# canopus

## Monthly Newsletter of the Johannesburg Centre of ASSA

The crew of Apollo 17 took this photograph of Earth in December 1972 while the spacecraft was traveling between the Earth and the Moon

Next meeting at Johannesburg Observatory, 18a Gill St, Observatory

**Wednesday, March 8 2017**
**Speaker : CHARLEY FLEMMING**
**Topic: HARTMANN MASKS**

## Upcoming Events:

## Public viewing:

**Friday MARCH 2017: PROVISIONAL DATES: 17 MARCH AND 24 MARCH**
**Please watch the website for updates, cancellations or changes.**

- **Public Viewing :** Weather permitting
- **Venue:** Johannesburg Observatory, 18a Gill St, Observatory
- **Time: 19h00 - 22h30**
- **Binocular observing is encouraged. Please bring your pair.**

**Contact** :

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Notifications are posted on Facebook ( https://www.facebook.com/assajhb), assajhb@yahoo.com and Twitter @JoosteJerome on the viewing day.

## Our next monthly Braai and Sky takes place on:

- **Date:** Sunday 26 March 2017
- **Time:** 16h30
- **Location:** Jhb. Observatory, Top of the hill at the Herbert Baker Library. Map.
- **Topic:** Whats Up – a detailed overview of some objects.
- **Donation**: R20 pp for the fire wood. Children under 15 free.

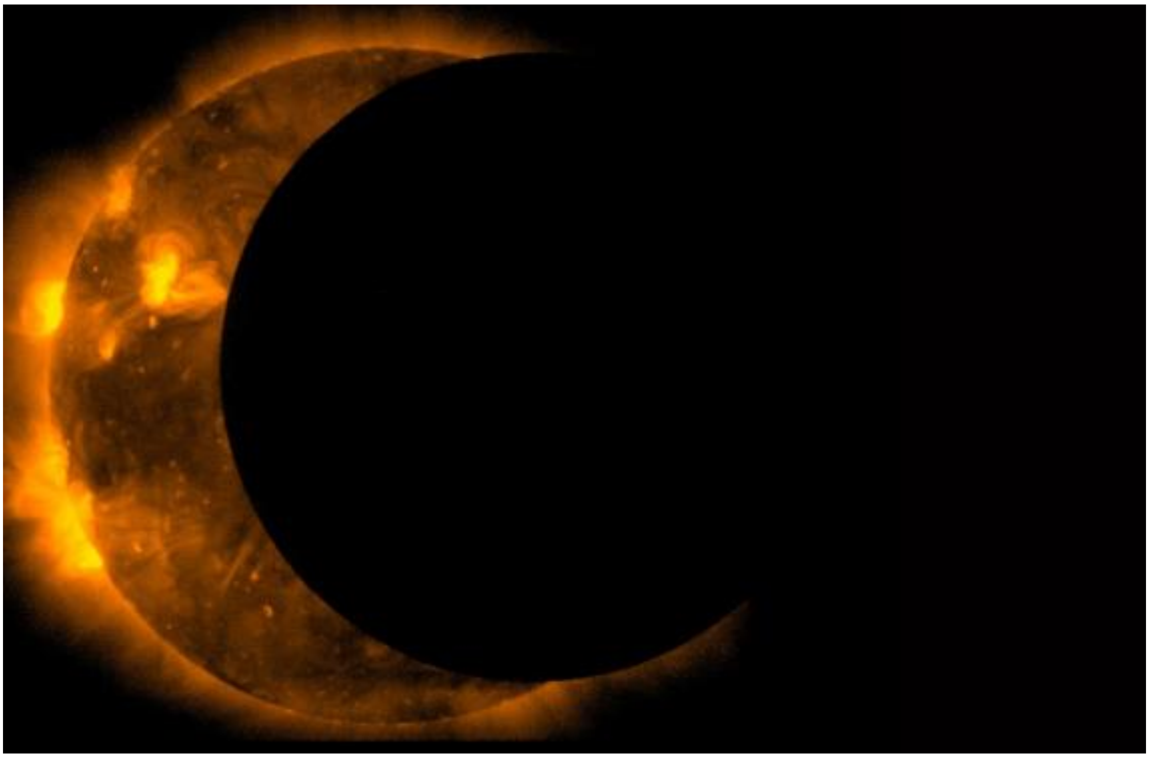
## THE SUN IN MARCH 2017:

| Date | Sunrise | Sunset | Length of day |
|---|---|---|---|
| 03/03/2017 | 06:03 | 18:37 | 12:34 |
| 10/03/2017 | 06:07 | 18:37 | 12:30 |
| 15/03/2017 | 06:09 | 18:24 | 12:15 |
| 20/03/2017 | 06:12 | 18:19 | 12:07 |
| 31/03/2017 | 06:17 | 18:07 | 12:09 |

## Autumnal Equinox:

On the two equinoxes every year the Sun shines directly on the Equator and the length of day and night is nearly equal – but not exactly.

This year our Autumnal Equinox occurs on 20/21 March. Equinox meaning equal day and night. Thereafter our days become shorter and nights longer.



www.nasa.gov/sites/default/files/thumbnails/image/eclipse.jpg

https://www.timeanddate.com/sun/south-africa/johannesburg

## THE MOON IN MARCH:

| Date | Moonrise | Moonset | |
|---|---|---|---|
| 5/03/2017 | 12:46 | 23:59 | First Quarter |
| 12/03/2017 | 18:32 | 05:46 | Full Moon |
| 17/03/2017 | 21:38 | 09:20 | |
| 20/03/2017 | 23:48 | 12:43 | Last Quarter & Autumn Equinox |
| 28/03/2017 | 06:22 | 18:41 | New moon |

https://www.timeanddate.com/moon/phases/south-africa/johannesburg

In March one can study, **Mare Nectaris**, on the moon. It is a volcanic plain which appears darker on the surface of the moon. The Location is eastward from the centre of the moon. A big lavafilled crater borders the southern coast of the sea. This is called Frascastorius and is about 124 km. in width.
The lava filling of Mare Nectaris is younger than the base itself and mare material is about 1000m in depth.
https://en.wikipedia.org/wiki/Mare_Nectaris

Best seen: 5 days after New Moon and 4 days after Full Moon.
2017 Sky Guide Africa South.

**https://www.nasa.gov/sites/default/files/moon_and_earth_lroearthrise_frame_0.jpg**

## PLANETS IN MARCH:

**Mercury:** This planet can be seen in the evening sky from mid-March to mid-April. It will appear as a small dot low in the east just before sunrise.

**Venus:** Did you know Venus can be seen in broad daylight when it is near greatest elongation and when it is near the moon which serves as a visual anchor. It is very bright and is in the evening say until mid-March. Towards the end of March it can be seen in the morning sky and remains visible until the end of the year again.

