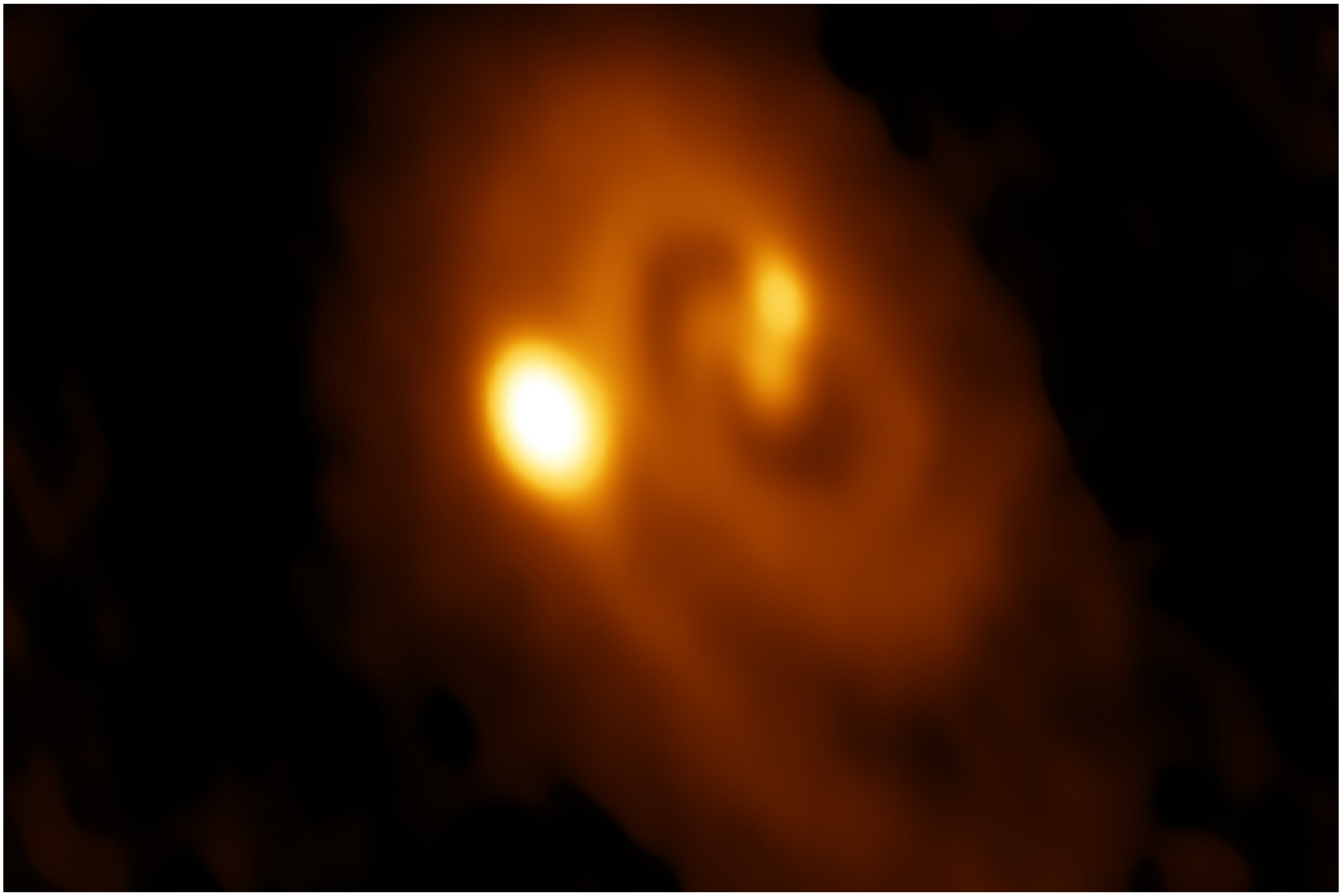
Space News Update

— June 16, 2017 —

Contents

1. New Evidence that all Stars are born in Pairs



Did our sun have a twin when it was born 4.5 billion years ago?

Almost certainly yes—though not an identical twin. And so did every other sunlike star in the universe, according to a new analysis by a theoretical physicist from UC Berkeley and a radio astronomer from the Smithsonian Astrophysical Observatory at Harvard University.

Many stars have companions, including our nearest neighbor, Alpha Centauri, a triplet system. Astronomers have long sought an explanation. Are binary and triplet star systems born that way? Did one star capture another? Do binary stars sometimes split up and become single stars?

Astronomers have even searched for a companion to our sun, a star dubbed Nemesis because it was supposed to have kicked an asteroid into Earth's orbit that collided with our planet and exterminated the dinosaurs. It has never been found.

The new assertion is based on a radio survey of a giant molecular cloud filled with recently formed stars in the constellation Perseus, and a mathematical model that can explain the Perseus observations only if all sunlike stars are born with a companion.

"We are saying, yes, there probably was a Nemesis, a long time ago," said co-author Steven Stahler, a UC Berkeley research astronomer.

