Detection with Infrared spectroscopy and Computer-simulations

Water on the Sun: Experiments and Theory

• Experimental: observation of the emission spectrum of the sun
• In this experiment also the water vapour of the atmosphere is an inevitably observed complication!
• But in the infrared spectrum of atmospheric water vapor there exist “windows” which allow the observation of the spectrum of the umbras.
• A careful experimental and theoretical analysis clearly demonstrates the existence of water vapor in the Umbras, but the water molecules are thermally highly excited: “hot molecules”; these hot molecules give rise to a much more complicated infrared spectrum than that known from the “cold molecules” on the Earth.
• The infrared spectrum of the water vapor of the Umbras are compared with very hot water prepared on the Earth and good agreement is obtained!
• The theoretical analysis of the IR—spectrum of “hot water molecules” is extremely complicated (quantum mechanics, coupling of electronic and atomic motions, relativistic treatment of electrons...).
10.3 The inner Solar System

- The planets Mercury, Venus, Earth, and Mars belong to the terrestrial or “rocky” planets.

- They are characterized by a relative clearly defined interface between their surfaces and their atmospheres.

- Compared to the outer planets, they are very small.

The God Mercury

Mercury: Herald of the Roman Empire and the Ambassador of Roman Gods
Water and Ice on the Mercury?

- Since the planet Mercury is closest to the Sun, its highest temperature can rise up to 430 °C, its lowest temperature can, however, be as low as -170 °C.
- One would therefore assume that the existence of water–ice is relatively improbable.

Space flight pictures from Mariner 10 show, however, many craters and suggest the presence of ice in deep craters.

Radar – signals taken from the earth (left) show red spots: strong radar signals
- eventually from water–ice in craters.

Yellow, green and blue areas: progressively weaker reflections.
- small amounts of water–ice in these areas

Birth of the Goddess Venus

Sandro Botticelli (about 1486)

Venus (meaning “Love” or “sexual desire” in Latin) was a major Goddess principally associated with love, beauty and fertility. From the third century BC, the increasing Hellenization of Roman upper classes identified her as the equivalent of the Greek Goddess Aphrodite (see p. 458).
No water on the Venus!

View to the CO$_2$ atmosphere of the Venus

Venus, the goddess of Love

View onto the hemisphere of Venus across the clouds (Magellan-mission)

Today, Venus has no water! In the past there existed eventually oceans, which evaporated due to the enrichment of CO$_2$ in the atmosphere. It is believed that this was the consequence of a self-enhancing greenhouse effect.

Michelangelo: Godfather

Creator of the Earth and of Water
Aphrodite: Goddess of Love and Beauty

Robert Fowler (1853 – 1926)

Gaia: The Goddess of the Earth

Gaia, the mother of Earth: Her suffering expression reflects the tortured Earth.
The Goddess

In the beginning, before the world was created, God was wandering around through the nothingness trying to find something. He had almost given up hope and was dead tired when suddenly he came to a big shed. He knocked. A Goddess opened the door and asked him to come in.

She said she was just busy working on Creation but he should take a seat for a while and watch what she was doing. At the moment she was planting various water plants in an aquarium.

God was astonished at what he saw. He would never have come up with the idea of creating a substance like water. It is precisely this, the Goddess said smilingly, that was, so to speak, the basis of life.

After a while God asked if perhaps he could help a bit and the Goddess said she would be very grateful if he could take the water and the things she had created so far to one of the planets that she had set up a little further in the back. She would like to start with the least significant one as a test.

So God began to deliver the Goddess’ creations one after the other from her shed to the Earth, and it is not a surprise that later, people on this planet knew only about the God who had brought it all and who they assumed was the actual creator of all.

Of the Goddess who had thought it all up, however, they knew nothing, and therefore it’s high time she gets mentioned.

Franz Hohler
translated from „Die blau Amsel“
The Dry – Land Hemisphere is defined as that part of the Globe which contains the largest part of land. It contains Europe, Africa, North–America and Greenland as well as about 95 % of Asia and two thirds of South America. From the total surface of the Dry – Land Hemisphere, 53 % is covered by water and 47 % by land. Note that from the global surface, 29 % is Dry - Land and 71 % is Water.

