Celestial Water

Module 14 • i2P • H2O Tour

"Life, for ever dying to be born afresh, for ever young and eager, will presently stand upon this earth as upon a footstool, and stretch out its realm amidst the stars."

- H. G. Wells, The Outline of History, 1920.

Space Aliens

Is there life in space? Long a subject of debate, this question has been defined in popular culture by claims that the Earth has been visited by extraterrestrial beings. Grainy photographs of disk shaped objects upheld as evidence that 'alien space ships' have visited our planet. Many maintain these photos are fraudulent and in no way support the existence of extraterrestrial life.

Stepping away from the domain of UFO's and space aliens however, the question of whether life can be supported beyond the Earth's environment is a serious question. To address this question, one approach taken by scientists is to establish whether there is water in space; the premise being that without water there can be no life.

Imagine an Earth free of water. With no water there would be no lakes. Ray and Kevin (presuming that they could still exist without water!) would have just run the length of the

Figure 1: Ray Zahab on Lake Baikal. Standing atop 20% of the world's liquid fresh water. (source: Kevin Vallely i2P).

deepest continental hole in the world. The seven hundred kilometer long depression - all that's left of an empty Lake Baikal - would make for a long, thirsty and barren trip, with a great deal of climbing.

The Big Water

But there is water on Earth and it fills the world's biggest continental depression to the brim, forming the worlds biggest lake. Ray and Kevin (themselves effectively two bags of water) passed over top on a thin crust of ice, below their feet the lake plunges to over a mile in depth. It's a depression that holds roughly 20% of all liquid surface water on the Earth (see: Lake Baikal).

> Did You Know?
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> Water in liquid form does not exist in space because of temperature and pressure conditions.

Lake Baikal straddles the intersection of three tectonic plates. These plate are slowly pulling apart, causing the gradual expansion of the lake. The continual shifting of these plates causes frequent earthquakes in the region. From the joints between the tectonic plates thermal vents feed the floor of Lake Baikal, promoting the circulation of water. Water warmed by the thermal vents rises, displacing cooler water to the bottom of the lake. The steady circulation of water also carries a rich supply of oxygen from the surface to the depths of the lake.

The oxygen rich waters of Lake Baikal help make it home to more unique species of life than any other lake in the world (Lake Baikal). Among the animals found in the lake is the Nerpa, a freshwater seal that can dive up to 1000 meters in depth and stay underwater without coming up for air for over an hour. The Nerpa often feeds on the remarkable golomyankas (Baikal oil fish). Golomyankas, the most plentiful fish in the lake, are famous for disintegrating into a pool of oil and bones when exposed to sunlight. All of these creatures enjoy remarkably clear waters that allow people to peer down 130 feet from the surface. The clarity of the water is a byproduct of a huge population of small crayfish

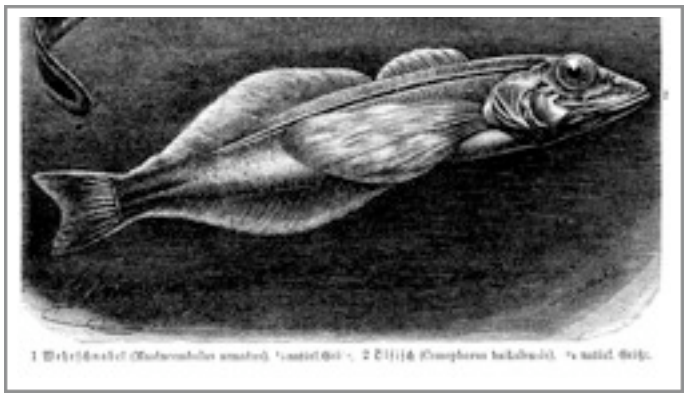

Figure 2: A Golomyankas - Baikal Oil Fish. They disintegrate into a pool of oil and bones when exposed to sunlight (source: Wikimedia Commons)

(*baikal epishura*) that filter out algae and other particulate matter as part of their diet, rendering the lake crystal clear.

Did You Know?

