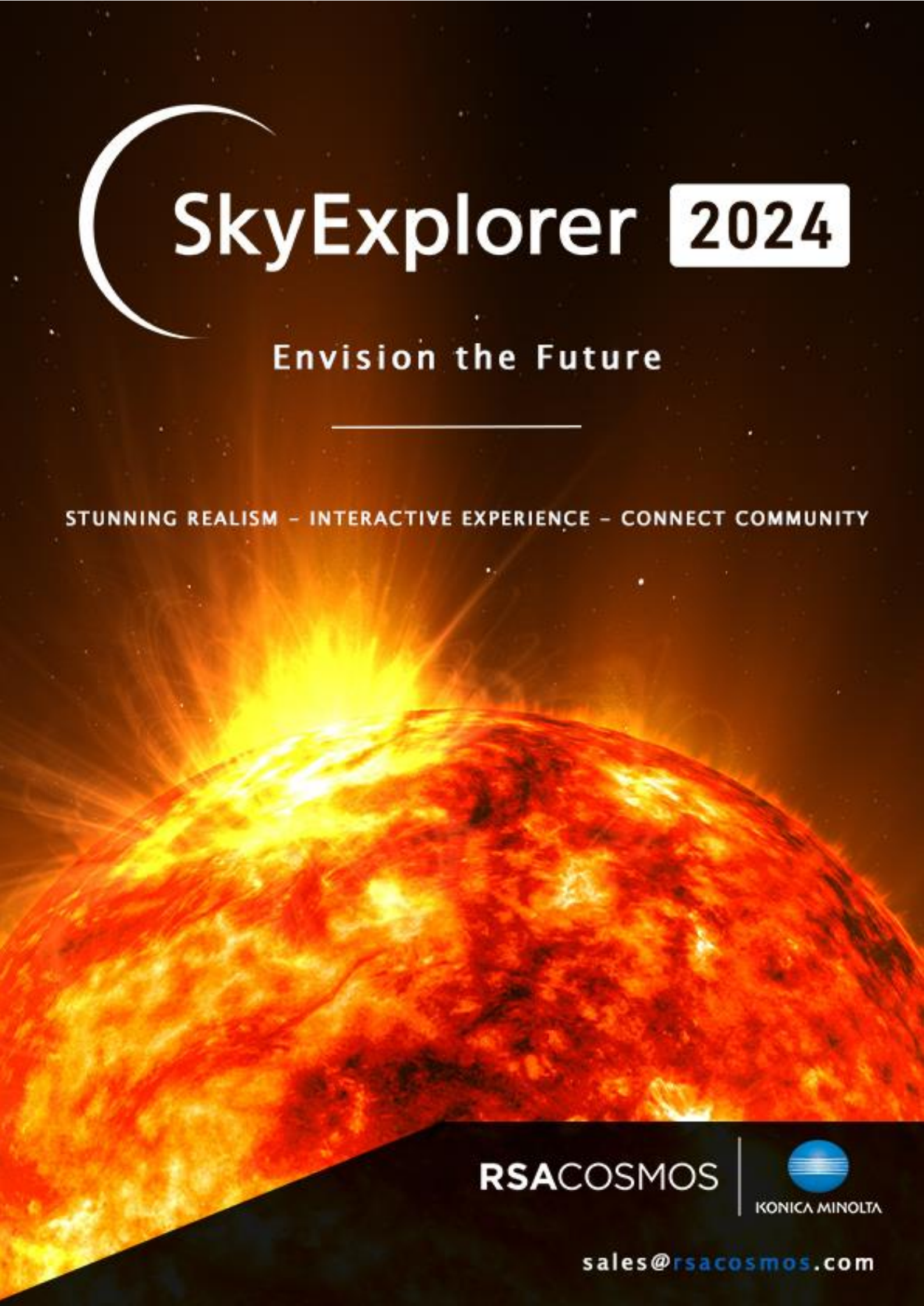
SkyExplorer 2024

Envision the Future

STUNNING REALISM – INTERACTIVE EXPERIENCE – CONNECT COMMUNITY



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SkyExplorer

- **SkyExplorer brings the most stunning journeys through the Universe in real-time with scientifically accurate data, offers direct connections to scientific institutions & the astronomical community, and enables great interactive experiences thanks to a variety of interactive and interconnected tools.**

- **A new version is released every year with the latest developments in astronomy and scientific learning.**

Initially released in 2002, SkyExplorer evolves every year.

This new release not only ensures all the core features of a planetarium allowing to show stars, grids, constellations and planets, but incorporates as well more databases, a greater rendering capacity, greater simulation performance.

SkyExplorer's inner core has been developed based on 2 concepts, allowing our end user:

- To travel **"from the atom to the Universe"** very easily, passing continuously from 10^{-18} m particles to a Universe 10^{27} m wide.

- To enjoy "**continuous motion management"** switching from one reference to another at any time seamlessly thanks to an accurate positioning with a strict presentation of astronomical phenomena.

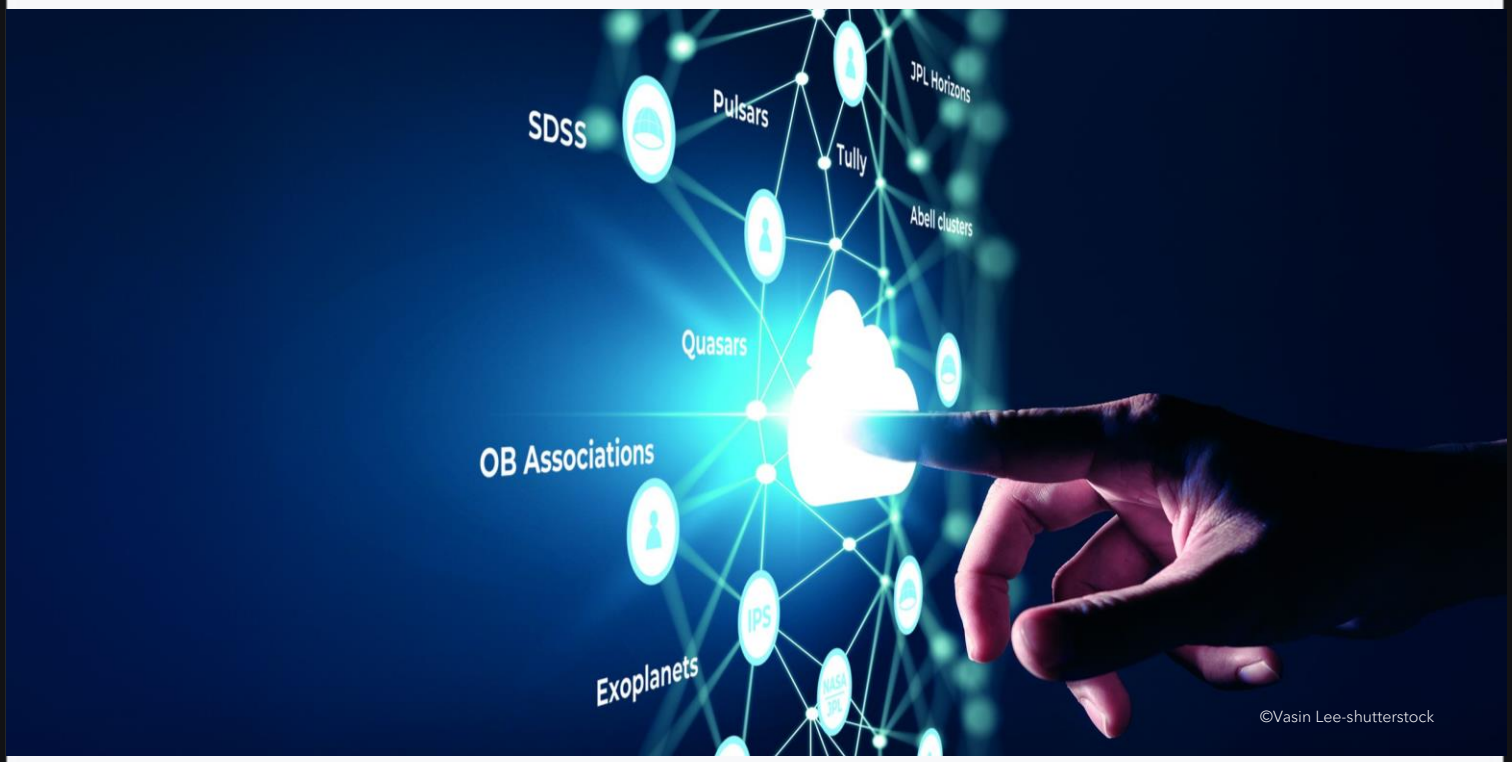
SkyExplorer is a software dedicated to **multiple projection displays** working on a computer cluster. All the necessary technologies are embedded in SkyExplorer (geometry correction, image uniformity correction, synchronization of image generators, etc.).

SkyExplorer will be presented following its main assets:

RSA Cosmos also offers another software, complementary to SkyExplorer, to bring new content and open up to new utilizations beyond astronomy.

CONNECT COMMUNITY

Users have access to a considerable range of up-to-date data, by sharing content with other users from around the globe & connecting to online scientific datasets.



A WORLDWIDE COMMUNITY OF USERS

- **Community Cloud**

SkyExplorer comes with a cloud sharing feature that brings together the worldwide SkyExplorer user community.

The integrated cloud feature in SkyExplorer enables any user to share content with others from around the globe. It is easy to upload or download any content available in the resource manager tab (scripts, images, 3D models, video and audio).

With its built-in search engine, it is easy to find content created by others and use it for your own animations.

- **Community Network**

The SkyExplorer cloud is more than a content sharing platform.

Every user can follow institutions or users and get a notification each time they share content on the cloud.

Institutions, users or content can be liked.

Community Network is also a platform which helps planetariums to market and distribute their productions.

- **Domecasting**

SkyExplorer's Domecasting feature enables users to broadcast live dome presentations to other planetariums.

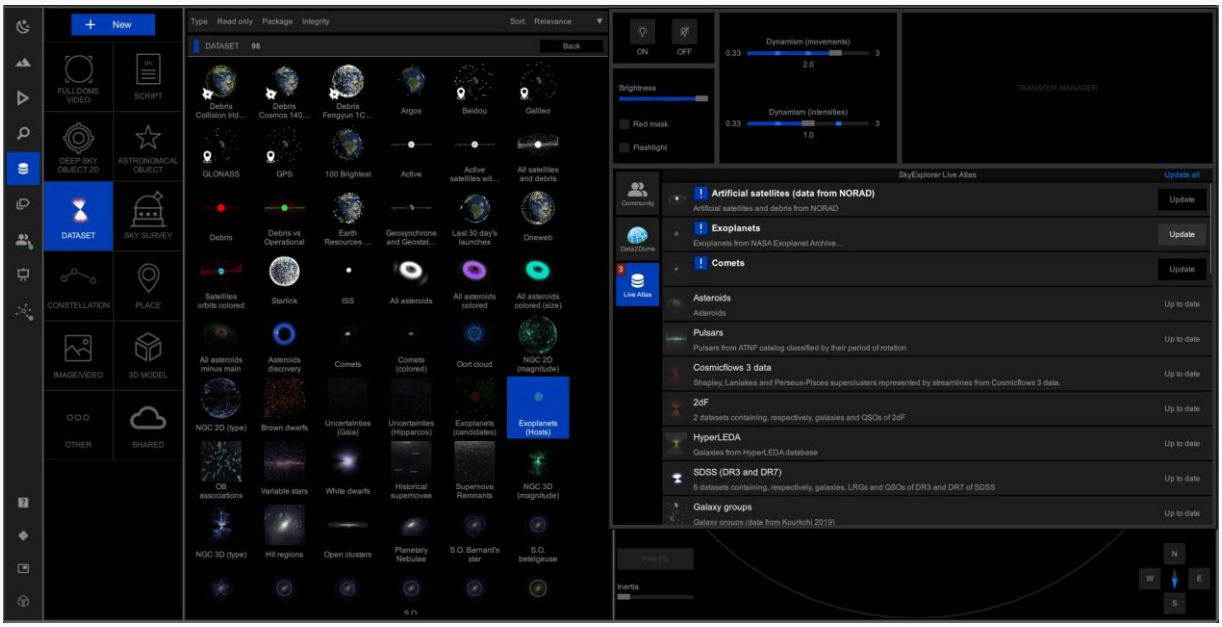
The host planetarium sends instructions to the attendees so they can present the same content (images, 3D models, video, simulation, etc.) at the same time.

SkyExplorer shows the schedule of all Domecasting events and users can register to participate.

CONNECT TO THE LATEST DATASETS

- **SkyExplorer Live Atlas**

SkyExplorer Live Atlas is the largest fully integrated Live Atlas directly connected to scientific institutions. All astronomical datasets and catalogs can be updated online with a single click by planetariums, offering up-to-date and scientifically accurate content.
To further amaze the audience, our Atlas was developed using great levels of aesthetics and HDR techniques to offer stunning renderings.

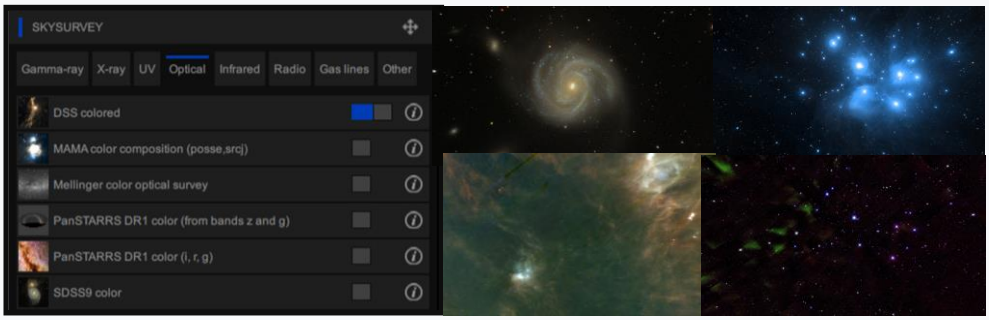


- **Sky Surveys (HiPS)**

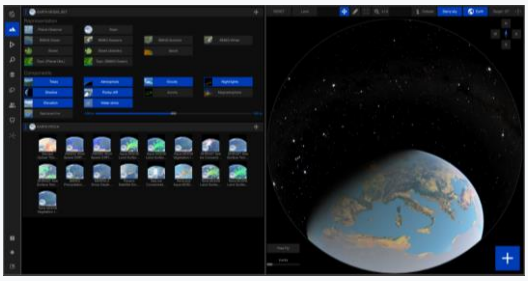
SkyExplorer streams high definition sky maps directly from HiPS (Hierarchical Progressive Surveys) servers registered by the CDS (Centre de Données Astronomiques de Strasbourg) and gives access to hundreds of sky maps available online, , using the HealPix projection and multi-resolution structure.

It is also possible to add further HiPS sky maps easily and instantly into SkyExplorer by simply copying the URL of the sky map from the HiPS server and pasting it into SkyExplorer.

Combined with our Smart Zoom function, SkyExplorer offers a constantly high resolution by progressively downloading new data on the fly & displaying more objects when zooming in. Our Smart Zoom Function refines the image, as if users were using a telescope.



- **Terrain Map Streaming (WMS)**



SkyExplorer can show surface maps for planetary bodies coming from online servers using the WMS (Web Map Services) protocol family. These maps are multi-resolution, allowing SkyExplorer to progressively download new data on the fly to offer a constantly high resolution & display more data when getting closer to the surface.

