A dedication to realism

RSA Cosmos is a company that designs and installs optical planetariums and cutting-edge software. Here, CEO **Benjamin Cabut** reflects on their success to date, including the innovative veRTIGE project

How do three-dimensional (3D) or 4D planetariums, such as those installed in Rome and Paris, create a simulation of the cosmos? How realistic is the experience?

Our company is designing an educational tool that gives the planetarium the ability to transport the audience anywhere in the known Universe! We have developed an astronomical simulator, a kind of serious video-game, that allows planetarium narrators to interact with the audience and decide 'on the fly' where to go and what to show.

In developing this software, we are working closely with astronomers in order to realistically simulate astronomical and physical phenomena such as solar and lunar eclipses, planetary atmospheres, dust and plasma emitted by comets, and light interaction in planetary nebulae. We are also integrating many scientific datasets such as high-definition terrain and volcano positions on Mars, satellites and debris orbiting around Earth, and exoplanets.

3D (perception of relief in the image) and 4D (seats with motion and effects) capabilities allow the planetarium to give the audience a more intense experience by adding more effects during the show. Imagine a flight between International Space Station modules in 3D so you can feel the station above your head, and feeling weightlessness thanks to 4D effects!

Novel software is essential in the pursuit to remain at the cutting-edge of planetarium technology. How has RSA Cosmos achieved 3D real-time programming?

RSA Cosmos is composed of a team of 3D real-time specialists who come from the video games industry and have PhDs in 3D real-time

Stars in their eyes

Emerging as a model for industrial and academic collaboration, a pioneering venture based in France called **RSA Cosmos** aims to create the most advanced planetarium software ever using real-time astronomical data

IN 1939, THE beloved astronomer Carl Sagan visited the World's Fair that was then taking place in New York. The experience was a formative one – on seeing a tuning fork's vibrations being displayed on an oscilloscope, he recalled: "Plainly, the world held wonders of a kind I had never guessed. How could a tone become a picture and light become a noise?" Many scientists have stories of a similar kind, their passion being sparked by a particularly singular, and often extracurricular, childhood experience.

Creating the moments which can inspire the next generation of scientists is an incredibly important task, and along with it comes the need to communicate scientific advances and understanding to the general public who have left education – a goal that academia is sometimes criticised for not always achieving. Along with science journalism, museums and other public engagement strategies have a huge part to play here, as does industry. A French firm called RSA Cosmos is playing an influential role by designing and installing planetariums in countries as diverse as Russia, South Korea and Brazil.

REMAINING CUTTING-EDGE

RSA Cosmos began in 1988 manufacturing optical planetariums, and has since successfully built a business around supplying new and innovative planetarium solutions, often integrating optical and digital technologies. The company has now taken on an enterprising research project – aiming to develop software that allows real-time exploration of the entire known Universe. This enables a scientific mediator to take audience feedback and develop an interactive show, making for a much more involving experience than the static recorded shows of the past.

Developing this software is a daunting task, and relies on working at the vanguard of both astrophysics and three-dimensional (3D) computer simulation. When RSA Cosmos made its first inroads into software development, Chief Executive Benjamin Cabut was intent on utilising the world-class academic expertise within France to help cement the country's reputation as an international leader in research. He duly reached out both to the Observatoire de Paris and the research laboratory INRIA Grenoble, for mutually beneficial collaborative enterprises; RSA Cosmos could provide outreach for the Observatoire, and was also willing to push the development of INRIA's Gigavoxel technology, thereby optimising it for galaxy visualisation. These partnerships came to fruition in the (visually enhanced) Real Time and Interactive Galaxy for Edutainment (veRTIGE) project.

veRTIGE rendering of our Milky Way.

programming. Their work is remarkable; not only do they have to be experts in this field, but they also have to understand a lot of physical and astronomical phenomena and equations in order to implement them in our real-time software.

What are the goals of RSA Cosmos' (visually enhanced) Real Time and Interactive Galaxy for Edutainment (veRTIGE) project? How is this progressing?

The main goal of veRTIGE is to create real-time navigable scientific models of galaxies and to create a direct collaboration between astronomers and 3D real-time programming specialists. The fact is that we can find publications about how to represent astronomical data or phenomena from various laboratories in the world, but none from France, despite having world-renowned specialists in both astronomy and 3D real-time representation of physical phenomena. This R&D programme is an impetus to rebalance that expertise.

Which recent examples of new astronomical or physical phenomena or objects that you have incorporated in your software have proved most challenging, and why?