**Mars**: Mars is visible in the evening sky until mid-June but by then it lies too near the sun for observation. Mars does not have mountains or lakes so it is noticeable by its rusty dust shadings.

**Jupiter:** Can be seen at night befor the early hours of dawn, until mid-April. Jupiter is the third brightest object in the Sky. Outshone only by Venus and the Moon.Jupiter also has the foour Galilean moons, Io, Europa,Ganymede and Callisto that make observation very interesting.

**Saturn:** Is in the morning sky before sunrise until mid-June.

**Uranus:** Will be in the evening sky until late March when it lies too near the sun for observation.

**Neptune:** It reaches conjunction on March 02 and will reappear in the morning sky in the second half of March.


## EARTHLINGS STIR WITH EXCITEMENT:

On February 22, 2017 NASA made a great announcement: - the discovery of a cool star with no less than seven planets revolving around it. The first three planets revolving around their sun, Trappist -1, have been described as Earth-like.

Ever since the announcement, Earth has been buzzing with excitement for the possibility of finding life "out there".

1. Trappist-1 lies 39/40 light years from Earth, in the direction of our constellation Aquarius.

2. Trappist-1 has been classified as an ultra cool M Dwarf. Being cool, allows for a possibilty of finding water on these planets. Liquid water could survive on three of the planets orbiting close to Trapist 1. These planets have the correct surface temperature for water.

3. " If these planets have atmospheres, then the James Webb Space Telescope will be the key to unlocking their secrets". Said Doug Hudgins, Exo-planet Program Scientist at NASA Headquarters in Washington.

4. Scientists have discovered more than 3000 Exo-planets in the last twenty years but the greatest importance of this find is that his Trappist-1 solar system is going to be the test bed for a qicker search for "alien life".

## Seven-Planet Star Hides Age, Might Be Deadly:

By: Camille M. Carlisle | March 6, 2017

***The star with seven exoplanets puts out enough high-energy radiation to tear away the inner planets' atmospheres in a few billion years.***

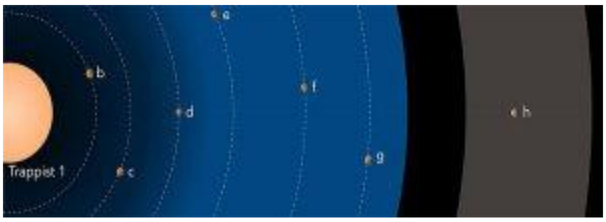



Diagram of the planetary system around TRAPPIST-1. The sizes of the objects are to scale, but the distances have been reduced tenfold. The star's color is realistic. The bluish area indicates the zone where liquid surface water might survive on the planets' surfaces, assuming an Earth-like atmosphere and composition. The greyish area shows the possible range of orbital distances for planet h.

*© Franck Selsis / Laboratoire d'astrophysique de Bordeaux (CNRS / Université de Bordeaux)*

.

The team found that TRAPPIST-1 emits less than half as much Lyman-alpha radiation as other cool, exoplanet-hosting *M* dwarfs — including Proxima Centauri, which spews forth six times more in ultraviolet as TRAPPIST-1 does. That's to be expected, since TRAPPIST-1 is also cooler than the other *M* dwarfs are.

However, last year the team also found that TRAPPIST-1 emits about as much in X-rays as Proxima Centauri. These X-rays come from the stars' coronas.

The ratio of X-rays to ultraviolet is interesting for a couple of reasons. First, X-ray and ultraviolet output decrease with time for these stars, but X-rays drop off much faster. The fact that TRAPPIST-1 emits roughly a third as much energy in Lyman-alpha as it does in X-ray suggests that the star is "relatively young," the team posits in their March 2017 *Astronomy & Astrophysics* article.

What "relatively young" means is an open question. Astronomers know the star is at least 500 million years old, because it's "settled" into being an adult star. Beyond that, it's anyone's guess. Jeffrey Linsky (University of Colorado, Boulder), who has worked extensively on *M* dwarfs and the trends in Lyman-alpha and X-ray emission for different types of stars, says that TRAPPIST-1 seems both old and young. Stars are born spinning quickly, then slow as they age. TRAPPIST-1 whips around every 1½ days, which at face value would point to it being young, he says — but astronomers don't know how fast these ultracool dwarfs spin down. Furthermore, the star's fast motion through space usually would indicate it's a member of the old stellar population that comprises the galaxy's halo, but goodness knows if that's a fluke.

Bourrier agrees that the age question is currently unanswerable. The ratio of X-ray to ultraviolet emission seems to indicate that TRAPPIST-1 is "not extremely old," he says, "but I do not think that at this point we can say much more than this."

The second reason the X-ray and ultraviolet levels matter is for habitability, a possibility which has received perhaps more attention than it deserves. Although the ultraviolet level is low, the radiation overall is still high enough that it could strip an Earth-like atmosphere from the inner two planets, b and c, in 1 to 3 billion years; for the planets d, e, f, and g (e, f, and g are in the putative habitable zone), the process would take anywhere from 5 to 22 billion years. The team does see a hint of atmospheric escape from b and c, although the slight drop in starlight that implies it might instead be due to coronal variability.

Due to the worlds' methodical spacing, astronomers conclude the planets likely migrated to their current orbits from farther out. But we don't know how long ago that happened, or whether the orbits are stable long term. “If they migrated within a disk, typical time scales are about 100 million years, but that may not be valid for a system like TRAPPIST-1,” Bourrier cautions. “Uncharted terrritory here.”

## THE NUT HUT:

by Jerome Jooste

Here is an article penned by Bruce Dickson, ex committee member of ASSAJHB and now resident in Canada. The title of his section is headed "Matters and Mutters"

Until his transfer to Toronto, Bruce Dickson was a long term member of the Johannesburg Centre. He is now Chief Scientist of Gedex Technologies based in Mississauga, Ontario. An active observer with almost 45 years' experience, he mostly spends his evenings glaring at clouds.

## MATTERS & MUTTERS:

## How Telescopes Really Work:

**by Bruce Dickson**

The first thing to understand is that when a photon is emitted by an atom, it doesn't have a preferred direction. Instead, the photon is spread out over an approximately spherical shell. It's only approximately spherical because it will travel through regions of differing optical density which have the effect of changing the propagation velocity.

Sooner or later, the phase front from the photon reaches the aperture of a telescope. Since stars are pretty far away, the wavefront is essentially planar over the scope's aperture. Some of the wavefront is reflected (alternatively refracted) and focused towards the focal surface. Note that the entire surface of the aperture captures some of the wavefront.

Typically, telescope optics are designed to convert the part of the wave that arrives perpendicular to the optical axis into a spherical convergent wavefront. This is the process of achieving focus. Assuming a photon detector is located at the focal surface, the wavefront will collapse into a photon and be converted into a charge.