"We ran a series of statistical models to see if we could account for the relative populations of young single stars and binaries of all separations in the Perseus molecular cloud, and the only model that could reproduce the data was one in which all stars form initially as wide binaries. These systems then either shrink or break apart within a million years."

In this study, "wide" means that the two stars are separated by more than 500 astronomical units, or AU, where one astronomical unit is the average distance between the sun and Earth (93 million miles). A wide binary companion to our sun would have been 17 times farther from the sun than its most distant planet today, Neptune.

Based on this model, the sun's sibling most likely escaped and mixed with all the other stars in our region of the Milky Way galaxy, never to be seen again.

"The idea that many stars form with a companion has been suggested before, but the question is: how many?" said first author Sarah Sadavoy, a NASA Hubble fellow at the Smithsonian Astrophysical Observatory. "Based on our simple model, we say that nearly all stars form with a companion. The Perseus cloud is generally considered a typical low-mass star-forming region, but our model needs to be checked in other clouds."

The idea that all stars are born in a litter has implications beyond star formation, including the very origins of galaxies, Stahler said.

Stahler and Sadavoy posted their findings in April on the arXiv server. Their paper has been accepted for publication in the Monthly Notices of the Royal Astronomical Society.

Stars birthed in 'dense cores'

Astronomers have speculated about the origins of binary and multiple star systems for hundreds of years, and in recent years have created computer simulations of collapsing masses of gas to understand how they condense under gravity into stars. They have also simulated the interaction of many young stars recently freed from their gas clouds. Several years ago, one such computer simulation by Pavel Kroupa of the University of Bonn led him to conclude that all stars are born as binaries.

Yet direct evidence from observations has been scarce. As astronomers look at younger and younger stars, they find a greater proportion of binaries, but why is still a mystery.

"The key here is that no one looked before in a systematic way at the relation of real young stars to the clouds that spawn them," Stahler said. "Our work is a step forward in understanding both how binaries form and also the role that binaries play in early stellar evolution. We now believe that most stars, which are quite similar to our own sun, form as binaries. I think we have the strongest evidence to date for such an assertion."

According to Stahler, astronomers have known for several decades that stars are born inside egg-shaped cocoons called dense cores, which are sprinkled throughout immense clouds of cold, molecular hydrogen that are the nurseries for young stars. Through an optical telescope, these clouds look like holes in the starry sky, because the dust accompanying the gas blocks light from both the stars forming inside and the stars behind. The clouds can, however, be probed by radio telescopes, since the cold dust grains in them emit at these radio wavelengths, and radio waves are not blocked by the dust.

The Perseus molecular cloud is one such stellar nursery, about 600 light-years from Earth and about 50 light-years long. Last year, a team of astronomers completed a survey that used the Very Large Array, a collection of radio dishes in New Mexico, to look at star formation inside the cloud. Called VANDAM, it was the first complete survey of all young stars in a molecular cloud, that is, stars less than about 4 million years old, including both single and mulitple stars down to separations of about 15 astronomical units. This captured all multiple stars with a separation of more than about the radius of Uranus' orbit—19 AU—in our solar system.

Stahler heard about the survey after approaching Sadavoy, a member of the VANDAM team, and asking for her help in observing young stars inside dense cores. The VANDAM survey produced a census of all Class 0 stars – those less than about 500,000 years old – and Class I stars – those between about 500,000 and 1 million years old. Both types of stars are so young that they are not yet burning hydrogen to produce energy.

Sadavoy took the results from VANDAM and combined them with additional observations that reveal the egg-shaped cocoons around the young stars. These additional observations come from the Gould Belt Survey with SCUBA-2 on the James Clerk Maxwell Telescope in Hawaii. By combining these two data sets, Sadavoy was able to produce a robust census of the binary and single-star populations in Perseus, turning up 55 young stars in 24 multiple-star systems, all but five of them binary, and 45 single-star systems.

Using these data, Sadavoy and Stahler discovered that all of the widely separated binary systems—those with stars separated by more than 500 AU—were very young systems, containing two Class 0 stars. These systems also tended to be aligned with the long axis of the egg-shaped dense core. The slightly older Class I binary stars were closer together, many separated by about 200 AU, and showed no tendency to align along the egg's axis.

"This has not been seen before or tested, and is super interesting," Sadavoy said. "We don't yet know quite what it means, but it isn't random and must say something about the way wide binaries form."

Egg-shaped cores collapse into two centers

Stahler and Sadavoy mathematically modeled various scenarios to explain this distribution of stars, assuming typical formation, breakup and orbital shrinking times. They concluded that the only way to explain the observations is to assume that all stars of masses around that of the sun start off as wide Class 0 binaries in egg-shaped dense cores, after which some 60 percent split up over time. The rest shrink to form tight binaries.

"As the egg contracts, the densest part of the egg will be toward the middle, and that forms two concentrations of density along the middle axis," he said. "These centers of higher density at some point collapse in on themselves because of their self-gravity to form Class 0 stars."

