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The Tactile Universe

Accessible astrophysics public engagement with the vision impaired community

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Abstract. The Tactile Universe is an on-going public engagement project started in 2016 at the UK's University of Portsmouth that is making current topics in astrophysics research more accessible to the blind and vision impaired (BVI) community. We discuss the history of the project and how we have developed our core 3D printed resources and associated educational workshops through co-creation with the BVI community. We'll discuss how we have used these resources to engage with and inspire school students, how we have grown the project to a national level through resource provision and training, and talk a little about the project's plans for the future.

1. Introduction and Motivation

Astronomy is traditionally perceived to be a very visual science. Everything from how astronomers view their data and do their research, to the way we communicate with and educate the public (including the language and analogies we use) has strong visual ties. For this reason, people who are blind or vision impaired (BVI) can often find it difficult to fully engage with astronomy as a hobby, interest or as a profession. This is reflected in the small number of professional astronomers currently active who identify as blind or vision impaired and the challenges that they face. (Noel-Storr & Willebrands 2022)

The Tactile Universe[1] is a public engagement project started in 2016 at the University of Portsmouth which aims to engage the blind and vision impaired public with current astronomy research in more accessible ways, with a particular focus on working with young people in school settings. We do this through the use of 3D printed representations of real astronomy data, other lower-tech tactile resources, and in the latest phase of the project, with the addition of audio resources.

The project is led by vision impaired astronomer Dr Nic Bonne, with assistance from Dr Coleman Krawczyk (Project technical lead), Dr Jen Gupta (Outreach and pub-

[1] Retrieved January 10, 2024, from www.tactileuniverse.org

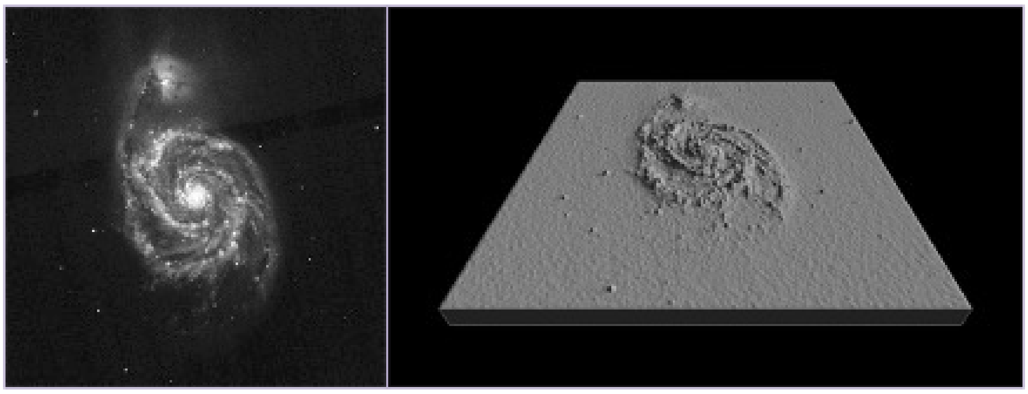

Fig. 1. A side by side comparison of a u-band (blue light) image of galaxy Messier 51 (also known as the Whirlpool Galaxy) from the SDSS DR13 data release (left) and the resulting 3D surface produced in Blender (right).

lic engagement advisor) and Dr Laura Nuttall (Gravitational waves science advisor).

Since its inception in 2016, the project has reached over 14,800 members of the public, school children and professionals working as science communicators or educators worldwide, with over 590 of those engaged being blind or vision impaired.

The central goals of the project are to: (1) Show young people with vision impairments that STEM subjects can be for them, and raise their aspirations (2) Work with the BVI community to develop and share accessible resources for learning and research and (3) Help and inspire others to communicate their science in more accessible ways.

2. Core project resources

The core resource of the Tactile Universe project are 3D 'height maps' created from monochrome telescope images of galaxies, sourced from the Sloan Digital Sky Survey (SDSS) DR13 data release Albareti et al. (2017). Created using a custom plug-in for 3D modelling software Blender[2], the models map the brightness of the pixels in the image into corresponding tactile features, where brighter pixels represent more raised features and dimmer pixels lower ones. In Figure 1 we show an example of how the software maps an image to the 3D surface.

