Sounds of the Universe

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part of the program:

AstroTES

INTRODUCTION:

In 1999 a group of teenagers from Mar Plata, all blind, reached the top of the Lanín volcano with the collaboration of a team of climbers who understood that there are no impossible challenges if you and wish for it work hard.

I knew that group because they were close to a radio show I was working on at that time. My contact with them allowed me to talk to them many times, about astronomy, share knowledge and anecdotes and face the challenge of what the sky is like for blind people. Thus was born the idea of transforming the different luminosities of stars and other celestial objects into a scale of sounds of different volume and the use of low to high frequencies to represent the different colors in an astronomical observation.

The project approached the Galileo Galilei Planetarium, later to other places too. Where different workshops showed a science that seemed, a priori, contradictory to be taught to blind people. In 2003, the first astronomy software for the blind allowed me to share this idea with more people.

In 2009, during the International Year of Astronomy, the Education Office of the Astronomical Observatory of the University of Valencia projected a planetary function for the blind with sounds based on this idea from ten years ago, recognizing that the idea was born in Mar del Plata, Argentina, and my authorship in particular. Today, Dr. Amelia Ortíz Gil is an international reference in the subject, with her and many other professionals in the world, we keep passion and commitment to bring this science, to really everyone.

Since 2010 I have been doing workshops of what I like to call "accessible astronomy" in more than 30 cities in Argentina, and I also did it in Paraguay, Uruguay, Brazil, Chile, Colombia, Spain and Italy.

Abroad, beyond workshops and presentations at international Congresses in the aforementioned countries, an important point was the presentation of the project at the Congress "Astronomy and its instruments before and after Galileo", organized in Venice by the University of Padova (Italy) in commemoration of the International Year of Astronomy in 2009.

To give more dissemination to the topic in 2015 I was summoned by TEDxMardelPlata to give a talk about this work, which more than 27,000 people have already seen on the web in (https://www.youtube.com/watch?v=SXilOmInCU0).

In 2019 I was an advisor to two Astronomy projects for blind or low vision people in Chile: one from the Catholic University of Chile and another from the University of Antofagasta, the latter, ASTROBVI ended up developing an educational kit that was distributed in more than 20 countries.

After many years of visiting different institutions we find the need of schools for the blind, of educational entities for these people, to have their own teaching material. The teaching of science for blind people has its peculiarities. It needs a lot of tactile material, especially designed with that purpose. And done with the advice of someone who really understands the problem. This is how "AstroTES, astronomy to play, listen and feel" was born (www.astrotes.org) with which today we are already in more than 100 kits distributed in 20 countries.

This book follows the same spirit of all of the above. We live in a Universe of the invisible, today we study it through X-ray, gamma, ultraviolet or infrared light telescopes. All of them show us the celestial objects that are there, with information elusive in our eyes but amazingly useful for their understanding.

Through the next pages we will think about the Universe through its smells, textures, sounds and we will see what place people with disabilities will occupy in the future in this wonderful adventure of space exploration. It is a free distributed book so I would like you to read it, share it, print it, give it away, so that many more people know some curiosities about current astronomy and a Universe that it is, now yes... for everyone.

THE SOLAR SYSTEM TO SUIT YOU

When we open an Astronomy book, which refers, for example, to the Solar System. How far do we get to understand those numbers followed by so many zeros? When reading these figures, we will hardly realize how big Jupiter is or how far the Earth is from the Sun. Those who want to make us believe that astronomy is complicated, usually mention the size of its numbers and how disproportionate they are with respect to our daily scales. To get to size the distances and diameters of the bodies that accompany us in the Solar System, we will reduce their figures to others that are more accessible and thus, easily, we will relate them to things that we handle every day. That is why we are going to take a single scale, that is, we are going to divide the size of the planets by the same number that we will do with their distance to the star king. So, we will be left with a Solar System capable of fitting into a city. I propose that you take a map of yours and tour with me our closest neighbors in the Universe.

In the center of the Sun, about 65 cm in diameter, we will place it in an important corner of the city and from there we will start a trip through the Solar System where maybe your house is.

About 27 meters from our starting point is Mercury, a small ball of 0.2 cm (2mm) totally dominated by that huge gaseous balloon that is the Sun and that for now we have very close. Our next encounter will be with Venus, we are 50 meters from our star, and who is actually a beautiful disk covered with clouds is presented to us on our scale as an insignificant body of just 0.56 centimeters. 70 meters from our starting point, we are in the place occupied by the Earth itself, our house. But do not be disappointed much, on our scale it will only be a sphere of 06 cm in diameter (a diameter 110 times smaller than that of the Sun,

and if we think about volume, precisely a million and a half of planets Earth would enter our star). What about the Moon? A sphere of 0.15 cm; rotating around the Earth at a distance of 21 centimeters. After all this, if it serves us as a consolation (I know I haven't tried it more than once) let's think that all our problems take place in an almost microscopic place in the Universe.

And now yes! The long-awaited visit to Mars, the red planet, we can do it this afternoon by getting 115 meters from our Sun, of course the only thing we are going to find is a 3mm ball, accompanied by its two moons Phobos and Deimos, you will not see those because on this scale they are too small but they will be 0.30 and 1 centimeter respectively from Mars.

We have traveled through the so-called Interior Solar System, populated by planets that are quite similar to us, are made up of rocks and are small. It didn't cost us much to travel through this region, we saw that they are relatively close to each other and at least on our stopover we were able to make this trip on foot. Now we will have to walk careful not to step on any asteroid of those between the orbits of Mars and Jupiter to reach precisely the latter, a giant of 6.5 cm in diameter (11 times that of the Earth) and revolves around the Sun at a distance of 778,000,000 km, sorry, I think that at this point we no longer like the numbers of so many figures, let's continue with our scale and Jupiter will be 350 meters from the Sun.

Jupiter has many natural satellites or moons, the four largest of which can be seen with a pair of binoculars from Earth. On our scale it is from Jupiter at a distance of 20 cm (Io), 31 cm (Europe), 50 cm Ganymede and 88 centimeters at Callisto. To reach the most distant moon of all, we should be 10 meters away from Jupiter.

In the Outer Solar System the distances are getting bigger and bigger, and to see Saturn (a sphere of 5.6 centimeters in diameter) we have to move away 650 meters from our Sun. Of course, to see the outermost of the rings we will move 21 cm (comparing it with the distance from the Moon to the Earth we see that it is the same), it is equivalent to say 38 Earths next to each other.

Continuing with this fast and bearable way of traveling through the Solar System, which any science fiction writer would envy us, we arrived at Uranus, another gas balloon this time 2.3 cm in diameter at 1,400 meters from the Sun.

At this point in our journey, perhaps the best thing would be to be on a bicycle. We find Neptune 2,100 meters from the Sun and it is a sphere similar to that of Uranus, about 2.3 cm in diameter. It is the last of the planets of the Solar System, like the last three, it is giant, gaseous, cold and with rings (although we have mentioned nothing more than those of Saturn) and with a large number of moons.

Finally, we will visit Pluto (1mm). We no longer consider it a planet since, in 2006, the International Astronomical Union redefined what one is and this rock very far from the Sun and surrounded by other similar ones remained as another object of the Kuiper Belt, an area, like a second asteroid belt, which goes from the orbit of Neptune to 3,800 meters. Beyond, a diffuse disc full of other minor objects will extend, according to what some astronomers tell us, up to 70km of the Sun.