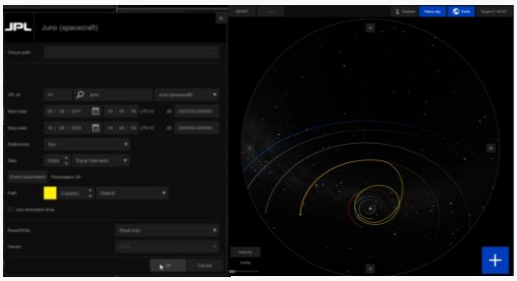
- **Data2Dome (ESO)**

Data2Dome is a JSON Feed integrated into SkyExplorer.

It includes many sets of data (images, videos and news) which are downloaded directly from the ESO server.

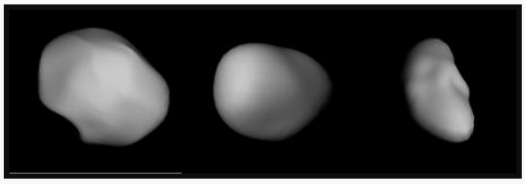
Available at any time to the presenter, it gives the possibility during live shows to access to the latest content available online to be able to answer questions from the audience. Also available during show production, it enables users to integrate any content in order to create up-to-date animations.

- **JPL Horizons Path**



SkyExplorer offers a direct connection to JPL Horizons data regarding the position of spacecraft, asteroids, comets, etc. With a few clicks in our dedicated interface, the user will be able to visualize the path in the Solar System of any object referenced in JPL Horizons, place a 3D model of the object on the path, and watch it move according to the simulation time.

- **3D Models of Asteroids**



SkyExplorer is connected to "DAMIT" database (https://astro.troja.mff.cuni.cz/projects/damit/). All 3D models of asteroids registered on this website can be downloaded and visualized in SkyExplorer. More than 5,000 models are available.

- **DataToDome (IPS initiative)**

SkyExplorer integrates data and technologies developed by the IPS Science Data & Visualization Task Force.

INTERACTIVE EXPERIENCE

Users & the audience will live outstanding experiences, thanks to SkyExplorer's user-friendly GUI & interactive tools.

USER-FRIENDLY INTERFACE

- **Total Control from the Master Unit**

All the equipment is controlled from a single computer: the master unit running under Microsoft® Windows. The master unit controls:

- Astronomical simulation
- High definition full dome video
- 3D objects display
- Multimedia display
- Multitrack audio
- Projection system
- Standard lighting
- Software and computer management

This unit is integrated into the control desk. The master unit is equipped with remote maintenance software in order to make it possible for RSA Cosmos' technical staff to connect themselves to the planetarium and to take control of the system. This allows diagnostics, breakdown service when feasible and update of the software by technicians without requiring on-site services.

The GUI (Graphical User Interface) can be used by non-specialist presenters. Thanks to its Interactive Dome View, presenters can focus on their presentation. Such interactive and intuitive GUI is a key point to offer an interactive experience to your audience by giving control to all devices of the planetarium including the astronomical simulation.

- **4 key features**

No programming code: No coding knowledge is necessary to create your own scripts.

Drag and drop: Quickly move and place objects from your library into SkyExplorer, with a mouse click.

Interactive dome view: Fisheye reproduction of the dome on your interface to facilitate creating your show.

Autopilot function: Progressive and fluid motion to astronomical objects to observe them from the right distance.

LIVE SHOW MODE

- **Multiple direct controls**

During planetarium shows, the main interface is dedicated to the control of the astronomical simulator. This interface allows the presenter to show and explain astronomical phenomena without using the keyboard. This interface was developed and tested in partnership with users in order to obtain a powerful user-friendly tool, enabling users to:

- Turn on and off the starry sky, the Milky Way, the planets and satellites, the Sun, atmospheric effects (rainbow, clouds, aurora, rain, snow, lightning, moonlight, twinkling), shooting stars, the zodiacal light, the Messier & deep sky objects
- Customize the atmospheric effects thanks to the atmosphere widget directly from the graphical user interface.
- Turn on and off the orbits of planets or satellites, trails/trajectories, pointers, the constellations and asterisms (lines, pictures, boundaries, names)
- Scale-up astronomical objects
- Display images with animations (size, position and orientation)
- Control time (instant, diurnal, annual, analemma, precession), including access to ephemeris, presets and sidereal time. It is possible for users to save and load their favorite date/time and favorites motions.
- Control the positioning and orientation of the camera seamlessly
- Access a large set of astronomical objects (planets, satellites, stars, comets, asteroids, etc.), fly to them by selecting either the autopilot function (select an object & SkyExplorer will fly smoothly to it) or the teleportation function (fade out, fade in)

- Customize the rendering of the celestial body using a list of options available. Users will have access to different models of the Earth and other bodies of the Solar System, to the sea level, trees, etc.
- Enrich the sky thanks to advanced sky control (sky quality, star variability & proper motion, Milky Way picture & brightness, zodiacal light, auroras, moonlight, etc.)
- Apply real time filters on Gaia DR2 catalog (spectral type, luminosity class, temperature, absolute / apparent magnitude, distance, catalog, radius, proper motion, distance, right ascension and declination)
- Customize the color of the stars depending on their B-V magnitude
- Enhance user controls of customizable groups (constellations, asterisms, deep sky objects)
- Activate the dataset manager to display astronomical datasets automatically selected from the current position in the Universe
- Display astronomical grids (ecliptic, equatorial, horizontal, etc), marks (cardinal points, precession circle, meridian, etc.) and information (latitude, longitude, date, time)
- Access user pages to customize your session. A list of pre-produced user pages is available to users in addition to the ones they can create by themselves.
- Thanks to an embedded browser, open any web page in user page tabs by setting its URL.

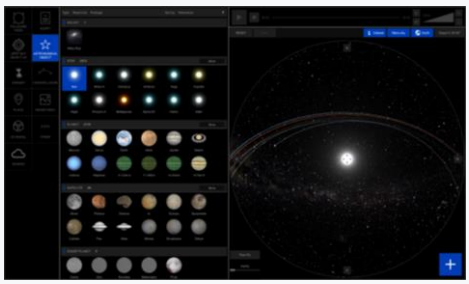
The live show mode also enables users to control the equipment of the planetarium such as projectors, cove lighting and main lights, audio, audience response system, etc

- **Position Widget**

The position widget enables a direct vizualisation of the current position and changes the position and orientation of the camera easily. It gives access to a zoomable map of the planet with a mapped terminator (on Solar System planets, dwarf planets and satellites).

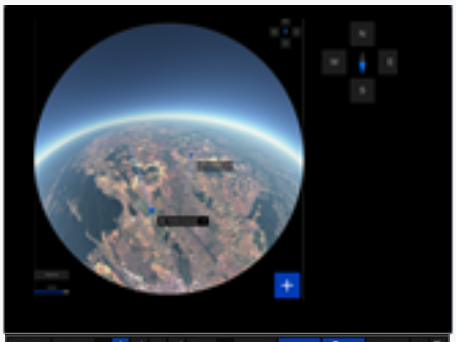
An advanced position interface also allows to control each parameter such as position, orientation, and coordinate system. Each object in SkyExplorer, such as planets, stars, satellites, etc. comes with a full set of coordinate systems that allows to move the camera in different ways : synchronous, aligned with the ecliptic, always above day-side/night-side or terminator, etc.

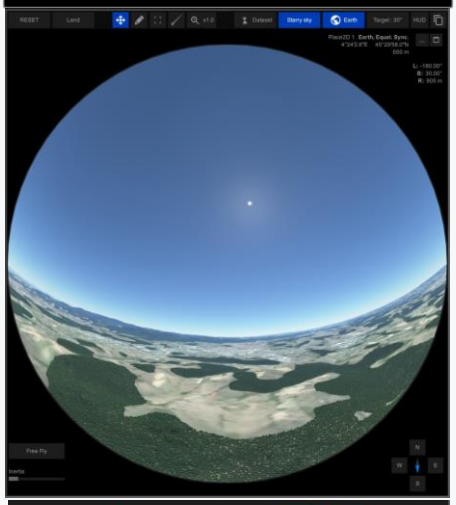
- **Interactive Dome View**

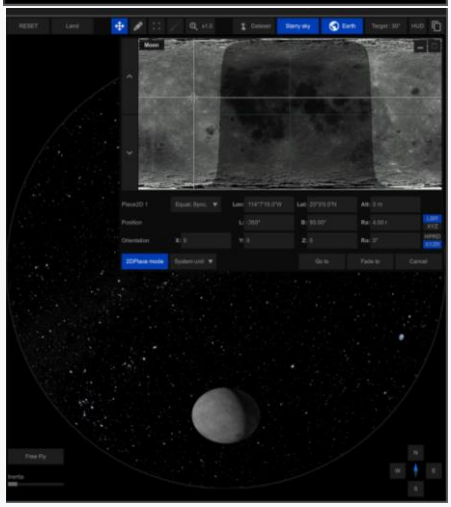


SkyExplorer includes in its interface a faithful preview of the image that is presented to the audience, typically as a fisheye view of the dome. This dome view is interactive using 4 different modes that are available in the interface, enabling fluid motions and precise explanations:

- **Manipulator**







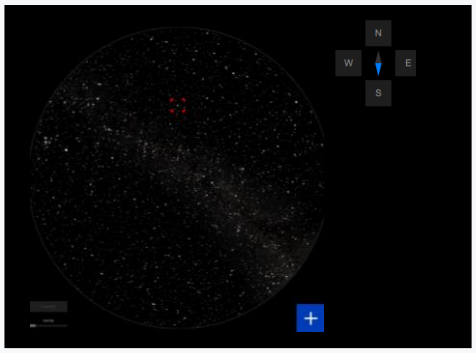
This mode moves the camera in the simulation, changing its orientation and positioning.

3 main views are available within the simulation:
- Sky view: camera on the ground watching the sky
- Terrain view: camera looking at the object (a planet for example) from up close
- Space view: camera looking at the object from far

Several types of motions are available to enable smooth motions within the simulation:
- Motions with inertia: the camera carries on moving in a uniform motion indefinitely until a direct change is operated. It is possible to operate smoothly two movements at once. For example, to draw away from the object and turn around it at the same time.
- Flight-like motions: the speed of the motions are adapted to the distance of the object, and the camera follows smoothly the shape of an object, of the terrain, etc.
- Free Fly motions: the camera operates continuous and uniform traveling, for example when traveling inside of the ISS.

The orientation and positioning of the camera can be operated through simple mouse clicks or using a gamepad.
The gamepad provides greater flexibility, giving access to multiple motions thanks to several buttons, triggers and thumbsticks. A scroll-down menu of predefined destinations is available. Users can also add their own destination requests to this list.

A compass also gives a direct access to the cardinal points for smooth rotations.

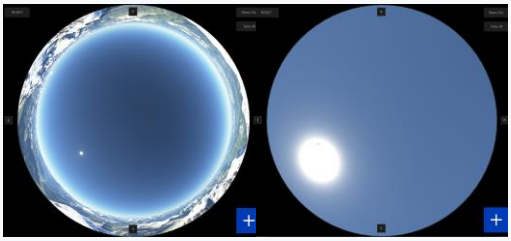


- **Pointer**

This mode is used as an alternative to a laser pointer. When the user clicks on the interactive dome view the pointer appears.

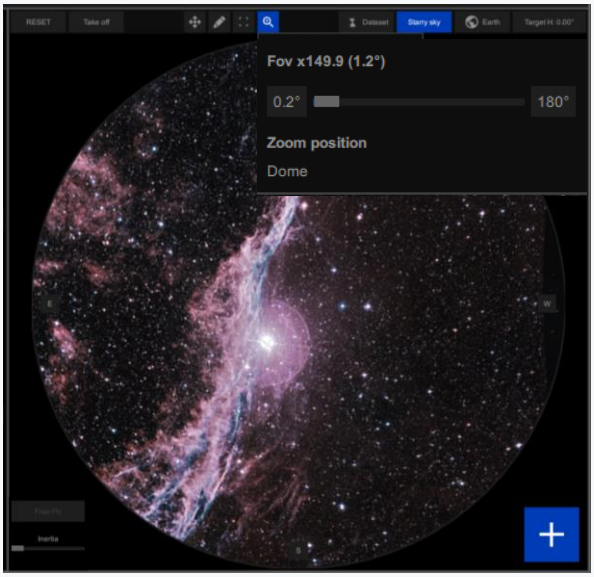
- **Smart Zoom**

The zoom function enables virtually to change the field of view of the dome to zoom in on (or out from) an object or a point on the dome.



For example, this allows to display more terrain along the entire horizon, or to show an eclipse up close as if looking through a telescope, and even display deep sky objects.

Our zoom function has smart capabilities:



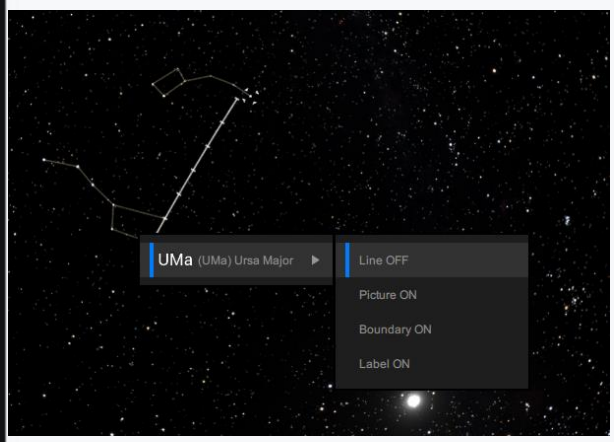
- It changes the field of view of the dome to zoom on a selected object wherever it is located on the dome.
- It comes with an automatic “click and lock” capability, thanks to which the zoom remains centered on the selected object while the time goes by in the simulation.
- It guarantees high quality rendering with dynamic auto-exposure and automatic refinement capabilities. When visualizing SkyExplorer’s Gaia Night Sky, more and more stars are displayed as the zoom field of view narrows down to visualize the richest starry sky computed from a collection of 1.3 billion stars from the Gaia DR2 catalog. When visualizing HiPS sky surveys, SkyExplorer automatically refines the image using multi-resolution data as the zoom field of view narrows down.

- **Blackboard**

Drawing on the dome becomes as easy as on paper.

Blackboard enables to draw lines, points, arrows and shapes on the dome by freehand drawing on the interactive dome view. Drawings can use several reference frames: Starry Sky (to draw on the celestial sphere), Cardinal (such as draw cardinal points from sky view), and Dome (drawing will not move with the observer or simulation). The width and color can be changed for each line, and an eraser is available.

This feature also enables high interactivity with the audience when operated from an tablet.



- **Picking and Interactivity**

Picking technology allows you to directly click on an object in the interactive dome view to have access to a contextual menu depending on the clicked object. If several objects are close to the mouse cursor, SkyExplorer Studio gives access to a list of the most relevant objects.
You can also add live interactivity to your show by connecting an action to any object on the dome. During a live presentation, you can then click on the object in the Interactive Dome View: this will trigger the action such as playing the associated script.

- **Drag & Drop**

It is possible to drag & drop a resource from the resource manager on the dome view. Depending on the resource type, the simulation will react with the most appropriate action. For example, if you drag & drop an image, it will appear on the dome where it has been dropped. If you drag & drop a constellation, it will toggle its visibility.

- **Autopilot function**

Thanks to our autopilot function, if you drag & drop a resource (a star, a galaxy, a planet, a city, etc.) in the dome view, SkyExplorer will automatically go to that destination using a nice motion automatically adjusted depending on the current position in the Universe.