"Within our picture, single low-mass, sunlike stars are not primordial," Stahler added. "They are the result of the breakup of binaries. "

Their theory implies that each dense core, which typically comprises a few solar masses, converts twice as much material into stars as was previously thought.

Stahler said that he has been asking radio astronomers to compare dense cores with their embedded young stars for more than 20 years, in order to test theories of binary star formation. The new data and model are a start, he says, but more work needs to be done to understand the physics behind the rule.

Such studies may come along soon, because the capabilities of a now-upgraded VLA and the ALMA telescope in Chile, plus the SCUBA-2 survey in Hawaii, "are finally giving us the data and statistics we need. This is going to change our understanding of dense cores and the embedded stars within them," Sadavoy said.

Source: Phys.org Return to Contents

2. MAVEN's top 10 discoveries at Mars

On June 17, NASA's MAVEN (Mars Atmosphere and Volatile Evolution Mission) will celebrate 1,000 Earth days in orbit around the Red Planet. Since its launch in November 2013 and its orbit insertion in September 2014, MAVEN has been exploring the upper atmosphere of Mars. MAVEN is bringing insight to how the sun stripped Mars of most of its atmosphere, turning a planet once possibly habitable to microbial life into a barren desert world.

"MAVEN has made tremendous discoveries about the Mars upper atmosphere and how it interacts with the sun and the solar wind," said Bruce Jakosky, MAVEN principal investigator from the University of Colorado, Boulder. "These are allowing us to understand not just the behavior of the atmosphere today, but how the atmosphere has changed through time."

During its 1,000 days in orbit, MAVEN has made a multitude of exciting discoveries. Here is a countdown of the top 10 discoveries from the mission:

10. Imaging of the distribution of gaseous nitric oxide and ozone in the atmosphere shows complex behavior that was not expected, indicating that there are dynamical processes of exchange of gas between the lower and upper atmosphere that are not understood at present.

9. Some particles from the solar wind are able to penetrate unexpectedly deep into the upper atmosphere, rather than being diverted around the planet by the Martian ionosphere; this penetration is allowed by chemical reactions in the ionosphere that turn the charged particles of the solar wind into neutral atoms that are then able to penetrate deeply.

8. MAVEN made the first direct observations of a layer of metal ions in the Martian ionosphere, resulting from incoming interplanetary dust hitting the atmosphere. This layer is always present, but was enhanced dramatically by the close passage to Mars of Comet Siding Spring in October 2014.

7. MAVEN has identified two new types of aurora, termed "diffuse" and "proton" aurora; unlike how we think of most aurorae on Earth, these aurorae are unrelated to either a global or local magnetic field.

6. These aurorae are caused by an influx of particles from the sun ejected by different types of solar storms. When particles from these storms hit the Martian atmosphere, they also can increase the rate of loss of gas to space, by a factor of ten or more.

5. The interactions between the solar wind and the planet are unexpectedly complex. This results due to the lack of an intrinsic Martian magnetic field and the occurrence of small regions of magnetized crust that can affect the incoming solar wind on local and regional scales. The magnetosphere that results from the interactions varies on short timescales and is remarkably "lumpy" as a result.

4. MAVEN observed the full seasonal variation of hydrogen in the upper atmosphere, confirming that it varies by a factor of 10 throughout the year. The source of the hydrogen ultimately is water in the lower atmosphere, broken apart into hydrogen and oxygen by sunlight. This variation is unexpected and, as yet, not well understood.

3. MAVEN has used measurements of the isotopes in the upper atmosphere (atoms of the same composition but having different mass) to determine how much gas has been lost through time. These measurements suggest that 2/3 or more of the gas has been lost to space.

2. MAVEN has measured the rate at which the sun and the solar wind are stripping gas from the top of the atmosphere to space today, along with the details of the removal processes. Extrapolation of the loss rates into the ancient past -- when the solar ultraviolet light and the solar wind were more intense -- indicates that large amounts of gas have been lost to space through time.

1. The Mars atmosphere has been stripped away by the sun and the solar wind over time, changing the climate from a warmer and wetter environment early in history to the cold, dry climate that we see today.

"We're excited that MAVEN is continuing its observations," said Gina DiBraccio, MAVEN project scientist from NASA's Goddard Space Flight Center in Greenbelt, Maryland. "It's now observing a second Martian year, and looking at the ways that the seasonal cycles and the solar cycle affect the system."

MAVEN began its primary science mission on November 2014, and is the first spacecraft dedicated to understanding Mars' upper atmosphere. The goal of the mission is to determine the role that loss of atmospheric gas to space played in changing the Martian climate through time. MAVEN is studying the entire region from the top of the upper atmosphere all the way down to the lower atmosphere so that the connections between these regions can be understood.