Now this is where it gets weird. Recall that the photon went everywhere. This suggests that the photon's energy was spread out over a very large surface. We know that the photon is a quantised amount of energy so how did all the photon's energy suddenly arrive at the detector? The secret lies in a well established principle of Quantum Electro-Dynamics that says a photon can travel along any possible path between two points but it is vastly more likely that it will travel along the shortest path. It turns out that the direct path from the emitter, flying through space in the direction of the scope and passing through its optical path is the shortest path... so that's what the photon actually does.

Because the optical train creates a spherical wave, *any path that ends on the primary surface of the optic results in a shortest path* - thus the photon can be thought of as being spread evenly and with constant phase over the primary optic *and nowhere else*. At this point you can switch to classical optics (see for example Goodman's *Fourier Optics*) and derive the diffraction pattern of the aperture. This leads naturally to the Airy pattern.

The image formed from a point source is described exactly by the Fourier transform of the clear aperture. Typically, it has a central peak, surrounded by a strong first null followed by a weak ring followed by another null. The Airy pattern is just the Fourier transform of a circular aperture. The angular diameter (in radians) of the null for a circular aperture is given by Theta = 2.44 * wavelength / aperture diameter. The angular resolution of the scope is about half this value - let's say Angular Resolution (radians) = 1.22 * wavelength / aperture diameter. Since this expression only depends on the wavelength and the diameter of the aperture, it is clear that every scope with the same aperture is capable of the same angular resolution.

By noting that Theta = Spatial Resolution / Focal Length, we can rewrite the angular resolution in spatial terms. In this case we have Spatial Resolution / Focal Length = 1.22 * wavelength / aperture diameter. Re-arranging this, the spatial resolution can be written as Spatial Res = 1.22 * wavelength * f#. This implies the spatial resolution of an optical system is inversely proportional to its f-ratio. This is just saying that long focal lengths produce large images.

If an impinging wavefront is not perpendicular with the optical axis, it is brought to an approximate focus that is somewhat displaced from the centre of the focal surface. In general, it is not possible to map an angular distribution onto a flat surface without some form of distortion. Depending on its design, the telescope will distort either the point spread function (stars won't be round) or the displacement between them (the scale will vary radially) or both. The HST design - a Ritchey-Chretien - opts for minimal distortion of the shape of stars and a curved focal surface.

Now you might wonder why the Hubble telescope was designed with such a long focal length. The reason lies in the CCD detectors that were available during it's design phase in the late 1970's to early 1980's.

First we note that the focal ratio of the Hubble telescope is f/24 and it aperture is 2400 mm. This implies that the focal length is 57600 mm. The plate scale is thus 57600/206265 mm/arcsec = 0.279 mm/ arcsec. For light with wavelength of 400 nm, the spatial resolution limit is 11.7µm which implies the telescope's sensor can (in principle) resolve 0.042 arcsec. The original WFPC (wide field planetary camera) installed in the Hubble telescope had an effective 1600x1600 pixel array capable of about 0.1 arcsec resolution. The servicing missions have upgraded this to 0.043 arcsec.

In other words, the focal length of the Hubble telescope was originally matched to the resolution of ccd cameras with an expectation that the resolution would double over the lifetime of the instrument.

I'll wrap this up by considering what happens when an eyepiece is inserted into a telescope. The purpose of an eyepiece is to convert the spherically convergent wavefronts back into parallel wavefronts while amplifying the angles between the wavefronts coming from different parts of the focal surface. In other words, a telescope + eyepiece collects light and acts as an angle amplifier. It is the amplified angles that we perceive as magnification.

## AN INSECT BY NAME OF NGC 6210

BY MAGDA STREICHER

So many of the objects in space have nicknames (which are not, of course, particularly scientific), and the planetary nebula NGC 6210 is one of these, having been nicknamed for its remarkable resemblance in shape to a beetle or even a turtle. A very long time ago this gaseous nebula shed of gas layers to which have given the object its existing distinctive shape, trimmed by winds of change caused by the soaring hot inner star. In order really to appreciate this nebula it is necessary to use a fair amount of magnification and, of course, to do one's observation in the darkest night conditions possible.

NGC 6210 is located in the northern constellation Hercules and many of us in the southern hemisphere may find it difficult to spot. The northern hemisphere amateurs refer to this object as the Turtle Nebula. The use of filters and a medium-sized telescope is, therefore, recommended. A filter that makes such an object much easier to see is the normal nebular filter or perhaps the UHC (ultra-high contrast) filter. Planetary nebulae, tell a story with their shapes in different categories, it is also possible to observe a large amount of detail.

NGC 6210 was discovered by Friedrich Georg Wilhelm Struve, initially as a small out-of-focus puff of light. To my eye this planetary nebula does not appear completely round, and it has an uneven fringed edge. It reveals a shade of light blue to grey-green with an easily seen central star. With high magnification some markings can be spotted on the surface.

