"2nd Workshop on Astronomy Beyond the Common Senses for Accessibility and Inclusion (2022)"
Revista Mexicana de Astronomía y Astrofísica Serie de Conferencias (RMxAC), **54**, 53–56 (2022)
© 2022: Instituto de Astronomía, Universidad Nacional Autónoma de México
https://doi.org/10.22201/ia.14052059p.2022.54.11

2nd Workshop on Astronomy Beyond the Common Senses for Accessibility and Inclusion (2WAI)(Virtual-Modality, November 17-18, 2021)
Editors: S. Vargas, B. García, G. Hemming, S. Duffau, N. Vázquez, and A. Pérez-DOI: https://doi.org/10.22201/ia.14052059p.2022.54.11

CHANDRA'S ACCESSIBLE UNIVERSE: FROM SIGHT TO SOUND & TOUCH

K. Arcand[1]

ABSTRACT

The nature and complexity of various kinds of astronomical data visualizations can be challenging to communicate with people who are blind or low vision. In consultation with members from blind and low vision communities, we present an overview of 3D print, sonification and visual description projects at NASA's Chandra X-ray Observatory Communications group as well as NASA's Universe of Learning, and how the 3D prints, sonifications, and descriptions are currently being used for our mission and programs. We describe how we can integrate verbal explanations of the scientific phenomena along with descriptions of what the visual viewer was seeing in the presented imagery, sonification or 3D model to create a more accessible, cohesive package. Our proposition is that this process of creating content for audiences who are blind or low-vision can and should be applied to other types of astronomy content and even a wider range of science communication content.

RESUMEN

La naturaleza y la complejidad de varios tipos de visualizaciones de datos astronómicos pueden ser un desafío para comunicarse con personas ciegas o con baja visión. En consulta con miembros de comunidades ciegas y con baja visión, presentamos una descripción general de los proyectos de impresión, sonificación y descripción visual en 3D en el grupo de Comunicaciones del Observatorio de rayos X Chandra de la NASA, así como en el Universo de Aprendizaje de la NASA, y cómo las impresiones, sonificaciones y las descripciones se están utilizando actualmente para nuestra misión y programas. Describimos cómo podemos integrar explicaciones verbales de los fenómenos científicos junto con descripciones de lo que el espectador visual estaba viendo en las imágenes presentadas, la sonificación o el modelo 3D, para crear un paquete cohesivo más accesible. Nuestra propuesta es que este proceso de creación de contenido para audiencias ciegas o con baja visión puede y debe aplicarse a otros tipos de contenido de astronomía e incluso a una gama más amplia de contenido de comunicación científica.

Key Words: sonification — tactile models — X-ray astronomy

1. INTRODUCTION

The Chandra and/or Universe of Learning 3D modeling and printing, sonification and visual description program is a set of accessible digital projects to help connect users – particularly those who are blind, have low vision, or have different learning needs – with the science of NASA's Chandra X-ray Observatory and other astronomical missions. The 3D modeling and printing project was launched a decade ago, the sonification project was launched in 2020, and the description project was launched in 2021.

The latter project provides detailed verbal descriptions of Chandra and multiwavelength data (primarily images and data-driven movies or sonifications[2], as well as illustrations when required) as they are released in real-time. The information is provided in both text[3] and audio[4] formats, and used as alternative texts for web and social media platforms. The audio recordings of the visual descriptions have also been concatenated into a podcast XML feed after obtaining user feedback[5].

Sonification is the process that translates data into sound. The sonification project therefore brings parts of our Milky Way galaxy, and of the greater Universe beyond it, to listeners through creating soundscapes of the image and spectral or other data. The sonifications are provided as audio only files and in video/audio compilations.

Finally, the 3D printing project was built off the first 3D data model released from Chandra in 2009. By combining X-rays from Chandra with infrared data from another orbiting NASA observatory, the Spitzer Space Telescope, plus visible light informa-

[1]Center for Astrophysics — Harvard & Smithsonian, USA (kkowal@cfa.harvard.edu).