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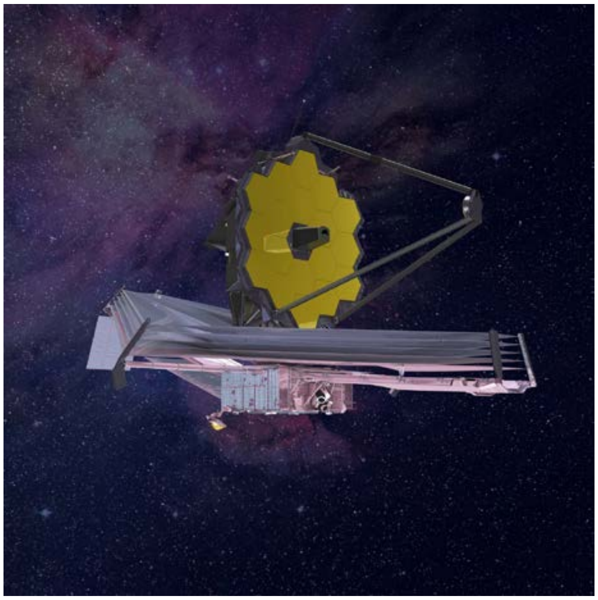
3. Icy moons, galaxy clusters, and distant worlds selected targets for Webb Telescope



Mission officials for NASA's James Webb Space Telescope announced some of the science targets the telescope will observe following its launch and commissioning. These specific observations are part of a program of Guaranteed Time Observations (GTO), which provides dedicated time to the scientists that helped design and build the telescope's four instruments.

"From the very first galaxies after the Big Bang, to searching for chemical fingerprints of life on Enceladus, Europa, and exoplanets like TRAPPIST-1e, Webb will be looking at some incredible things in our universe," said Eric Smith, James Webb Space Telescope Director at NASA Headquarters in Washington. "With over 2100 initial observations planned, there is no limit to what we might discover with this incredible telescope."

The broad spectrum of initial GTO observations will address all of the science areas Webb is designed to explore, from first light and the assembly of galaxies to the birth of stars and planets. Targets will range from the solar system's outer planets (Jupiter, Saturn, Uranus, and Neptune) and icy Kuiper Belt to exoplanets to distant galaxies in the young universe.

"The definition of observations to be conducted by the Webb Guaranteed Time Observers is a major milestone along the timeline for producing revolutionary science with this incredibly powerful observatory. These observations by the teams of people who designed and built the Webb instruments will yield not only amazing science, but will be crucial in putting the observatory through its paces and understanding its many capabilities," said Dr. Ken Sembach, director of the Space Telescope Science Institute, which will lead science and mission operations for Webb.

"I am very pleased that we're at this point since it is now possible for the broader science community to begin selecting targets and designing observations for the Early Release Science program and the Cycle 1 call for proposals, which will be issued this fall," he added.

Observing time on Webb is scheduled in a series of cycles. Cycle 1 will encompass about 8,700 hours, or nearly a year. For their dedicated work on the project, the Guaranteed Time Observers were awarded 10 percent of the total JWST observing time in the prime mission. To maximize the overall JWST scientific return, the GTO projects will be scheduled earlier in the mission, and are expected to be completed within the first two years of telescope operations.

The observations announced today will help the broader scientific community plan their proposals for observations to be made during Cycle 1. A call for proposals for regular Cycle 1 observations will be issued later this year.

Source: EurekAlert Return to Contents

The Night Sky

Friday, June 16

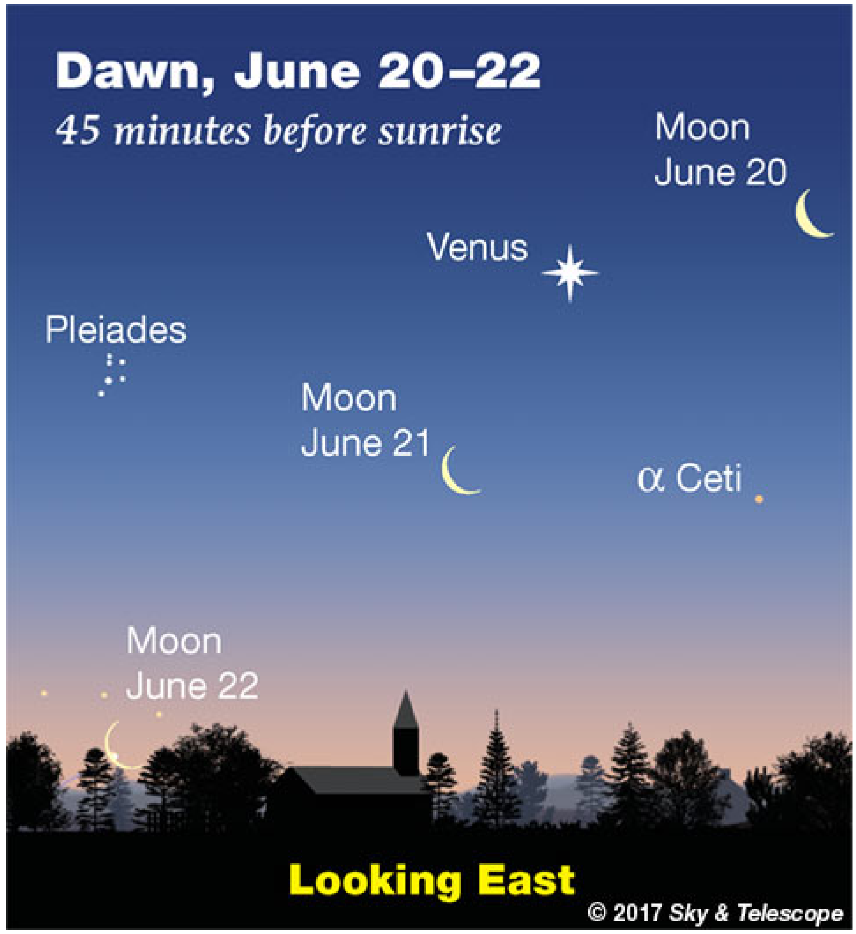
• By the time it's fully dark this week, Altair is shining well up in the east. A finger-width above it or to its upper left is its little sidekick Tarazed (Gamma Aquilae), actually an orange giant that's far in the background. Altair is 17 light-years from us; Tarazed is about 460.