The Water – Hemisphere constitutes that part of the Globe which contains the largest water content. Its center is located in the Pacific near New Zealand. From the continents and there land areas it contains only Australia, the Antarctic and some per cents of Asia. The surface of the Water – Hemisphere is covered by 89 % of water and by 11 % of dry – land.

Poseidon (greek) or Neptun (roman):
God of Water or the Sea
The Moon of our Earth

Comparision of Earth and Moon

<table>
<thead>
<tr>
<th>Earth</th>
<th>Moon</th>
</tr>
</thead>
<tbody>
<tr>
<td>12,742</td>
<td>3,476</td>
</tr>
<tr>
<td>5.974 \times 10^{24}</td>
<td>7.349 \times 10^{22}</td>
</tr>
<tr>
<td>9.78</td>
<td>1.62</td>
</tr>
<tr>
<td>Diameter (km)</td>
<td>Mass (g)</td>
</tr>
</tbody>
</table>

Why could water have been present on the Moon?

Answer: for the same reason as on the Earth: by Impacts of Comets and asteroids about 4 billions years ago.

But: the gravitation on the Moon is much smaller than on the Earth → Most of the water vapour can not be attracted → Evaporation into space!
Apollo space crafts of NASA (1968–1972) confirm that the surface of the Moon has suffered a large number of impacts of comets and asteroids.

Apollo and Lunar Prospector Moon travels

Observation of H$_2$, but no water has been found until very recently! (see p. 467)

The humid layer on the Moon!

A continuous current of hydrogen ions H$^+$ could be the source of the water on the Moon.

Several space crafts have discovered water at the surface of the Moon. The H$_2$O–molecules are found in a very thin layer at the surface. (NZZ: September 2009).
In October 2009, NASA deliberately crashed its LCROSS experiment on the south pole of the Moon, creating two impact craters. One of them was caused by the spent Centaurus rocket stage that the LCROSS instrument was carrying, while the second was made by the $78 million spacecraft itself, as it fell to its demise while snapping photos of the Centaurus impact site.

An artist’s conception shows the LCROSS probe of NASA, observing the crash of its Centaur upper stage into the Lunar surface.

Water absorption bands on the Moon discovered!

Data from the down-looking near-infrared spectrometer of the Lunar Crater Observation and Sensor Satellite (LCROSS).

The red curve shows how the spectra would look for a „grey“ or „colourless“ warm (230 °C) dust cloud. The yellow areas indicate the water absorption bands.
Mars – The Roman God of War

Mars in readiness of battle

Mars in full speed towards war

Water – Ice on the North – Pole of Mars

Discovered by “European Space Agency” (ESA) (July 28, 2005)

The diameter of the crater is about 35 km and its maximum depth is about 2 km. The circular blue area in the centre is residual water–ice!

It has been possible to prove that the blue area is not composed of CO\textsubscript{2} (dry ice).
10.4 The Outer Solar System

General Remarks to the outer Solar System

• The “Outer Solar System” contains the giant planets Jupiter, Saturn, Uranus and Neptun. Since the discovery of the Kuiper belt (Gürtel), the outermost parts of the Solar System are considered a distinct region consisting of the objects beyond Neptun.

• The giant planets possess a liquid or metallic core. The largest part of their mass consists, however, of Hydrogen and Helium with traces of Water vapor and other gases. Therefore, they are referred to as “gas giants”.

• In contrast to the “rocky” planets, the “gas giants” do not have a well-defined surface; their atmospheres gradually increase by approaching their cores. They are possibly interspersed by liquid or even solid matter.

• Uranus and Neptun form a separate class of “gas giants”; they are often called “ice giants”, since they contain often large quantities of ice and water vapor at very high pressures. It is speculated that they contain super–ionic or even metallic ice.
Jupiter, Father of the Gods

In Greek mythology: Zeus

The interior of Jupiter

- 10,000 km below $\text{H}_2$ layer: $P \approx 1\text{,000,000 atm}$, $T \approx 6000 \text{ K}$!
- Liquid and metallic hydrogen: $\text{H} \rightarrow$ protons and electrons
- Electric currents produce very strong magnetic fields!
- Within nucleus: glowing water-ice at extremely high pressures and temperatures.