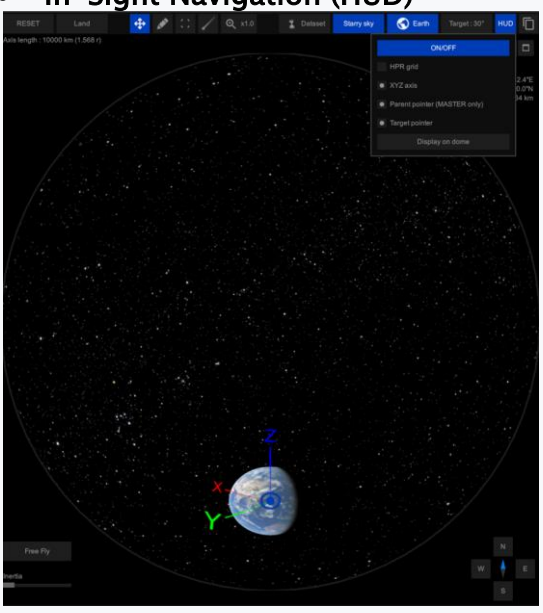
This way, users can stay focused on their speech instead of taking care of the camera's movements.

- **Augmented Presenter Tools**

The Augmented Presenter Tools allows the visualization of additional information only visible by the presenter, on the interactive dome view, and provides fast and easy access to many features.

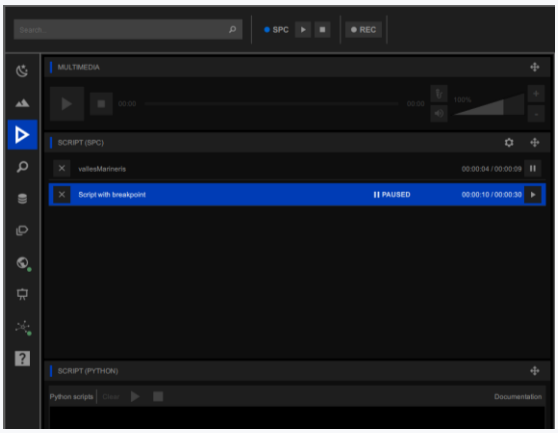
- Users can drag an image onto the interactive dome view, position it (using the spider grid if need be) & adjust its position without the audience seeing this action, up until the image is dropped. It then becomes visible by the audience.
- Objects are highlighted on the dome view when a link to an action has been associated to them.
- Control tools are displayed on the videos in order for users to be able to play/pause/stop whenever needed. The videos remain invisible to the audience, until the user has clicked on the play button.

- **In-Sight Navigation (HUD)**



HUD (Head Up Display) comes with Widget Position to provide additional information about camera position to the operator. These information are displayed directly on the fisheye view, to allow the operator to move while keeping a look on the simulation.

- **Play Widget**



The Play Widget gives access in one single panel to all the files currently being played:

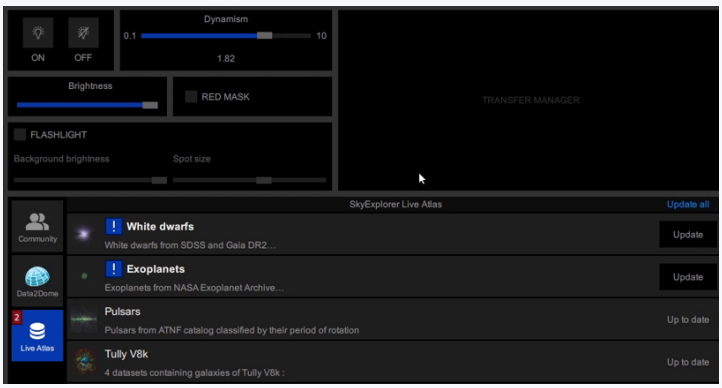
- to the video and audio files within the multimedia widget.
- to the scripts in the SPC and Python lists.

Users can instantly play, pause or stop each one of them independently.

Within the Multimedia Widget users can control both audio & video: play, pause, stop, seek in a smooth way (fade in, fade out) and control the volume (including buttons to mute or temporarily reduce the volume).

- **Control Center**

The Control Center gives a global overview and an easy access to several operational tools.

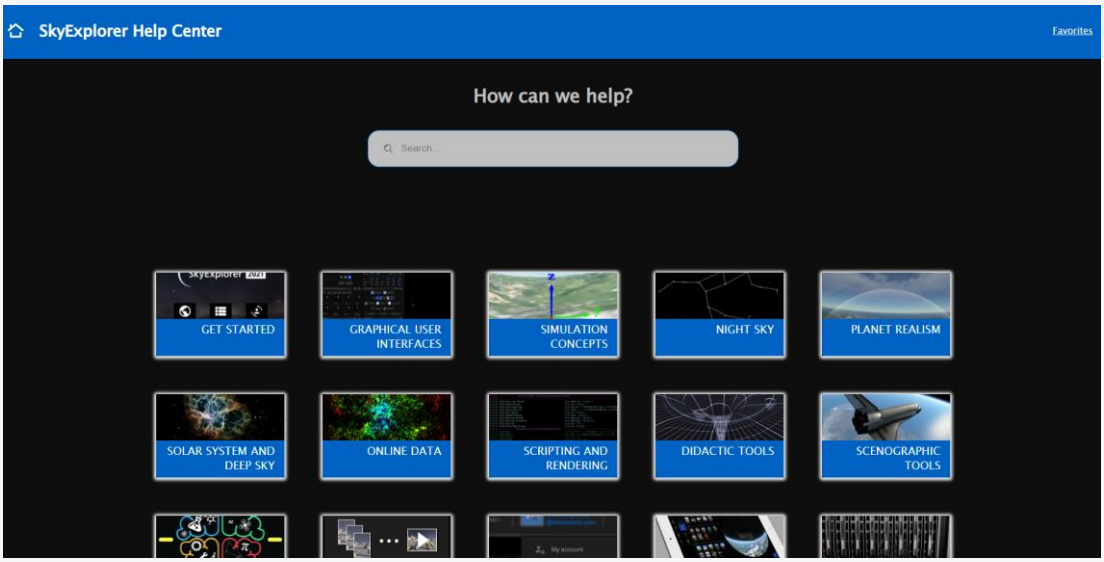


- **The Light Widget** to easily turn on and off DMX-controlled lights in the audience room (like cove lighting).
- **The Dynamism Slider** to adjust the speed of the actions undertaken like the movement in the simulation using the manipulator.
- **The Dark Mode to** help avoid visual pollution & will help in maintaining the highest level of darkness inside the dome. Several dark modes are available: one changing the brightness, another one adds a red filter in front of the GUI, and another dark mode with a flashlight circle around the mouse cursor.

- **The Transfer Manager** in SkyExplorer synchronizes user files (images, 3D models, etc). This way, users do not need to take care of file synchronization on each computer anymore. Users can add/modify/delete files only in the MASTER computer and SkyExplorer will handle the synchronization. At any time, synchronization status is visible in the Studio Control Center.
- **The News Feed** to receive notifications and access instantly the latest content shared by RSA Cosmos, the SkyExplorer user community and scientific institutions.

HELP CENTER

SkyExplorer Help Center is an interactive user guide that centralizes all the information regarding SkyExplorer's functionalities.
It is accessible directly from the graphical user interface.
Thanks to this, users have access to a wide range of details regarding the different functionalities and has a performing field search to find information in a split second.



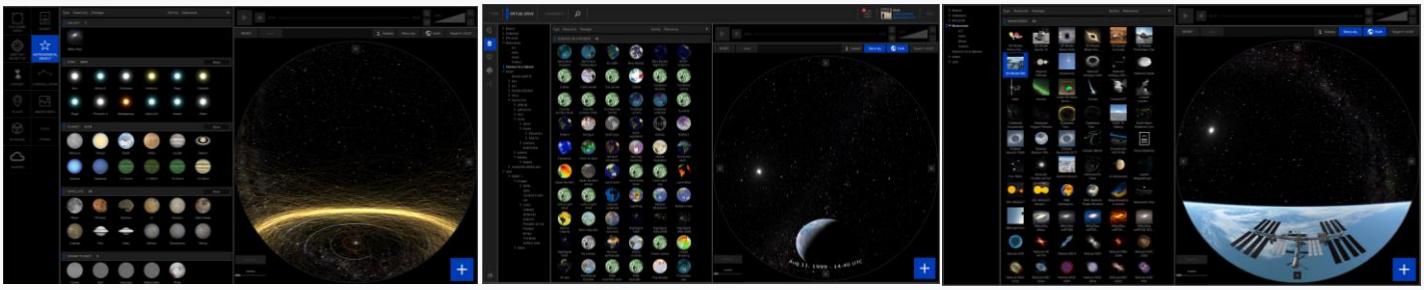
RESOURCE ACCESS

SkyExplorer allows easy access to resources, such as:

- All astronomical objects of SkyExplorer
- All videos / images / audio / 3D Models installed on the system
- Predefined dates, or locations in space

All resources are classified by categories, shown with an icon that can be user-defined.

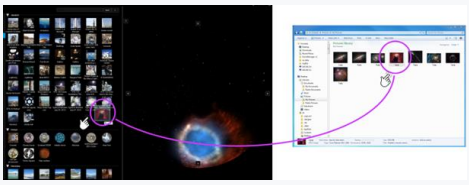
A search bar is available. It keeps track of former actions and provides drop-down lists, thus offering quick and efficient searches through the interface.



- **Tags**

Users can assign one or several tags to resources, and organize them as they wish, to be able to find any resource in a split second.

- **External Drag & Drop**



Two External drag & drop actions are available:

- Drag & drop a file inside the resource manager automatically installs this file on the computers in the system and creates the corresponding resource in the resource manager.
- Drag & drop a resource in the Show Editor automatically creates the corresponding succession of commands in the script.

- **Bookmarks**

SkyExplorer allows to create bookmarks to easily come back to a saved position and date of simulation.

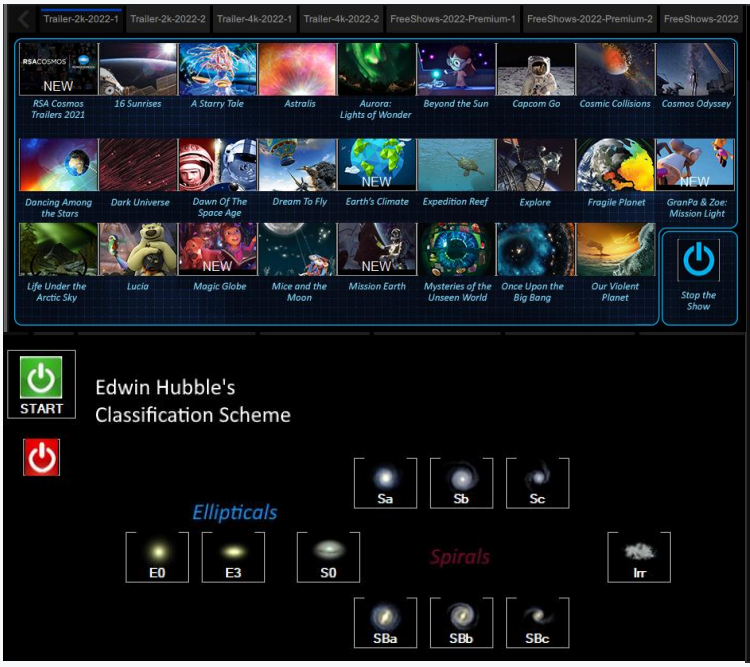
- **User Configuration**

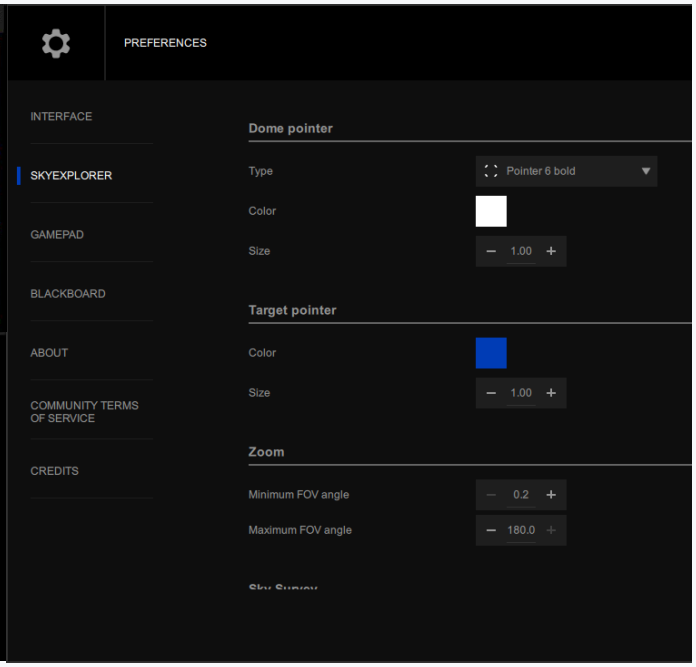
SkyExplorer is designed to be highly customizable to match users' expectations and offer the best experience to the audience.

Customization goes from details (such as camera speed, take off angle, pointer color, time speeds) to high levels (interface layout, sky qualities, show sequences) passing through favourite contents (such as dates, places).

Combined with user accounts and role administration, SkyExplorer adapts to both the user's profile (operator, administrator, technician, etc.) and to the audience's profile (school, basic, advanced, etc.).

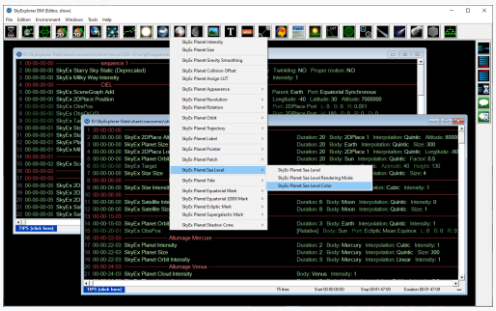
SkyExplorer comes with various languages by default, such as English, French, Japanese, Korean; and is fully translatable (simulation, interface, message boxes, documentation) in all languages.





SHOW PRODUCTION

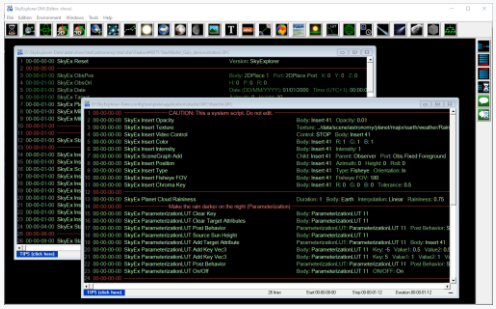
- **Show Editor**



Set of commands for an object in the simulator

The Show editor is a powerful tool to create fulldome shows or small animations for live presentations.
It is a graphical editor, which does not require learning a programming language and offers a wide range of possibilities when creating scripts.

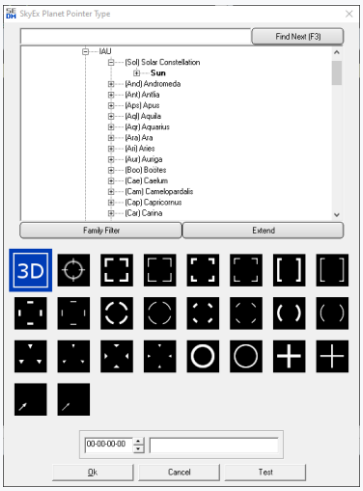
It allows to control every device in your planetarium, such as astronomical simulator, audio, lights, projectors, audience response system, etc.



Script files

It enables users to create show files with a sequence of actions by combining simple commands, timings and customizable parameters. For example: turn off lights in 5 seconds, then 5 seconds later start the audio track, synchronized with a video; at the end of the video, turn on the starry sky, then turn on the Earth.

It proposes wizards to create quickly and easily the necessary commands for various features.



Command window

It supports including a script into another script. Once the script is modified, then all the shows using this file will be updated.