By producing physical versions of these models through processes like 3D printing, users who interact with them can feel the shape of the galaxy in question by running their hand across the surface without the need to look at a more traditional image.

To communicate ideas around the colours in images of galaxies, we produce separate blue and red-light tactile images of each galaxy, created from telescope images taken through filters that isolate these wavelengths of light. These models help to emphasise the redder and bluer features in each galaxy image.

3. The importance and benefits of co-creation

Co-creation has played a crucial role in many aspects of the project, from the development and refinement of physical resources, to the development of the language and analogies we use to talk about the astronomy we want to communicate. Even though the project is led by a blind astronomer, a vision impairment (or any other disability) can be a very personal thing, with individuals developing unique strategies for accessing the world around them. There is almost never a 'one

[2] Retrieved January 10, 2024, from www.blender.org

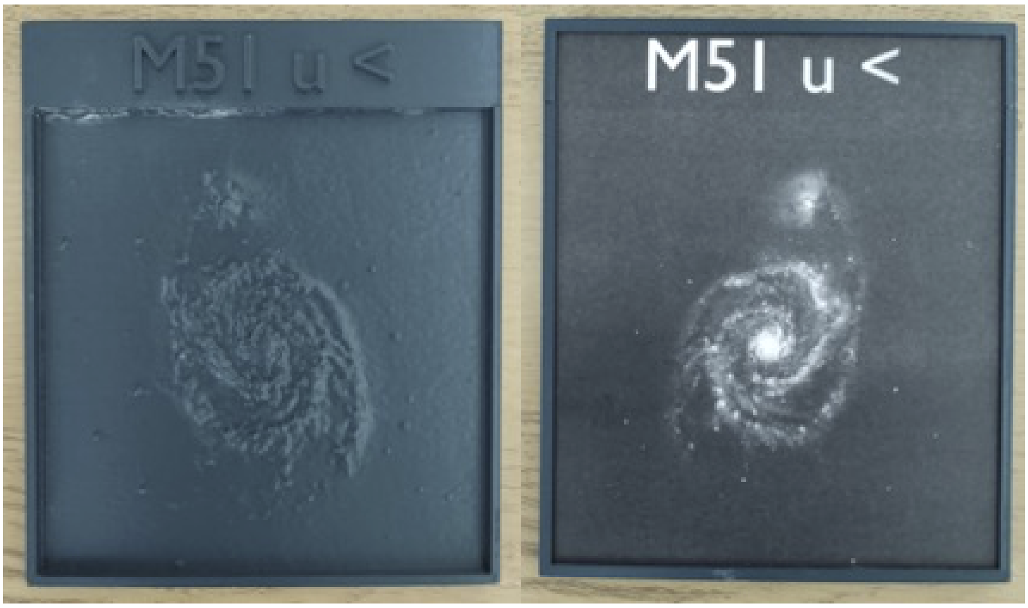

Fig. 2. An example of a 3D printed version of one of our tactile images. The front of the model (left) has the tactile surface, a tactile name plate and a raised border around the edge to help users calibrate what they are feeling. On the back (right) of each model we have attached the image used to make the model which mirrors the tactile features on the opposite side.

size fits all' solution and accessibility solutions need to be versatile as a result.

From the early stages of the project we have engaged with the BVI community (through local support groups, public events and school visits) to get feedback on these aspects of the project.

As a result, our resources are more versatile and include features that we would never have thought to include on our own. Examples are that one user wanted to be able to work out how comparably bright different parts of the model were. To accommodate this we have included a raised border around the edge of each model that is as high as the brightest feature. Users can bridge their hand between this and any part of the model to calibrate what they are feeling. Another user pointed out that they had some usable vision, and wanted to leverage this to understand the models. To accommodate this, we modified our models to include a black and white image on their rear face. This mirrors the tactile features on the front face of the model, so users with some vision can look at this while feeling the tactile features on the other side. An example of one of our 3D printed models, front and back can be seen in Figure 2.