And that's where the Solar System ends? Not really. The Oört cloud, where most of the comets come from, would be on this same scale, at... 12,000 kilometers away! Yes, very far away from what we have already become accustomed to. Understanding that the orbits of all planets are within the same city, within a

radius of 2,100 meters, the limit of the Solar System, that is, where the gravity of the Sun ceases to attract objects around it, would be the equivalent of the distance between Buenos Aires and Madrid.

I hope that those great distances of millions of kilometers have been more bearable in this way, but don't worry, in the real Solar System, there is still room for everyone.

THE SUN:

The Sun is a star, like all those we see at night it is a sphere of gases (mainly hydrogen and helium) where two forces are in equilibrium. The force of the gases that tends to expand, and the gravity that tends to take them to the center. Thus, in that balance, the Sun lives most of its long life, of about 10 billion years.

In the nucleus, at about 15 million degrees of temperature, the Sun converts hydrogen atoms into helium and in the process releases gamma rays (heat), photons (light) and neutrinos, subatomic particles that have so little mass that they can cross almost without resistance anything, even our bodies. Every second, tens of billions of neutrinos cross every square centimeter of skin of every person on Earth. They enter the human body and come out again without colliding with anything, and we, not even aware of it.

We do know that we need the light and heat of the Sun to live, and we need it almost all life on our planet. Each photon of light that is produced inside the Sun, is a million years inside it, bouncing, until it finally reaches its surface and from there, at 300,000 kilometers per second, it reaches the Earth in about 8 minutes.

After the nucleus, a plasma area. And more to the outside an area where the heat is moved by convection. Here we have hot material moving towards the upper areas, and less hot currents going down inland. It is a turbulent, dense area, immediately before reaching the surface of the Sun, the photosphere.

It is in the photosphere that solar activity is reflected. One of those brands is sunspots. Galileo Galilei observed them for the first time with his telescope and since then, professional and amateur astronomers, follow their appearance and disappearance with their instruments, and the appropriate filters. They usually have a very dark central area and a twilight around them, and they can be the size of the Earth, even more. In reality, the darkness is not such, and it is only a matter of contrast, they are areas that are at a lower temperature than their environment, about 4,000º against the 6,000º of the photosphere in general, that's why they are also less bright, 30% of their contiguous areas.

After the photosphere and eclipsed by it, the chromosphere appears, we cannot see it except during solar eclipses, when the Moon covers the brightest part of our star. And the last layer will be the crown, much fainter but very extensive.

The Sun, compared to other stars, is a quiet star, but it has cycles of greater activity. It is there that we will observe more spots on its surface and when ejections of coronal mass, radiation waves and solar wind are more frequent, that is, electrically charged particles that detach from the Sun and when they reach the Earth they still have the power to put our instruments in orbit at risk.

SIMULATED SOUNDLANDSCAPE OF THE INTERIOR OF THE SUN - COURTESY DIEGO PORTALES UNIVERSITY (CHILE):
https://astronomia.udp.cl/es/espanol-astronomia-inclusiva-un-viaje-sonoro-desde-el-interior-del-sol/

SOUNDS OF THE SUN (SOHO OBSERVATORY - NASA):
https://www.nasa.gov/feature/goddard/2018/sounds-of-the-sun

THE SOUNDSCAPES OF OTHER WORLDS:

We have already learned that we cannot be on another planet or moon in the Solar System without the protection of a space suit, even in some places, nor would this be enough to keep us alive. Even so, it is interesting to think about what the soundscapes of other worlds are like.

Outer space is the world of silence, since there is no means in which sound spreads, even the most violent stellar explosions occur without anything being heard around, but on some planets, things are different.

On Venus, for example, all sounds are amplified. Venus is a hell of 450°C all the time, a thick fog around us, toxic gases and an atmospheric pressure 90 times that we experience on Earth at sea level. If we could hypothetically withstand all this, and we were standing on its surface, the sounds would reach our ears in a deafening way.

Hundreds of rays a day, and perhaps even explosive volcanic eruptions dozens of times stronger than we heard on our planet would make us escape in search of a calmer environment.

On Mars, things go to the other extreme. In its subtle atmosphere, of only one percent of the Earth's atmosphere, sounds travel more slowly, it takes a third more to reach from where they are emitted to the listener (a lightning that struck 10 kilometers from where we are on Earth, we hear it 29 seconds later, while on Mars we would do it 44 seconds after observing it). The gaseous envelope of Mars is rich in carbon dioxide, which is very good at absorbing vibrations in the air, so it ends

up silencing the sounds.

The cold also reduces the speed of sound and on Mars it is very cold. It will be a planet with few stimuli. With a weak atmosphere even a tornado will carry little air that hits our face, the landscape will be still and the noises will be barely whispers. Serious whispers in a world that seems to move in slow motion.

We do not know if on the gaseous planets, Jupiter, Saturn, Uranus and Neptune, we have an earth to step on under its dense layer of gases but if so, they would be worlds where the speed of sound would be three times that of Earth. Loud and high-pitched sounds, coming from gas shocks and thunderstorms. Squeaky in convulsed environments.

On Saturn's moon, Titan, things are similar to the Earth. The sounds there would be familiar to us. Its atmosphere is approximately 50% denser than ours and it is colder so the sound will travel slower and will be as if we heard it come out of a container, but thanks to the abundance of nitrogen, the volume will be higher.

Imagining ourselves standing in other worlds and knowing what and how we would listen to it is, for now, the closest thing we have to travel to them. Today we have a ship on the surface of Mars, NASA's Perseverance with an open microphone to what happens there. Making us hear that slight and subtle tapping of the air on the instrument. Another different thing are the sounds of radio waves from Jupiter's magnetic field. Those are captured by the instruments of spacecraft that have arrived nearby and that were then translated into mechanical waves so that our ears can hear them, they seem somewhat phantasmagorical, like those of some nebulae, stars or the Sun but of course we would not hear that if we traveled to those places.

In the same way that the planets look different, they sound different, they smell different and our movements would not feel the same way in each of them. But that's another issue...

AUDIO VENERA 14 (1982) ON THE SURFACE OF VENUS:
https://www.youtube.com/watch?v=Hl6f3_yyq4I

SOUND OF WIND ON THE SURFACE OF MARS:
https://www.youtube.com/watch?v=PdoTDgyG82M

SOUND OF JUPITER'S MAGNETIC FIELD:
https://www.youtube.com/watch?v=yXgWfzR4gDg

SOUNDS OF SATURN:
https://www.youtube.com/watch?v=pfuR5cgzgqY

WHAT DO THE PLANETS SMELL LIKE? SPACE? THE SPACESHIPS?

In principle, and as with sounds, smells need a medium by which to be transported, which is why outer space does not smell or, what is more correct, we do not perceive how it smells, but astronauts have sniffed out its characteristics when returning from a spacewalk, which is when they leave, armed only with their suits, the spaceships in which they travel. The suits always have, according to them, a recognizable plastic smell, but upon returning from their extravehicular activities, the smell that remains on their clothes, on their tools or on some instrument that enters the ship is different.

In space, enormous combustion occurs within stars. Stars convert hydrogen into helium to shine and also expel these materials in periodic explosions or at the end of their lives. In supernova explosions, stars release oxygen, carbon, and ultimately, all the elements of the periodic table. This mixture of elements generates polycyclic aromatic hydrocarbons that astronauts define in a less technical way as burnt metal.

There are other, more pleasant approximations, such as some who describe the smell of the space as like grilled steak or the smell of barbecue. Welding gases or an electric discharge also appear, like when you take off a sweater or a t-shirt with static.