All Windows editor based functions are available (copy, paste, cut, delete, undo/redo, find/replace, etc.).

All parameters of the system (simulation date, camera position and orientation, parameters of objects such as intensity, opacity, colors, etc.) can be modified with a duration from an initial state to a target state using many different models of interpolation, such as Linear, Cubic & Sinusoidal (as a function of time).

- **Slideshows**

Our interface allows to create and edit slide-based presentations on the fly, by directly and graphically interacting with image resources. Place the contents of your slides on the dome using drag & drop operations, customize transition animations, then save the result as a resource that you can load later for editing or playing the presentation.
Users can then play their slideshow in front of the audience as simply as a PowerPoint presentation, and even control it from an tablet.

- **Rendering Mode**

SkyExplorer includes a specific rendering mode which allows to capture image per image a show made with SkyExplorer. Images can be fulldome (dome masters), VR (equirectangular 360°) or conventional rectangular screen. This feature allows users to share content with any planetarium equipped with any digital solution & to create fulldome shows.

- **Python Compatibility**

Python is a programming language which gives access to advanced dynamic capabilities of SkyExplorer.

Python opens your planetarium to:

  - Scientific and Numerical Computing
  - Advanced dynamic animations that are not possible with classic SkyExplorer scripts.

Python scripts enable users to launch a list of instructions quickly, by listing them all in a programing file. They also allow users to make loops in scripts, to set & apply conditions (for example as soon as the Earth is displayed, Python automatically displays informative labels next to the Earth), and to operate advanced controls when using the Gamepad (for example it is possible to take control of a 3D model's animations using the Gamepad controllers).

The astronomical community frequently uses the Python language to create independent astronomical modules. SkyExplorer users can easily add these into their scripts.

Python scripts can also be shared between SkyExplorer users via our Cloud Community, bringing an ever more collaborative dimension to SkyExplorer.

- **Javascript**

JavaScript enables to develop a web application and control SkyExplorer from this external web application.

HARDWARE SOLUTIONS

- **Touch Screen & Full Tablet Control (iPad and Android)**

SkyExplorer has been entirely designed for touchscreen technology and can therefore be used on an tablet device. Thanks to this unique technology, you can access the same interface as the one installed on the master computer of the planetarium, including the Interactive Dome View.

Being able to control SkyExplorer on the dome using the interactive dome view directly from a tablet, in front of the audience, is an incredible experience. SkyExplorer is compatible with iPad and Android.

- **Gamepad Control**

SkyExplorer includes gamepad controls.

Movements in the universe, including flying over terrain, are made even easier and are adapted to the new generation of presenters.

Anyone can use it to fly through Saturn's rings or around our 3D Volumetric Milky Way.

You can also give it to your audience for more interactivity.

- **Manual Consoles**

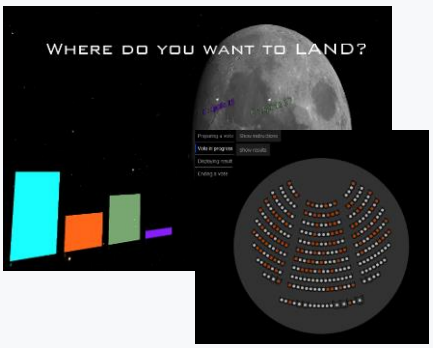
SkyExplorer can be controlled by various manual consoles.

It is possible to use a MIDI console, such as Korg nanoCONTROL, to control the simulation using various attributes such as the intensity of celestial bodies, the speed of the simulation, and the cove lighting.

A more advanced console can also be used, the JL Cooper console. This console enables higher control possibilities such as carrying out the sessions without turning on the screen of the master computer.

All the consoles can control either digital only, optical only or hybrid systems.

- **Audience Response System**



RSA Cosmos has designed its exclusive Audience Response System, installed in the armrest of each seat.

SkyExplorer fully integrates these devices and offers specific functions that are fully connected with the astronomical simulation.

Your audience will therefore be able to answer quizzes, select different scenarios for a show or take control of the camera path during the session, to fully engage in their experience and learning process.

The voting device comes with 5 or 8 buttons.

- **SkyExplorer Production VR**

SkyExplorer is compatible with Oculus VR system.

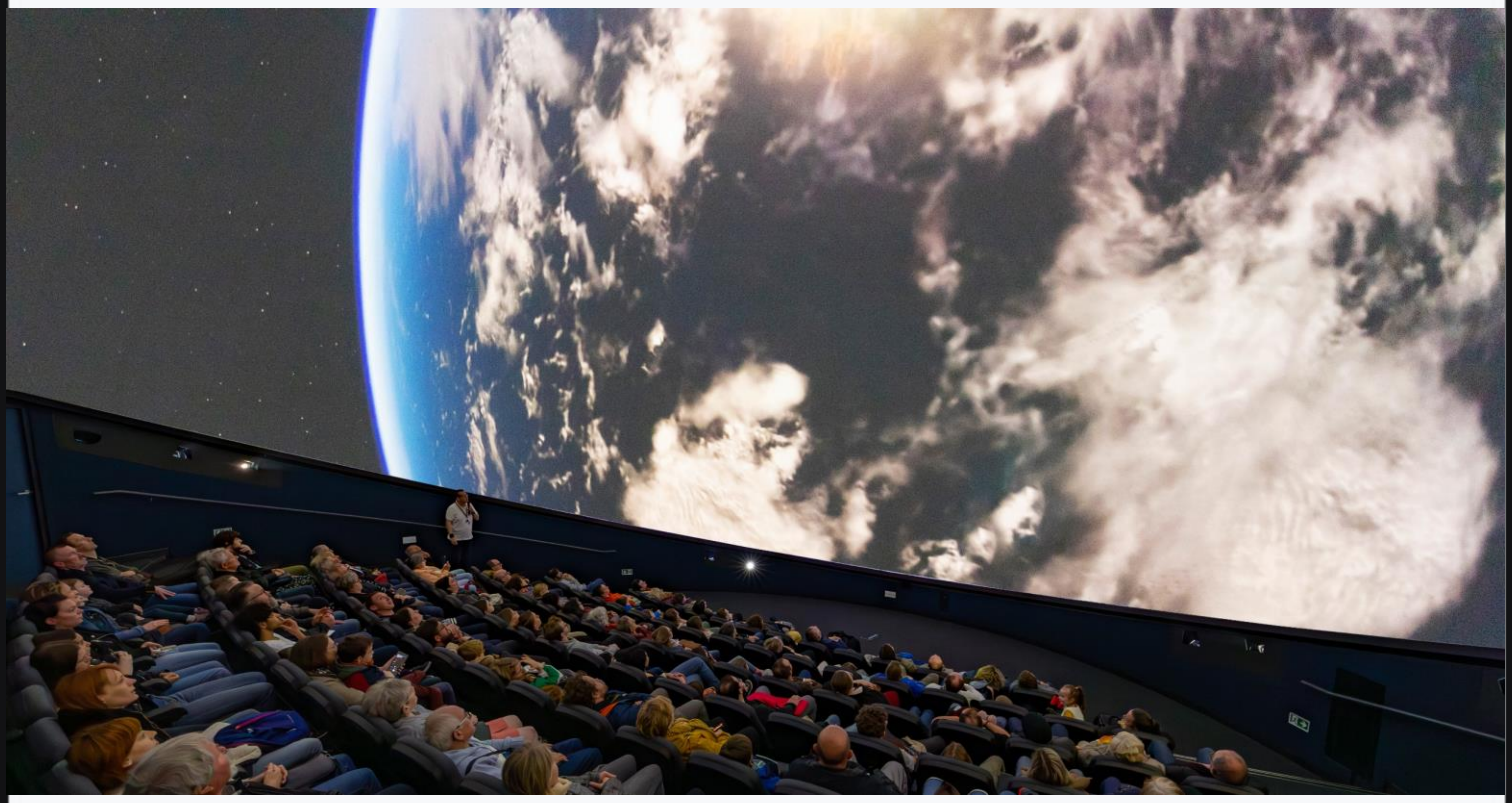
Preview what a show would look like under the dome from a production station. Simulate the universe not only on a dome but on a complete sphere and control the camera with your head.

- **Plug & View**

Thanks to the addition of the NewTek NDI Spark, it is possible to plug one or several 4K signals (3840x2160@60fps) and display them on the dome using all the features of SkyExplorer video inserts. This function enables planetariums to open up to new content and to new utilizations by allowing external presentors to broadcast their own content which can go beyond astronomy, for example art, music, etc. simply by plugging their device using a HDMI cable.

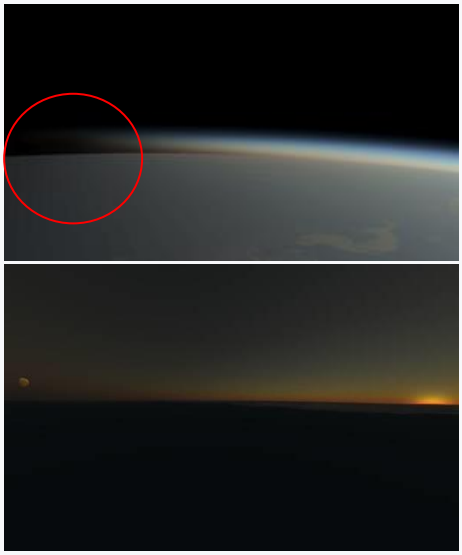
STUNNING REALISM

SkyExplorer uses physically based rendering techniques to display high quality realistic images rendered in real-time.



PLANET RENDERING TECHNOLOGY

Exclusive



- **Realistic Atmospheric Effects**

The representation of the atmospheres has been given particular attention in SkyExplorer. Based on a model accounting for the physical phenomena (extinction, Rayleigh scattering, Mie scattering), this representation produces an extremely realistic view of planets Earth, Mars and Venus. This effect allows us to show, for example, the atmospheric scattering on distant mountains on the horizon and the Belt of Venus or anti-twilight arch.

The same physical model is also used to compute how distant objects are seen through the atmosphere: the Moon and Sun redden on the horizon, stars scintillate. Stars, planets, the Milky Way & Zodiacal Light appear at dusk and disappear at dawn based on their magnitude and the brightness of the atmosphere.

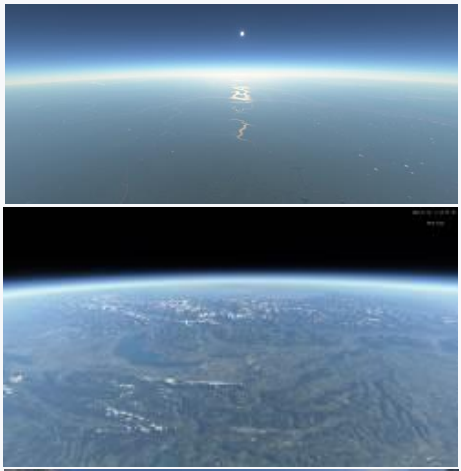
- **Precise 3D reconstruction of the terrain geometry**

SkyExplorer is able to render the 3D surface of planets and satellites in real-time from very high resolution elevation and imagery maps with precision up to 10cm.

First, the overall ellipsoidal shape of the reference surface is respected, to ensure solar eclipses and transits of artificial satellites happen at the right place and time. Then, the 3D geometry of the terrain on this surface is reconstructed on the fly from the elevation map, using dedicated techniques to ensure high positional accuracy.

The flattening of the planets and the scale of elevation values can be customized to amplify or disable these two effects.

Finally, imagery maps and other secondary maps are used for lighting the computed terrain geometry.



- **Realistic Lighting of the Terrain**

  Terrain features in SkyExplorer use HDR (high dynamic range) lighting routines, fully integrated with the physical model for atmospheric scattering and extinction. This way, any viewpoint on the surface of Earth, Venus and Mars offers a realistic image with consistent physically based lighting on all natural elements: terrain and sky, plus trees and clouds on Earth.
  In addition, shadows are cast in real time from the geometry of the terrain like mountains and craters. On Earth, the reflection of the Sun and Moon on water is calculated in real time and light generated by civilization is visible on the night side of the planet.

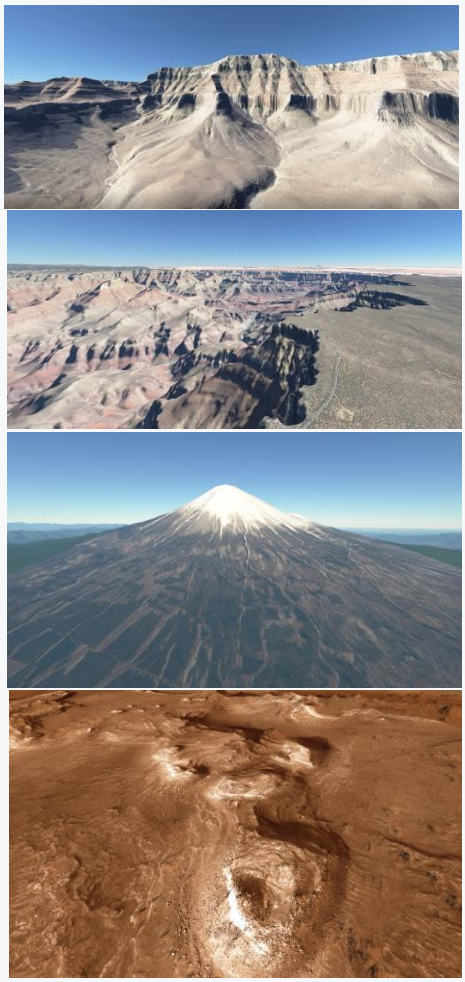
- **Terrain Levels of Detail**

  SkyExplorer uses a multi-resolution algorithm to manage the levels of detail of planets and satellites to offer a very high level of realism. Thanks to the Proland Technology that is designed to gradually refine the terrain according to the observer's distance, you will have gentle transitions between the levels of detail to prevent popping phenomena.
  In addition, SkyExplorer increases the detail by adding procedural information where the data lacks resolution, thereby enabling good terrain quality even when the observer gets close to the surface. SkyExplorer also detects vertical cliffs and automatically adds suitable colors to the terrain in order to make the cliffs appear like rock

- **Terrain Models in the Solar System**

System	Body	Terrain map	Type of data	Resolution (m/px at equator)
Mercury	**Mercury**	Messenger MDIS DEM	Elevation	665
		Messenger MDIS LOI	Imagery (grayscale)	166
Venus	**Venus**	Magellan ALT	Elevation	4641
		Magellan C3-MDIR	Imagery (colorized)	4641
		Magellan SAR FMAP	Imagery (grayscale, not global)	225
Earth	**Earth**	MERIT DEM (SRTM + AW3D + Viewfinder + misc)	Elevation	90
		NASADEM (SRTM + ASTER + misc)	Elevation	30
		BMNG Summer, Winter, Seasons (MODIS)	Imagery (color)	500
		PlanetSAT Global (Landsat 7+8 + Sentinel-2)	Imagery (fully homogenized color)	10
		VIIRS Nighttime Lights Annual	Night imagery	500
		Copernicus Global Land Cover	Land cover (water + vegetation)	100
		BMNG Ocean (MODIS)	Imagery (including seafloor, shaded)	500
		SRTM15+	Elevation (including seafloor)	500
	Moon	SLDEM (LOLA + Kaguya)	Elevation	118
		Clementine UVVIS	Imagery (grayscale)	118
		LROC GLD	Elevation	100
		LROC WAC	Imagery (grayscale)	100
Mars	**Mars**	HRSC + MOLA	Elevation	200
		MOC	Imagery (colorized)	232
		Viking MDIM	Imagery (color)	232
		THEMIS IR Day	Imagery (grayscale)	100
		CTX	Imagery (grayscale or colorized)	5
Asteroid Belt	**Ceres**	DAWN FC HAMO DTM	Elevation	140
		DAWN FC HAMO	Imagery (grayscale)	140
		DAWN FC LAMO	Imagery (grayscale)	35
	Vesta	DAWN FC HAMO DTM	Elevation	70
		DAWN FC HAMO	Imagery (grayscale)	60
		DAWN FC LAMO	Imagery (grayscale)	20
Jupiter	**Jupiter**	Cassini + Juno	Imagery (color)	31194
	Io	Galileo SSI + Voyager	Imagery (color)	1000
	Europa	Galileo SSI + Voyager	Imagery (grayscale)	500
	Ganymede	Galileo SSI + Voyager	Imagery (color)	1500
	Callisto	Galileo SSI + Voyager	Imagery (grayscale)	1000

System	Body	Terrain map	Type of data	Resolution (m/px at equator)
Saturn	Mimas	Cassini	Imagery (colorized)	200
	Enceladus	Cassini	Imagery (colorized)	100
	Tethys	Cassini	Imagery (colorized)	250
	Dione	Cassini	Imagery (colorized)	250
	Rhea	Cassini	Imagery (colorized)	400
	Titan	Cassini ISS	Imagery (grayscale)	450
	Iapetus	Cassini	Imagery (colorized)	400
Neptune	Triton	Voyager 2	Imagery (color, not global)	600
Pluto	Pluto	New Horizons	Elevation (not global)	300
		New Horizons	Imagery (grayscale, not global)	300
	Charon	New Horizons	Elevation (not global)	300
		New Horizons	Imagery (grayscale, not global)	300



- **HD Imagery & Elevation Patches**

SkyExplorer offers its end user the possibility to add georeferenced high definition patches to the global terrain (imagery and geometry), allowing for a definition down to 10cm per pixel. By combining imagery and elevation patches, the ground representation becomes hyper realistic.