That is a difficult question! Many phenomena we are integrating into our software are challenging! Speaking about veRTIGE, the main challenge we faced was that we wanted our simulation to be as close as possible to astronomical images you can find of other galaxies on the internet, but using real physics calculations to obtain these results. There are several difficulties here: firstly, an astronomical image is nearly always rendered using 'false colour' and is actually a combination of several pictures of the same object at different wavelengths. Telescopes take pictures of the sky with wavelength filters, and the exposure duration of the sensor will also vary depending on what astronomers want to highlight. Furthermore, astronomers can use post-production techniques on images taken by telescopes in order to make a specific area or phenomenon more visible. In developing our veRTIGE model, we therefore had to be able to create an image composed of several wavelengths with different exposure times and a different colour range for each wavelength filter. This posed a major challenge, since the physics can be drastically different in each wavelength considered.

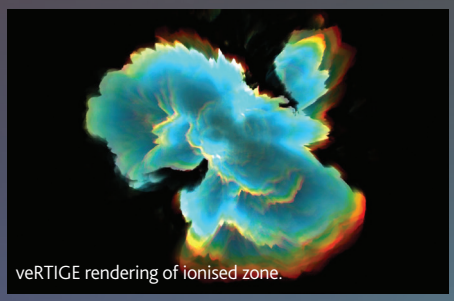
Secondly, a global view of the Milky Way is composed of several subsystems underpinned by various physics. It is already complex to synthesise the physics of a subsystem, but in addition to the global view, you have to integrate all those effects together.

Could the innovative technology that RSA Cosmos is developing be used for any other applications? What could these innovations lead to?

RSA Cosmos is focusing on the planetarium field, and so this is our primary target, but the improvements by both ourselves and INRIA adding to Gigavoxel within the project could be useful for other applications. This technology will probably be used in the future in other 3D real-time applications such as video games or simulators.

Who do you collaborate with to achieve your ambitions?

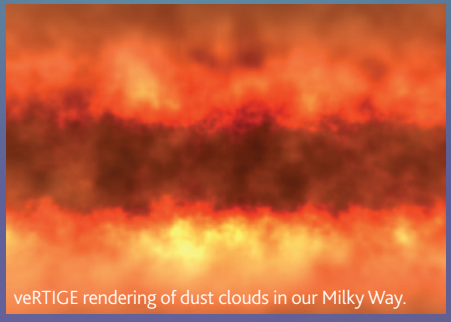
We would like to thanks the Agence national de la recherche (ANR), INRIA and Observatoire de Paris, for their support and expertise. Since the beginning of the project three years ago, it has been a real technical and human adventure for all of us!


veRTIGE rendering of ionised zone.

DIVERSE COLLABORATION

veRTIGE is a next-generation display software platform for planetariums. In order to create scientific shows that cover the full range of astronomical phenomena, it is necessary to represent length scales from that of the Solar System to that of the entire Milky Way. Previous displays have provided little more than an artist's impression of the full Galaxy; the ambitious project being undertaken by the RSA Cosmos-led group is to provide a full simulation of the Galaxy using data drawn from real astrophysical studies. These datasets are provided by a team at the Observatoire de Paris, headed by Françoise Combes and Frederic Arenou who are modelling the early Universe through simulation in a project known as GALMER. In presenting simulations in planetarium displays worldwide, veRTIGE offers a unique link between the results of an academic study and the imaginations of the general public.

Under the guidance of project leader Fabrice Neyret, INRIA is contributing to the project through its Gigavoxel technology, a tool used to represent data in spaces of huge volume. It is capable of visualising over 20 million star and dust particles, corresponding to over 159 billion individual stars. This marks a step change from RSA Cosmos' previous software platform, which could only represent 5,123 units of volume, known as voxels. By comparison, veRTIGE can currently model $32{,}768^3$ voxels in a carefully optimised real-time display.


veRTIGE rendering of dust clouds in our Milky Way.

INTELLIGENCE

RSA COSMOS

OBJECTIVES

- To design a planetarium solution, comprising screen, seats, projection system, sound and lighting, multimedia, etc.
- To develop novel software suites for planetariums, and specifically a three-dimensional (3D) real-time astronomical simulator

KEY COLLABORATORS

Françoise Combes; **Frederic Arenou**, Observatoire de Paris (team leaders)

Fabrice Neyret, INRIA Grenoble (team leader)

FUNDING

Agence national de la recherche (ANR)

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