$\text{NH}_3$
$\text{CH}_4$
$\text{H}_2$
$\text{H}_2\text{O}$

Ice - nucleus
Water on Jupiter and its ring system

- NASA 2000: The atmosphere contains methane (CH₄), ammonia (NH₃), and water vapor. Condensation of water vapor → clouds, rain, thunderstorms! There exist dry and humid areas.

Jupiter’s Jovian ring system

- showing four main components.
- This ring system is faint and consists mainly on dust and rocks.
- It comprises mainly four components:
  - a thick inner torus known as “halow ring”
  - a relatively bright “main ring”
  - two wide, thick and faint outer rings, called “gossamer rings.”

Running red rings around Jupiter

- Jupiter’s rings are darker and appear as fine particles or rocks.
- The six pictures at the right were taken in infrared light from the Infrared Telescope Facility in 1994, and cover a time span of two hours.
- The origin of Jupiter’s rings remains unknown.

Wolfgang Amadeus Mozart (1756 - 1791)

- Fourth movement (Molto allegro) of the Jupiter Symphony, KV 551

primary theme:

10 – 17
**The Jupiter Moon Europe**

Photo of a small part of the ice–crust (70 km x 30 km) of the Conamara-region of Jupiter’s Moon Europe, taken with the space probe Galileo.

Note the ruptures in the ice crust; they can be produced by several plausible reasons.

Interior of Jupiter’s Moon Europe, based on several independent observations.

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**Saturn with Ice-Ring – System - 1**

Pictures taken from the spacecraft Telescope Hubble: The planet with his rings has been viewed from different angles (2001).

Saturn is composed of about 75% hydrogen and 25% helium.

The rings of Saturn seem to be composed primarily of water–ice but they may also include rocky particles with ice coatings. The water–ice particles are swirling due to the gravitational field of the planet. Therefore, they can not condense to a moon.
Saturn with ring – system - 2

- Discovered by Galileo (1610)!
- Visits by: NASA's Pioneer 11 (1979), Voyager 1 and 2. Cassini approached Saturn in 2004 and is still circling around it.
- As Jupiter, Saturn is a “giant-gas”-planet with a similar atmosphere (75% H\textsubscript{2} und 25% He).
- The interior of Saturn has the same structure as Jupiter: a glowing nucleus of H\textsubscript{2}O-ice, liquid and metallic H\textsubscript{2} and H\textsubscript{2}-gas.

Saturn: God of Harvest and Time

Saturn: (Caravaggio in 16th Century)
Uranus is the earlier Greek god of the sky.

Neptune is the Roman god of the Oceans; in Greek mythology, Poseidon.

The diameter of Neptune is 49,248 km (smaller than Uranus). Its colour is blue–green, which is due to methane in its atmosphere. For an orbit around the sun it takes about 165 years. The interior of Neptune is similar to that of Uranus: a rocky nucleus, covered by an ice layer, a mantel containing water, methane, and ammonia, followed by a thick atmosphere.

As Uranus, but in contrast to Jupiter and Saturn, Neptune consists probably on clearly distinguishable layers. Its surface temperature is -218°C. Neptune seems to possess an internal heat source. The velocity of the wind can reach values up to 2,000 km/h, which is due to the inner heat source just mentioned. This is the highest velocity of wind in the solar system.
Possible internal structure of Neptune and Uranus (*)

“Gas” : molecular hydrogen (H₂) and helium (He) as well as methan (CH₄)

“Ice” : hot ice (glowing !) mixed with H₂ and CH₄ at very high temperatures (about 1700 °C) and at very high pressures (10 GPa = 100’000 atm)

“Rock” : rocks and ice at about 7’700 °C and at pressures of 800 GPa = 8 millions atm (!)

(*) Uranus and Neptune have a very similar structure and and are often referred to as “giant - ice” - planets.

Superionic conducting water in Neptune and Uranus ??

The extreme conditions that exist deep within Uranus and Neptun could be ideal for water in the superionic state in which the molecules have been broken into oxygen and hydrogen ions (*)

In fact, the results from computer models strongly suggest that a layer of (solid) superionic water should extend out to about halfway to the surface (red area). The simulations assume temperatures up to 6000 °C at pressures of 7 millions atm (**).