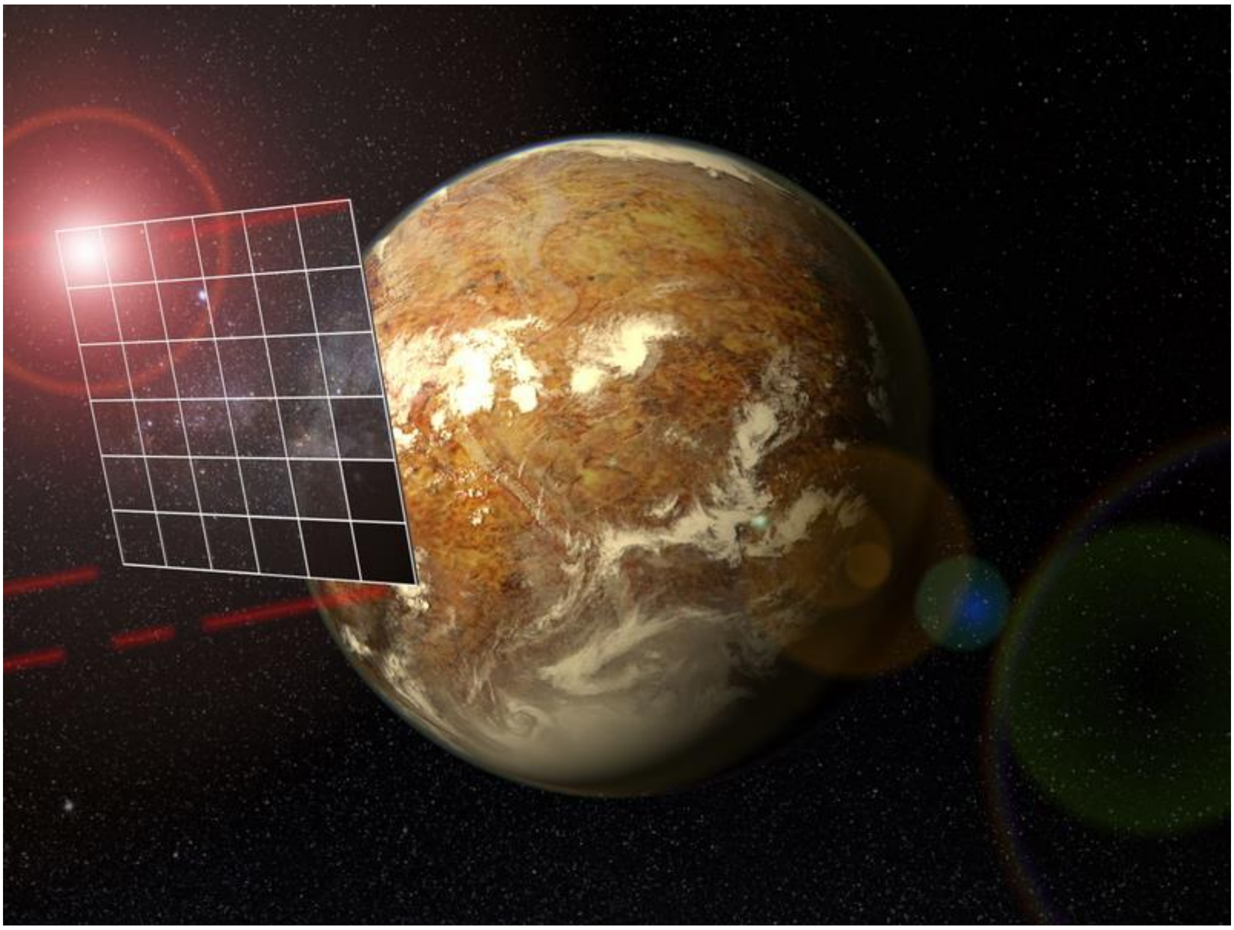
The town Tarto, now the second large town in Estonia, is the place where the famous astronomer Friedrich Georg Wilhelm Struve once, from the year 1818 to 1839 worked, and was also the director of the institute. He use the 9 inch Fraunhofer refractor, which was at that time, from the year 1824 to the year 1854 the largest telescope in the world and the first telescope to be clock-driven. In 1838 he was a pioneer in the measurement of stellar parallax with Bessel and Thomas Hendersson! The star which distance he defined was Vega (alpha Lyrae), in the well know Lyra-constellation. His work with the double stars is very famous and his "Measurae Micrometricae" has details of over 3000 pairs. And last, but not least, he supervised the measurement of the Russo-Scandinavian arc of meridian stretching the line from the Black Sea to the Arctic Ocean. The results were published in 1860. Credit goes to Astronomy friend Risto Heikkilä, who visit Tarto and provide this information and picture of Struve's telescope. (fig 1. Fraunhofer refractor).

This object, always reminds me of the wonderful work done by the so-called dung beetle to balance our natural environment.

| OBJECT | TYPE | RA | DEC | MAG | SIZE |
| --- | --- | --- | --- | --- | --- |
| NGC 6210 | Planetary Nebula | 16h44m.5 | +23°48'.0 | 9.3 | 0.30" |

## WILL STAR TRAVEL BECOME A REALITY?:

Our scientists study travel to our neighbouring planets.
We talk about finding life in Space and we all wonder if it is possible to live on Mars. It is possible the answers will all come to us eventually. Yet, there is one concept that we might have thought of, briefly, then cast aside as impratcial and impossible. That is Star Travel.
Thus, it was quite amazing to discover that this dream is actually alive and well.



The dream of star travel is alive and well. An enormous rectangular photon sail might power the first starships to the Alpha Centauri system, closest star system to Earth. In this artist's concept, the four red beams emitted from the corners of the sail depict laser pulses for communication with Earth. Image via Max Planck/ Planetary Habitability Laboratory, University of Puerto Rico at Arecibo.

In April of 2016, Russian high-tech billionaire Yuri Milner and others announced the Breakthrough Starshot, a plan to spend $100 million on proof-of-concept studies in the coming years to explore the dream of star travel in our time. The Breakthrough Starshot concept is an exceedingly fast flyby mission to the next-nearest star system, Alpha Centauri, located about 4 light-years or 25 trillion miles (40 trillion km) away. Breakthrough Starshot's goal is to reach Alpha Centauri with a fleet of nanostarships within 20 years. Let's assume it turns out to be feasible. Is it possible we could do more than sweep past? Two scientists have now announced a braking method, using the radiation and gravity of the Alpha Centauri stars themselves. If a hypothetical starcraft could be decelerated, it could then, possibly, be rerouted to explore the red dwarf star Proxima Centauri and its newly discovered Earth-like planet Proxima b.

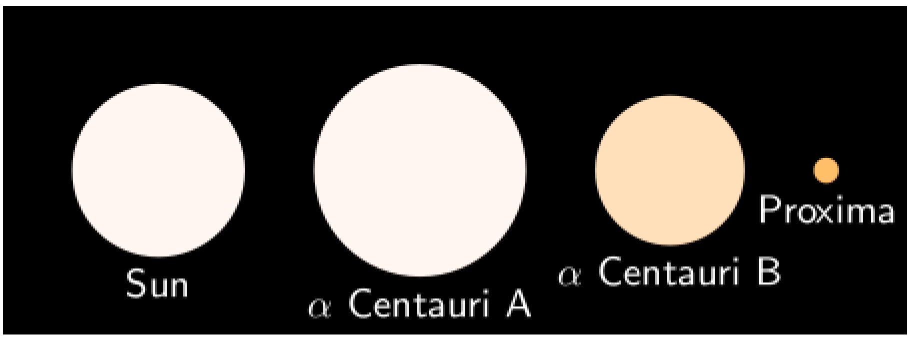
Astrophysicist René Heller of the Max Planck Institute for Solar System Research in Göttingen and IT specialist Michael Hippke worked together on this idea, which they submitted online at arXiv.org in late January 2017. For their study, they didn't use Breakthrough Starshot's concept of nanostarships, which are envisioned as weighing about a gram (0.036 ounces) each.

Instead, they considered just one slightly bigger starship, weighing about 0.2 pounds (less than 100 grams). It would be mounted to about a million-square-foot (100-thousand-square-meter) sail. That's a sail about equal in size to the area of 14 soccer fields.

