Astronomy for All Senses

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In this article, we describe the content of a small and cost-effective exhibit at Planetarium Südtirol in northern Italy, in the hope that other science centres can benefit from it and reproduce it. The exhibit is called Astronomy for All Senses, and it interacts with all five human senses to facilitate learning about the Universe.

Introduction

Planetarium Südtirol is a small education centre in the Italian Dolomites. As the nearest settlement to this centre is located at some distance, we wanted to offer the public more than a standard planetarium show to make their journey worthwhile. So, we planned an exhibit that added to their visit.

Together with a student apprentice, we developed Astronomy for All Senses, a free-of-charge exhibit consisting of astronomy-related experiments, ideas, articles and illustrations that engaged with all five human senses: taste, smell, sight, hearing and touch. Many such multi-sensorial astronomy-related activities are already available, such as the g-astronomy project (Trotta, 2018)[1]. Most often, tactile ideas and activities developed are for the visually impaired[2]. For our exhibit, we combined these existing activities from different science communicators around the world into one special exhibit.

The exhibit was self-explanatory, as the planetarium had only two staff members who were usually busy with planetarium shows and not available as tour guides. Using off-the-shelf products from hardware stores and supermarkets, some LEGO bricks and a little bit of creativity, we were able to prepare a didactically entertaining and worthwhile exhibit for under 1000 euros. The exhibit was open to the public from 10 October 2017 until the end of September 2018.

Here, we describe the various stations, so as to enable other planetaria and science centres to do something similar.

Taste

Drink a Planet
To help our visitors visualise the sizes of the planets in our Solar System, we modelled them using various types of fruit. Because it is almost impossible to find real fruit in the exact shapes and sizes needed to make everything to scale, we printed the fruit on paper and used fruit juices for the taste component.

We selected the following juices: black currant (Mercury), small strawberry (Venus), cherry tomato (Earth), bilberry (Mars), large pineapple (Jupiter), large grapefruit (Saturn), apple (Uranus) and peach (Neptune). The determining factor for the selection was not only scientific accuracy, but also the availability of the juices. For instance, a watermelon would have been a

Figure 1. *Drink a planet exhibit. Credit: David Gruber.*

Box 1. Connection between objects and its smell

- Using the radio telescope IRAM in Spain, scientists discovered the chemical ethyl formate in Sagittarius B2, a dust cloud in the center of the Milky Way. This chemical is the dominant flavour in raspberries, as well as an important one in rum.
- Astronauts on the Moon reported that as soon as the lunar dust reacted with the atmosphere in the lunar module they were reminded of the smell of spent gun powder.
- Several studies report the existence of ammonia in comets.
- The atmosphere of Venus consists, among other things, of sulphur dioxide with clouds consisting of sulphuric acid.
- On Europa, the moon of Jupiter and Enceladus, a moon of Saturn, we discovered liquid oceans underneath their icy crust, hence the smell of water.

Figure 2. *Glass bottles with different contents. Credit: David Gruber.*

better choice for Jupiter, but it was not possible to source the juice. An Austrian beverage company Rauch was kind enough to sponsor the juices for this specific exhibit.

Smell

What's That Smell?

In the first of our two smell stations, we had five small glass bottles – one each for sulphur, water, raspberry spirit, ammonia (diluted with water) and some gun powder from fire crackers to resemble black powder (its possession is illegal in Italy). The bottles were labelled with the letters A to E. The goal for the audience was to smell the contents of each bottle and assign each scent to a given astrophysical object, printed on a sheet of paper

The correct matches were as follows: Venus with sulphur, which should really be sulphur dioxide (Marcq, 2013); Europa with water; Sagittarius B2 with raspberry (Belloche, 2009); a comet with ammonia (Wyckoff, 1989); and the Moon with black powder[3]. On the back of the paper, we listed the correct solution, with a short explanation on why the objects smell like they do.

Figure 3. *Postcard with 67P/Chury's scent. Credit: David Gruber.*

Eau de Comète

The scent firm The Aroma Company crafted a mixture to mimic the odour of comet 67P/Churyumov Gerasimenko, as reported by the ESA lander Philae. According to Philae's findings, 67P smelled like rotten eggs, cat urine and bitter almonds[4]. The cometary odour was captured on post cards which we displayed at our exhibit, together with an explanation.

Sound

The Sounds of Space

The first sound exhibit consisted of a desktop computer and a set of headphones. Using interactive buttons, our visitors could click through various slides that contained six astrophysical phenomena and their respective sounds.

Among the sounds used were winds recorded by the ESA lander Huygens during its descent through the atmosphere of Saturn's moon Titan[5], the sound of the oscillation of 67P's magnetic field[6], the sound of the aurora[7,8] and the sonification of stellar oscillations by the Sun, a White Dwarf, a Red Giant and a pulsar. In addition to allowing visitors to play back the sounds, we included a very short description on each slide.