Saturday, June 17

• The last-quarter Moon rises late tonight, around 1 a.m. daylight-saving time. Watch for it to breach the horizon to the lower right of the Great Square of Pegasus.

Sunday, June 18

• Here it is almost summer. But as twilight fades, look very low in the north-northwest for wintry Capella very out of season. The farther north you are, the higher it will appear. You may need binoculars. If you're as far north as Portland or Montreal, Capella is actually circumpolar.



Monday, June 19

• A double shadow transit occurs on Jupiter tonight from 10:04 to 10:38 p.m. EDT, when both Io and Europa are casting their tiny black shadows onto opposite sides of the planet's face.

• Dawn on Tuesday the 20th find Venus shining to right of the waning crescent Moon, as shown here.

Tuesday, June 20

• This is "Midsummer's Night," the shortest night of the year in the Northern Hemisphere. Astronomical summer begins at the solstice, 12:24 a.m. EDT (4:24 UT) on the 21st; that's 9:24 p.m. on the 20th PDT.

The term "Midsummer's Night" is left over from when the seasons were commonly defined as beginning and ending around the cross-quarter days. Be like your ancestors — build a bonfire tonight and organize some all-night revelry while magic is afoot. Dawn will come soon enough — when you'll see Venus over the crescent Moon, as shown above.

Source: Sky & Telescope

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ISS Sighting Opportunities

For Denver:

No sightings for Denver

Sighting information for other cities can be found at NASA's Satellite Sighting Information

NASA-TV Highlights

(all times Eastern Daylight Time)

7 a.m., Friday, June 16 - ISS Progress 67 Docking Coverage (Docking scheduled at 7:42 a.m. ET) (all channels)

11 a.m., 2 p.m., 8 p.m., 9 p.m., Friday, June 16 - SpaceCast (all channels)

8 a.m., 2 p.m., 6 p.m., Saturday, June 17 - Replay of the NASA Agency Honor Award Ceremony at the Langley Research Center (NTV-1 (Public))

10 a.m., 4 p.m., Saturday, June 17 - Replay of SpaceCast (all channels)

7 a.m., 6 p.m., 9 p.m., Sunday, June 18 - Replay of the NASA Agency Honor Award Ceremony at the Langley Research Center (NTV-1 (Public))

9 a.m., 8 p.m., 11 p.m., Sunday, June 18 - Replay of SpaceCast (all channels)

11:30 a.m., Monday, June 19 - ISS Expedition 52 Educational In-Flight Event with the Fayette County Public Library in Fayette, Georgia with Flight Engineer Jack Fischer of NASA (starts at 11:45 a.m.) (all channels)

3 p.m., 7 p.m., 11 p.m., Monday, June 19 - Replay of the ISS Expedition 52 Educational In-Flight Event with the Fayette County Public Library in Fayette, Georgia with Flight Engineer Jack Fischer of NASA (all channels)

Watch NASA TV on the Net by going to the NASA website.