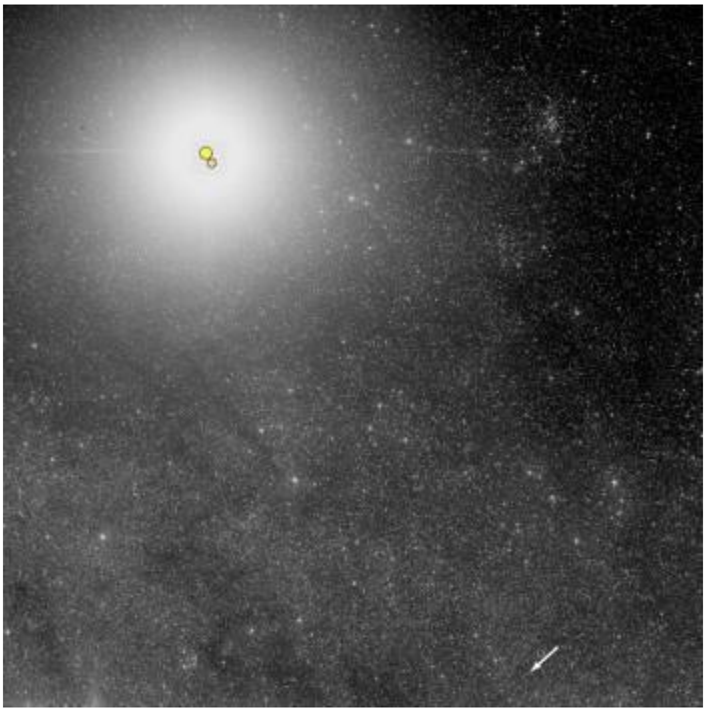
Heller and Hippke's concept is for the probe's sail to be redeployed as its nears the Alpha Centauri system, so that the spacecraft would be optimally decelerated by the incoming radiation from the stars in the Alpha Centauri system. Their statement explained:

The tiny spacecraft would first need to approach the star Alpha Centauri A as close as around four million kilometres [2.4 million miles] … at a maximum speed of 13,800 kilometres per second [8,600 miles per second, or 4.6 per cent of the speed of light]. At even higher speeds, the probe would simply overshoot the star.

During its stellar encounter, the probe would not only be repelled by the stellar radiation, but it would also be attracted by the star's gravitational field. This effect could be used to deflect it around the star. These swing-by-manoeuvers [aka gravity assists] have been performed numerous times by space probes in our solar system.




A comparison of the sizes and colours of the stars in the Alpha Centauri system with our sun. Via Wikimedia Commons.



Alpha Centauri A and B are a double-star system, and a third star Proxima – whose location with respect to the other two is indicated here by arrow – might or might not be gravitationally bound to them. Proxima is the closest star to Earth. Image via the European Southern Observatory.

Their concept might work, they determined, but the sacrifice would be the speed of the trip. Breakthrough Starshot originally said it wanted to try to reach the Alpha Centauri system in 20 years, that is, within the span of some of our lifetimes. In Heller and Hippke's braking scenario, the craft would take longer to reach Alpha Centauri. Hippke said:

"In our nominal mission scenario, the probe would take a little less than 100 years – or about twice as long as the Voyager probes have now been traveling."

The payoff would be huge, though. Rather than shooting past the system (a flyby), in theory an autonomous, active light sail – as visualized by Heller and Hippke – could settle into a bound orbit around Alpha Centauri A – the largest star of three in the Alpha Centauri system – and possibly explore its planets. However, the two scientists are thinking even bigger. Their statement said:

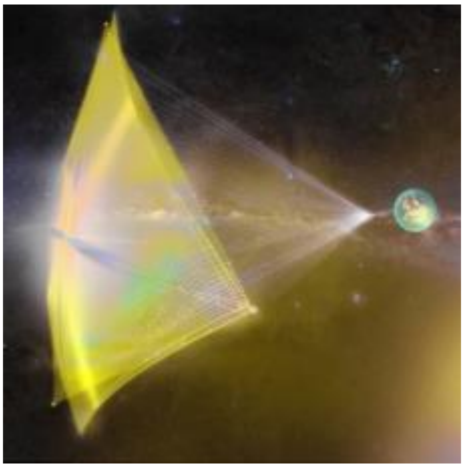
"The sail could be configured so that the stellar pressure from star A brakes and deflects the probe toward Alpha Centauri B [second-largest star in the system], where it would arrive after just a few days. The sail would then be slowed again and catapulted towards Proxima Centauri, where it would arrive after another 46 years – about 140 years after its launch from Earth".

Proxima Centauri – the smallest of the three stars in the Alpha Centauri system, and the actual closest star to Earth – caused a sensation in August 2016 when an observing campaign called Pale Red Dot, begun in early 2016 under the auspices of the European Southern Observatory (ESO), found a planet orbiting around it. This is Proxima Centauri b, which appears to be only slightly more massive than Earth. It's in Proxima Centauri's habitable zone, meaning there's a potential for liquid water to exist on its surface. Water, of course, is a prerequisite for life as we know it. Heller said: "This finding prompted us to think about the possibility of stopping a high-velocity interstellar lightsail at Proxima Centauri and its planet".

The two astronomers are now discussing their concept with the members of the Breakthrough Starshot Initiative, to whom they say they owe the inspiration for their study. Heller commented:

Our new mission concept could yield a high scientific return, but only the grandchildren of our grandchildren would receive it. Starshot, on the other hand, works on a timescale of decades and could be realized in one generation. So, we might have identified a longterm, follow-up concept for Starshot.

Read more about Heller and Hippke's study via Max-Planck



Artist's concept of Breakthrough Starshot nanostarship. A 100-gigawatt light beam to propel approximately 1,000 ultra-lightweight nanocraft like this one to 20 percent of light speed. This fleet of nanostarships could reach the three stars of the Alpha Centauri system within about 20 years of launch. Image via BreakthroughInitiatives.org.

Bottom line: Using the Breakthrough Starshot project as their inspiration, two scientists have calculated the feasibility of full braking – and entering orbit – around the stars in the Alpha Centauri system.

http://earthsky.org/space/full-braking-at-alpha-centauri

## CONSTELLATIONS:

Mid March hails the important arrival of our Autumn season as the Autumn Equinox takes place on 20/21 March.In the Southern Hemisphere we have in our sky the following Autumn Constellations.
Bootes, Cancer, Crater, Hydra, Leo, and Virgo. Crux, Corvus, Centaurus and more. Within each constellation there are bright stars to be observed, each with their own patterns and interesting tales to tell.

Star maps are easily available on the Internet, for example: **www.skymaps.com**

## GALAXIES:

**The Sombrero Galaxy**: also known as M104 or NGC 4594, is an unbarred spiral galaxy in the constellation Virgo. It has a bright nucleus, an unusually large central bulge, and a prominent dust lane in its inclined disk. The dark dust lane and the bulge give this galaxy the appearance of a sombrero. The galaxy has an apparent magnitude of +9.0, making it easily visible with amateur telescopes. The large bulge, the central supermassive black hole, and the dust lane all attract the attention of professional astronomers.
Virgo is in our Eastern Skies for the Autumn Making the Sombrero Galaxy easily visible in our Autumn skies.