A growing collection of free HD patches for the Earth, Moon and Mars are included in all SkyExplorer releases. More patches are available on demand or as an option, any georeferenced image can be loaded, and online WMS maps can be added to SkyExplorer as patches.

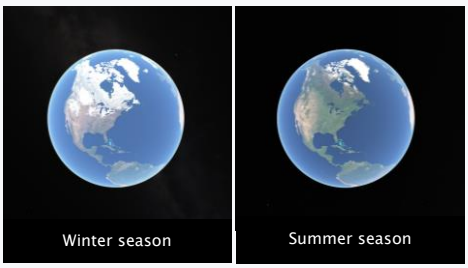
EARTH

- **Offline PlanetObserver Imagery** Exclusive

SkyExplorer allows a resolution up to 10m per pixel for terrain photography over the planet Earth without any needs of internet connection.

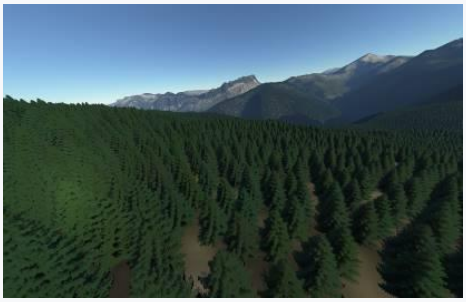
This imagery is developed by PlanetObserver, and RSA Cosmos has the exclusive use of this product in the planetarium field.

This data comes from Sentinel-2, Landsat 7 & 8 satellite images which were processed to render a homogeneous image over the whole globe, in natural colors and without clouds.



- **Seasons**

Our end users can choose to display the Earth following the different seasons, or they can speed up the time to show the changes of appearance of the Earth over a year.



- **3D Forests** Exclusive

To offer the most realistic scenery for your observation from Earth, SkyExplorer generates 3D trees at its surface. The distribution of the trees & their species is based on real data from Copernicus GLC.

- **Volumetric Clouds**

Like the terrain and atmosphere, clouds use physically based lighting routines to provide realistic effects: red sunset, magnitude-based star hiding, light scattering, moonlight, glory and fogbow, the illumination of the clouds by the Sun and the Moon, the projection of the cloud's shadows on the terrain.

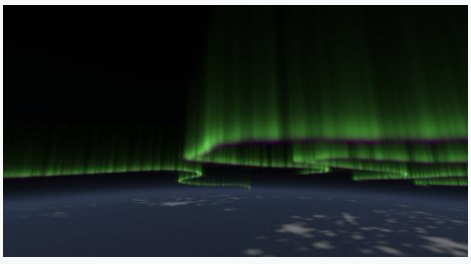
From space, the cloud layer is a global seamless image. From up close, a volumetric procedural cloud layer is used, animated and with more detail.

The volumetric clouds are fully customizable directly from the user interface. It is possible to choose their thickness, altitude, and type.

It is possible to fly around and through them with realistic renderings.

- **Rainbow**

On the Earth, a rainbow can be shown in the atmosphere if physical conditions are met. The simulation allows to show primary and secondary rainbows as well as Alexander's band.



- **Aurora**

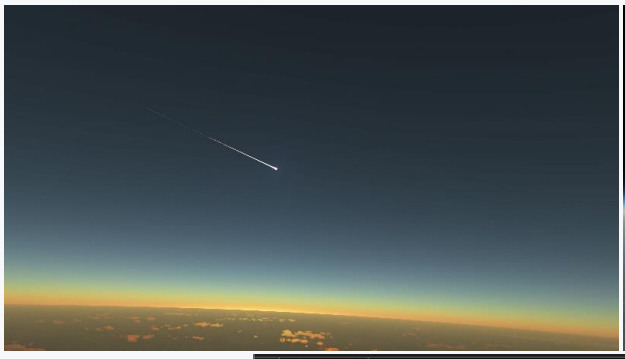
SkyExplorer is able to show auroras on Earth based on Dr. Lawlor's published works. This 3D representation of an aurora arc is animated depending on the Earth phase and can be viewed continuously from the Earth's surface up to space.

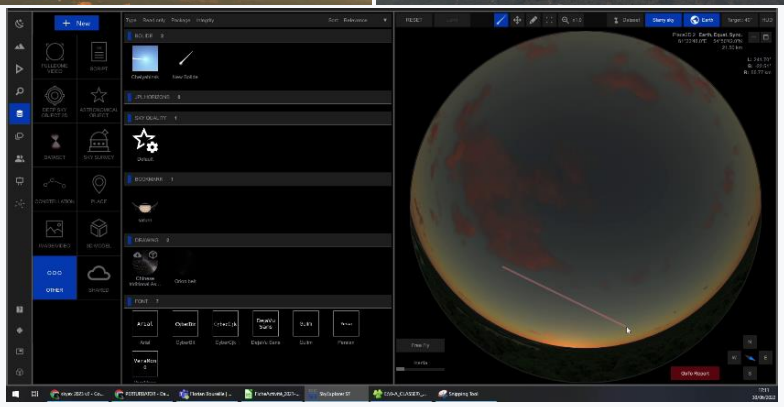
- **3D Bolides**

SkyExplorer shows bolides entering the Earth atmosphere, it gives access to models of bolides such as the famous model of Chelyabinsk, with a realistic rendering and accurate date and times of the phenomenon, and enables users to create a customized bolide directly from the graphical user interface and visualize it in 3D, meaning that it is possible to take off the Earth Surface and visualize the bolide trajectory properly from atmosphere or from space.

It is possible to select directly the chemical composition of the bolide, its color, its speed, then draw it on the dome view and visualize it on the dome instantly.

The lighting of the bolides affects the Earth's atmosphere and terrain, providing realistic renderings when visualized from the ground as well as from space looking down to the ground.

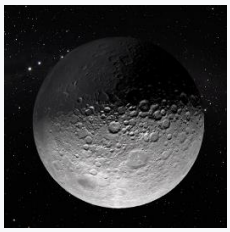




- **Shooting Star**

The shooting star effect enables users to start off an individual shooting star or a meteor shower. You can configure the representation of the stars (brightness, trail, midpoint), the speed, the number of shooting stars for a meteor shower & the starting and arrival position. The user can display the shooting stars wherever required on the dome or use celestial coordinates to position them accurately.

SOLAR SYSTEM



- **Earthshine & Moonlight**

  SkyExplorer's lighting takes into account the proper planetshine on the Moon & the Earth according to their phase.

- **Eclipses**

  SkyExplorer manages different levels of inter-body shadowing: of the satellites on their planet, of the rings on their planet, of the planet on its rings, of the planets on satellites, of satellites on satellites.

  During a total solar eclipse, SkyExplorer automatically reproduces various phenomena such as diamond ring, Baily's beads and solar corona.

  When the moon is entering the shadow of the Earth, this shadow is projected onto the Moon, with its typical red hue.

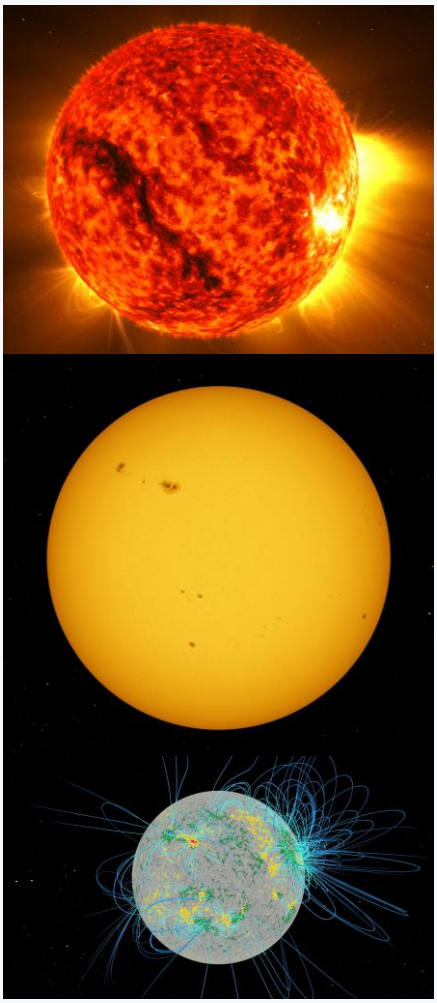
Exclusive

- **Zodiacal Light and Gegenschein**

  SkyExplorer simulates Zodiacal Light and Gegenschein. The scattering of the Sun light in the interplanetary dust covering the inner Solar System's ecliptic plane was generated using measures published in *1997 reference of diffuse night sky brightness* (Astronomy and Astrophysics supplement series 1998). This simulation allows to visualize a realistic view of this phenomenon from under the Earth's atmosphere when the right conditions are met. It is also possible to leave the Earth for an extrapolated view of the dust cloud around the Sun.

- **Rings of Saturn**

  The model integrated into SkyExplorer allows for the rings to be approached, to see that they are made up of billions of pieces of ice, dust and rocks. These blocks and particles orbit Saturn and can be approached close enough to be replaced by individual models. The lighting of the rings is computed in real time. You can also visit and observe the 3D models of shepherd moons within the rings: Atlas and Pan.



- **Advanced 3D Models of the Sun** Exclusive

SkyExplorer offers two 3D models of the Sun based on data from the Solar Dynamics Observatory (SDO) satellite.

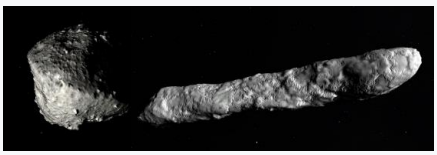
These models support smooth transition between filters and cycles (high, medium and low activities). All components of the models will react to cycle change and all feature representations will match positions of magnetic poles for selected cycles.

The available filters are:

  - Visible: natural saturated white sun with flare and eclipse effects (corona, Baily's beads and diamond ring).
  - Intensitygram: yellow Sun with spots, limb darkening and granules.
  - 304 ångström: red Sun with granules, spicules, 3D volumetric prominences and corona to show the appearance of the Sun in in UV radiation (ionized helium at 304 ångström).

One of the main models has animated granules on the surface, while the other has high-resolution surface imagery matching NASA visuals but without surface animation.

Optional components are also available to display the Sun's magnetic field for every activity cycle: 3D magnetic lines and 2D surface magnetogram.



- **Realistic 3D Models of Asteroids & Interstellar Objects**

SkyExplorer includes various 3D models of asteroids and interstellar objects: Vesta – Ryugu – Itokawa – Bennu – 'Oumuamua – Didymos & Dymorphos

- **Animated 3D Models of Comets** Exclusive

SkyExplorer includes the following models of comets: Bradfield – Hale-Bopp – Halley – Hyakutake – McNaught – as well as a generic 3D model. The orientation of the comet, of the dust and plasma trails are animated according to its position with respect to the Sun. All the parameters can be adjusted in order to allow users to customize the models.

- **Animated 3D Model of Comet Nucleus** Exclusive

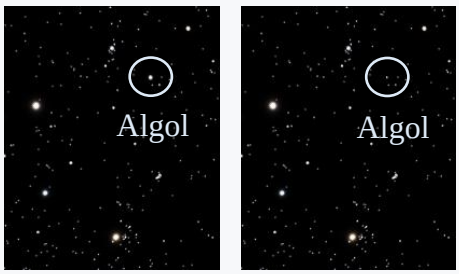
SkyExplorer simulates comet nucleus jets to explain the activity of these comets. Jets are physically generated based on the sunlight reaching the nucleus. 67P/Churyumov-Gerasimenko nucleus is available to allow you to show the discoveries made by Rosetta.

STARRY SKY

- **Star representations**

SkyExplorer offers advanced control to precisely adjust the representation of the stars: size according to magnitude, diffraction pattern or picture, color index, limiting magnitude, color according to B-V magnitude, etc. All these parameters allow a realistic representation of the starfield in various conditions.

Stars are rendered according to the Point Spread Function (PSF) with a High Dynamic Range (HDR) to allow maximum control in both exposure and contrast.



- **Variable Star Simulation**

Information from the General Catalog of Variable Stars (GCVS) are used to simulate variability with the accuracy based on the data available. The speed of the variability can be artificially increased to help in showing the stars without having everything else go too fast in the simulation.

- **Proper Motion**

Stars move in 3D over time according to their proper motion. The speed of the proper motion can be artificially increased to help in showing the stars without having everything else go too fast in the simulation.

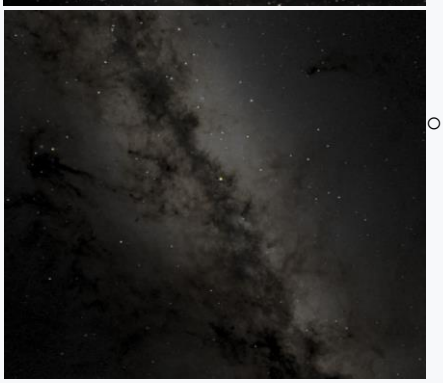
DEEP SKY

- **Gaia Night Sky**

SkyExplorer's Gaia Night Sky gives access to the richest starry sky and the most stunning representation of the Milky Way. Our Gaia Night Sky was generated using the entire Gaia DR2 catalog.