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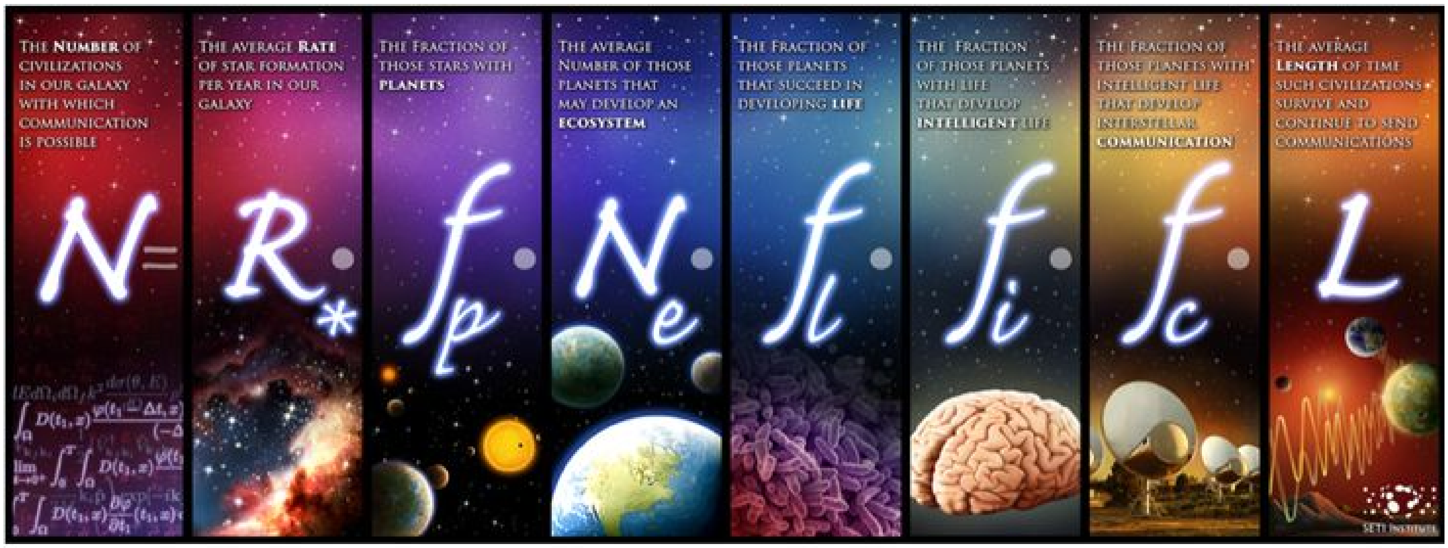
Space Calendar

The JPL Space Calendar is not available today due to technical issues with the JPL website.

Source: JPL Space Calendar Return to Contents

Food for Thought

What is the Drake Equation?



Is there life out there in the Universe? That is a question that has plagued humanity long before we knew just how vast the Universe was – i.e. before the advent of modern astronomy. Within the 20th century – thanks to the development of modern telescopes, radio astronomy, and space observatories – multiple efforts have been made in the hopes of finding extra-terrestrial intelligence (ETI).

And yet, humanity is still only aware of one intelligent civilization in the Universe – our own. And until we actually discover an alien civilization, the best we can do is conjecture about the likelihood of their existence. That's where the famous Drake Equation – named after astronomer Dr. Frank Drake – comes into play. Developed in the 1960s, this equation estimates the number of possible civilizations out there based on a number of factors.

Background:

During the 1950s, the concept of using radio astronomy to search for signals that were extra-terrestrial in origin was becoming widely-accepted within the scientific community. The idea of listening for extra-terrestrial radio communications had been suggested as far back as the late 19th century (by Nikolai Tesla), but these efforts were concerned with looking for signs of life on Mars.

Then, in September of 1959, Giuseppe Cocconi and Philip Morrison (who were both physics professors at Cornell University at the time) published an article in the journal *Nature* with the title "Searching for Interstellar Communications." In it, they argued that radio telescopes had become sensitive enough that they could pick up transmissions being broadcast from other star systems.

Specifically, they argued that these messages might be transmitted at a wavelength of 21 cm (1420.4 MHz), the same wavelength of radio emissions by neutral hydrogen. As the most common element in the universe, they argued that extra-terrestrial civilizations would see this as a logical frequency at which to make radio broadcasts that could be picked up by other civilizations.

Seven months later, Frank Drake made the first systematic SETI survey at the National Radio Astronomy Observatory in Green Bank, West Virginia. Known as Project Ozma, this survey relied on the observatory's 25-

meter dish to monitor Epsilon Eridani and Tau Ceti – two nearby Sun-like stars – at frequencies close to 21 cm for six hours a day, between April and July of 1960.

Though unsuccessful, the survey piqued the interest of the scientific and SETI communities. It was followed shortly thereafter by a meeting at the Green Bank facility in 1961, where the subjects of SETI and searching for radio signals of extra-terrestrial origin were discussed. In preparation for this meeting, Drake prepared the equation that would come to bear his name. As he said of the equation's creation:

"As I planned the meeting, I realized a few day[s] ahead of time we needed an agenda. And so I wrote down all the things you needed to know to predict how hard it's going to be to detect extraterrestrial life. And looking at them it became pretty evident that if you multiplied all these together, you got a number, N, which is the number of detectable civilizations in our galaxy. This was aimed at the radio search, and not to search for primordial or primitive life forms."

The meeting, which included such luminaries as Carl Sagan, was commemorated with a commemorative plaque that is still in the hall of the Green Bank Observatory today.

The Formula:

The formula for the Drake Equation is as follows:

$$N = R^{*} \times f_p \times n_e \times f_l \times f_i \times f_c \times L$$

Whereas N is the number of civilizations in our galaxy that we might able to communicate with, R^{*} is the average rate of star formation in our galaxy, f_p is the fraction of those stars which have planets, n_e is the number of planets that can actually support life, f_l is the number of planets that will develop life, f_i is the number of planets that develop intelligent life, fc is the number civilizations that would develop transmission technologies, and L is the length of time that these civilizations would have to transmit their signals into space.