New research, based on data collected by three previous lunar missions, suggests that there may be water on the moon. Some hope there is enough water to support a permanent manned colony. Such a colony would allow scientists to conduct extensive, first-hand research on the moon and could serve as a launching pad for more distant explorations.

see: Moon colony

Origins

What is the origin of the water that fills lake Baikal? Tracing the origin of water on Earth leads one back to the creation of the universe. Scientific evidence demonstrates that the universe is expanding. Many authorities agree that this expansion is the consequence of a massive explosion that led to the creation of the universe, and that the matter created in this explosion continues to be propelled outward. According to the theory the four lightest atoms, hydrogen, helium, lithium and beryllium were created in the Big Bang (see: big bang) Following the explosion, matter was scattered in all directions, gradually coalescing into stars and solar systems. The intense heat of stars - which are basically balls of burning hydrogen - causes the formation of more complex atoms, including oxygen.

Element	Rank
Hydrogen	1
Helium	2
Oxygen	3
Carbon	4
Neon	5
Iron	6
Nitrogen	7
Silicon	8
Magnesium	9
Sulfur	10

Table 1: List of most abundant elements in the universe by order of elemental mass.

Until recently, water on Earth was thought to have arisen from hydrogen and oxygen produced by the core of the planet as it cooled following the creation of the solar system 4.5 billion years ago (see: core water). Although this theory has not been fully discredited, new studies have lead to a startling new theory that the water on Earth came from space.

Hydrogen is the most common element in the universe, constituting about 90% of the universe's total elements (75% of the elemental mass of the universe). Oxygen is the third most common element. Thus water is the byproduct of the 1st and 3rd most common atoms in the universe. Hydrogen - thought to have been produced by the Big Bang - exists freely in deep space. Oxygen is produced by the intense heat of stars and thrown out into space by solar explosions and supernovas. Researchers have now established that the oxygen launched into space by solar explosions combines with hydrogen to form great clouds of cold water in deep space. These clouds of water however are almost exclusively