Lastly, it became apparent very quickly that without the right language and analogies, our models would be very difficult to use well with this audience. Analogies had to be relatable (e.g. linking to things that people were more likely to have touched or heard, rather than seen). An example of this occurred after one test session where we used, and were rightly called out on, overly visual language when talking around the colours of galaxy images. To correct this we were able to modify the way we spoke about this, linking the physical processes causing this galaxy colour (red light comes from regions with older, cooler stars, blue light comes from hotter younger stars) and making sure these links were emphasised with our audience.

4. Changing our focus to working with schools and development of schools workshops

After the 2016 pilot, we made the conscious decision to focus our efforts on engagement specifically with children with vision impairments in schools settings, so as to have an impact on how this audience views astronomy and other STEM subjects at a young age. In 2017, we began work with a small number of vision impaired pupils, teachers and support teachers at local primary and secondary schools to develop a series of workshops covering the solar system and galaxies. These workshops were designed to be appropriate for students in upper primary and lower secondary school.

The solar system workshops deal with ideas around size and scale, where students interact with commonplace objects (like peppercorns, tennis balls and beach balls) to get a sense of how the sizes of the planets and the Sun compare to one another. Students then map out the solar system on a long strip of paper with the correct spacing between each planet, marking their positions with tactile stickers.

The galaxies workshop builds on these ideas of scale by providing tactile examples of the night sky and describing our place in our own Milky Way galaxy. Students then build a 3D model of a Milky-Way-like spiral galaxy using a CD and play-doh. Finally, using a set of our tactile galaxy images representing 10 distinct galaxy types, students do an exercise where they are asked to come up with their own galaxy classification scheme. This second workshop can be expanded on for students in secondary school to include more discussion of the physics going on inside and around galaxies to give them their various morphologies. We also introduce more of our blue and red light galaxy images to discuss the kinds of stellar populations contained within different galaxy types.

The accessible nature of these workshops also gives us options in terms of how we deliver them to school students. Many of the blind and vision impaired students in the UK are embedded in mainstream classrooms, where they may be the only child in their class with a vision impairment. Though we can deliver our workshops to smaller groups of vision impaired students outside of these mainstream classrooms, there are also advantages to delivering them to these mainstream classrooms. In a mainstream classroom, by getting everybody (regardless of their level of vision) to engage with our activities at the same time, we can begin to break down barriers and open up communication between students. BVI students have also reported feeling more included alongside the rest of their classmates in these scenarios.

5. Expanding the reach and impact of the project

In 2018 the project team were awarded a highly competitive Science and Technology Facilities Council (STFC) Nucleus Award to fund the national expansion of the project. To achieve this, we produced 20 full physical resource kits containing everything needed to run our schools workshops and then ran 5 training workshops in 2019 (attended by 66 people) in London, Portsmouth, Birmingham, Manchester and Edinburgh. Through an application process, we then awarded these resource kits to trainees so that they could deliver our workshops in schools and students local to them.

Training workshop attendees came from a variety of backgrounds, including researchers, science communicators, educators (a mixture of specialist and mainstream) and even interested members of the public. Several of our trainees were even visually impaired themselves. Because of this mix of backgrounds and expertise, we split the content of the training workshops between educating attendees about the astronomy our resources communicate, while also covering the dos and don’ts of working with blind and vision impaired people, and to dispel any concerns or stigma surrounding this.

To expand the reach of our resources even further, we also made freely available for download the software plug-in used to make our tactile images, 3D printable versions of all