- **Gaia star field**

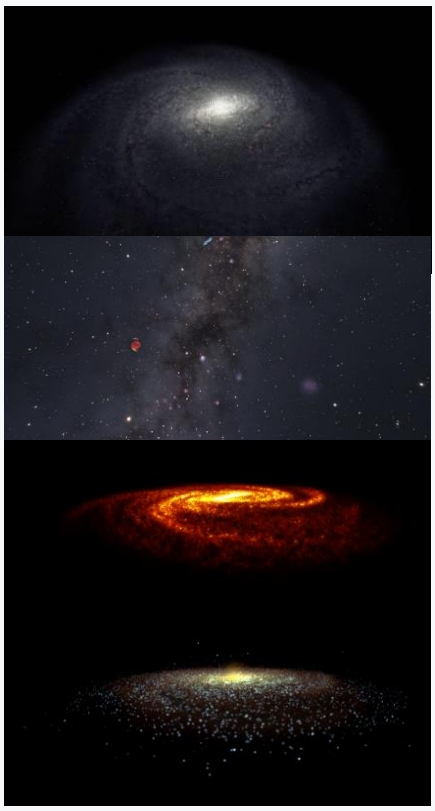
More than 1.3 billion stars are compiled and are all represented individually with their proper magnitude and color at their best expected 3D position. Proper motion can be shown for stars with such available data.
Combined with our Smart Zoom Function, the stars displayed will dynamically be selected by SkyExplorer depending on the position of the camera and zoom level. Using auto-exposure, when zooming in, more and more stars are displayed with a continuously high level of details.



- **Gaia Milky Way** Exclusive

The main image was generated by accumulating the luminosity of more than 1.6 billion stars into an 8K image. This HDR image provides a photometric rendering of the Milky Way, allowing users to customize the aspect of the Milky Way image (color, brightness, contrast) while continuously maintaining the highest quality levels.

- **3D Volumetric Scientific Milky Way** Exclusive



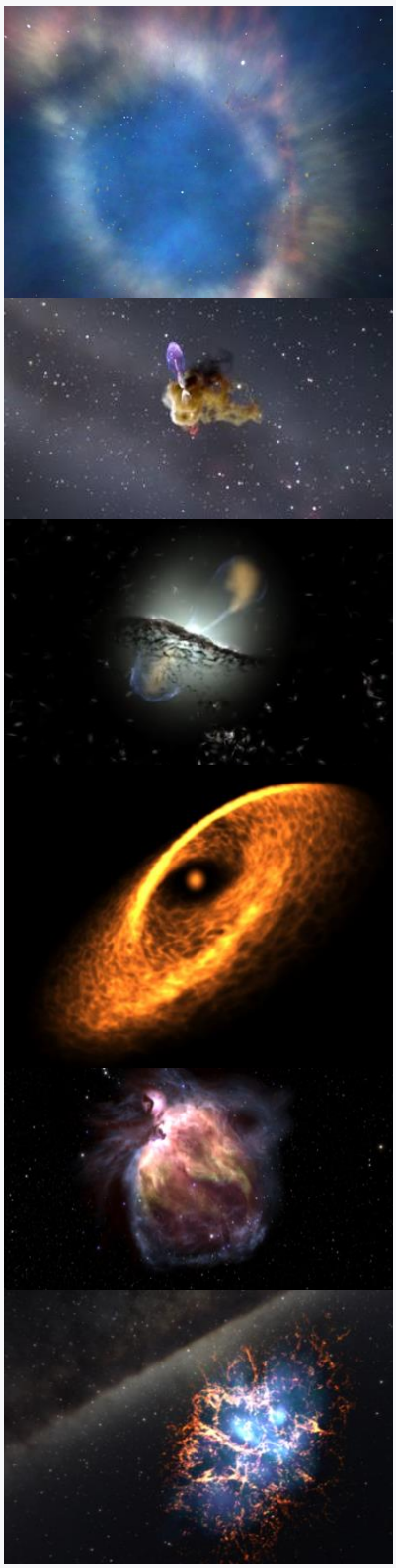
SkyExplorer offers the most advanced representation of our Milky Way in the planetarium industry. This model has been generated using a GALMER simulation of a barred spiraled galaxy from Observatoire de Paris Meudon using 10,240,000 star SPH particles and the same number of gas & dust particles. It simulates the emission and absorption of star light according to density and distribution of stars, gaz and dust in various wavelengths. It was developped within an R&D project in collaboration between RSA Cosmos, Observatoire de Paris Meudon and INRIA of Grenoble.

This model is available in multiple wavelengths (Near IR, Far IR, UV, UV+Visible, Visible) and includes volumetric features (including over 41,500 HII regions) as well as a procedural generation of more than 159 billion stars and more than 85,000 open clusters. Light emission, extinction and ionization are simulated in real time with respect to the spectrum of the objects involved, providing beautiful and physically accurate visuals.

- **3D Volumetric model of the Sagittarius Stream**

The volumetric 3D model of the Sagittarius Stream available in SkyExplorer represents the trail of the Sagittarius dwarf galaxy. It was generated based on images from 3D physical simulations of the Sagittarius dwarf galaxy, and interactively constructed based on available imagery at optical, infrared and radio wavelength.

It is possible to travel through and around this 3D volumetric model to see the stream from up close.



- **3D Volumetric Models of Deep Sky Objects** Exclusive

  SkyExplorer includes the following 3D models of deep sky objects in its database:

  1 Helix Nebula (NGC 7293)
  2 Abell 39 (PN A66 39)
  3 Dumbbell Nebula (M27)
  4 Little Dumbbell Nebula (M76)
  5 Owl Nebula (M97)
  6 Butterfly Nebula (NGC2346)
  7 Eskimo Nebula (NGC2392)
  8 Southern Ring Nebula (NGC3132)
  9 Ghost of Jupiter (NGC3242)
  10 Blue Planetary (NGC3918)
  11 Red Spider Nebula (NGC6537)
  12 Glowing Eye Nebula (NGC6751)
  13 Blinking Planetary (NGC6826)
  14 NGC7027 Planetary Nebula
  15 Rotten Egg or Calabash Nebula (OH231.84+4.22)
  16 Cat's Eye Nebula (NGC6543)
  17 Bug Nebula (NGC6302)
  18 Saturn Nebula (NGC7009)
  19 Minkowski's Butterfly Nebula (M2-9)
  20 Red Rectangle Nebula (HD44179)
  21 Ant Nebula (Mz3)
  22 SNR0509-067.5 Diffuse Nebula
  23 HH47 Herbig-Haro object
  24 Centaurus A radio galaxy (NGC 5128), Visible & IR
  25 Orion Nebula (M42, M43)
  26 Eagle Nebula (M16)
  27 Crab Nebula (M1)

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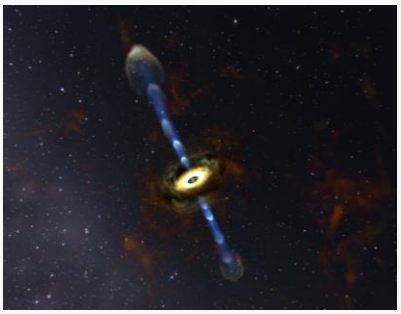
- **Nested Volumetric Models of Deep Sky Objects**

SkyExplorer gives access to nested volumetric models using multi-resolution data and high definition areas. The nested technology enables to see every detail of the models from up close with the highest levels of resolution when travelling around and through the models.

- **Nested Volumetric Model of the Eagle Nebula**

The nested volumetric model of the Eagle Nebula uses multi-resolution data and high definition areas to go close to the Pillars of the Creation. Using this technology, every level of detail of the nested model increases the resolution by a factor of 4, enabling to see the details of the Pillars of Creation in a subregion with 16 times the overall resolution.



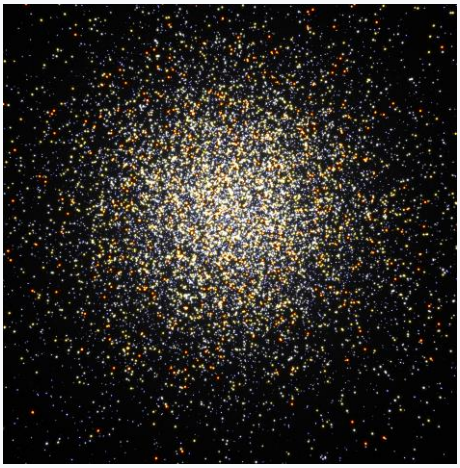
- **Nested Volumetric Model of Young Stellar Object (YSO)**

SkyExplorer gives access to two nested volumetric models of young stellar objects (YSO), a proto-planetary nebula, using the same nested technology as for the model of Eagle Nebula, to see every detail of the protoplanetary disk from up close with the highest levels of resolution.

One model of a standard YSO is available, representing the gas and dust around a newly formed star. The other nested volumetric model available of a YSO is more similar to HH-111.

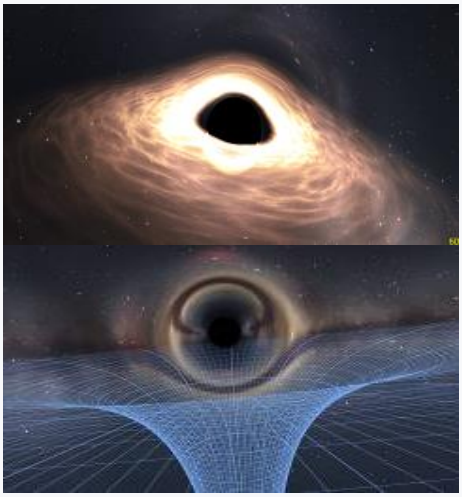
These models include the thin disk near the star where new planets form within the gaps of the disk. They also show, when seen from the side, that the disk thickens and dims and the dust is able to absorb the light from the star and the inner disk. From the central region they reveal jets of hot gas emerging perpendicular to the rotating disk.

It is possible to modify the position of both YSO models within the Universe.



- **3D Globular Clusters**

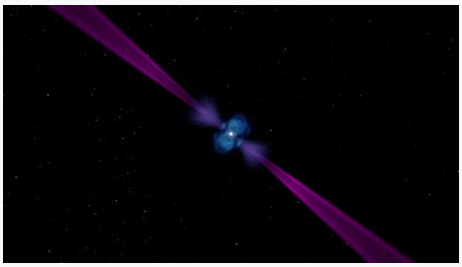
  162 globular clusters can be visited in SkyExplorer in 3D.
  The catalogs of both Harris and Baungardt were used to define position, size, and type of globular clusters. Each one has its own representation using the Plummer Model.



- **Schwarzschild Black Hole Model**

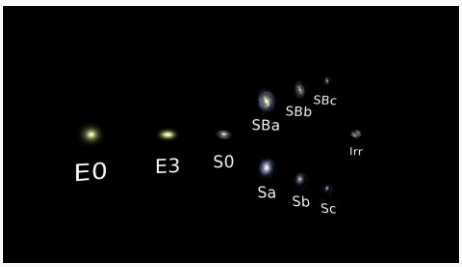
  SkyExplorer offers a 3D model of a Schwarzschild black hole, including a dynamic and realistic space-time distortion effect and its accretion disk. It is also possible to display a space-time curvature to help show the singularity.

  A 3D volumetric Milky Way model is available with a high-definition area centered on the black hole to enhance the immersive experience when visiting it.



- **Animated 3D Model of a Pulsar** Exclusive

  SkyExplorer includes a 3D model of a rotating pulsar, with animated representation of closed and open magnetic field lines as well as radio jets.



- **Volumetric Hubble Sequence galaxies**

SkyExplorer includes 10 3D volumetric models of the galaxies represented in Hubble's Tuning Fork Diagram.

Users can display the Diagram entirely revealing all the galaxies, then travel around, through and between each one of them.

- **Stellar Evolution**

A generic model of star can be customized to represent any star, including the surface appearance (color, granularity) and the visualization of the internal composition and its dynamics (convective / radiative). The whole model is animated with time.

Two high-level contents are available, based on this generic star :

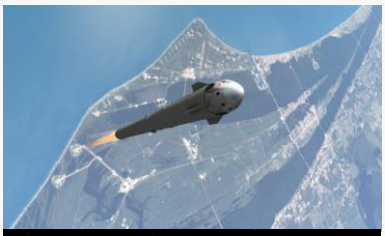
1/ A flat assembly of many 3D models (generic star, black hole, pulsar, volumetric objects) to form an explanatory diagram of the stellar evolution cycle showing the different phases of evolution. The generic model is used to represent the following list of stars: brown dwarf, red dwarf, solar-like type, red giant, blue giant, red supergiant and white dwarf.

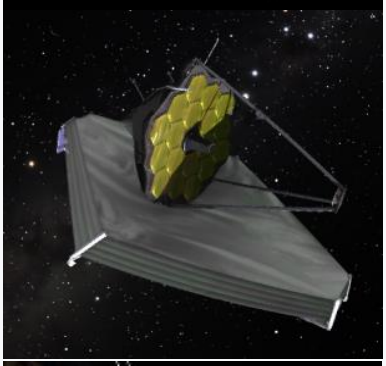
2/ A 360° presentation of the 8 main spectral types (O, B, A, F, G, K, M, L) with composition comparison.

ARTIFICIAL OBJECTS

- **Advanced 3D Models of artificial objects**

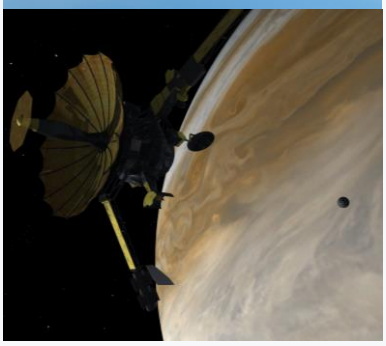
SkyExplorer comes with a catalog of advanced 3D objects. The catalog of 3D objects includes (non exhaustive list):




Spacecrafts:

- Block II GPS satellite
- Cassini
- Cloudsat
- Crew Dragon
- CSM
- Dawn
- DART
- Euclid
- Gaia with labeled instruments
- Galileo spacecraft
- Grace satellite
- Hayabusa 2
- Hubble
- Insight spacecraft
- International Space Station inside & outside
- Iridium satellite
- James Webb Space Telescope
- Juno
- LiciaCube
- Messenger
- New Horizons
- OSIRIS-Rex
- Pioneer
- Rosetta
- Sentinel-6
- SF interplanetary spaceship
- Soyuz spacecraft
- Space Shuttle
- Sputnik
- TESS
- Tiangong 2

- Voyager

Rovers & landers:

- Curiosity
- Insight Lander
- LEM Apollo 11
- Perseverance
- Philae
- Venera 9 Probe

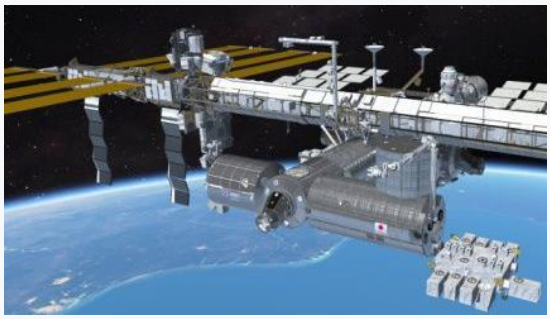
Rockets:

- Ariane 5
- SLS-Block 1 Crew (Artemis)
- Falcon 9
- Saturn V (all stages)
- Soyuz rocket

Other objects:

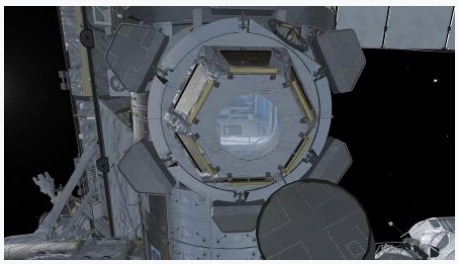
- Airbus A320 jetliner
- Amateur telescopes (Refractor, Newtonian, Schmidt-Cassegrain)
- Artemis Spacesuit
- Kennedy Space Center LC-39A pad
- Ingenuity
- Montgolfier Balloon
- Royal Aircraft Factory SE5

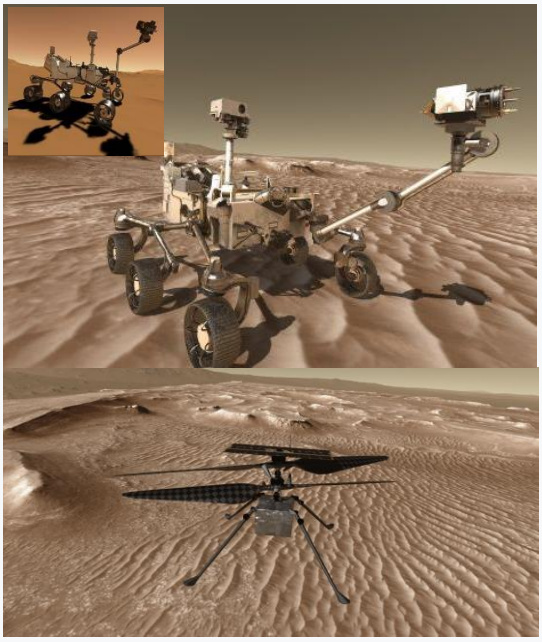
Exclusive



- **Advanced 3D Model of the International Space Station inside & outside**

SkyExplorer comes with a high definition representation of the International Space Station including the possibility to enter the station and visit all the modules.