[2]Chandra X-ray Center, Sonification page:

[3]Chandra X-ray Center, Text example:

[4] Chandra X-ray Center, Audio example:

[5] Chandra X-ray Center, URL for XML feed:

2nd Workshop on Astronomy Beyond the Common Senses for Accessibility and Inclusion (2WAI)(Virtual-Modality, November 17-18, 2021)
Editors: S. Vargas, B. García, G. Hemming, S. Duffau, N. Vázquez, and A. Pérez-DOI: https://doi.org/10.22201/ia.14052059p.2022.54.11

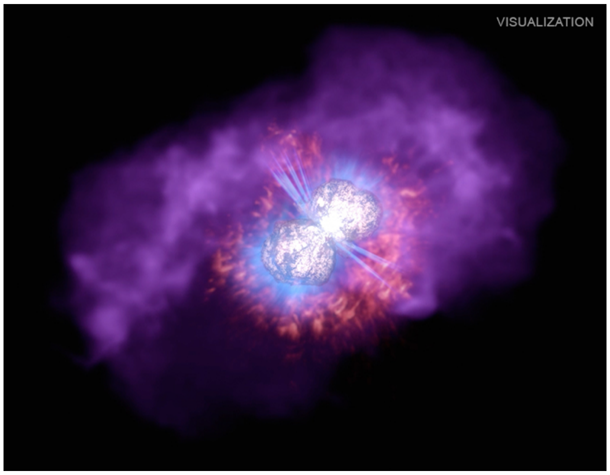

Fig. 1. Massive star Eta Carinae.

Fig. 2. Cat's Eye nebula.

tion from telescopes on the ground, for the first time, a three-dimensional reconstruction of a supernova remnant was created using these data taken in different types of light. That 3D model was then eventually improved with input from students at the National Federation of the Blind Arcand et al. (2019) before being printed as a 3D print. Subsequent objects from other types of exploding or interacting stars for example have been added to the 3D print collection since

Many of the results disseminated to the public from Chandra science involve other telescopes that have capabilities of detecting light across the electromagnetic spectrum and even multi-messenger astronomy. As a result, these accessible projects also typically cover this content from other missions, telescopes, and instruments beyond Chandra. Our data suggest that users are eager to have astronomical information from any and all types of observations in a form that is more accessible to them.

2. EXAMPLES

2.1. *Eta Carinae 3D model*[6]

Visual Description: Today's release features a visualization of a massive star, Eta Carinae, which expelled about 10% of its mass in an event known as the Great Eruption observed in the 1840s. This eruption created a small nebula around the star, the Homunculus Nebula. Images taken in different wavelengths of light by the Hubble Space Telescope, Chandra X-ray Observatory, and Spitzer Space Telescope have helped visualization specialists create a digital 3D model that can be rotated 360 degrees. This visualization is presented in a short video that shows the digital model being constructed, layer by layer.

The video begins with static images of each layer: Visible, Ultraviolet, Hydrogen, and X-ray, as well as an image combining all of the above wavelengths. When frozen in time, the Great Eruption resembles a peanut in the shell. The bulbous knobby shapes at either end represent the erupting nebula, while the star itself occupies the tapered space between them.

In the 2D image and 3D model of the Great Eruption in visible light, Eta Carinae is presented in mottled and veiny browns and tans. This 3D rendering is the base image onto which subsequent layers are added. As the model rotates, cloudy columns shooting out of the glowing core become evident.

As the 3D model continues to rotate, bright blue ultraviolet light is added to the visualization. This light blankets the peanut shape in a soft neon blue cloud. Thin shafts of blue light burst from the core, extending beyond the cloudy brown columns.

Next, the emission from hydrogen atoms is added to the still-rotating model. This resembles a translucent ball of red flames encircling the peanut shape and the blue ultraviolet light. Inside the cloud, the visual layer appears to glow.

Finally, an irregular cloud of purple X-ray light surrounds the red hydrogen emission. This cloud appears soft in texture, and is longer than it is wide, similar in shape to the glowing eruption at its core.

2.2. *Cat's Eye sonification*[7]

Visual Description: The Cat's Eye video features a static image of an ethereal shape surrounded by con-

[6] Chandra X-ray Center, Eta Carinae 3D model page:

[7] Chandra X-ray Center, website for example sonification:

2nd Workshop on Astronomy Beyond the Common Senses for Accessibility and Inclusion (2WAI)(Virtual-Modality, November 17-18, 2021)
Editors: S. Vargas, B. García, G. Hemming, S. Duffau, N. Vázquez, and A. Pérez-DOI: https://doi.org/10.22201/ia.14052059p.2022.54.11

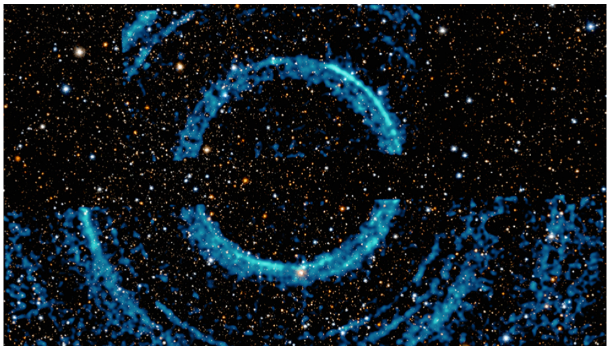

Fig. 3. V404 Cygni binary system.

centric circles. The shape is the Cat's Eye nebula, a huge cloud of gas and dust blown off of a dying star. The concentric circles are bubbles expelled by the star over time. The dust cloud resembles a translucent pastry pulled to golden yellow points near our upper right and lower left, with a blob of bright purple jelly inside the bulbous pale blue core. The jelly-like center represents X-ray data from Chandra.