But this smell might not be that of all of space, wherever you are, but rather that of the surroundings of the Earth. The cause of this metallic smell could be ozone, present in small quantities even beyond lunar orbit. This is how we begin our tour, prepare yourselves, because not all places will remind us of a Sunday

with the family with some hamburgers (a little soggy) on the charcoal grill, there are worlds where things smell very bad.

Let's get into the ship! Inside the International Space Station, odors are a concern for space agencies that send their men and women on long stays in Earth orbit. George Aldrich and his NASA team spend their time sniffing everything that can travel to space, the paints with which the facilities are covered, the Velcro with which things are held in microgravity, the electrical circuit consoles, the clothing, the ink from the notebooks and even the diapers pass through the noses of these people, who sacrifice themselves so that the noses of the astronauts suffer as little as possible during their work in Earth orbit. The thing is that the materials will experience large changes in temperature that can make them very intense and unpleasant to the sense of smell, even to that of an astronaut who, due to how bodily fluids behave in microgravity, may be congested all the time and smell less.

With the materials of the Space Station exposed to the high radiation of space and extreme temperatures, the ship also smells a little burnt, which is not as unbearable as the continuous hum of the equipment.

Mercury's atmosphere is very weak, unable to retain enough gases for us to smell. However, by making an effort, perhaps we could distinguish a very subtle salty smell, with a sensation of metallicity, due to the sodium and magnesium in its exosphere. A haven to enjoy, because what is coming is not good.

Reviewing the planetary scents we arrive at Venus. With an atmosphere with abundant sulfur dioxide, Venus smells like rotten eggs.

We pass through the Earth, it contains the smells that we love the most, the grass after the rain, the aromas of the flowers, the intense salinity of the sea of an afternoon on the beach. Everything we know, the references for good and bad, we will take from this third sphere around the Sun that has been and still is our home forever. Perhaps moving away from it we will value more its welcoming landscapes, visuals, sounds, and its captivating perfumes.

Between 1969 and 1972, twelve men walked on the Moon. They took photos and put instruments there, took samples of the terrain... and smelled. The first to do so, obviously, Armstrong and Aldrin on the Apollo XI mission, upon re-entering the ship, encountered a worrying smell of burning gunpowder. Of course it is not such a thing, but the iron, copper, nickel and the rest of the minerals in the soil added together give that sensation to the smell. I was able to experience it personally. For my workshops, I have simulated lunar regolith at home, a soil made in NASA laboratories, precisely, with the exact chemical composition that we learned on the missions that have reached the Moon. When I opened the package that arrived from the United States, that smell of gunpowder gave me an idea close to the description of the astronauts.

The carbon dioxide prevailing in the Martian atmosphere makes it almost odorless, yes of course, if we could put a handful of soil to our nose we would smell the iron oxide that makes it red.

So much for the rocky planets, the ones where we can imagine walking and smelling around us, obviously forgetting the fact that we can't breathe on any of them, so being outside a ship without a helmet would kill us in seconds. For what follows, we will have to imagine an extra scenario, falling through the thousands of kilometers of the gaseous envelopes of the giant planets, crossing layers of different gases, with different smells.

Let's go to Jupiter. Its outermost layers smell of ammonia, an unpleasant mixture between cleaning products and urine. We can only be grateful that the enormous gravity of this giant pushes us down with much more force than on Earth and at the speed at which we go we only endure this for a few seconds. Although what is coming is not better, an intense smell of rotten egg, penetrating our ears in bursts of dense gases at enormous speeds makes us think: why don't I stay on Earth? Finally, the interior of Jupiter is rich in hydrogen cyanide, which has a smell that reminds us of almonds.

About Saturn, scientists still do not agree when choosing the fragrance of the ringed planet but it is very interesting, as we did in the case of sounds, to enter the atmosphere of its moon Titan, a world of hydrocarbons that smells, precisely, like a service station. They are those invasive odors that some hate and others love, so I don't dare classify Titan as a place where being with a helmet is an advantage or a disadvantage.

Although the outer layers of Uranus are odorless, like those of Neptune, we know that its interior has hydrogen sulfide, ammonia, methane and carbon dioxide. Uranus smells like gases, but humans usually escape from them.

These games of listening, smelling, walking, "as if" we were somewhere else are always fun. Even the smell of the vicinity of the Earth, or of the interior of a spaceship, is something that only 0.00000008% of the human population has experienced to date. So imagining those practically impossible worlds generates a certain fascination. The members of the European Space Agency took this further when they released a limited edition, only for some scientific and technical members, of the perfume of the comet Churyumov-Gerasimenko. Thanks to the data collected by the Rosetta ship, they knew that the core of this comet contains hydrogen sulfide, ammonia, methane (yes, you know that this is not going to end well), sulfur dioxide and other

elements that give an unpleasant mixture between cat pee, alcohol and rotten eggs. I don't think any of those who received the bottle have put it on for a party, perhaps for a meeting with creditors.

Leaving the Solar System, in fact, very far away, about 25,000 light-years very close to the center of the Milky Way, we find a huge molecular cloud. Astronomers call it Sagittarius B2 and it is composed of ethyl formate, which gives the aroma and flavor to raspberries and rum.

Our Universe is beautiful, its different corners, full of bright colors and shapes, amaze our eyes. But it is also a Universe that we can hear, touch, smell, feel. Humans have the possibility of knowing through all these ways, the ability to collect all this diverse information for our astonishment and enjoyment, to feel part of this immense everything.

STARS IN THE SKY:

In 1999 a group of teenagers from Mar Plata, all blind, reached the top of the Lanín volcano with the collaboration of a team of climbers who understood that there are no impossible challenges if you have enough work and desire. That group was close to a radio activity that I maintained for those years and my contact with them allowed me to talk many times about astronomy, share knowledge and anecdotes and face the challenge of what the sky is like for a blind person in the face of their first questions. By then, I had been giving talks on astronomy for more than 10 years, giving courses, organizing exhibitions on the subject, but I had never stopped at a fact that I found as shocking as it is stimulating for my future work: heaven, for a blind person... it does not exist.

It does not exist from the perspective that we cannot access it by any means other than our view. The night sky is not heard, it is not felt, and of course, it cannot be touched. Thus was born the idea of transforming the different luminosities of stars and other celestial objects into a scale of sounds of different decibels and the use of low to high tones to represent the different colors present in an astronomical observation. Why so much worry about showing heaven to those who don't see it?

I am convinced that one of the most important aspects for a person's development is their relationship with the environment in which they live. The knowledge of this will be the origin of all the questions and future curiosities, it will be the motivator of study and will provide the necessary security to experiment with it. Astronomy is, according to many, the mother of all natural sciences since the most varied disciplines

of human knowledge have been reflected in celestial phenomena. But it is also a branch of knowledge with which an ambivalent feeling is experienced: on the one hand that desire to scrutinize the mysterious and on the other, the notion of immeasurability it represents makes many believe that this is for few placing Astronomy on a level of elitist knowledge that is difficult to access. I know that knowledge is a good that anyone can access and it is the responsibility of those who know how to adapt the messages to the different levels of the interested parties.

One of the most important astronomers of antiquity was Hipparchus of Nicea (c. 190-120 BC), a Greek astronomer named because he was born in the city of Nicea, Bithynia (today Iznik, Turkey). His studies came to us thanks to the great astronomer Ptolemy who in the year 90 BC wrote a work that would be inevitable in the library of any person who was considered cultured, until the Renaissance. The Work is called the Almagesto and is a compilation of the astronomical knowledge of his time, of studies of Tolemy himself and works carried out by third parties such as the catalog of the stars of Hipparchus where they appeared on a celestial map (that's what they are called) the position of more than 1,000 stars divided according to their brightness in six magnitudes numbered from 1 to 6. The stars of magnitude 6 would be the ones that the human eye can barely see and those of magnitude 1 would correspond to the brightest stars in the sky.