The observed curious magnetic fields of Uranus and Neptun are consistent with nearby patches of the surface of liquid ionic water (brown area) having fields of opposite polarity .

(*) The Physics of Superionic Conductors is outlined in detail by P. Brüesch (see Ref. R.10.4.15).

(**) The Computer models have been studied by a team led by Ronald Redmer at the University of Rostock (References R.10.4.13 and R.10.4.14).
Pluto, Greek god of wealth (ninth planet from the Sun).

Modern astronomers have abolished God Pluto from his base!

Reason: it has been realized, that Pluto has to be considered as a "dwarf planet"; in addition it became clear that there exist many similar planets having the same size and structure.
10.5 Extra – Solar Water

L’Univers populaire: Camille Flammarion, Wood engraving, Paris 1888 (*)
(*) A composition (“Montage”) of C. Flammarion for his art work
“L’Astronomie populaire“, created 1880.
Our Milky - Way Galaxy

The observable Universe contains 100 - 400 billions (100 – 400 * 10^9) of Galaxies similar to that of our Milky Way system shown in this Figure. One light year (ly) is equal to 9.46 * 10^{12} km! The age of the oldest known star is about 13.2 billion years (13.2 * 10^9 years).

Our Milky Way is a stellar disk - 1

Diameter :
about 10^5 light years 
(9.5 * 10^{17} km)

thickness :
about 10^3 light years
(9.5 * 10^{15} km)

age :
about 13.6 billions of years
(13.6 * 10^9 years)

number of stars :
about 300 billions
(300 * 10^9 stars)
Our Milky–Way Galaxy

The Milky–Way Galaxy is a vanishingly small part of the Universe; its dimension is of the order of about 100,000 light years.

The Figure at p. 490 shows the shape and the dimension of the Milky–Way System: a spiral–shaped Galaxy containing at least 200 billions of stars.

Our Sun is deeply hidden in the Orion–Arm, the distance of which is about 26,000 light years from the galactic center.

Approaching the center of the Galaxy, the density of Stars is much larger as in the vicinity of our Sun.

In the Figure of p. 490 we can observe the existence of small spherical star–clusters as well as the presence of a dwarf–Galaxy, the so–called Sagittarius dwarf, which is slowly swallowed by our Galaxy.

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The diske–shaped Milky–Way Galaxy - 2

Edwin Hubble studied Galaxies and classified them into various types of elliptical, lenticular, and spiral Galaxies. The spiral Galaxies were characterized by disc shapes with spiral arms as shown in Figures 489 and 490 for the example of the Milky Way System.

[An elliptical Galaxy is a Galaxy having an approximately ellipsoidal shape and a smooth, nearly featureless brightness profile. They range in shape from nearly spherical to highly flattened. A lenticular Galaxy is a type of Galaxy which is intermediate between an elliptical Galaxy and a spiral Galaxy.]
The Milky Way , or simply the Galaxy , is the Galaxy in which our Solar System is located. It is a barred spiral Galaxy that is part of the Local Group of Galaxies. It is one of billions of Galaxies in the observed Universe.

The stellar disk of the Milky Way (s. pp 489, 490 and 492) is approximately 100'000 light-years (ly) \( (9.5 \times 10^{17} \text{ km}) \) in diameter, and is considered to be, on average, about 1'000 (ly) \( (9.5 \times 10^{13} \text{ km}) \) thick. It is estimated to contain at least 200 billion of stars and possibly up to 400 billion stars, the exact figure depending on the number of very low-mass stars, which is highly uncertain.

As a guide to the relative physical scale of the Milky Way, if it were reduced to 10 m in diameter, our Solar System, including the Oort cloud (spherical cloud of Comets), would be no more than 0.1 mm in width! This is a factor of 100'000 (!).

By including the estimated age of the stars in the globular cluster (about 13.4 billion years), the age of the oldest stars in the Milky System has been estimated to about 13.6 billion years. Based upon this newest scientific result, the Galactic thin disk is estimated to have been formed between 6.5 and 10.1 billion years ago.