Limits and Criticism:

Naturally, the Drake Equation has been subject to some criticism over the years, largely because a lot of the values it contains are assumed. Granted, some of the values it takes into account are easy enough to calculate, like the rate of star formation in the Milky Way. There are an estimated 200 – 400 billion stars within our Milky Way, and modern estimates say that there between 1.65 ± 0.19 and 3 new star form every year.

Assuming that our galaxy represents the average, and given that that there are as many as 2 trillion galaxies in the observable Universe (current estimates based on Hubble data), that means that there are as many as 1.5 to 6 trillion new stars being added to the Universe with every passing year! However, some of the other values are subject to a great deal of guess work.

For example, estimates on how many stars will have a system of planets has changed over time. Currently, it is estimated that the Milky Way contains 100 billion planets, which works out to about 50% of its stars having a planet of their own. Furthermore, those stars that have multiple planets will likely have one or two that lies within their habitable zone (aka. "Goldilocks Zone") – where liquid water can exist on their surfaces.

Now let's assume that 100% of planets located within a habitable zone will be able develop life in some form, that at least 1% of those life-supporting planets will be able to give rise to intelligent species, that 1% of these will be able to communicate, and that they will able to do so for a period of about 10,000 years. If we run those numbers through the Drake Equation, we end up with a value of 10.

In other words, there are possibly 10 civilizations in the Milky Way at any time capable of sending out signals that we could detect. But of course, the values used for four parameters there – f_l, f_i, f_c and L – were entirely assumed. Without any real data to go by, there's no real way to know how many alien civilizations could really be out there. There could just be 1 in the entire Universe (us), or millions in every galaxy!

The Fermi Paradox:

Beyond the issue of assumed values, the most pointed criticism of the Drake Equation tend to emphasize the argument put forth by physicist Enrico Fermi, known as the Fermi Paradox. This argument arose in 1950 as a result of conversation between Fermi and some colleagues while he was working at the Los Alamos National Laboratory. When the subject of UFOs and ETI came up, Fermi famously asked, "Where is everybody?"

This simple question summarized the conflict that existed between arguments that emphasized scale and the high probability of life emerging in the Universe with the complete lack of evidence that any such life exists. While Fermi was not the first scientists to ask the question, his name came to be associated with it due to his many writings on the subject.

In short, the Fermi Paradox states that, given the sheer number of stars in the Universe (many of which are billions of years older than our own), the high-probability that even a small fraction would have planets capable of giving rise to intelligent species, the likelihood that some of them would develop interstellar travel, and the time it would take to travel from one side of our galaxy to other (even allowing for sub-luminous speeds), humanity should have found some evidence of intelligent civilizations by now.

Naturally, this has given rise to many hypotheses as to how advanced civilizations could exist within our Universe but remain undetected. They include the possibility that intelligent life is extremely rare, that humanity is an early arrival to the Universe, that they do not exist (aka. the Hart-Tipler Conjecture), that they are in a state of slumber, or that we are simply looking in the wrong places.

The "Great Filter" Hypothesis:

But perhaps the best known explanation for why no signs of intelligence life have been found yet is the "Great Filter" hypothesis. This states that since that no extraterrestrial civilizations have been so far, despite the vast number of stars, then some step in the process – between life emerging and becomes technologically advanced – must be acting as a filter to reduce the final value.

According to this view, either it is very hard for intelligent life to arise, the lifetime of such civilizations is short, or the time they have to reveal their existence is short. Here too, various explanations have been offered to explain what the form the filter could take, which include Extinction Level Events (ELEs), the inability of life to create a stable environment in time, environmental destruction. and/or technology running amok (some of which we fear might happen to us!)

Alas, the Drake Equation has endured for decades for the very same reason that if often comes under fire. Until such time that humanity can find evidence of intelligent life in the Universe, or has ruled out the possibility based on countless surveys that actually inspect other star systems up close, we won't be able to answer the question, "Where is everybody?"

As with many other cosmological mysteries, we'll be forced to guess about what we don't know based on what we do (or think we do). As astronomers study stars and planets with newer instruments, they might eventually be able to work out just how accurate the Drake Equation really is. And if our recent cosmological and exoplanet-hunting efforts have shown us anything, it is that we are just beginning to scratch the surface of the Universe at large!

In the coming years and decades, our efforts to learn more about extra-solar planets will expand to include research of their atmospheres – which will rely on next-generation instruments like the James Webb Space Telescope and the European Extremely-Large Telescope array. These will go a long way towards refining our estimates on how common potentially habitable worlds are.