It was the first time that it was evident that not all stars are seen with the same brightness. Of course, in the time of Hipparchus there were no large cities that are covered by a mantle of light that prevents us from seeing many stars, nor did environmental pollution exist. Today, from Mar del Plata for example, we can observe up to magnitude 4.5 and beyond that we will need the help of a telescope.

The interesting thing about all this is that Hipporch used the only thing he had to study the sky that were his own eyes, without any type of instruments that would increase or improve in some way his ability to observe. We can then easily take these concepts to a sound emission that will be useful to achieve a "mind map" of the sky that has the greatest possible correspondence with the real one. The magnitudes of this boy from Nicaea increased 2.5 times the previous magnitude, that is, a star of magnitude 3 would be 2.5 times brighter than one of magnitude 4. But our eye does not distinguish those differences with such subtlety and on the other hand, taking this to the audio would be conceptually wrong and what stars that I can observe without causing any problem in my eyes would become, in our new scale, annoying noises that would confuse the reality we are studying.

If Hipparchus had taken our premise he would surely have placed the magnitude 6 in the stars that are heard at 10 dB; more or less what we consider the threshold of human hearing, those who do not listen very well cannot hear the magnitudes 6, in the same way that many of us, I include myself, that we do not have a perfect vision (and now forgetting that this is currently impossible from the big cities from what we mentioned earlier) we cannot observe those same stars in the sky. The stars of magnitude 5 will be related to a sound in 20 dB; which corresponds to the noise of the leaves of the trees, the next magnitude (4) will correspond to about 30 dB; and will be comparable to the existing noise in a normal urban house. To the stars of magnitude 3, easily observable for anyone who has a not very dimined view we will pass them to 40 dB, which is a conversation in a low voice and the stars of magnitude 2 will correspond to 50 dB; which is the equivalent of a radio listening to soft music. Hipparchus came to the fach that the brightest stars were those of magnitude 1 and we will match those with 60 dB; which is the level of sound that an ordinary conversation has (and a conversation where bad words are not said as well).

But what we forget to say is that current scientists had to correct this good Greek because, "listening" to the sky better, they discovered that some stars and planets were above magnitude 1. Then they called them of magnitude 0 and we will give them 70 dB; but since they were still short they had to add more and using negative numbers we have magnitude -1 with 80 dB; which is something like the noise that emanates from a street with a lot of traffic, magnitude -2 (90 dB.), magnitude -3 (100 dB.) and magnitude -4 like the one that reaches Venus, for example, to which we are going to give a sound level of 110 dB; that will sound like a rock drill and maybe in this way we will achieve Give an idea that from the sound that emanates from the latter to the noise of the leaves of the former there is an important difference, which is the same existing in the observed brightness of the stars in the sky.

At this point the readers of this chapter will understand more of the sky than many unsuspecting people who are surprised when someone makes them see that the stars in the sky are shown with different brightnesses and also, as we will see below, with different colors. Due to their age, the stars have different temperatures and sizes, the temperature makes them different colors such as red, yellow or blue. There are more distinctions but we will use these to determine with which colors the stars are shown in the sky.

For that we will agree that red will be a deep sound while blue will correspond to a higher emission, yellow will be halfway between the two and white light, which is actually a saturation of all colors, will be represented in a sound that also represents the sum of the previous ones.

At this moment our knowledge of the sky is good enough to handle us in it with total naturalness, almost, as if we knew it all our lives, even, almost as if we could touch it. But to improve our idea a little, it is worth highlighting some other figures that are

presented to us in the night sky and for this we must study something more about Astronomy.

Our galaxy, the Milky Way, is a spiral-shaped galaxy and, in one of its outermost arms, is the Sun and rotating around it, the Earth along with the other planets, asteroids, comets and minor bodies of the Solar System. That is why the galactic arm that is right next to the one that contains us can be seen in the sky as a cloudy strip. We will call that "cloudiness" "noise or interference" because it acts in the same way. Further back from that interference we can't observe anything because it covers us in the same way that the noise we call frying makes a telephone conversation difficult for us. We will give you about 20 dB; to get an idea of its magnitude.

This is how our map of the sky is complete, we have populated it with stars but also in the magnitudes given above will enter the planets that can be heard without the need for any instrument to amplify them, these are: Mercury, Venus, Mars, Jupiter and Saturn. They will differ from the stars because they could say that they have an intermittent noise since they are sources of sound, while the planets bounce the sound of the stars (we would say in more common terms that reflect the light of the stars) and that is why, although they are opaque bodies we can see them and in our particular case hear them.

THE LIFE OF THE STARS:

For a long time we thought that the stars were eternal, that they had always been there and always would be. But even when their lives are measured in billions of years compared to the decades that last ours, they are also born, evolve and die. There are very different ones and even today astronomers are busy unraveling their secrets.

I like the prehistoric image of the stars, the one that imagined them as distant bonfires, and that explained that our bonfires would look like a star from a distance. But today we know that the stars are not of fire. They are spheres of gases (mainly hydrogen and helium) that balance two forces: the gravity that pushes them towards the center, and the force of the gases that tend to expand.

The stars are born from huge clouds of gas. When in a small region of these clouds, by chance, the gravity is slightly higher than that around it, the gas begins to accumulate at that point. The more material accumulates, its force of gravity increases and continues to add gas. The pressure is already so great that the temperature increases. At millions of degrees in the core of these gas spheres, hydrogen nuclei fuse to form helium atoms, that's the way stars shine.

Stars live lives of different duration, very massive stars, they use up their fuel quickly and only live a few million years, for a star like the Sun, of medium mass, it will be about 10 billion years and much more for a star of small mass, which consumes its material so slow that it can last hundreds of millions of years.

When hydrogen begins to become scarce, and the nucleus already has more helium atoms than this, the energy needed for helium to become carbon is much greater than in the case of hydrogen. Everything will depend on the initial mass of the star. The life of these suns will be divided into two possible paths, those of those that have a mass greater than eight solar masses and stars with a mass below that limit.

In stars with a mass of less than eight solar masses, helium cannot fuse on its own. The star will begin to collapse to get the temperature and pressure necessary to continue shining. When it gets energy again, the star expands again but cools down little by little with which it acquires a red color. They are red giants, which awaits our Sun in 5 billion years. Then the star will lose the layers of its gaseous envelope in a process known as a planetary nebula, a gas bubble expanding at 70 times the speed of sound.

In the most massive stars, the process is more violent. Within the nucleus there is still pressure and temperature to convert carbon into oxygen and it fuses with other atoms to form neon, silicon, and even iron. To continue obtaining energy, the core collapses again. The core is now very dense. The rest of the star is not so much and begins to rush to the densest area, almost at the speed of light. When falling into the dense core, this matter produces vibrations in the upper layers similar to earthquakes and from there they bounce off a monstrous explosion that we know as a supernova.

What remains after the explosion will also depend on its mass, giving rise to a neutron star (small and very dense) or a black hole, an even more massive object with such a force of gravity that not even light, the fastest in the Universe, will be able to escape its influence.
It will be the gases expelled from the stars, which come together

in new clouds to give the birth scenario to a new lot of them. Thus the Universe regenerates and continues its cycle, as it has done in its almost 14 billion years.