The outer cloud and translucent circles represent visible light data from the Hubble Space Telescope. As the video unfolds, a white line emanating from the center of the nebula scans the image in a circle, like the second hand on a clock, or the radial arm on a radar screen. The more of the nebula that's in its path, the richer the accompanying sound. Light that is farther from the core has a higher pitch than light that is close to the core. X-rays are represented by a harsher sound, while visible light data sound smoother. The concentric circles create a constant hum interrupted by a few sounds from spokes in the data. Additional videos feature Cat's Eye images and audio from separated X-ray and optical data sets

2.3. *V404 Cygni image*[8]

Visual Description: This composite image features a series of incomplete concentric rings in a black field dotted with gleaming white, yellow, and golden stars. The giant rings are light echoes, a phenomenon similar to echoes from sound waves bouncing off of hard surfaces. These light echoes were produced when X-rays burst from gas near a black hole at the center of the image and bounced off of cosmic dust clouds. Black holes themselves, like this one in the V404 Cygni binary system, are invisible.

Here, the X-rays are rendered as hazy neon blue rings. The smallest, near the center, is the brightest and the most substantial. The remaining concentric rings are somewhat wispier, but are much larger, and extend beyond the edges of the image. These rings are not clearly defined like the clean ridges on a record album. Instead, they appear vague and blurred, resembling curving tire marks left in wet snow. The rings are incomplete, with gaps at our upper right, and upper left. A string of gaps appears in a horizontal line across the middle of the image, as if portions of the neon blue X-ray rings were removed with a straight swipe of an eraser. These gaps show the edges of Chandra's field of view during the observations, or the sections of the field Chandra did not observe.

[8]Chandra X-ray Center, website for example sonification.

3. CONCLUSION

Since the Chandra Communications group began implementing these accessible programs, we have continued to survey the results among the audiences we are trying to reach. We have presented the projects at numerous community events, particularly for participants who are blind or low vision, with highly positive feedback. As we learn more about the needs and wants of these communities, we will adapt further to refine our best practices. We intend to submit a paper on the quantitative data on the sonification project and to also conduct a formal qualitative and quantitative user study on the newest program on visual descriptions. Moreover, we have shared what we have learned with other NASA and professional astronomy and science communications organizations and are developing a master class workshop to help other groups apply these techniques for their own programs. There is a keen interest throughout the field to be more responsive to and inclusive of what have traditionally been underserved audiences.

These projects were created by a team consisting of Dr. Kimberly Arcand, Dr. Peter Edmonds, Megan Watzke, April Jubett, Nance Wolk, Kristin DiVona, Kayren Phillips, Khajag Mgrdichian, and Kelly Williamson of Chandra, Universe of Learning team members, as well as sonification experts Dr. Matt Russo and Andrew Santaguida of System Sounds, and visual description consultants J.J. Hunt and Christine Malec as well as other volunteers.

These materials were developed with funding from NASA under contract NAS8-03060 for the Chandra X-ray Center (CXC). NASA's Marshall Space Flight Center manages the Chandra program. The Smithsonian Astrophysical Observatory's Chandra X-ray Center controls science from Cambridge Massachusetts and flight operations from Burlington, Massachusetts. Additional funding comes from NASA's Universe of Learning under award

#NNX16AC65A with Caltech/IPAC, JPL, and the Smithsonian Astrophysical Observatory.

Disclaimer: The CXC does not endorse any commercial product.

Conflict of Interest Statement: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

REFERENCES

Arcand, K., Jubett, A., Watzke, M., Price, S., Williamson K., & Edmonds, P., 2019, Journal of Science Communication, 18, 4.

2nd Workshop on Astronomy Beyond the Common Senses for Accessibility and Inclusion (2WAI)(Virtual-Modality, November 17-18, 2021)
Editors: S. Vargas, B. García, G. Hemming, S. Duffau, N. Vázquez, and A. Pérez-DOI: https://doi.org/10.22201/ia.14052059p.2022.54.11