

Virtual Reality for increasing the awareness of current scientific research

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Introduction

Istituto Nazionale di Astrofisica (INAF) is the Italian public body in charge of performing research in the Astrophysics and Space Physics domains and promoting it worldwide. Its Education and Outreach team has always investigated new ways to inform, involve and engage people, especially young people, through direct interactions between front-run scientists and students. Among these ways, Virtual Reality (VR) can offer unique educational experiences for effectively communicating astronomy, simulating the user's physical presence in an astronomical virtual environment. Thanks to the possibility of navigating inside these simulations and interacting with astrophysical objects - literally by using your body and hands - VR enhances the capability of grasping details and extract information, offering a sensorial perception of the object under examination.

INAF has a long-standing tradition in developing digital tools to analyze astrophysical phenomena and in 2019 some researchers at the INAF Palermo Observatory started a project to visualize astrophysical objects in VR. The project is named 3DMAP-VR², which is the acronym for 3-Dimensional Modeling of Astrophysical Phenomena in Virtual Reality.

The 3D models produced are very accurate and full of details about the shape, the temperature, the density, the chemical composition, and other physical characteristics of the object under examination, thus making it easier for the researchers to analyze and understand the phenomena they are studying.

It was immediately clear the enormous potential of the 3DMAP-VR project for communicating astronomy to the public and increasing the awareness of the current scientific research, especially in the youngest segments of the citizenry, to include the next generations in cutting edge scientific debate.

Since teenage students are often so accustomed to high levels of interactivity and games, that they easily lose their interest when teachers or communicators use traditional methods, through experimental activities using VR, we aim to introduce students to discoveries in every field of astronomy, thrilling and giving them the motivation, the ability and tools to better know the universe.

The 3DMAP-VR project gives the public the opportunity to visit the space as we know it today and directly interact with current scientific data used by researchers to conduct and publish their own studies. In 2021 INAF started also the PRIN Project "VIRTUAL REALITY AND AUGMENTED

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² http://cerere.astropa.unipa.it/progetti_ricerca/HPC/3dmap_vr.htm

REALITY FOR SCIENCE, EDUCATION AND OUTREACH” to share the experiences and the activities related to virtual and augmented reality that have been carried on in many INAF structures, take up new technologies and develop new models and exhibitions, that can be used in VR and AR to explore the world of astronomy, thus making people visualize abstract concepts, promoting the understanding of even the most complex topics and demonstrating the usefulness and the beauty of science. Many of the VR experiences already developed are uploaded to the edu.inaf platform in order to share them effectively with other researchers, the general public and especially the students, with the goal to engage, train and inspire them to consider a career in STEM research areas.

Method

To create VR models of astronomical objects, we combined accurate 3D HD/MHD codes (e.g., the FLASH code, Fryxell et al. 2000, or the PLUTO code, Mignone et al. 2007) performed for scientific purposes, on high-performance computing facilities (e.g., CINECA, Bologna, Italy), data analysis and visualization applications (e.g., Interactive Data Language, 2 YT project, 3 ParaView, 4 Visit, 5 MeshLab, 6 MeshMixer 7) to realize navigable 3D graphics and to create a VR representation of the models (Fig.1). The 3D representations are realized using a mixed technique consisting of multilayer isodensity surfaces with different opacities. Once the 3D graphics are ready, they are uploaded on Sketchfab, one of the largest open-access platforms to publish and share 3D VR and Augmented Reality (AR) content.