THE MUSIC OF THE STARS:

Astronomy, perhaps, is the most art-based science of all. Just looking at a starry sky or the beauties that we can see by bringing our eye closer to a telescope, generates that emotion that, like few scientific phenomena, excites us. I remember my last two total solar eclipses, both in Argentine territory, in 2019 and 2020 and in each of them, tears flowed from my eyes moved in the same way that I could be listening to a symphony.

My father was a piano concert player, however he never managed to keep me on the stool and my fascination was the astronomy books. However, there are not a few who combined their love for heaven and music.

Galileo said that mathematics is the language with which God wrote the Universe, but he was no stranger to music, on the contrary. He was part of a family of musicians, Vincenzo, his father, perhaps he was the one who instilled the scientific method in him when as a child Galileo saw him experiment with strings of different length, material and tension, crossed from wall to wall of the family house, looking for new sounds for his lute.

Later, when Galileo leaves his medical studies at the University of Pisa to study mathematics, this father-child duo will continue to strengthen. Galileo's mathematics and physics stimulated Vincenzo's thinking about the technical problems of acoustics. Vincenzo tried to unravel the secrets of the strings of different instruments, which sounded different depending on the size and shape of the spaces where they were executed. The

vibrations and lengths of the strings resulted in experiments, first, and in mathematical formulas, then, thanks to the help of the musician's son.

The motivations and inspiration between physics and music constitute an exact example in this paragraph of History. For the law of falling of the bodies, Galileo needed to measure time, but he did not have suitable instruments for small intervals, smaller than the second. It was based on reasons and proportions, and perhaps, already entering a terrain closer to speculation, in his musical ear. The inclined planes used by Galileo between 1603 and 1604, where the time elapsed by a ball traveling through a gutter is measured by the action of small bells, are musical instruments in themselves. Galileo can measure intervals of tenths of a second even when no time instrument of the time could give him that accuracy, only his musical ear, his training in the string experiments of his father, Vincenzo, and of a nature that also speaks in the language of proportions.

From Pythagoras we try to find proportions and harmony in the positions and movements of celestial bodies. Kepler thought he found a musical note to represent each of the planets that revolve around the Sun and with that he tried to discover the music of the stars.

Among the examples of men with chins raised to the sky who also placed their fingers on an instrument is William Herschel, the discoverer of Uranus. Herschel also had a musician father, a soldier in this case, and along with him and his brother Jacob he was part of the band of the Guard Regiment as an oboe interpreter. The music enveloped him in harmonies and led him to the dissonance of the war. He fled to England where he became an organist in Halifax and later a conductor in Bath. He composed beautiful symphonies while discovering nebulas of hundreds, he measured the times between the notes with the same expertise as the distances of the stars closest to his

telescopes.

Others are the cases of the musicians who were inspired by the celestial objects: Gustav Holst, Urmas Sisask and now Amanda Lee Falkenberg find on planets and moons the notes that flow in the staffs with the same grace as they do in their orbits.

Albert Einstein played the violin and the piano. Mozart was his favorite composer and for him, Mozart's music was so pure that it seemed that he had always been present in the world, waiting to be discovered by the master. Almost as if it were the laws of the Universe. In our days an example of astrophysicist and musician is guitarist Brian May who can both compose "Too Much Love Will Kill You" and study the zodiacal light or participate in the mission to Pluto, New Horizons.

Music inspires us, elevates us, influences perhaps what makes us more human, our emotions. He also represents us. Two ships launched by NASA in 1977 take our music to huge groups of stars. With them, perhaps two of our greatest expressions of culture will become an interplanetary embassy: music and our scientific curiosity will show us how what we are, and even better, as always happens with a good work of art or an ingenious explanation of the universe, it will mean the best we can be.

EXOPLANETS:

We always knew that other stars must have planets, that the Sun couldn't be the only one with a court of these objects around it. Nicholas of Cusa (1401-1464) and Giordano Bruno (1548-1600) already spoke about the infinity of worlds, they were convinced that up there, luminous points imperceptible to us would even be inhabited worlds. Today we know many, but we know that there are many more awaiting discovery. According to Ann Druyan in her latest book, “Cosmos, Possible Worlds” in a Universe with one hundred billion galaxies, each with an average of one hundred billion suns, one planet will form every second... and another... and another in this very moment.

In 1991, while the International Astronomical Union was meeting in Buenos Aires, a Pole, Aleksander Wolszczan, reported on the discovery of an extrasolar planet around a pulsar. Although this precise discovery was a miscalculation, the same astronomer, using the Arecibo radio telescope, found not one, but 3 planets around the pulsar PSR1257+12 the following year. It was the first confirmation of our suspicions. Other stars, in this case a type of dead star, had planets orbiting them.

In 1995, another team, in this case led by Michel Mayor and Didier Queloz, from the University of Geneva in Switzerland, discovered the first planet circling a normal star, 51 Pegasi. Today we call it a hot Jupiter, since it is a giant planet, even larger than Jupiter in our Solar System, but “close” to its star, with a temperature of 1,000 degrees and orbiting it once every 4 days.

Today we know more than 5,000. They are very different worlds, there are hot giants, others frozen, others, in the same way that our Moon with the Earth, always give the same face to its star, keeping one hemisphere in an unbearable hell and the other in an eternal and cold darkness. . We know of worlds similar to ours, located in their orbits in such a way that they receive enough energy from their star, but not too much, so that if there was water it would flow liquid on its surface. Our instruments have already detected planets with enormous rings that dwarf those of Saturn, extrasolar moons and even clouds of comets around other suns. Everything in our galaxy, only, and not much further than the 1,500 light-year distance limit. 5,000 planets discovered 30 years after the first, in a small portion of 0.03% of the total galaxy, ours, among 100,000 million others. An adventure that has just begun.

Of all of them, we have seen very few, and in any case they are only almost imperceptible points near their star. The vast majority are discovered indirectly. Guessing its existence from a strange behavior of its central star, which moves, or changes brightness, in an otherwise inexplicable way. Of them, more than half were shown to us by a single instrument, the Kepler Space Telescope, launched in 2009, found more than 2,600 of them and still has a list of 3,500 to be confirmed. He found almost all of them in a very small piece of sky, 400 telescopes like him would be needed to cover the entire sky but it would not be strange to suppose that we would have found 400 times more planets there.

We have found a planet orbiting the closest star to the Sun, Proxima Centauri, which is 4 years and four months away traveling at the speed of light. And systems of up to seven planets around the same star, similar to ours, although in reality in miniature, such as Trappist-1. There are new telescopes that join the search, in space and on dry land, with the same dream of continuing to discover, of populating the Universe with known worlds, perhaps, of hoping for one of them the greatest

discovery of Humanity so far. , to know if we are alone or not in the Cosmos, but for that, we will have to wait.

SONIFICATION TRAPPIST-1 SYSTEM:
https://www.system-sounds.com/trappist-sounds/

HOW THE MILKY WAY LOOK´S LIKE?

The Milky Way, the galaxy where the Solar System is located, has a barred spiral shape. A central core in the shape of a peanut crossed by a rod of gas and dust from the ends of which arms emerge that close forming a spiral. It has between 200,000 to 400,000 million stars or suns and a diameter of 200,000 light years. They really are all unimaginable numbers for us.

Let's play with more accessible data. Let's think that these spiral arms form a disk that is 200 meters in diameter, that is, our galaxy will now cover a square like most of those we find in the cities of Argentina, 2 blocks by 2. The disk is much wider How thick, if we place it on the floor it will reach 80 cm in height, a little above our knees. The Sun is not in the center, but about 26,000 light years from the galactic center, on our scale, about 30 meters.