## FAMOUS PEOPLE:

**Sir Thomas Walter Bannerman Kibble**, CBE FRS (23 December 1932 – 2 June 2016), was a British theoretical physicist, senior research investigator at the Blackett Laboratory and Emeritus Professor of Theoretical Physics at Imperial College London. His research interests were in quantum field theory, especially the interface between high-energy particle physics and cosmology. He is best known as one of the first to describe the Higgs mechanism, and for his research on topological defects. From the 1950s he was concerned about the nuclear arms race and from 1970 took leading roles in promoting the social responsibility of the scientist.

https://en.wikipedia.org/wiki/Tom_Kibble

## HIGGS BOSUN:

Higgs boson Subatomic particle.
The Higgs boson is an elementary particle in the Standard Model of particle physics. It is the quantum excitation of the Higgs field, a fundamental field of crucial importance to particle physics theory first suspected to exist in the 1960s.
Classification: Boson
Symbol: $H^0$
Mass: 125.09±0.21 (stat.)±0.11 (syst.) GeV/$c^2$ (CMS+ATLAS)
Electric charge: 0 e
Spin: 0
WIKIPEDIA

The Large Hadron Collider (LHC) is the world's largest and most powerful particle accelerator. It first started up on 10 September 2008, and remains the latest addition to CERN's accelerator complex. The LHC consists of a 27-kilometre ring of superconducting magnets with many accelerating structures to boost the energy of the particles along the way.

Inside the accelerator, two high-energy particle beams travel at close to the speed of light before they are made to collide. The beams travel in opposite directions in separate beam pipes – two tubes kept at ultrahigh vacuum. They are guided around the accelerator ring by a strong magnetic field maintained by superconducting electromagnets. The electromagnets are built from coils of special electric cable that operates in a superconducting state, efficiently conducting electricity without resistance or loss of energy. This requires chilling the magnets to -271.3°C – a temperature colder than outer space. For this reason, much of the accelerator is connected to a distribution system of liquid helium, which cools the magnets, as well as to other supply services.

the large Hadron Collider is the world's largest and most powerful particle accelerator (Image: CERN)

Thousands of magnets of different varieties and sizes are used to direct the beams around the accelerator. These include 1232 dipole magnets 15 metres in length which bend the beams, and 392 quadrupole magnets, each 5–7 metres long, which focus the beams. Just prior to collision, another type of magnet is used to "squeeze" the particles closer together to increase the chances of collisions. The particles are so tiny that the task of making them collide is akin to firing two needles 10 kilometres apart with such precision that they meet halfway.

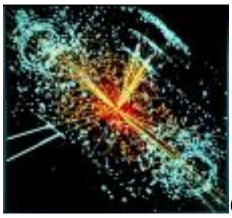
Stephen Hawking bet Gordon Kane $100 that physicists would not discover the Higgs boson. After losing that bet, when physicists detected the particle in 2012, Hawking lamented the discovery, saying it made physics less interesting. Now, in the preface to a new collection of essays and lectures called "Starmus," the famous theoretical physicist is warning that the particle could one day be responsible for the destruction of the known universe.

Hawking is not the only scientist who thinks so. The theory of a Higgs boson doomsday, where a quantum fluctuation creates a vacuum "bubble" that expands through space and wipes out the universe, has existed for a while. However, scientists don't think it could happen anytime soon.

"Most likely it will take 10 to the 100 years [a 1 followed by 100 zeroes] for this to happen, so probably you shouldn't sell your house and you should continue to pay your taxes," Joseph Lykken, a theoretical physicist at the Fermi National Accelerator Laboratory in Batavia, Illinois, said during his lecture at the SETI Institute on Sept. 2.

"On the other hand, it may already have happened, and the bubble might be on its way here now. And you won't know because it's going at the speed of light so there's not going to be any warning."

Simulated data from the Large Hadron Collider particle detector shows the Higgs boson produced after two protons collide.


*Credit: CERN*.

## STEPHEN HAWKING SAYS HIGGS BOSON COULD WIPE OUT THE UNIVERSE:

The Higgs boson, is a tiny particle that researchers long suspected existed. Its discovery lends strong support to the Standard Model of particle physics, or the known rules of particle physics that scientists believe govern the basic building blocks of matter. The Higgs boson particle is so important to the Standard Model because it signals the existence of the Higgs field, an invisible energy field present throughout the universe that imbues other particles with mass. Since its discovery two years ago, the particle has been making waves in the physics community.

Now that scientists measured the particle's mass last year, they can make many other calculations, including one that seems to spell out the end of the universe.

**Universe doomsday**

The Higgs boson is about 126 billion electron volts, or about the 126 times the mass of a proton. This turns out to be the precise mass needed to keep the universe on the brink of instability, but physicists say the delicate state will eventually collapse and the universe will become unstable. That conclusion involves the Higgs field.

The Higgs field emerged at the birth of the universe and has acted as its own source of energy since then, Lykken said. Physicists believe the Higgs field may be slowly changing as it tries to find an optimal balance of field strength and energy required to maintain that strength. [5 Implications of Finding a Higgs Boson Particle]

"Just like matter can exist as liquid or solid, so the Higgs field, the substance that fills all space-time, could exist in two states," Gian Giudice, a theoretical physicist at the CERN lab, where the Higgs boson was discovered, explained during a TED talk in October 2013.

Right now, the Higgs field is in a minimum potential energy state — like a valley in a field of hills and valleys. The huge amount of energy required to change into another state is like chugging up a hill. If the Higgs field makes it over that energy hill, some physicists think the destruction of the universe is waiting on the other side.

But an unlucky quantum fluctuation, or a change in energy, could trigger a process called "quantum tunneling." Instead of having to climb the energy hill, quantum tunneling would make it possible for the Higgs field to "tunnel" through the hill into the next, even lower-energy valley. This quantum fluctuation will happen somewhere out in the empty vacuum of space between galaxies, and will create a "bubble," Lykken said.

Here's how Hawking describes this Higgs doomsday scenario in the new book: "The Higgs potential has the worrisome feature that it might become metastable at energies above 100 [billion] gigaelectronvolts (GeV). … This could mean that the universe could undergo catastrophic vacuum decay, with a bubble of the true vacuum expanding at the speed of light. This could happen at any time and we wouldn't see it coming." [10 Implications of Faster-Than-Light Travel]

The Higgs field inside that bubble will be stronger and have a lower energy level than its surroundings. Even if the Higgs field inside the bubble were slightly stronger than it is now, it could shrink atoms, disintegrate atomic nuclei, and make it so that hydrogen would be the only element that could exist in the universe, Giudice explained in his TED talk.