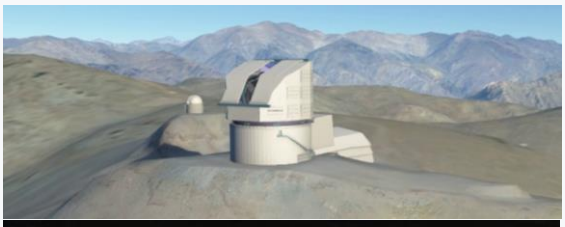
- **Advanced & Animated 3D Model of Mars Rovers & Ingenuity**

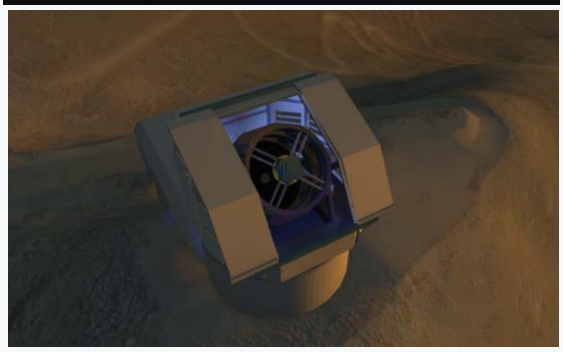
SkyExplorer offers its end users a beautiful animated 3D model of Curiosity & Perseverance rovers and of Ingenuity, the robotic helicopter.

The 3D model of Perseverance can be used to illustrate the exploration in Jezero crater on Mars. Its camera and arm deploy to drill and collect samples, and the wheels automatically rotate when the rover is on the move.

The 3D model of Ingenuity comes with improved textures for SkyExplorer as well as automatic animation of the rotors when time is passing in the simulation: rotors are fixed when the time is stopped and rotate to full speed when time is resuming, using a nice motion blur effect.

- **Smart 3D Models**





SkyExplorer gives access to Smart 3D Models perfectly integrated on the terrain, using the same atmospheric lighting as the terrain, allowing to switch between day and night, and casting real-time shadows.

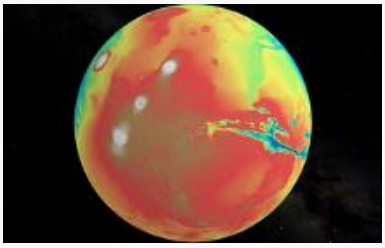
The Smart 3D Building of Vera C. Rubin is seamlessly integrated on the terrain. Photogrametry from a drone footage was used to model and texture the building and the ground around it. This model also includes atmospheric lighting, and comes with animations, auto-illumination and real-time shadows. It uses a new rendering that allows to switch between day and night, including the possibility to display night lights to see the observatory at night.

Users can import 3D models on the terrain and the rendering will automatically use this smart technology for a perfect integration on the terrain applying the atmospheric lighting and real-time shadows.

PLANETARY SCIENCE

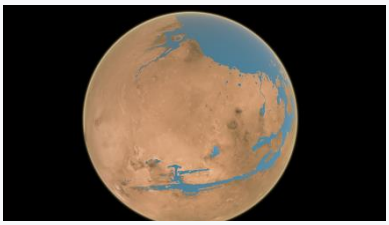
SkyExplorer provides all the essential data to explore the Solar System and discover the multiple objects in it.

EXTERNAL LAYERS



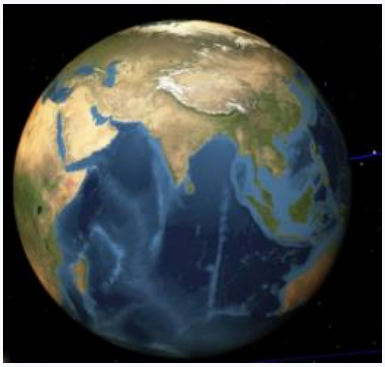
- **Topography Coloring**

  SkyExplorer enables users to highlight the topography of bodies with elevation maps (Mercury, Venus, Earth, Moon, Mars, Ceres, Vesta, Pluto, Charon) with colors of their choice. Based on the elevation, SkyExplorer will apply the colors to the terrain.



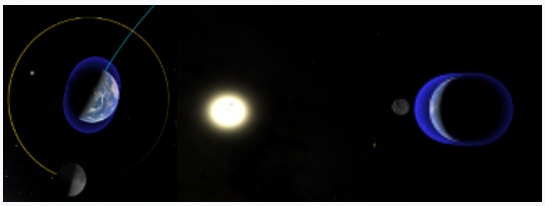
- **Real-time sea level adjustment**

  SkyExplorer offers the possibility to change in real time the sea level on Earth, and to simulate surface bodies of water on bodies with elevation data like Mars.



- **Bathymetry data**

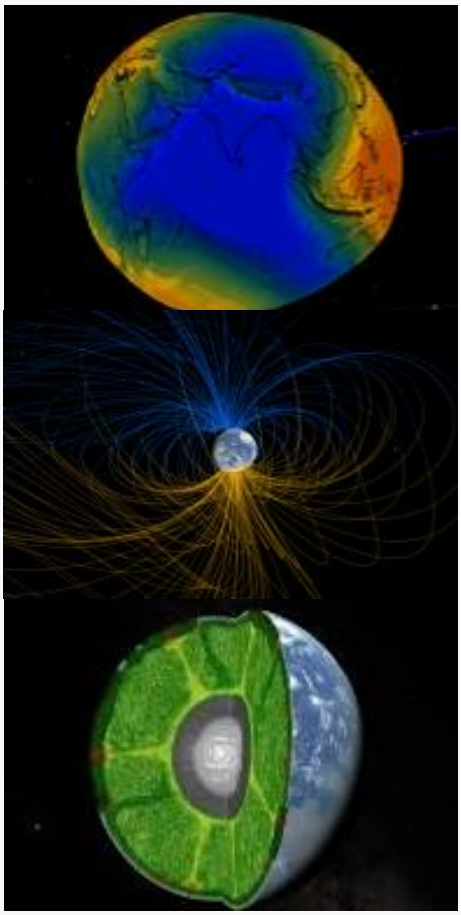
  It is possible to display a model of the Earth with the visualization of seafloor, in 3D and with shaded colors. Combined with topography rendering and sea level adjustment, it is possible to visualize the evolution of the coast lines for any referenced sea level.



- **Tides Simulation** Exclusive

  It is possible to explain the evolution of the Earth tides, using an exaggerated water “envelop” around the Earth. The shape of this envelop will be deformed using static theory of tides, depending on the position of the Moon and of the Sun. It is also possible to remove Sun and Moon attraction separately.

INTERNAL COMPONENTS



- **Earth Geoid** *Exclusive*

  The geoid is a representation of the Earth highlighting the variations of the gravitational field at its surface. On this representation the "altitude" and the color of each point on the surface of this globe represent the strength of gravity at this point.

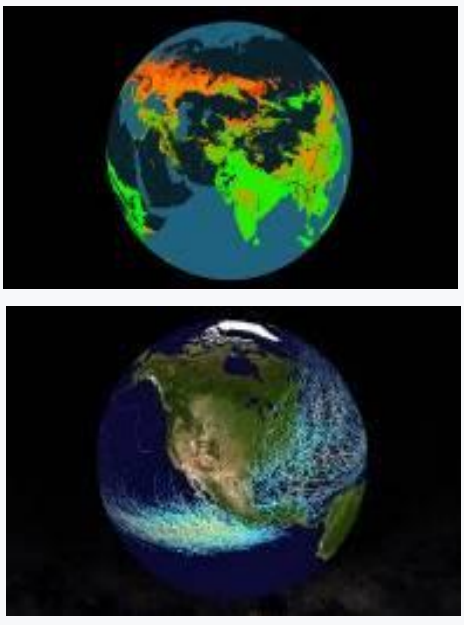
- **Dynamic 3D Magnetosphere**

  SkyExplorer enables users to display a dynamic 3D representation of the Earth's magnetosphere. Based on Tsyganenko's calculations, the model can represent the motion of the magnetosphere over 12 months.

- **Interior Structure of Planets and Satellites**

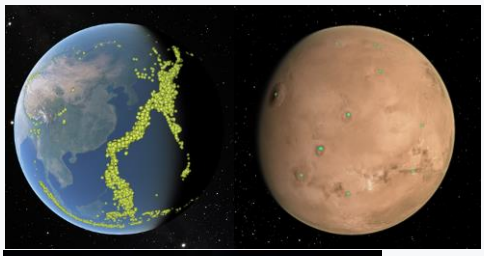
  It is possible to display special models of planets and of satellites to show cross-sections of their interior. Two schematic representations are available for each. This work has been done in collaboration with Dr. Pierre Thomas from Lyon University, to simulate the different layers of their internal structures.

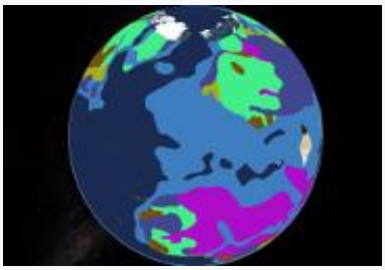
SURFACE DATASETS



- **NOAA Science on a Sphere**

  Thanks to Science on a Sphere® (project of National Oceanic and Atmospheric Administration), it is possible to display planetary data onto the globe in SkyExplorer. Animated images of atmospheric storms, climate change, and ocean temperature can be shown on Earth, to explain complex environmental processes in a way that is simultaneously intuitive and captivating.





- **Placemark Datasets** Exclusive

SkyExplorer includes datasets of craters and mountains (Earth, Moon, Mars, Venus, Mercury), cities and earthquakes to allow our end user to present geological data.

It is also possible to load custom TSV files for placemark datasets. These files can contain elevation data, for example to visualize the depth of earthquake epicenters. Placemarks can be displayed with labels and a color code according to a weight given to each point.

- **Vector Terrain / KML File Support** Exclusive

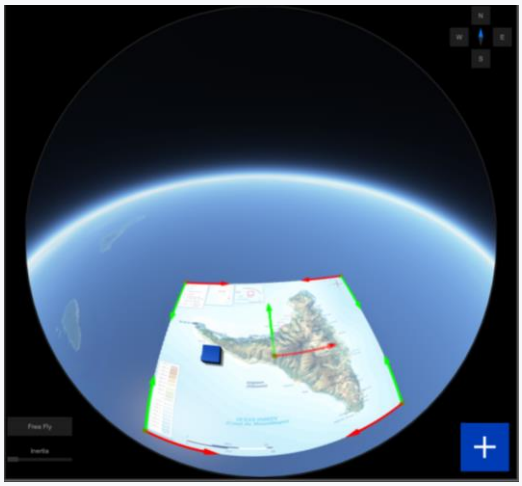
SkyExplorer terrain models support KML vector files. It is therefore possible to show complex lines and areas on the surface of the terrain.

Several datasets are included, such as: Type and positions of mountains, Age of Earth's floor, Position of the continents at several ages, Tectonic plates position, Passive and active margins.

It is also possible to load custom KML vector datasets on any planet or satellite with terrain. This means that you can create your own vector shape dataset using Google Earth, and import the result in SkyExplorer, or use an existing KML file.

- **User Terrain Patch**
  - **Georeferenced Patch**

SkyExplorer terrain models support the addition of georeferenced images as patches for both the imagery and the elevation. SkyExplorer will position the patch automatically on the surface of the celestial body based on the georeferencing metadata embedded in the image. Images and/or image mosaics of any size and resolution can be used, so this feature is suitable both for global data visualization purposes and for very high definition local improvements to the realistic terrain surface. SkyExplorer uses the GDAL library to load georeferenced images, therefore it supports a very wide range of formats (geotiff, ECW, JPG2000, etc.).



- **Live Patch** Exclusive

Standard images (non-georeferenced) can also be added onto the terrain through the “Live Patch” feature. Just like HD georeferenced patches, the image is embedded in the terrain, following the geometry. Users can adjust the size, position & rotation of the image to fit perfectly with the real terrain data, using a dedicated interface in the Interactive Dome View.

- **Online Terrain Patch (WMS)**

SkyExplorer comes with easy access to:

- WMS terrain maps for Earth with frequent updates (near real-time, daily, weekly or monthly) on various topics (like climate and meteorology), available through NASA GIBS, NASA Neo and NOAA NowCoast services
- WMS terrain maps for Mars, Moon and Titan using data from various missions, available through NASA Trek services

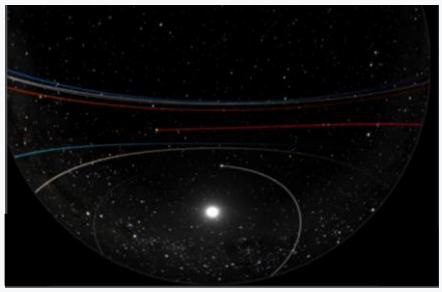
More WMS maps can regularly be added into SkyExplorer through SkyExplorer Live Atlas or directly by the user.

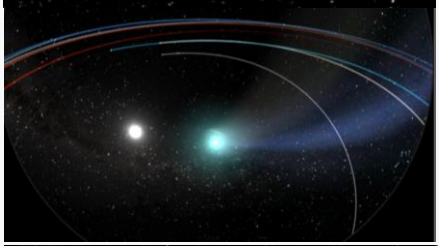
MASSIVE DATASETS

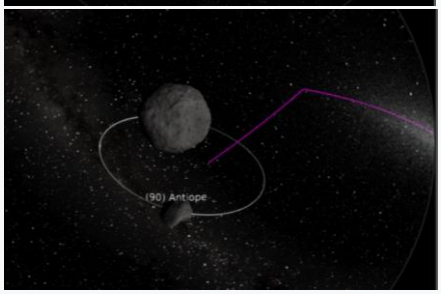
SkyExplorer can handle a huge amount of data, and is in direct connection with latest scientific datasets available online.

SKYEXPLORER DATABASE

- **Solar System**







The 8 planets of the Solar System and their natural satellites are simulated in SkyExplorer. Also, all 5 dwarf planets are represented.

All planets have a basic representation – a textured sphere with the possibility for the user to change the textures used.

Any comet with their astronomical parameters can be viewed and animated in real time. 5 real representations (Halley, Bradfield, Hale-Bopp, Hyakutake, McNaught) and one generic customizable 3D model are available.

Over 1,300 asteroids with their astronomical parameters are available. Users have access to 6 real representations and to 6 generic 3D models. All 3D models of asteroids registered on the "DAMIT" website can be downloaded and visualized in SkyExplorer.