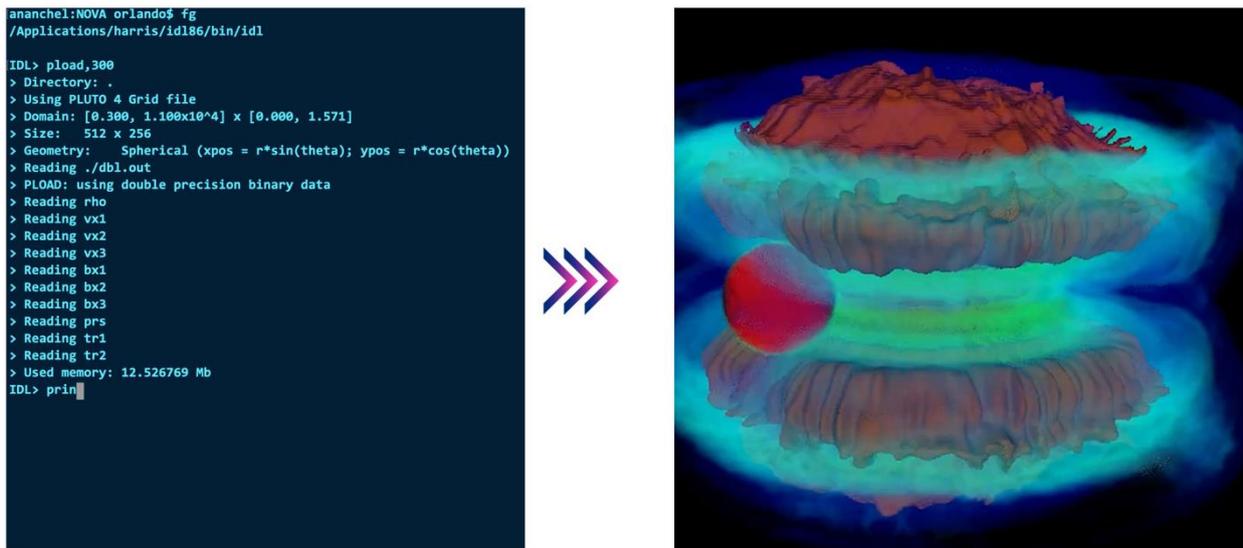


Figure 1. The picture shows how scientific data can be analyzed to developed a visual 3D model like this one, which represents the evolution of nova outbursts. Credits: S. Orlando

Using virtual reality, researchers can observe and analyze aspects that are difficult, even impossible, to highlight with traditional analysis techniques, such as the distribution of chemical elements, the configuration of magnetic fields, the complex morphology of the phenomena or the objects studied. Moreover, the use of these models allows the researchers to present their scientific results more effectively both to university students and other professional astrophysicists, illustrating the results of their paper with an immersive and innovative way of communication.

Thanks to the expertise of researchers from different institutes spread throughout Italy, INAF plays a leading role in the development of physical models of astronomical objects. Technology continues to evolve at a rapid **pace**, the potential of these tools – such as virtual reality experiences but also augmented reality ones - can be leveraged to enable educational and outreach purposes (Fig. 2).



Figure 2. People enjoying a walk through space during public events. Credits: L. Leonardi

The 3DMAP-VR team project started to share online the models developed by researchers for scientific research, uploading them on the Sketchfab platform (<http://sketchfab.com/>). The team tested how using VR in education and outreach was effective to engage teenagers and facilitates powerful learning experiences, through allowing visualize the invisible, improving the sense of presence, immediacy and immersion, and increasing content understanding. Since 2019, using Sketchfab we have hosted a wide range of public events combined with explanatory notes from a professional astrophysicist that is extremely entertaining and the concepts are easy to be caught and understood. Besides, the realism and accuracy of the models catch the attention of the audience and the use of VR adds the “wow” factor, to engage the youngest.

People can enjoy the virtual experience through a computer or even through a smartphone or a tablet. In addition, by using a virtual reality headset, 3D data are visualized in a fully immersive environment, creating interactive experiences and providing personal experiences of astronomical phenomena.