But using a calculation that involves the currently known mass of the Higgs boson, researchers predict this bubble would contain an ultra-strong Higgs field that would expand at the speed of light through space-time. The expansion would be unstoppable and would wipe out everything in the existing universe, Lykken said.

"More interesting to us as physicists is when you do this calculation using the standard physics we know about, it turns out we're right on the edge between a stable universe and an unstable universe," Lykken said. "We're sort of right on the edge where the universe can last for a long time, but eventually it should go 'boom.' There's no principle that we know of that would put us right on the edge."

## Not all doom and gloom

Either all of space-time exists on this razor's edge between a stable and unstable universe, or the calculation is wrong, Lykken said.

If the calculation is wrong, it must come from a fundamental part of physics that scientists have not discovered yet. Lykken said one possibility is the existence of invisible dark matter that physicists believe makes up about 27 percent of the universe. Discovering how dark matter interacts with the rest of the universe could reveal properties and rules physicists don't know about yet.

The other is the idea of "supersymmetry." In the Standard Model, every particle has a partner, or its own anti-particle. But supersymmetry is a theory that suggests every particle also has a supersymmetric partner particle. The existence of these other particles would help stabilize the universe, Lykken said.

"We found the Higgs boson, which was a big deal, but we're still trying to understand what it means and we're also trying to understand all the other things that go along with it

"This is very much the beginning of the story and I've shown you some directions that story could go in, but I think there could be surprises that no one has even thought of," Lykken concludes in his lecture.

.http://www.livescience.com/47737-stephen-hawking-higgs-boson-universe-doomsday.html

## DIAMOND "SUPER EARTH" MAY NOT BE QUITE AS PRECIOUS AS ONCE THOUGHT:

A new study of "diamond planet" 55 Cancri e suggests the world might not be that carbon-rich.

By University of Arizona-Tucson | Published: Wednesday, October 9, 2013
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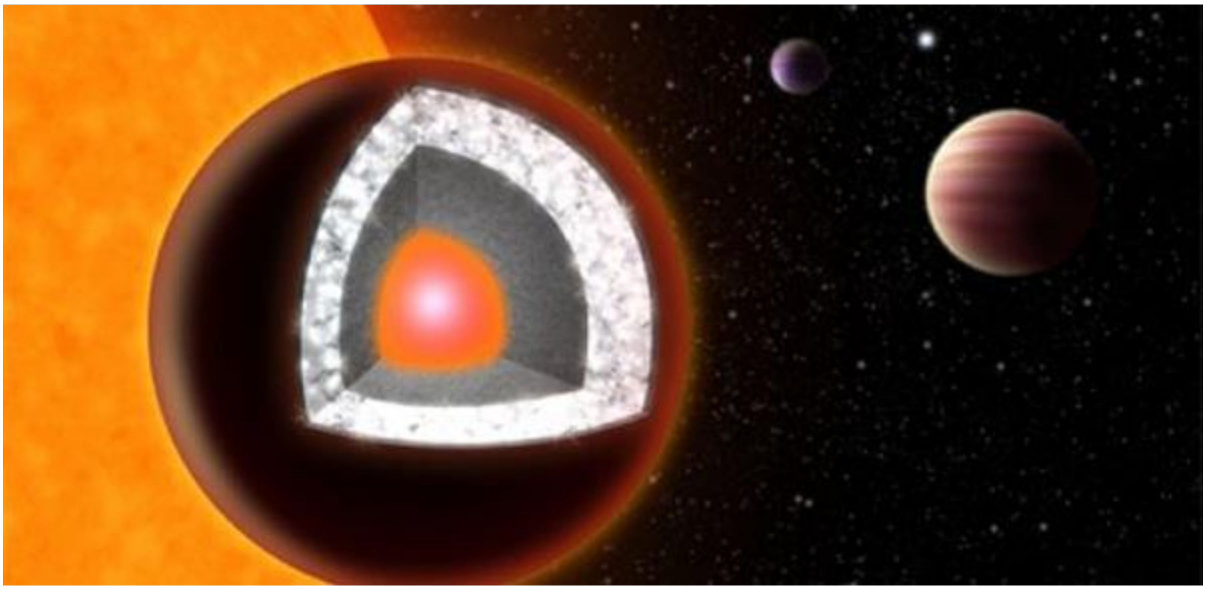


In the sky with diamonds? A so-called super-Earth, planet 55 Cancri e was believed to be the first known planet to consist largely of diamond, due in part to the high carbon-to-oxygen ratio of its host star. Artist's concept.
Haven Giguere/Yale University

A planet 40 light-years from our solar system, believed to be the first-ever discovered planet to consist largely of diamond, may in fact be of a less exquisite nature, according to new research led by Johanna Teske from the University of Arizona.

Revisiting public data from previous telescope observations, Teske's team analyzed the available data on the exoplanets 55 Cancri e in more detail and concluded that carbon — the chemical element diamonds are made of — appears to be less abundant in relation to oxygen in the planet's host star, and by extension, perhaps the planet, than was suggested by a study of the host star published in 2010.

"The 2010 paper found that 55 Cancri, a star that hosts five planets, has a carbon-to-oxygen ratio greater than one," Teske said. "This observation helped motivate a paper last year about the innermost planet of the system, the 'super-Earth' 55 Cancri e. Using observations of the planet's mass and radius to create models of its interior that assumed the same carbon-to-oxygen ratio of the star, the 2012 paper suggested the planet contains more carbon than oxygen."

"However, our analysis makes this seem less likely because the host star doesn't appear as carbon-rich as previously thought," Teske said.

Observations obtained in 2010, together with simulations astronomers use to model a planet's interior based on data like radius, mass, and orbital velocity, had yielded a carbon-to-oxygen ratio greater than one — in other words, an alien world based on carbon instead of oxygen as most planets are in our solar system, including Earth.

"The Sun only has about half as much carbon as oxygen, so a star or a planet with a higher ratio between the two elements, particularly a planet with more carbon than oxygen, is interesting and different from what we have in our solar system," said Teske.

Based on the previous results, it was suggested that the "diamond planet" is a rocky world with a surface of graphite surrounding a thick layer of diamond instead of water and granite like Earth.

The new research by Teske and collaborators calls this conclusion in question, making it less likely a hypothetical space probe sent to sample the planet's innards would dig up anything sparkling.

Teske's group found that the planet's host star contains almost 25 percent more oxygen than carbon, about midway between the Sun and what the previous study suggested.

"In theory, 55 Cancri e could still have a high carbon-to-oxygen ratio and be a diamond planet, but the host star does not have such a high ratio," Teske said. "So in terms of the two building blocks of information used for the initial 'diamond-planet' proposal — the measurements of the exoplanet and the measurements of the star — the measurements of the star no longer verify that."