Even though most of our visitors generally understood the concept of sonification, an elementary school student was confused, as she (correctly) assumed that because of the absence of air (or another medium), space should be quiet. We updated our slides with a statement that all the presented oscillations were shifted to the audible spectrum and that a carrier medium would be required.

Your Voice on Another Planet

The second sound station was a mathematica computer programme called soundmorph, which was created by Prof Timothy Leighton from the Institute of Sound and Vibration Research, University of Southampton (Leighton, 2016). This software can modify the speech of a visitor in accordance with the underlying physics to reproduce those vocalisations as if they had been produced on Mars, Venus and Titan. In addition, it contained sounds of other natural phenomena on the aforementioned planets, for instance thunder and cryovolcanoes.

Touch

How Much Do I Weigh on…

In this exhibit, visitors could compare what it felt like to lift a bottle of a certain weight here on Earth and on a planet with a different gravitational acceleration. We filled one half litre bottle with about 0.3 kilograms of fine beach sand; this served as the reference bottle on Earth. We then used another set of bottles filled with sand to show how the weight would change under the gravitational acceleration on other planets. In addition, we put an image of the planet in question on the lid of the bottle. As gravitational acceleration is very similar on Venus, Saturn, Uranus and Neptune, we also used a small kitchen scale to make it easier for our audience to see the differences in weight. In the description, we explained the difference between mass and weight and provided a multiplication factor with which a visitors could calculate their weight on each planet and on the Moon.

Touching the Moon

NASA has an archive of open source 3D models[9], which everyone can download and print with an appropriate 3D printer. Using a 3D printer from computer solutions company IDM[10], we printed the landing site of Apollo 15[11] and the Aristarchus plateau[12], the highest reflectance feature on the Moon.

Using an LED reading lamp, visitors could play around with different incident illumination of the Sun to see how craters and mountains cast shadows.

Figure 4. *Desktop PC with headphones to listen to space. Credit: David Gruber.*

Figure 5. *A microphone, speakers and a laptop running soundmorph to let visitors listen to their own voice on another celestial object. Credit: David Gruber.*

Figure 6. *Various bottles filled with beach sand. Credit: David Gruber.*

Sight

Landing on the Moon

At the Touching the Moon exhibit, we provided visitors with the means to see the Moon in 3D using anaglyph (blue/red) glasses. Stereoscopic images shot by the Lunar Reconnaissance Orbiter (LRO) are widely available online to make this possible[13,14].

In addition, we used Google cardboard[15] and the smartphone app Apollo 15 VR[16] to let our visitors experience the lunar landscape through virtual reality. Visitors downloaded the app on their own smartphones. Note that not all smartphones support a virtual reality mode.

LIGO with LEGO®

The University of Osnabrück built a Michelson interferometer using LEGO® bricks, a couple of small mirrors and a class II laser. The building instructions (both pdf and video), including the list of necessary bricks, are available online[17]. We bought the bricks on bricklink.com, the largest online marketplace to buy individual LEGO® parts. The prices of the bricks depend highly on the chosen colours, which is why our version of the interferometer is rather colourful. We ordered a 650 nm, 1 mW laser 20 (laser class II)[18], which is sufficient to show the interference pattern. Assembling the interferometer was relatively easy. We refrained from building the breadboard as it would have been too expensive given the large number of bricks. Without the breadboard, which dampens unwanted noise, small vibrations (talking or walking next to it) were picked up by the interferometer and were visible in the interference pattern.

A Lycra Universe

To illustrate the bending of spacetime by a massive body, we used a large sheet of Lycra, which we bought from a local tailor. We stretched the sheet over four PVC tubes forming a square and secured it to the tube with twelve plastic clamps. We loosely followed the building instructions given in a YouTube video called *Gravity Visualized*[19]. We used small rocks, marbles of different sizes and Chinese stress balls to further illustrate Einstein's view of the Universe. A word of warning: without supervision, children tended to misuse the Lycra universe as a trampoline for the marbles, which led to many missing balls over the course of the exhibit.

Discussion

Because of the lack of personnel, we were not able to robustly evaluate whether our visitors understood astronomical concepts better after their visit and/or how much time they spent at each station. However, we know that visitors usually come to the planetarium on average thirty minutes before a show to buy their tickets, and this is the time they spent at the exhibit. Verbal feedback from visitors has been positive. Children seemed to like the voice changer and the juices (especially after a long planetarium show) while adults were more interested in Lycra Universe and the LEGO interferometer.