Sketchfab gave the 3DMAP-VR project huge visibility. On this platform we published four galleries of astrophysical models: “Universe in hands”³, shows the results of magneto-hydrodynamical models of different astrophysical phenomena developed by astrophysicists of the INAF Palermo Observatory; “The Art of Astrophysical Phenomena”⁴ reports artist's views of astrophysical objects designed based on our current knowledge of these phenomena; “The Science of Science Fiction”⁵ spot well-known science fiction movies – such as *Star Wars* created by George Lucas or *Interstellar* directed and produced by Christopher Nolan - to highlight if and in which parts they get the science right - thus providing some accurate, plausible science - and to illustrate real phenomena and objects in Astrophysics; “Anatomy of astrophysical objects” aim to illustrate the structure of astrophysical objects. The content of the representations comes from the information extracted from the analysis

³ <https://sketchfab.com/sorlando/collections/universe-in-hands>

⁴ <https://sketchfab.com/sorlando/collections/the-art-of-astrophysical-phenomena>

⁵ <https://sketchfab.com/sorlando/collections/blue-science-of-science-fiction>

of multi-wavelength observations, from the development and study of physical models, and from the analysis of laboratory experiments that mimic the phenomena under study.

The use of tools and 3D models made available by the 3DMAP-VR team project had a tremendous impact on dissemination and outreach activities, also during the Coronavirus pandemic. As an example, the online event held for the European Researcher's Night 2020. To establish a direct communication flow between researchers and public, drawing attention and wonder to the beauty of the universe, the 3DMAP-VR team designed two video formats: video-pills⁶ and the web series called "Socialmente: condividiAMO l'Universo" (trad. literally "socially: we share the universe"; Wordplay to communicate researchers' love and passion into their job), published on Edu INAF⁷'s and INAF OAPa⁸'s YouTube channels and being reintroduced by Media INAF⁹.

Using a simple and direct way of speaking, and dynamic and modern communication channels like social media (YouTube and Facebook), these 3D models were presented with images and sounds in a funny and affordable way to all kind of people, while maintaining scientific information correct and clear.

This approach was particularly useful in the last months and after the publication of these two video formats, views and interactions on our social channels have skyrocketed (Fig. 3-4).

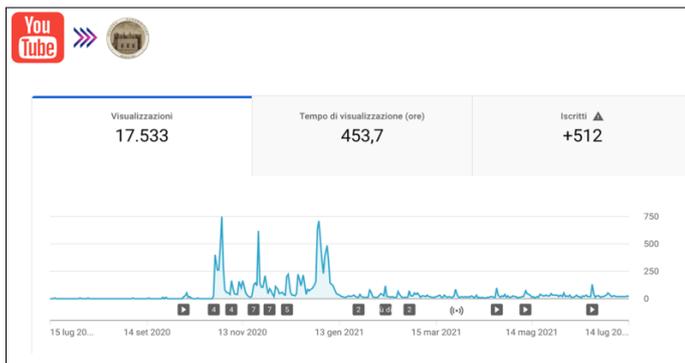


Figure 3 - Visualization and interaction on YouTube
<https://www.youtube.com/user/INAF0aPA>

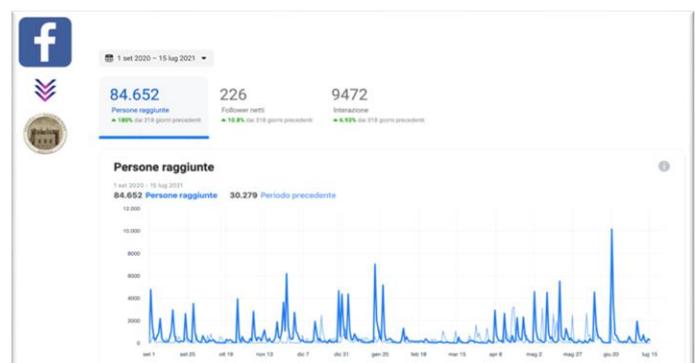


Figure 4 - Visualization and interaction on Facebook
page <https://www.facebook.com/astropa.news>

The team also published a documentary titled "Esplorando la vita delle stelle in Realtà Virtuale"¹⁰ (trad. Exploring stars' life in Virtual Reality) where one of our researchers presents the 3DMAPVR project and explains how scientific data can be transformed into immersive experiences through the use of virtual and augmented reality. The 3D models were presented with an innovatively, adding "a touch of magic" using augmented reality special effects (Fig. 5): Augmented reality video editing create outstanding videos, an excellent way to engage capture the attention of the user, especially young people, and empower communication.