In the meantime, all we can do is look, listen, wait and see…

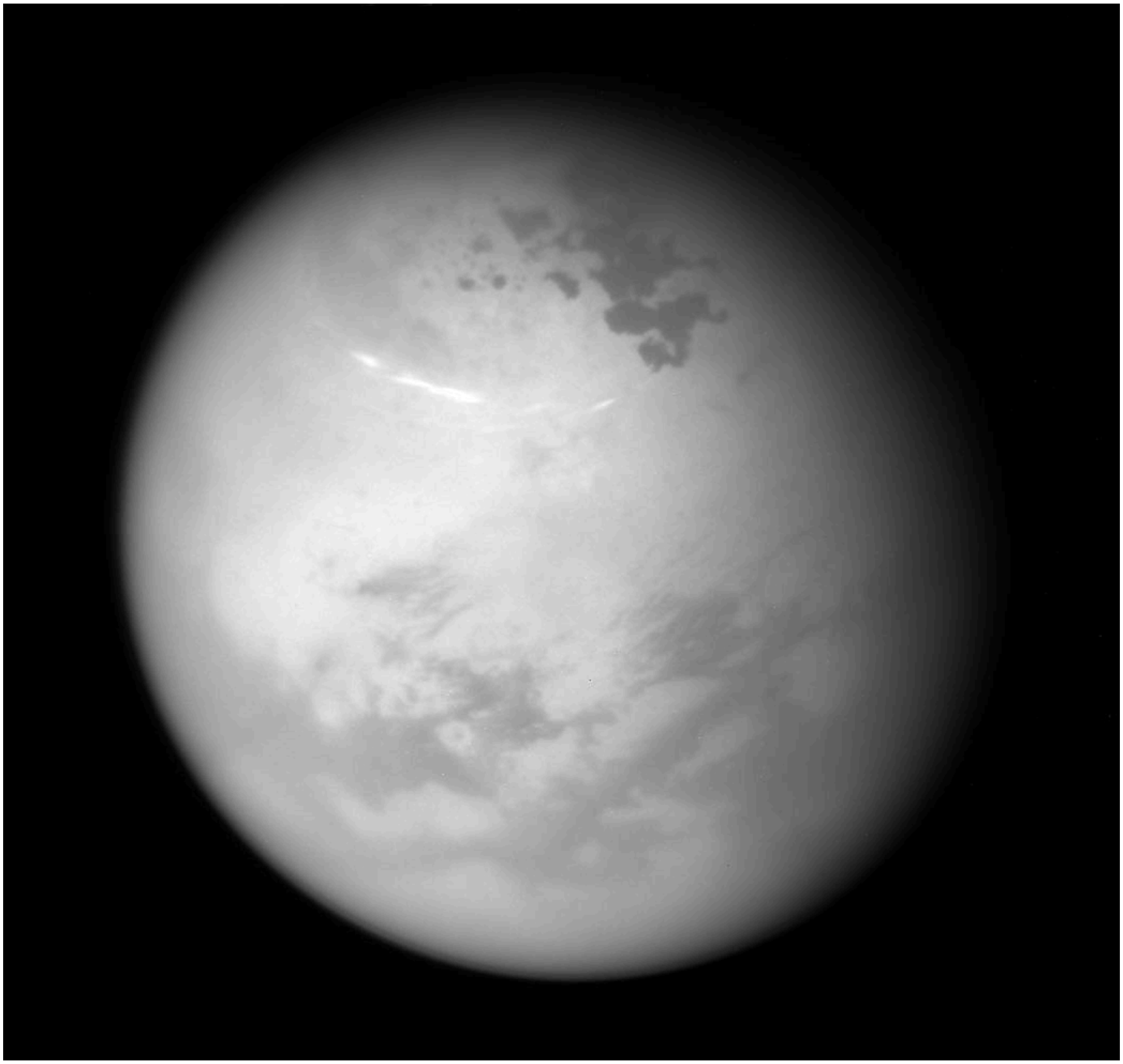
We have written many articles about the Drake Equation for Universe Today. Here's Inside the Drake Equation: A Chat with Frank Drake, The Odds of Intelligent Life in the Universe, A New Drake Equation? Other Life Not Likely to be Intelligent, A New Drake Equation for Potential of Life, Bayesian Analysis Rains on Exoplanet Life Parade, and Where are all the Aliens? The Fermi Paradox?

There are some great resources out there on the Internet. Check out this Drake Equation calculator.

We have recorded an entire episode of Astronomy Cast about the Drake Equation. Check it out here, Episode 23 – Counting Aliens with the Drake Equation.

Source: Universe Today Return to Contents

Space Image of the Week



Northern Summer on Titan

NASA's Cassini spacecraft sees bright methane clouds drifting in the summer skies of Saturn's moon Titan, along with dark hydrocarbon lakes and seas clustered around the north pole.

Compared to earlier in Cassini's mission, most of the surface in the moon's northern high latitudes is now illuminated by the sun. (See PIA08363 for a view of the northern hemisphere from 2007.) Summer solstice in the Saturn system occurred on May 24, 2017.

The image was taken with the Cassini spacecraft narrow-angle camera on June 9, 2017, using a spectral filter that preferentially admits wavelengths of near-infrared light centered at 938 nanometers. Cassini obtained the view at a distance of about 315,000 miles (507,000 kilometers) from Titan.

Source: NASA Return to Contents