It's lucky not to be in the core. There is the largest concentration of stars, the oldest, red giants, mostly millions of times larger than the Sun. Their attractive forces would have made it very difficult for the Solar System to form in that turbulent environment. Also in the core, we believe there is a huge black hole, with almost 3 million times the material that makes up our star and just as powerful. We could say that the entire galaxy revolves around it, even when the peripheries like the ones we inhabit never reach its zones of influence.

From the core comes a bar of about 13,000 light years in radius, it is a very active area in star formation. The arms emerge from its ends, two main ones called Shield-Centaur and Perseus, and two secondary ones, Sagittarius and Norma. From afar, the Milky Way should look very symmetrical, redder in its center due to the type of stars that

populate it and more bluish in the disk rich in young, hotter stars, and therefore of that color.

From as deep as the position of the Solar System is, it is difficult to study the shape of our galaxy. It was Edwin Hubble, the same man who gives his name to the most famous of the space telescopes, in 1926 who, observing other galaxies from the Mount Wilson Observatory in the United States, found different ways to classify them. Thus, he found among them spiral galaxies, barred spirals, elliptical galaxies (like more or less flattened spheres) and, of course, irregular galaxies without a defined shape.

Today we know that many of them, including ours, have a halo of dark matter around them. We don't know very well what it is, but perhaps it forms 80% of all the material in the Universe and is responsible for galaxies forming. Spirals like the Milky Way keep their shape and rotate the way they do.

Our Solar System rotates around the center of the galaxy every 228 million years. In its 4.6 billion years of age, it means that it has already made more than 20 laps throughout the galaxy, leaving one arm and entering another, successively “looking” towards different sectors of the Universe. Perhaps, in other times, other satellite galaxies of ours were visible in the Earth's sky.

As planets have satellites, stars can be accompanied by several others, also galaxies, and in particular the Milky Way has other, smaller galaxies around it. There are a dozen medium-sized galaxies and a few dozen diffuse, barely perceptible galaxies. All within the framework of a galactic “neighborhood”, the Local Group, an association of about forty main galaxies among which ours, along with Andromeda (the largest) and the Triangle are the three main members. Here the space between them does not

expand, on the contrary, within its limits, the force of gravity wins and in the future, within 5,000 million years, perhaps they will all have merged into a single, enormous, ball-shaped galaxy.

AN IMMESURABLY OLD UNIVERSE:

We live in a Universe governed by the invisible. Although we marvel at the images of galaxies and nebulae, with their brilliant colors and shapes, there is much more information there, where our eyes are blind. It is true that an astronomer studies the light of celestial objects, but for them, light is a broader concept than in everyday life.

We study the Universe in radio waves; in gamma rays; We detect "heat" in the infrared and we also study the Cosmos in the ultraviolet. We could say that we take x-rays of galaxies and collect particles that have traveled billions of light years to us.

The Universe is immeasurably old, today we believe it is about 13.8 billion years old, and it is very large. Since it has been expanding all this time, and even expanded faster in a very short time after the Big Bang, the size of our known Universe is around 93 billion light years in diameter. That is, light, traveling at 300,000 kilometers per second, would take about 93,000 million years to go from one end of our known Universe to the other, and even longer, because as long as it made this trip, the entire Universe would continue to expand.

Our Universe was born from a very small point that began to expand. It did not expand through space. Space and time itself emerged from there. Of course there was no celestial object yet, just dense energy at about 100 quintillion degrees Celsius. After an unimaginably short time that we know as Plank Time (Nobel Prize in Physics in 1918) and which is equivalent to a zero, comma, 42 zeros before 1, seconds, the Universe was still 100

trillionths of times smaller than an atom and a little later (always talking about very, very small fractions of the second) it begins to expand faster than the speed of light. When this very short period ends, the Universe will already have a size of one meter and within it, some differences in density will be the origin of future galaxies.
At a fraction 100 billion times smaller than the second after the Big Bang, our baby Universe is already the size of the current Solar System and continues to expand. Later protons and neutrons will be formed from smaller particles. But, let's go “faster”, much faster. A minute and a half after the Big Bang, the temperature of the Universe dropped to one billion degrees and nuclei of hydrogen and helium began to form, which are still the majority elements in the Cosmos.

Around 300,000 years after the Big Bang the temperature drops to about 3,500 degrees. Electrons and protons combine to form atoms and light can now be released. Until that moment, photons bounced off that dense and enormously hot mass that was the Universe, but from this moment on they begin to travel at the highest speed ever recorded. The Universe becomes visible. Therefore, this will be the limit for a telescope, no matter how powerful, to get close to the Big Bang. You will look at this moment when light began to travel untethered as we know it today.

100 million years later the first stars are formed, and when they group together, in enormous structures of hundreds of billions of them along with gas and dust, the first galaxies are born.

THE COSMIC CALENDAR:

In 1982, a great scientific popularizer named Carl Sagan made an adaptation of the enormous ages of the Universe for a better understanding. He reduced the 13.82 billion years of the History of the Universe to one Earth year, placing the Big Bang then, in the first second, on January 1st. On that scale, our galaxy, the Milky Way, will form in the first days of March and the Solar System will begin its evolution, from a cloud of gases around a rising Sun, on August 22. The Earth will appear on the scene on the 31st of that month, when the giants that formed closer to the Sun from its current position have migrated to their distant orbits, leaving room for small planets like ours to form. A large object will hit the Earth on September 8, tearing off a piece that will later become the Moon. On September 15, life will be born on our planet. This was simple, multicellular organisms will not arrive until November 30.

On December 12 of our cosmic calendar, the first animals appear and on December 17 the first vertebrates appear. The Earth begins to be populated in the seas and from there it moves to dry land. We found the first land plants on December 20, as if setting the stage for the first land animals to appear on December 22, they were the tetrapods (from the Greek "four legs") that evolved from fish with lobe fins to the early amphibians of the Devonian period. Life is something wonderful, almost improbable, whether it is from a “primitive broth” whose ingredients were found on our planet or whether life is something that came to us on a comet that crashed on the primitive Earth, it has revolutionized our planet. “day by day”... at least on this scale.

On December 23, reptiles begin to populate the Earth and at Christmas our astronomical Santa Claus brings us the dinosaurs themselves. On December 26, mammals appear, on the 27th, birds appear, and on the 28th, the Earth meets the flowers.

Perhaps it was the pollen from the flowers, perhaps due to a sudden climate change that cooled the Earth, the competition with the new inhabitants, the mammals, mostly more intelligent and more agile, the fall of a meteorite or for a sum of all these reasons. , dinosaurs became extinct on December 30 of our cosmic calendar, after having reigned on our planet for 5 days.

We reach the last day of the year, December 31. Only at 6:45 p.m. our planet is visited by the first Australopithecus. At 9:40 p.m. Homo Habilis appears and at 11:00 p.m. Homo Erectus. 15 minutes later we meet Homo Sapiens. That's where our story begins. Our year is ending, 13,700,000,000 years have actually passed since the Big Bang, which on our scale was located on the first second of January 1st. There is one minute left, it is 23 hours 59 minutes 10 seconds and Humanity creates the Venus of Willendorf, an exquisite piece that represents life, the feminine, and one of the most prominent luminous points in our skies. At 11:29 p.m. 48 seconds we built Stonehenge, 2 seconds later the Pyramids of Egypt and 2 minutes later Rome was founded. At 23 hours 59 minutes 54 seconds History welcomes Buddha and a second later, Jesus. In the last second of the year, at 23 hours 59 minutes 59 seconds, Columbus steps on America and our planet officially “finds itself” into its two halves.