⁶ https://edu.inaf.it/autore_didattico/3d-map-team/

⁷ <https://www.youtube.com/c/EDUINAF/featured>

⁸ <https://www.youtube.com/user/INAF0aPA>

⁹ <https://www.youtube.com/user/inaftv>

¹⁰ <https://www.youtube.com/watch?v=XXHoJm8bkWw&t=324s>

The method used need videos captured by the camera, then with a video-editing tool like iMovie we post-processed applying AR effects. The final result shows a total immersive environment in which the researchers explains and analyze the astrophysical objects as they are close to him.

After the publication of the documentary, both on Media INAF's and OAPa's YouTube channels, the 3DMAP-VR team was contacted by Mediaset, the largest broadcaster mass media company of Italy, to shoot a television report about the project titled "Cacciatori di stelle" (trad. Stars-hunters). One of our project team member had the possibility to work in Mediaset with the journalist Massimiliano Di Dio, to edit the tv report which has aired on Studio Aperto¹¹ on 13th March 2020; a terrific opportunity to spread the project all over the Italian Country.

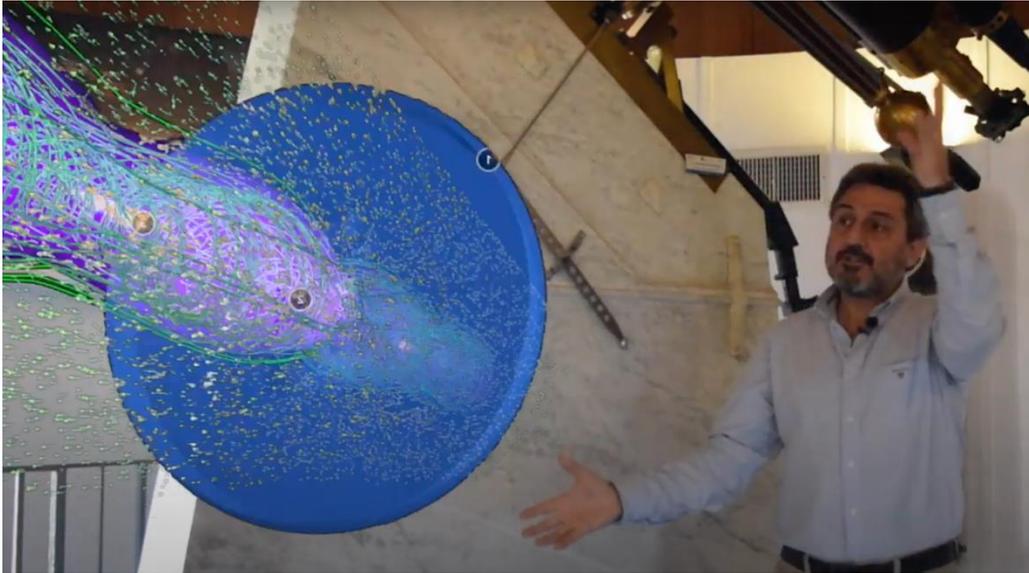


Figure 5 – A frame from the documentary "Esplorando la vita delle stelle in Realtà Virtuale". Here the researcher shows the simulation of the protostar DG Tauri.

Thanks to the success obtained from Sketchfab, also NASA contacted us to request some of our models that later were published on Voyager¹², a virtual platform created in collaboration with the Smithsonian Institution: six out of the nine models published were made by a team of researchers at INAF Palermo Observatory led by Salvatore Orlando.

Following the success in terms of appreciation and visibility, the INAF 3DMAP-VR project team launched a fully experimental project, based on 3D real data models integrated into a virtual reality environment where both INAF scientists and students could virtually meet and interact through the web, while making a journey inside the virtual world to discover where a star is forming, or where a star had died, or to take a look of exotic planets orbiting around stars like-sun (Fig. 6).