A so-called super-Earth boasting about twice Earth's diameter and eight times our world's mass, the "diamond planet" is the smallest member of a five-planet system located in the constellation Cancer. 55 Cancri e races around its host star at such a close distance that one year lasts only 18 hours and its surface temperature is more than 3000° Fahrenheit (1600° Celsius).

"With rocky worlds like 55 Cancri e, researchers use measurements of a planet's radius, mass, and density, and basic physical equations governing the internal structure of solid planets to calculate possible compositions of the planet's interior," Teske said.

"This planet is probably rocky or has a large rocky component," she said. "We don't really know if it has an atmosphere."

Since astronomers can't probe the makeups of stars and planets directly, they rely on indirect observational methods such as absorption spectra — each chemical element absorbs light at different wavelengths in a characteristic pattern that can be used as a fingerprint of that element. By analyzing the absorption spectra of starlight passing through a star's atmosphere, it is possible to deduce what elements are present in the star's atmosphere.

"Instead of using the same absorption lines in the spectrum of the host star as the previous study of 55 Cancri, we looked at more lines of carbon and more lines of oxygen," Teske said. "We find that because this particular host star is cooler than our Sun and more metal-rich, the single oxygen line analyzed in the previous study to determine the star's oxygen abundance is more prone to error."

Teske, instead, relied on several different indicators of the oxygen abundance that were not considered previously. "Averaging all of these measurements together gives us a more complete picture of the oxygen abundance in the star."

Teske pointed out that the "diamond planet" results hinge on the presumption that a star's composition bears some relation to the composition of its planets, a notion grounded in the idea that planets form from the same material as their host stars. However, as astronomers discover more and more extrasolar systems, a one-size-fits-all formula becomes less likely.

"We still don't know whether our solar system is common or uncommon in the universe," Teske said, "because many of the systems that we are finding have giant gas planets closer to the star, unlike our system where rocky planets dominate the inner orbits and gas giants occur further out."

There are so many processes, most of which are not fully understood, happening in a planet-forming disk that could influence the composition of planets. "At this point, I would honestly be surprised if there was a one-to-one correlation," Teske said.

"The compositions of planets and stars don't always match," she said, explaining that in a swirling disk of dust and gas giving birth to a star and planets, "you can have pockets where there is a lot of water, meaning an enhancement of oxygen. Or places where water has frozen out, leaving behind carbon species as the dominant gas molecules. So the planets that are accreting gas at those locations in the disk could be more carbon-rich instead of oxygen-rich."

Therefore, room for uncertainty remains, according to the researchers.

"Depending on where 55 Cancri e formed in the protoplanetary disk, its carbon-to-oxygen ratio could differ from that of the host star," Teske said. "It could be higher or lower. But based on what we know at this point, 55 Cancri e is more of a 'diamond in the rough.'"

http://www.astronomy.com/news/2013/10/diamond-super-earth-may-not-be-quite-as-precious-as-once-thought

## SPACE FLIGHT CHANGES BRAINS

It appears that spaceflight really goes to astronauts' heads.

Doctors and scientists have long known that exposure to a weightless environment causes muscles to atrophy, bones to weaken and vision to deteriorate, among other effects. Now, a new study has determined that spaceflight also causes some parts of the brain to expand and others to contract. [The Human Body in Space: 6 Wild Facts]

- "We found large regions of gray-matter volume decreases, which could be related to redistribution of cerebrospinal fluid in space," study principal investigator Rachael Seidler, a professor of kinesiology and psychology at the University of Michigan, said in a statement.

Astronauts who flew on ISS and space shuttle missions experienced changes in brain volume, a new study has found.
*Credit: NASA*

"Gravity is not available to pull fluids down in the body, resulting in so-called puffy face in space," Seidler added. "This may result in a shift of brain position or compression."

Seidler and her team studied magnetic resonance imaging (MRI) scans of 26 astronauts — 12 who flew on two-week-long space shuttle missions, and 14 others who lived aboard the International Space Station (ISS) for five to six months.

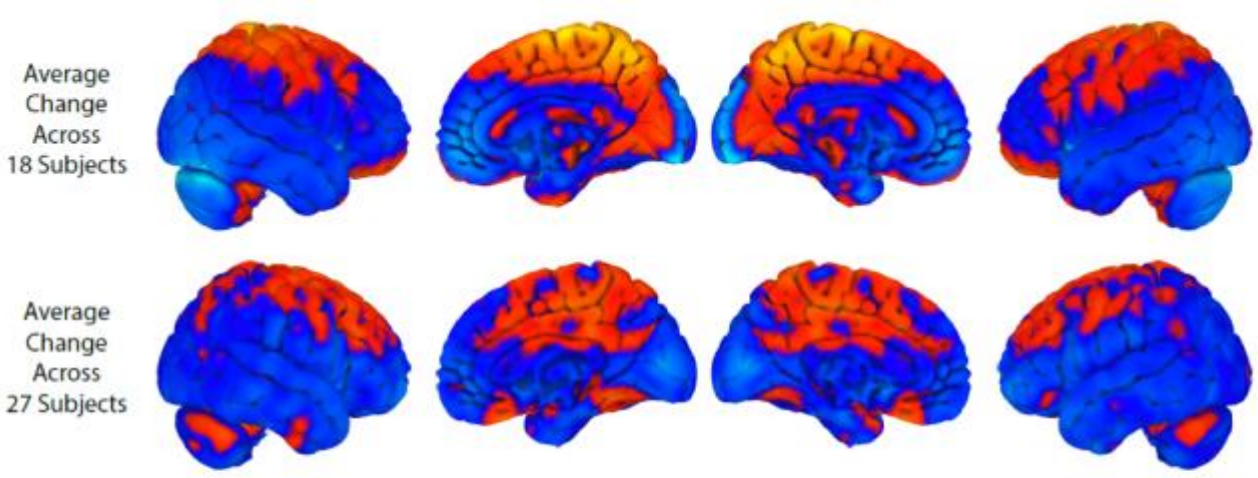
The brains of all 26 astronauts changed shape, as a result of their off-Earth stints, and the magnitude of these changes was greater in the ISS crewmembers.

The brain regions that expanded are associated with the control of leg movement and the processing of sensory information from the lower body, team members said. Therefore, the MRIs are likely capturing the brain learning a new skill — how to move in microgravity— and doing so around the clock, Seidler said.

"It's interesting, because even if you love something, you won't practice more than an hour a day," she said. "In space, it's an extreme example of neuroplasticity in the brain, because you're in a microgravity environment 24 hours a day."

It's unclear how long these changes last after astronauts come back to Earth, or how the shifts may affect cognitive ability, the researchers said. Seidler and her team are currently conducting another long-term study these questions.

The new study was published in December 2016 in the journal Nature Microgravity. The lead author is Vincent Koppelmans, of the University of Michigan's School of Kinesiology.

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