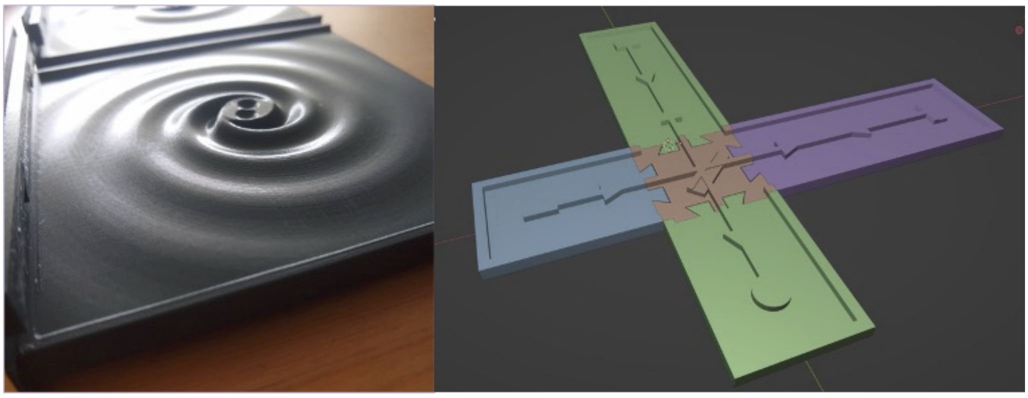

Fig. 3. Some of our newest tactile models communicating topics around the science and detection of gravitational waves. The image on the right shows one of several tactile 'snapshots' of gravitational waves rippling outwards from pairs of colliding black holes. The image on the right shows a tactile puzzle piece interferometer that students can construct as they follow the path that laser light takes as it travels through a gravitational wave detector.

of our models, as well as documents like best practice guides, workshop scripts and lesson plans. To ensure that everybody accessing and creating our resources this way has what they need to use them well, we have also produced a series of training videos and blog posts covering aspects of our in-person training sessions.

6. Current work and the future of the project

In 2020 we were awarded an STFC Public Engagement Legacy Award. This award has allowed us (with some significant delays during the global COVID-19 pandemic) to extend the project further by working with our University's gravitational wave research group as well as collaborators from Cardiff University to create additional resources and workshops which focus on the sources and detection of gravitational waves. These resources are aimed at students in upper secondary school and as before, we worked closely with local BVI students and specialist teachers to develop and test these new resources.

As well as creating more tactile resources, like a puzzle piece interferometer (that students can put together to understand how gravitational waves detectors work), and tactile snapshots that show gravitational waves rippling outwards from their source (see Figure 3), we have also combined these new resources with sonifications, or data converted to sound. Sonifications like the 'chirp'[3] produced by LIGO scientists, representing the signal from the first direct detection of gravitational waves in 2015. By opening up more modes of interaction for students, we hope to make our workshops even more accessible.

In November of 2023, we finalised the creation of new gravitational wave themed resource kits and travelled to the University of Birmingham, Cardiff University and University of Glasgow to train local gravitational wave research groups to use these new resources. We left a resource kit with each group and we are now supporting them as they begin to connect with their local BVI student communities and set up their first schools engagements.

Finally, in addition to developing and distributing these new resources, our goal was also to support existing kit holders in their work with our resources, and to distribute more of our old resource sets to even more people. To achieve this, over the course of the pandemic, we created 20 additional resource kits

[3] Retrieved January 10, 2024, from https://www.ligo.caltech.edu/video/ligo20160211v2

and then in 2023 we ran two additional training workshops, one at the University of Cardiff, where we engaged with Welsh researchers, educators and science communicators, and the second where we worked specifically with outreach and public engagement officers and experts associated with the South East Physics Network (SEPnet). Cardiff University now holds 5 of our resource kits and are acting as a hub, delivering workshops themselves and loaning kits out to schools who can use them. Several SEPnet officers have also taken kits to use in their own delivery. We still have several kits and will continue to assign these to groups and oganisations who could use them over the coming months.

In terms of the future of the project, we have some big ambitions. We plan to (1) Support trainees around the UK to use our resources and focus on our own delivery to local VI pupils; (2) Work more closely with trainee and established specialist teachers to improve accessibility in STEM classrooms across the UK; (3) Work with museums and science centres to improve accessibility; (4) Work to make the University of Portsmouth an accessible place for current and future BVI pupils to study physics and astronomy.

In the meantime, all of our resources are still available for free on the project website[4] and we're always happy to chat about the project, or help others make their own science communication more accessible.

[4] Retrieved January 10, 2024, from www.tactileuniverse.org

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