In one minute, out of a whole year, we have created something fantastic called science. It is just a tool and perhaps it contains many errors, but it is what has allowed us to find quite convincing explanations to tell what happened, how, and when, in the entire year that “we were lost” since the Universe was formed in the Big Bang.

Let's travel the Universe then, I invite you, today our technology does not allow us to do so. The fastest ships we have built travel at an average of 60,000 kilometers per hour and with that, it would take about 18,000 years to leave the Solar System and about 77,000 years to reach the star closest to the Sun.

MAKING SPACE FOR EVERYONE:

It all began on October 4, 1957, when the then Soviet Union launched the Sputnik 1 satellite, a sphere 58 cm in diameter, with four antennas almost 3 meters long that only made a beep-beep, but that would change History. forever. Then would come the first living being in orbit, the dog Laika and many other animals that before and after would teach us how life adapts to the conditions of microgravity. The first man to circle the Earth was also a Soviet, Yuri Gagarin did it on April 12, 1961 and then the first woman, two years later, Valentina Tereshkova.

Humans had already ventured into space. We had launched our first instruments and some men (and one woman) sent not only the product of their minds but their own bodies to orbit the planet. Alexei Leonov, on March 18, 1965, opened the hatch of his Voskhod 2 ship and spent 12 minutes floating alone in space, attached to his ship only by a rope. He was selected to carry out, three years later, a circumambulation flight of the Moon but it was cancelled; the Apollo 8 spacecraft achieved that milestone on Christmas 1968.

In July 1969 the United States put two men on the lunar surface, Neil Armstrong and Buzz Aldrin would become the first two on a list that would reach a dozen from then until 1972. No human being ever returned but that will change very much. soon with NASA's Artemis mission.

In 1975, both countries, previously opposed in their space races, would dock their ships in Earth orbit in the Apollo-Soyuz program. They would be the same Soyuz that would take

cosmonauts from 15 communist countries into space in the Intercosmos program. Today 42 nations have already had their representative in space aboard ships from different countries, of which only three: the United States, Russia and China can do so with their own ships.

NASA's space shuttle program still represents the image of access to space for us. Five were built, called Columbia, Challenger, Discovery, Atlantis and Endevour, which were used in 135 missions to Earth orbit. With them, planetary probes such as Magellan or Galileo were launched, and the Hubble Space Telescope, among other important investigations.

A review, no matter how brief, of manned space exploration will not be complete without the mention of space stations. The Saliut (the Saliut 7 ended up falling into hundreds of pieces in Argentina in 1991), the Skylab and the Mir Space Station, predecessors of the current International Space Station, a construction the size of a soccer field that since 1998 to date has already received more than 260 people from 19 countries. China's Tiangong Station is also in orbit.

Last year (2021) the European Space Agency announced that for the first time it would choose an astronaut with a disability, within its new call, which due to Lithuania's entry into that consortium was extended until July. Although at the time I am writing this article it is not known who he will be and his real physical condition is historic at all. Space is no longer the realm of perfect bodies, when the astronauts were young pilots and among them, the most rigorously selected.

A first step had been taken on October 29, 1998 when John Glenn, the first American to orbit the Earth, returned to space aboard the space shuttle Discovery at the age of 77. On that mission, many studies had been done on Glenn's body to

evaluate the consequences of microgravity on an elderly person. It was not the only case although we had to wait a long time for the next one. On July 20, 2021, at the age of 82, Wally Funk, a member of the Mercury 13 program of female astronauts who never reached space, did make it aboard Blue Origin's NS-16 mission. She remembered that she wouldn't hold it for long since in October, William Shatner, Star Trek's Captain Kirk, would make the same flight at age 90.

It is clear that these last two flights were of a few minutes, suborbital, and that they did not pose any demands on their crew members, but the fact that elderly people could do them meant that from now on, looking at the Earth from beyond 100 kilometers height, will not be the privilege of a few, or at least (since the cost of these flights is still very high) the impediment will not be age or physical condition.

But what about a person with a disability as a professional astronaut? One of the people I consulted about this was Guillermo Rojo Gil, Olympic athlete, guide for a Paralympic athlete, coach and even physical trainer for ESA astronauts. Guillermo has almost all the perspectives to give his opinion on the subject. “When we think about the physical condition of an astronaut, we do not think about superlative values, but we do think about balanced values. In my case, for example, I am an elite athlete, I compete in the 400 meters, I have a lot of muscular strength, a lot of explosiveness, but my flexibility values are not so good, I would not be a good astronaut prospect in that sense. With astronauts it is sought that all elements of physical condition are balanced. Obviously this is not going to happen with people with a severe disability either. Perhaps, in this first stage at least, we will look for people who have some amputation, preferably of legs that are not so necessary in space, but not the arms that are required to carry out the experiments proposed by the space agencies that manage the Space Station. International".

ESA says it is looking for people who are psychologically, cognitively, technically and professionally qualified to be astronauts, but who have a physical disability that would normally prevent them from being selected due to the requirements imposed by the use of current space hardware. Also, it is willing to invest in the adaptations that are necessary so that these astronauts with disabilities can participate in a useful and safe mission.
To do this, he sought the expertise of the International Paralympic Committee and used the table they developed to categorize the different types and degrees of impairments, especially the list of eligible impairments. For the European Space Agency (ESA), there were three categories:

1) Red: when the type and degree of disability was not safely compatible with the task.

2) Green: when the type and degree of disability can be compatible with the task.

3) Yellow: when the type and degree of the disability could be made fully compatible with the task with some adjustments, modifications or innovations.

It is almost clear in this first approximation that someone categorized as green will be chosen. Even the poster of the call advances as examples those who have short stature, a prosthetic leg or one leg that is shorter than the other.
Many times we see that astronauts do repetitive tasks, that they follow recipes, making us think that although they have to be very organized, many of them do not correspond to their areas of expertise. It seems that everything they ask for in the selection processes is, at best, too much. Overqualification is a matter of supply and demand, as Nancy Vermeulen1 says for this work: “it is about choosing the best of the best. If there are thousands of candidates with high profiles and you only need six, I think it is normal to choose these people with extraordinary skills and conditions to be sure that after

expensive training, they will be able to perform multiple missions. It's all about training costs and efficiency. The reason for using extensive checklists is to ensure that everything goes as planned and nothing is missed due to human error, the same reason airline pilots are trained to work to strict procedures despite their background.

As private commercial spaceflight becomes more common, people with less than perfect health conditions will have opportunities, but for the professional astronaut corps, in my opinion, that will not change."

Not everyone thinks the same, there are even those who see a person with a disability as an advantage when forming a space crew. Sheri Wells-Jensenen, a blind American linguist involved in the astroaccess2 project, reminds us what it means to be astronauts in our childhood minds, and the almost inescapable frustration that the vast majority of human beings have when faced with the conscious knowledge that this It will only remain in the territory of dreams. "Every six-year-old boy wants to be an astronaut. This career goal is right up there with firefighter, detective, cowboy, and dancer. Before long, however, most recognize that he does not, and indeed never will, meet the non-negotiable physical requirements for the job. They are too tall, or have a weak knee, flat feet, or some other slight but uncorrectable physiological irregularity that means they do not have what Tom Wolfe called "The Right Stuff."

But she believes that in the world of space exploration, there should not only be room for those with a physical handicap, but that this will improve the task as a whole. Diversity, in companies for example, helps with decision making, flexibility, respect, and creativity. But this, at least for now, does not seem to apply to a certain height above our heads. According to Sheri and talks about her from her personal perspective.