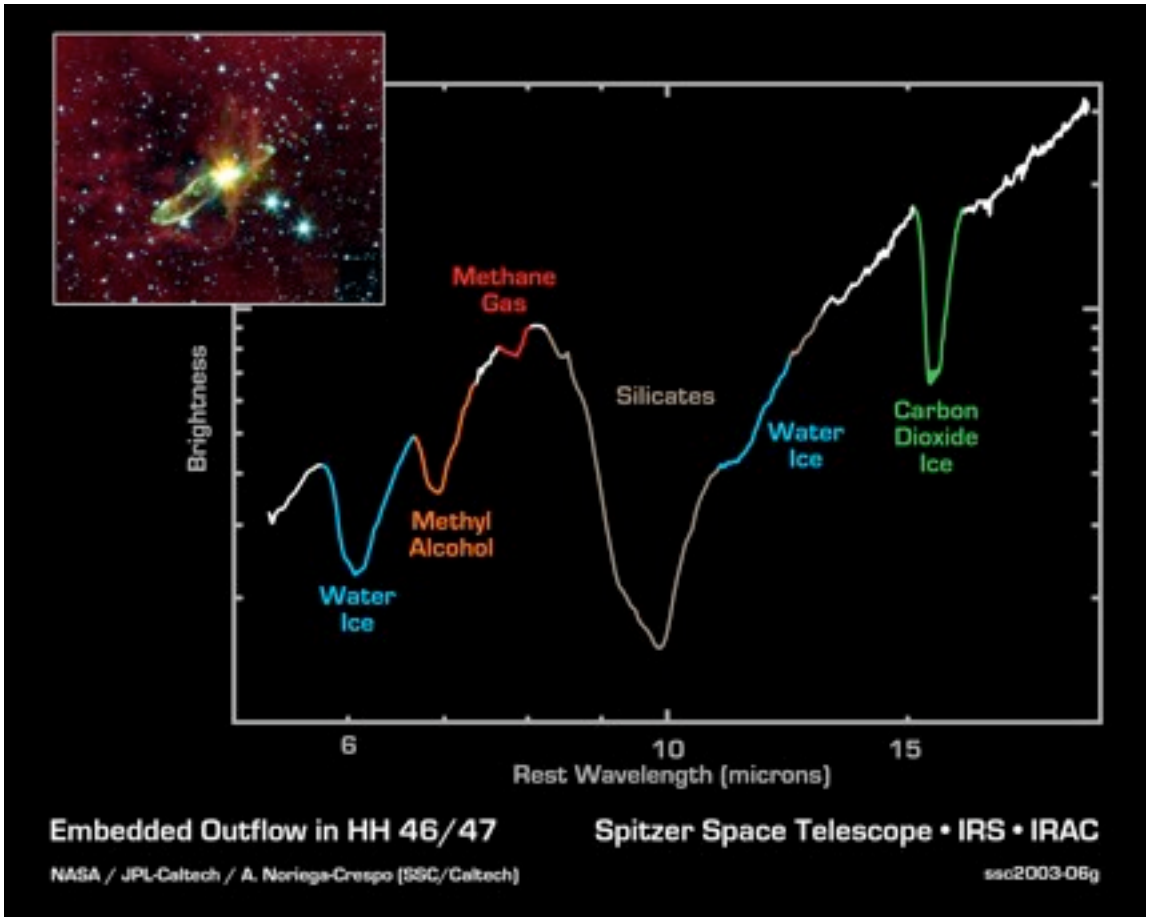

Figure 3: NASA's Spitzer Space Telescope is used to detect water, as well as other molecules in deep space (source: NASA).

in the form of tiny ice crystals (see: cold clouds).

Water is found throughout the universe. As of 2007 the most distant water observed in the universe is in a galaxy more than 11 billion light years from Earth (see: distant water). Water has also been found on the moon, and on many of the planets in our solar system. It has been established that comets are principally composed of frozen water. In short the universe is rich in water.

Student Exercise

Calculate how long in years it would take you to reach water in a galaxy 11 billion light years away if you were traveling 100 kilometers an hour.

Note: A light-year is a unit of length, equal to just under 10 trillion kilometers (i.e. 10^{16} meters). As defined by the International Astronomical Union (IAU), a light-year is the distance that light travels in a vacuum in one year.

How then has water been delivered from space to the Earth? The belief is that over the course of the 4.5 billion years of the

Earth's existence comets, meteorites and other water containing space debris have collided with Earth, gradually building up the planet's water stores (see: space water). Although the water introduced by space debris is in the form of ice the temperature and atmospheric conditions on Earth allow for the existence of liquid water.

Thus we can definitively affirm that there is water with the potential to support life found throughout the universe. However there is a problem: virtually all the water found beyond the Earth's atmosphere is in the form of ice. The great cold clouds of outer space water are 99% ice and 1% gaseous form (see: ice clouds). In fact virtually no liquid water has been located in space. Recall it is liquid water, not water in general that is essential for life.

Did You Know?

On March 22, 1998, a stony meteorite landed in Monahans, Texas, about 40 feet from where seven boys were playing basketball. The boys picked up the 2.7 pound stone while it was still warm and called police. Within 72 hours, it was under the watchful eyes of NASA scientists at the Johnson Space Center. Two days and numerous tests later, scientists cracked open the gray rock and found blue and purple halite, a salt crystal similar to table salt. The crystals were up to three millimeters in diameter, the largest halite crystals ever seen by scientists in any extraterrestrial material. Inside the blue crystals was an even bigger surprise—small droplets of water. Scientific analysis confirmed the presence of water inside the crystals. The crystals, turned blue and purple by radiation, are estimated to be as old as the Earth's solar system. (see: meteor)

Figure : Photo of the comet Hale-Bopp taken in the vicinity of Pazin in Istria/Croatia in 1997. Comets are principally composed of ice (source: Philipp Salzgeber)

Consequently efforts have turned to finding a planet with the correct atmospheric conditions to support liquid water. Such a planet would need to have an orbit that is not too close or too far from its star so that its surface temperature would rest between zero and 100 degrees Celsius (see: special planet). Thus far no such planet has been identified.

Is there life in space? Although we are not yet able to answer this

question, it now seems probable that the water that supports life on Earth first arrived as a visitor from outer space.

Did You Know?

Comets are essentially large, dirty snowballs.