In this article, we have presented a very cost-effective, reproduceable and easily realised multi-sensorial astronomy exhibit for audiences of all ages. The exhibit does not require extra security personnel or guides and can therefore be implemented

Figure 7. *Two 3D printed sceneries, together with anaglyph pictures of the Moon. Credit: David Gruber.*

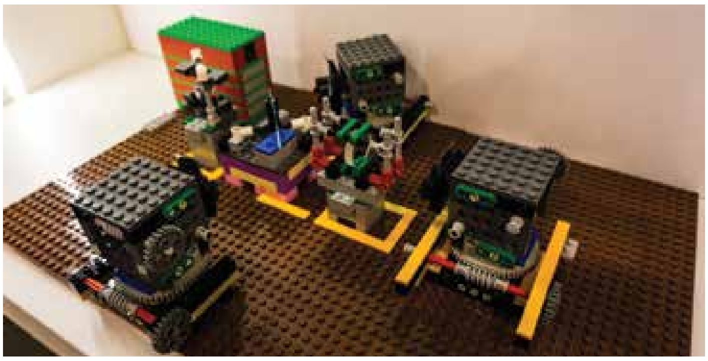

Figure 8. *LEGO interferometer. Credit: David Gruber.*

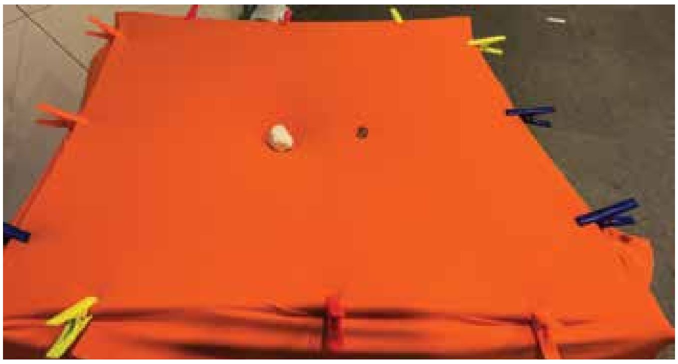

Figure 9. *Two-dimensional version of a universe, created with Lycra. Credit: David Gruber.*

in planetaria with limited human and financial resources.

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Notes

[1] More information on the g-astronomy project: www.kitchen-theory.com/g-astronomy-the-universe-at-the-tip-of-your-tongue/

[2] Examples of experiments for the visually impaired: http://sion.frm.utn.edu.ar/iau-inclusion/?page_id=75

[3] A first-hand account of the likeness of the moon's smell to that of spent gunpowder: https://science.nasa.gov/science-news/science-at-nasa/2006/30jan_smellofmoondust

[4] More information on the aroma company: http://www.aromaco.co.uk/portfolio/the-open-university/

[5] More on the sounds of Saturn's moon, Titan: http://www.esa.int/Our_Activities/Space_Science/Cassini-Huygens/Sounds_of_an_alien_world

[6] More on the sound of 67P's oscillating magnetic field: https://rosetta.jpl.nasa.gov/news/rosettas-singing-comet

[7] More information on the sounds of the aurora: https://www.gresham.ac.uk/lectures-and-events/the-sounds-of-the-universe

[8] Video content on the sounds of the aurora: https://www.youtube.com/watch?v=Zcef943eoiQ

[9] NASA's open-source 3D models can be found here: https://nasa3d.arc.nasa.gov/

[10] More information on IDM's 3D printer: https://www.idm-suedtirol.com/en/eu-projects/innovation/69-makerspace.html

[11] 3D model of Apollo 15: https://nasa3d.arc.nasa.gov/detail/Apollo15-Landing

[12] 3D model of the Aristarchus plateau: https://nasa3d.arc.nasa.gov/detail/aristarchus

[13] Stereoscopic image of the moon: http://lroc.sese.asu.edu/posts/733

[14] More information on the Lunar Reconnaissance Orbiter: https://www.nasa.gov/mission_pages/LRO/news/3d-moon.html

[15] Google cardboard: https://vr.google.com/cardboard/

[16] Smartphone app Apollo 15 VR: https://play.google.com/store/apps/details?id=com.ThomasKole.Apollo15VR&hl=de

[17] Building instructions for a Michelson interferometer using LEGO® bricks: https://www.ufp.uni-osnabrueck.de/en/education/myphotonics.html

[18] Laser built was the a 650 nm, 1 mW laser 20 (laser class II): https://www.laserfuchs.de/de/punktlaser/lfd650-1-4-515x68

[19] Video on YouTube demonstrating the bending of spacetime: https://www.youtube.com/watch?v=MTY1Kje0yLg

Biography

David Gruber studied gamma-ray bursts and other high-energy transients at the Max Planck Institute for Extraterrestrial Physics in Munich, Germany. After his PhD, he worked for five years at the Planetarium Südtirol in Italy as a science and astronomy communicator. Currently, he is Director of the Museum of Nature, South Tyrol, Italy. You can find him on Twitter (@antisophista) and Instagram (@dj_of_the_universe).