“A blind person on a space station probably seems, prima facie, very scary given that her colleagues might have to rely on her in an emergency. But blind adults are successful parents, teachers, scientists, and chefs, and they have no more accidents than sighted people. There is no inherent danger associated with a blind person doing her job.
The key to success here lies in adapting the instruments to generate information in braille and/or audio along with visual displays.”

It is making redundant technology, which is absolutely common in the space industry. Do things that have two or three ways of working, or two or three elements to do the same thing. Adding braille or audio to displays can also help a sighted crew member in a particular situation. On February 23, 1997, the fire at the Mir space station forced the cosmonauts to save the ship and their lives in the middle of a rarefied environment that barely allowed them to see. Also, Canadian astronaut Chris Hadfield, in 2001, on the STS-100 mission of the space shuttle Endevour, was blinded during a spacewalk due to problems with his helmet. Even Italian astronaut Luca Parmitano had it worse when his helmet filled with water, almost drowning him, while he was on a spacewalk in 2013. They covered their eyes, nose and ears with that water that in microgravity looks more like jelly. She could only breathe through her mouth, she couldn't hear, she couldn't communicate with anyone because the microphone was covered in water and she couldn't see. Perhaps in these cases, if the gloves had more flexibility than the current ones, and prioritized sensitivity to touch, adaptations that should be made if the crews considered blind people as an integral part, the resolution of these problems would have been easier.

Sheri Wells-Jensenen believes that “a blind astronaut will not feel the nausea caused by the lack of a visual horizon. (...) Likewise, there would be little reason to worry about the damage that microgravity causes to vision as fluid accumulates

in the eye, distorting the eyeball and, in some cases, putting pressure on the optic nerve."
As we have explained here, with the imminent possibility of having a disabled person on the access ramp of a space shuttle in the coming years, with the still exciting image in our retinas of "grandparents" astronauts on board a ship, it would seem that the topic is something new. That it is the product of an absolutely revolutionary time in access to space like the current one and that has to do with the more than 60 years of maturation of a manned space adventure. But it's not like that. Disability and this particular human activity have been intertwined since their beginnings.

In the early 1950s, when men in space were only in science fiction books, NASA was already preparing to make it a reality. At that time, he allied himself with Gallaudet University, they tested more than 100 deaf people and recruited 11, the "Gallaudet Eleven." The idea was to learn how the human body responds when the gravitational signals from the inner ear do not work. Many of the experiments would seem like torture, if it weren't for the fact that the volunteers hardly knew they were in one. They were put on a boat off the coast of Nova Scotia in the middle of a violent storm with winds of more than 70 km/h and very rough seas. The 11 deaf men played cards and laughed while the experiment had to be canceled due to the NASA researchers' dizziness. They also spent 12 days inside a room that rotated ten times a minute. They never got dizzy and after 3 days they had even adapted to walking and doing all their routines compensating for that movement. They put them on zero gravity flights and they did nothing, NASA learned a lot, Harry Larson, one of the "Gallaudet Eleven" said a famous phrase: "We were different in the way they needed." However, and despite the fact that a good portion of astronauts are not absolutely productive in their first days in orbit due to dizziness (especially women), neither NASA nor any other space agency has ever chosen a person with this condition for work. Yes, an intermediate case is that of American astronaut Leland Melvin, who during underwater training, suffered and only partially

recovered from a serious injury to his left ear that did not prevent him from returning to space.

Julia Velasquez, a deaf student at the University of San Diego, United States, has participated in a similar Mars mission in Hawaii and is not the only case of someone with a disability to take part in this type of research. Marcin Kaczmarzyk, Polish, blind, did it too.

These and other studies do not only think in the area of Earth orbit. We think about the Moon, Mars and other future worlds. We think about long trips and there too, perhaps, disability in space is not a problem to be avoided, but rather an element of diversity that can become an advantage. Accidents can happen, and as we venture into untested scenarios the possibilities will multiply. An astronaut who loses his condition of self-sufficiency, due to an accident, a confident and self-assured man or woman who must adapt to a situation where his physique no longer responds as before, even if not definitively, can be relieved if They have the psychological support and example of those who, with a difficulty, have adapted to work in a useful and efficient way.

Ships may already be adapted for blind people when one of their crew members without pre-existing difficulties is affected by vision loss caused by the level of cerebrospinal fluid (CSF) in the brain, a condition whose risks increase as the age increases. more time in space. A place designed for everyone, can be used by everyone, to different degrees and in different circumstances.

Hayley Arceneaux, as a medical specialist on SpaceX's Inspiration4 mission launched on my birthday (September 15) 2021, became the first person with a prosthetic limb to orbit Earth. As a child she suffered bone cancer and was treated at St. Jude Hospital in Memphis, United States, for which the mission

carried out a worldwide collection of more than 200 million dollars. When she was 10 years old she had her knee replaced and a titanium bar was placed in her left femur. Of course, Hayley limps and suffers from pain in her legs occasionally, but that didn't stop her from flying into space and inspiring thousands of children around the world, some with similar illnesses, who even had the chance to communicate with her during the flight. just over three days.

The space is there for many more in the future, for women and men different from the first, for all ages, for the physically privileged and the not so privileged, for those who make it their workplace and for those who make it their desired destination, a unique experience, a dream fulfilled. One of them is Argentine. Jean Maggi[5] is a Paralympic athlete from Córdoba, president of a foundation that has already given away thousands of bicycles adapted to children and young people in the country and whose new challenge is to reach higher than any other compatriot. Once the medical analyzes have been approved and the parabolic flight has been successfully completed, he intends to board a ship in the coming years that will take him beyond the Karman line. He wants to become the first Argentine to achieve this and wants to float in microgravity, releasing the crutches from him, as he did momentarily in the zero-g plane. Perhaps the very image of freedom. One of the most compelling examples that we can imagine in terms of equality and the possibility that there are no impossible professions when it comes to childhood desire. When any child wants to be an astronaut, and has examples similar to him as a goal, space will finally be for everyone.

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1. Nancy Vermeulen is Chief Training Officer at Fly Right Training and Founder & Private Astronaut Trainer at Space Training Academy.
2. Astroaccess is an initiative of a non-profit entity in the United States that is currently carrying out zero gravity flights with people with disabilities and plans, in the future, to send some of them to space.
3. As stated in the article titled “The Case for Disable Astronauts” published by Scientific American on May 30, 2018.
4. Julia Velasquez was also a candidate to be part of the crew of SpaceX's Inspiration4 mission.
5. You can watch the documentary “The Infinite Limit (2019)” on the Netflix platform, which tells of her life and sporting and social career.

ABOUT THE AUTHOR:

Sebastián Musso is a journalist and scientific communicator. He has participated in more than ***40 International Congresses*** in Argentina, Brazil, Uruguay, Paraguay, Chile, Colombia, Spain and Italy, as a speaker, especially on the topics of didactic tools for the teaching and dissemination of astronomy and related sciences. Among the many educational projects and unpublished teaching tools of which he is the author.
The ***First Acoustic Planetarium*** for people who are blind or have low vision in the World stands out. Within the framework of this work, he is a member of an international working group at ***Astronomers Without Borders*** for the creation of teaching materials for people with different disabilities, which is sponsored by numerous educational and public good entities. He is a member of the International Astronomical Union-***IAU Inclusive Outreach Committee.*** He was an advisor for international projects such as AstroBVI (Astronomy for Blind and Vision Impaired) promoted by the University of Antofagasta, Chile. He currently directs the Teaching and Accessibility area of the ***AstroTES project, astronomy to touch, listen and feel***, for teaching astronomy to people who are blind or have low vision. With this topic, he has given around 200 workshops in seven countries in more than twenty years

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