The Covid-19 pandemic has changed and is still changing our society and the models of interaction, accustoming students to having their teachers at home, through zoom, meet, skype. This experimental project was created to give students, from all over the world, the opportunity to visit space as we know it today, thanks to 3D models developed by astronomers and became the main actors of the educational process. Thanks to this project, students can leave their schools and their homes - becoming explorers of the universe – just using a computer or a smartphone, an Internet

¹¹ <http://gallery.media.inaf.it/main.php/v/video/inafintv/mediaset/20200313-cacciatori-stelle.mp4.html>

¹² <https://3d.si.edu/collections/chandra>

connection via videoconference or with the use of a green screen using the technique of Chromakey¹³.

Through the use of systems like zoom or meet, or by sending a message in chat, students from different schools in different parts of the world will have the possibility to interact in real-time between them and with the astronomer and ask him or her questions about the covered themes or any doubt or curiosity on other astronomical or physical matters.

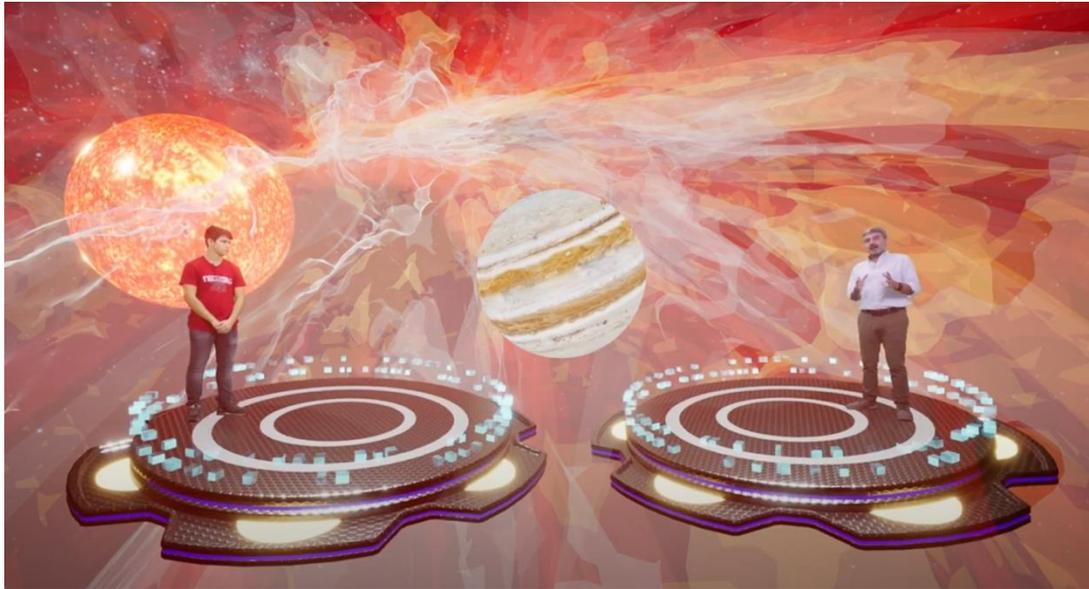


Figure 6 - A virtual journey through space

The final product was shared worldwide as an example of cooperation and distance teaching to reach effective communication of scientific and astronomical research.

INAF was invited to present this innovative live educational tool at the 75th United Nations General Assembly - UNGA75 - in New York, 2 Oct. 2020 to demonstrate the huge impact of digitalization to facilitate cross-culture exchanges and front-run scientists students' interactions to include the next generations in cutting edge scientific debate, awareness, engagement and discovery.

With this experimental demonstration, INAF wanted to instill a mindset of innovation and collaboration through sharing experiences, data and knowledge, to bring to higher educational levels, to achieve better quality standards and to obtain greater technological development. We would like to inspire other institutions to collaborate and put at the service of the community their discoveries to make our future sustainable thanks to research, technology and high-level education.

And last but not least, we would like to inspire governments to invest in culture - digital initiatives improve productivity reducing costs - and to reflect on some main points related to this and other high quality e-Education initiatives such as to develop students' digital skills, which are so important in today's world, both for personal life and for their future careers and to give chances of self-training as example of lifelong learning activities.

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¹³ Look at the demo: <https://youtu.be/zH39qFRW6UA>

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