The galactic disk, which bulges outward at the galactic center, has a diameter between 70'000 and 100'000 ly. The distance from our Sun to the galactic center is now estimated at 26'000 1400 ly.

The galactic center harbors a compact object of very large mass as determined by the motion of material around the center. The intense radio source named Sagittarius A*, thought to mark the center of the Milky Way, is newly confirmed to be a supermassive black hole. Most Galaxies are believed to have a supermassive black hole at their center.

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**The Effelsberg - and the Green Bank Radio Telescope**

Radio Telescope Effelsberg (Germany)  
Putting into operation: 1972  
Mirror diameter: 100 m  
Focal length: 30 m

Green Bank Telescope: GRT – Telescope (West – Virginia, USA)  
Putting into operation: 2001  
Mirror: 100 x 110 m  
The aperture is not blocked by the excentrically arranged detector!
The Hubble – Space Telescope (HST) is a Telescope, which circles around the Earth in an altitude of 590 km within 97 minutes. The operation of a Telescope outside the Earth's atmosphere is a big advantage since no filtering action for specific wavelengths of the electromagnetic spectrum, i.e. in the UV and IR range, is necessary.

In 1789, Frederick William Herschel constructed a Telescope with a mirror diameter of 126 cm and a focal length of 12 m. At May 14, 2009, the William Herschel Telescope, named to honor of Herschel, has been startet into space. Herschel will reach the so called second Lagrange-Point at a distance of 1.5 millions km from the Earth. Synchronously with the Earth, it will then circle around the sun. All the three perturbations arising from the Sun, the Moon, and the Earth, are approximately in line as viewed from the Lagrange-Point and are therefore hidden by a „sun shad“. Herschel can therefore observe under conditions free from perturbing temperature- and radiation conditions which originate from the Sun, the Earth, and the Moon.

The Herschel Telescope observes the emission of the extremely cold objects of the Galaxies in the wavelength range between the far infrared (FIR) and the sub-millimeter range (60 to 570 microns). With observations reaching deeply into space, it is aimed to explore the formation and development of the Galaxies since the beginning of the Universe. It is the aim of scientists to explore the physical and chemical properties of interstellar space, thereby gaining new insight into the formation of stars which have been formed from molecular clouds.

With the help of the Herschel Telescope it is possible to observe water molecules at very low temperatures – between 10 and 20 degrees Kelvin (−263 bis −253 °C). (In this temperature range, no photons in the optical region can be observed.).
The emission (or absorption lines) characteristic of water vapor can be identified if the observation of an object yields at least the three fundamental vibrations of the \( \text{H}_2\text{O} \) molecule (s. Chapter 2, pp 37 and 64). Besides molecular hydrogen (\( \text{H}_2 \)) and carbon oxide (\( \text{CO} \)), water (\( \text{H}_2\text{O} \)) is one of the most important and most stable molecules in the Universe. Due to the disturbing water vapor of the atmosphere of the Earth, water vapor in the Universe cannot be directly observed. With the aid of the Space Telescope Herschel, however (p. 496), it is now possible for the first time to observe water in the Universe and to explore its genesis and its implications for the formation of the planets.

Water plays an important role for the energy balance of stars since it regulates the temperature and cools down the stars. The existence and properties of water could also be responsible for the formation of heavy-mass and low-mass planets. This is because water plays an important role for the accumulation of matter during the formation of planets (accretion = growth of a massive object by gravitationally attracting more matter, typically gaseous matter). On the other hand, dust grains are surrounded by ice layers, thereby limiting the coagulation to larger boulders.

Remark: The Telescope of the next Generation is in the planning stage: the “European Extremely Large Telescope (E-ELT)”; its main mirror will have a diameter of 42 meters which is composed on 900 hexagonal mirror elements. Its construction will probably be started at 2011 and is expected to come to completion in 2020.

Observation of extrasolar Water

Observations of Comets such as for example Hale–Bopp, have shown that its water–ice contains many organic compounds.

Many scientists believe that in its earliest stage our Earth was hot, dry and sterile.

Therefore, it is possible that the origin of terrestrial life goes back to the complex organic molecules which have been formed in the “icy hart” of interstellar clouds.

Comet Hale–Bop and terrestrial Life

The Hale–Bopp Comet

From the 3 \( \mu \text{m} \) absorption band of water it follows that the comet looses water–ice by sublimation.
The Comet Hartley 2

The NASA spacecraft „Deep Impact“ has passed the Comet Hartley at November 4 2010. The photograph shows one of the most closest observed pictures.

The length of the comet corresponds to the distance between the Capital building and the Washington Monument in Washington.

The small Comet consists of a mixture of ice, rockets and dust.

NASA has photographed the Comet Hartley 2 from different directions and from a distance of about 700 km.

At the time when spacecraft „Deep Impact“ passed Hartley 2, the distance to the Earth was about 21 million km.

The Water - Planet HD 189733b in front of his Sun

Using the Spitzer Space Telescope, it has been possible to detect water vapor in the atmosphere of the gas-giant HD 189733b. An article about these findings has been published in „Nature“.

The planet studied circles around a Sun in the constellation of „Vulpera“, the distance of which is 63 light years from the Earth. The gas-giant is somewhat larger than Jupiter, but it is moving about 30 times closer around his Sun than the Earth, and for this reason it is extremely hot.

Based on the Spitzer – Telescope from NASA, an international Team of astronomers have been able to analyze in detail the wavelengths of the Sun light which have been absorbed by the atmosphere of the Planet. By analyzing the absorption spectrum in the infrared region, they found the signature of Water, i.e. the absorption lines of Water vapor.

Parts of the atmosphere are very hot - about 2000 °C. Therefore, the Water molecules are highly excited producing an extremely complicated vibrational and translational spectrum, a spectrum which is much more complicated than that shown in the Figure of pp 37, 64. The complication is due to the extremely strong anharmonic vibrations and the strong coupling between vibrational and rotational motions.
The dwarf star Gliese is approximately at a distance of 33 light-years from the Earth. Stellar models from the Star give an estimated size of about 42% of the Sun's radius and predicts a temperature of about 3300 K.

The star is orbited by the planet designed Gliese 436b (at the left of the Figure). The planet has an orbital period of 2.8 Earth days and transits the Star as viewed from Earth. It has a mass of 22.2 times the Earth's mass.

The planet is thought to be largely composed of hot ices with an outer envelope of hydrogen and helium (see p. 484) and is termed a „hot Neptun“.

Scale comparison of the relative size of the Earth and the Water-Planet Gliese 436 b.

Mass: $132.6 \times 10^{24}$ kg ($\approx 22.2$ times the mass of the Earth).

Orbital period about its Sun Gliese 436: 2.8 Earth days.

Based on its width, the mass and the proximity from its Star Gliese 436, the planet 436 b is now thought to be made mostly of hot, pressurized water ice in exotic forms (ices VII and X, see pp 48, 49: 55 - 56).

The composition of the atmosphere (yellow ring) is uncertain but may contain hydrogen, helium and water vapor.

The Figure shows the cross-section of the proposed structure and composition of Planet Gliese 436 b.

When the radius became better known, ice alone was not enough to account for the composition of the Planet. Another layer of hydrogen and helium up to 10% in mass would be needed on top of the ice. It has been suggested that this might even obviate the need for an ice core: alternatively, the planet may be a super-earth.
Astronomers have found the most distant signs of water in the Universe to date. According to Dr. Violetta Impellizzeri et al. from the University of Bonn, water has been found in a distance of 11.1 billion light-years from the Earth. However, because the Universe has expanded like a inflating balloon in the time, stretching out the distances between points, the Galaxy in which the water was detected is about 19.8 billion light-years away. The water emission is seen as a MASER, where molecules in the gas amplify and emit beams of microwave radiation in much the same way as a LASER emits beams of light. (MASER stands for Microwave Amplification by Stimulated Emission of Radiation).

The water vapour is thought to be contained in a jet ejected from a supermassive black hole at the centre of a Galaxy, named MG J0414+0534. The faint MASER signal is only detectable by using a technique called gravitational lensing, where the gravity of a massive Galaxy in the foreground acts as a cosmic telescope, bending and magnifying light from the distant Galaxy to make a clover-leaf (Kleeblatt) pattern of our images of MG J0414+0534. The spectrum of water vapour (s. p. 504) has been observed with the Radio–Telescope Effelsberg.
Astronomers have found the most distant Water yet seen in the Universe, in a Galaxy more than 11 billion light-years from Earth. Previously, the most distant Water had been seen in a Galaxy less than 7 billion light-years from the Earth.

The spectrum shown in the Figure at p. 504 is a “fingerprint” that revealed radio emission from Water Masers in the distant Quasar MG J0414+0534. The background image is an infrared image of the Quasar, made with the Hubble Space Telescope. The Quasar appears broken up into four components by a foreground Galaxy (diffuse object in the center), acting as gravitational lens and strengthening the signal by a factor 35. The inset with the Galaxy M87 shows how the Quasar might be seen from nearby.

The soggy Galaxy, dubbed MG J0414+0534, harbors a Quasar - a supermassive black hole powering bright emission - at its core. In the region near the core, the Water molecules are acting as Masers, the radio equivalent of Lasers, to amplify radio waves at a specific frequency.

The astronomers say their discovery indicates that such giant Water Masers were more common in the early Universe than they are today. MG J0414+0534 is seen as it was when the Universe was roughly one-sixth of its current age.

At the Galaxy's great distance, even the strengthening of the radio wave done by the Maser would not by itself have made them strong enough to detect with the radio telescope. However, the scientists got help from nature in the form of another Galaxy, nearly 8 billion light-years away, located directly in the line of sight from MG J0414+0534 to Earth. That foreground Galaxy's gravity served as a lens to further brighten the more-distant Galaxy and make the emission from Water molecules visible to the radio telescope.

The detection of water from MG J0414+0534 with the Effelsberg radio telescope also occurred to a touch of fortune. The object is within just the right redshift interval (Doppler shift) to stretch the line emission of the H$_2$O molecule from the original 22 GHz to 6 GHz and so within the tuning range of the 6 GHz receiver installed in the Telescope.

The Eagle Nebula in the Serpent Constellation

The „Eagle Nebula“ belong to the Serpent Constellation or „Serpens Clouds“.

The Eagle Nebula constitute a young and open cluster of Stars in the constellation Serpens.

The distance from the Earth is about 23 billions light-years.
Aliens need Water desperately, too!!

Believe it or believe it not: "Extended theoretical and practical investigations have revealed that extraterrestrial aliens are also heavily dependent on water and use to drink at least three gallons per day!!"  
(Text and Picture composed from P. Brüesch)
10. Water in the Solar System and in the Universe

10.1 Our Solar System (general)

R.10.1.1 THE SOLAR SYSTEM
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R.10.1.8 p. 447: Habitable zone in the solar system
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10.2 Water on the Sun

R.10.2.1 WATER ON THE SUN: THE SUN YIELDS MORE SECRETS TO SPECTROSCOPY
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R.10.13 p. 485: Superionic Water of Uranus and Neptune - New Scientist, 4 September 2010, p. 15

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10.5 Extra Solar System

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p. 212: It is estimated that in about 1.2 Billion years all water at the Earth will have
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Most distant detection of water in the Universe

Wasser in 11.1 Milliarden Lichtjahre Entfernung wurde entdeckt!
(Dr. Violetta Impellizeri et al., Universität Bonn)
http://www.spiegel.de/wissenschaft/weltall/0,1518,597100,00.html

Water detected in Quasar MG J0414+0534
www.raumfahrer.net/forum/smf/index.php?topic=526.15

Most distant Water in the Universe – Text to Figure at p. 497

Eagle Nebula
from: Eagle Nebula ➔ Bilder „thereisfuninmypocket.blockspot.com“ ➔ („God’s penis“)

Water in the Universe
Arnold Hanslmeier
Springer Netherlands (2010)
ISBN 9048199832

Das Schicksal des Universums:
„Eine Reise vom Anfang zum Ende“
Günter Hasinger
Wilhem Goldmann Verlag, München
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Aliens need Water desperately, too!
Picture composed by P. Brüesch from:
Figure at the left: www.topnews.in/aliens-do-exist-us-govt-hides-
Figure at the right: Internet search for: female aliens
merveser.blogspot.com/