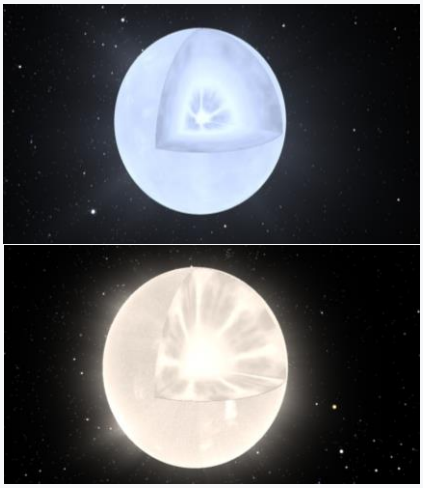
Users can add any other comet or asteroid they wish and customize their appearance and astronomical parameters.

- **Gaia Night Sky**

SkyExplorer's Gaia Night Sky was generated using the Gaia DR2 catalog compiling more than 1.3 billion stars.

It is possible to show stars and information from Tycho 2, Henry Draper (HD/HDE/HDEC), Hipparcos, Yale Bright Stars (BSC), Gliese & Jahreiss catalogs as well as Flamsteed & Bayer designation. Users also have access to various filters to display the stars they wish.

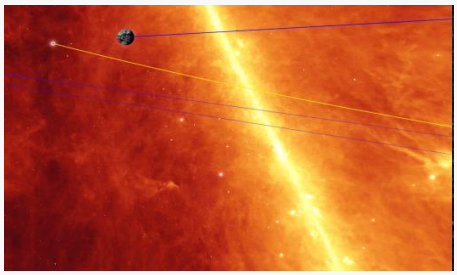
- **Individual stars**



More than 2,800 stars can be visited individually, to show their 3D appearance or explore their exoplanet system.

It is possible to display a model of these stars, including of the Sun, which can be opened to show cross-sections of the star's interior. The appearance of the surface and interior depends on star parameters such as color, spectral type, radius and luminosity. The interior can either show the radiative and convective zones, or layers of elements inside the star.

- **Milky Way**



From the Solar System, the Milky Way can be represented using various images at different wavelengths (photographic, FERMI, IRAS and COBE, 2MASS, Spitzer Glimpse / Mipsgal), in addition to the main HDR image of the Milky Way using Gaia DR2 catalog.
Out of the Solar System, the Milky Way switches to our 3D Volumetric Scientific Milky Way, which also offers various wavelengths.

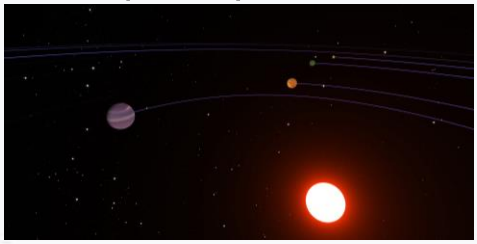
- **Deep Sky Objects**

The 110 objects of the Messier catalog and a selection of 110 top rated NGC-IC objects are present in the form of images positioned in 3D in the Universe and sized so as to have the exact angular size of the object as seen from the Earth. They can be scaled-up to help in visualizing them.
In addition, 25 nebulae and 162 globular clusters have 3D models allowing to visit them up-close.

- **Multiple Star Systems**

SkyExplorer counts more than 100 stars in multiple systems. Speeding up the time, we can see their relative motion & follow their orbit around the barycenter of the systems.

- **Exoplanet Systems**



SkyExplorer allows going into extrasolar planetary systems, where you can see more than 2,000 individual exoplanets orbiting their stars, with 3D models based on the 18 representations from Puerto Rico University

DIRECT CONNECTION TO ONLINE SCIENTIFIC DATASETS

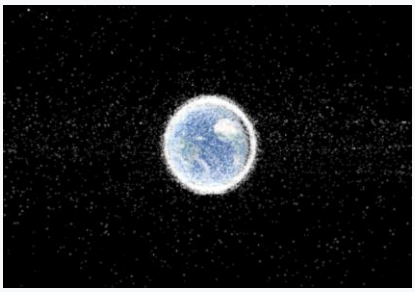
- **SkyExplorer Live Atlas**

All the catalogs integrated in SkyExplorer Live Atlas are directly imported from the original scientific catalogs. They are distributed to all our users, updated without additional costs, and do not require the establishment of a business license. As these catalogs are online, they can be updated at any time by the user with an internet connection.

Most datasets are visualized as points using a color code. Each color highlights a scientific classification which is explained by a legend, visible in the user interface. This color code is thus informative but also offers a stunning rendering to the audience.

SkyExplorer Live Atlas is in direct connection with all the following online datasets:

WITHIN THE SOLAR SYSTEM



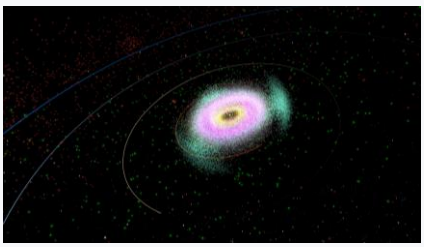
- **Artificial Satellites of the Earth**

Exclusive

The Spacetrack and Celestrak databases can be viewed and animated in real time. These databases give access to a total of 65 datasets and 25,800 objects. The orbits of the satellites are calculated using the SGP4 model.

4 datasets, accounting for total of 13,731 articial satellites, use real-time realistic rendering based on the intrinsic magnitude, the phase function and occultation of the satellites, as well as the atmosphere: 100 brightest satellites, active satellites, the ISS and Starlink.

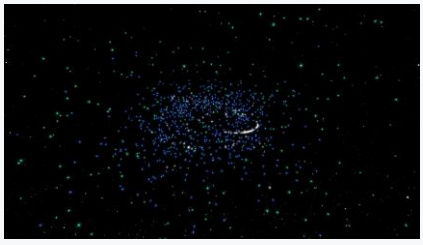
An automatic update of these databases takes place every 2 weeks.



Exclusive

- **Asteroids**

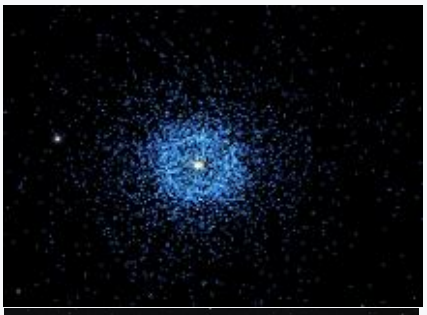
The whole Astorb database from Lowell Observatory can be viewed and animated in real time. This database contains 1,618,734 objects.



Exclusive

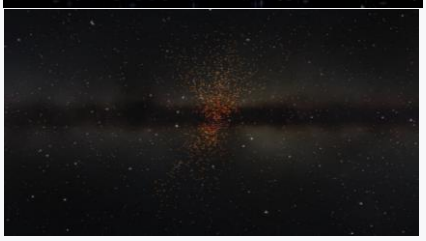
- **Comets**

This dataset includes 1,463 comets from the Minor Planet Center (MPC). They can be viewed and animated in real time.



- **Oort Cloud Representation**

As the Oort cloud has never been observed, there is no database enabling it to be modeled. However, based on a theoretical simulation by NAOJ, we have obtained a 3D representation.

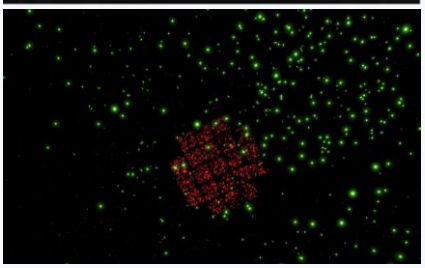


- **Brown Dwarfs**

This dataset includes more than 1,500 brown dwarfs of L, T & Y types.

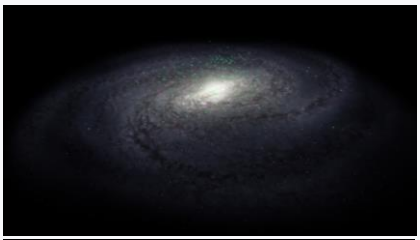
- **Exoplanets**

SkyExplorer includes a dataset of over 5,500 exoplanets from Nasa Exoplanet Archive in over 4,000 systems.



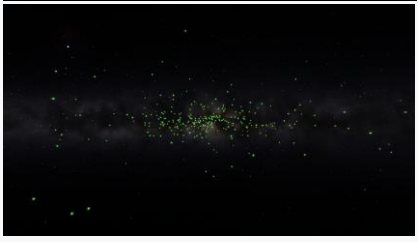
- **Exoplanet candidates**

This dataset brings together over 4,800 exoplanet candidates from 3 missions: Kepler, K2 and TESS (Transiting Exoplanets Survey Satellite). A color code is used to differenciate the data from the 3 missions.



- **SNR (Supernovae remnants)**

This dataset includes 164 SNR.

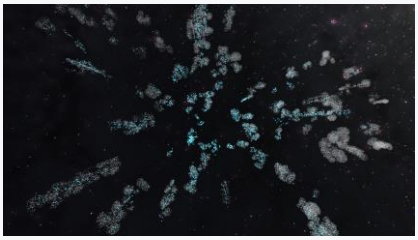


- **Planetary nebulae**

This dataset includes 289 planetary nebulae.

- **HII regions**

This dataset includes over 1200 HII regions.



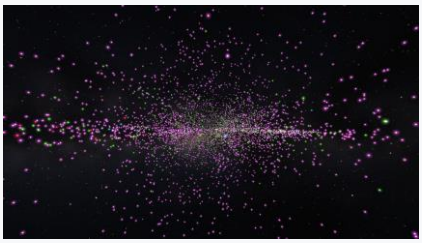
- **OB associations**

This dataset includes over 100 OB associations from the Gaia catalog data.

The groups of stars integrate OB type stars which are displayed in blue.

- **Open Clusters**

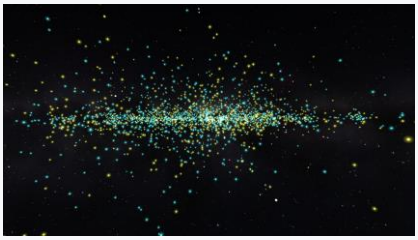
This dataset includes more than 2,600 open clusters.



- **Variable Stars** Exclusive

SkyExplorer offers more than 9,000 variable stars from the General Catalog of Variable Stars (GCVS).

DEEP SKY

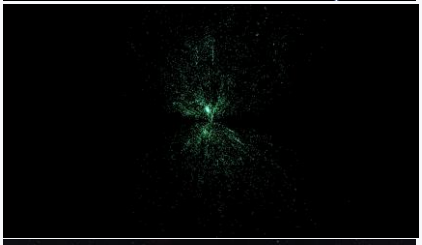


- **Pulsar** Exclusive

This dataset includes over 3,000 pulsars from the ATNF Pulsa[illegible].

- **Globular Clusters** Exclusive

This dataset includes 162 globular clusters from the catalogs of Harris and Baungardt.



- **NGC-IC Object** Exclusive

This dataset shows the location of around 14,000 NGC-IC objects in the starfield, from OpenNGC catalog. More than 7,500 of these objects are properly placed in 3D, using their distance in addition to their position in the starry sky.

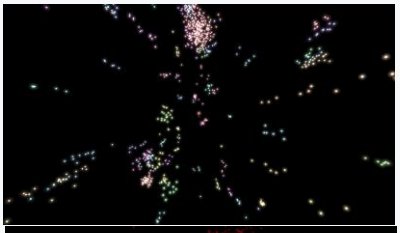
When displayed in 2D, they are represented using a virtual sphere to see how they can be observed from Earth.

- EXTRA GALACTIC

- **Local Group**

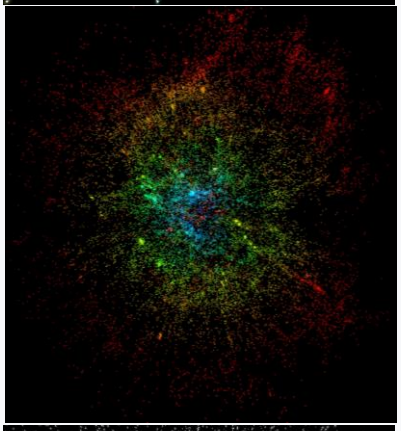
Exclusive

This catalog was composed using 143 galaxies or dwarf galaxies. It allows to show the neighborhood of our Milky Way up to 3Mpc.



- **Galaxy Groups**

This dataset gives access to 155 galaxy groups. Each galaxy group is represented using a color code. Labels are available for 63 galaxy groups.

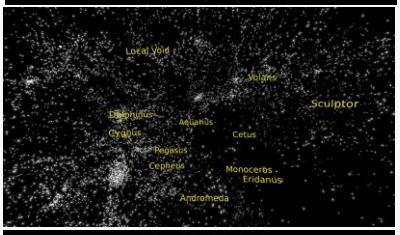


- **Tully Galaxy**

This dataset includes over 30,000 galaxies.

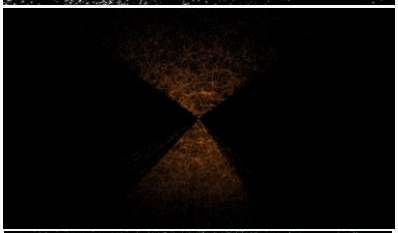
For galaxies in the Tully catalog, it is possible to display galaxies according to its distance or its type using a color code.

It is also possible to display the images of the galaxies or their position (without a color code).



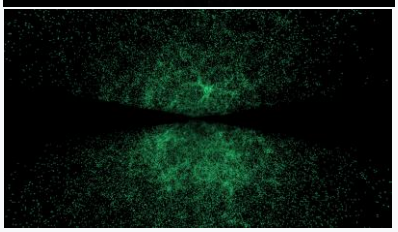
- **Voids**

This dataset includes 33 voids with their related labels.



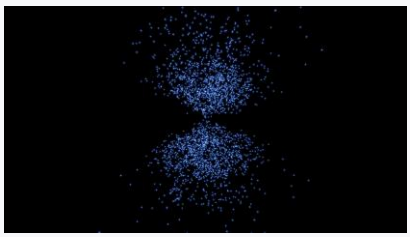
- **2dF Galaxy**

This dataset includes over 229,000 galaxies.



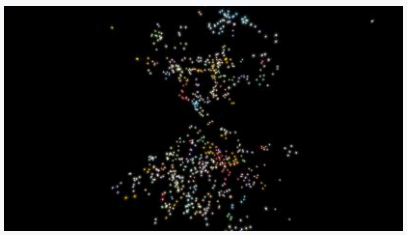
- **6dF Galaxy**

The datasets of over 110,000 galaxies are available.



- **Abell (galaxy clusters)**

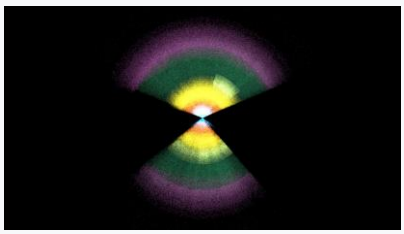
Over 3,000 galaxy clusters from the Abell catalog are available. Their position were based on the NED's (Nasa Extragalactic Database) distance measurements.



- **Superclusters**

172 superclusters are available.

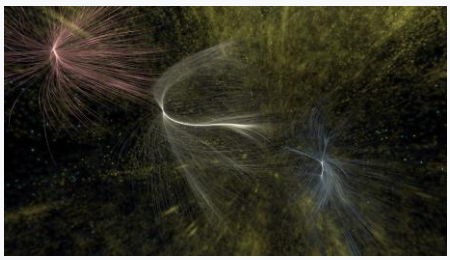
Labels are available for the 33 most known superclusters.



- **SDSS DR16 Galaxies**

The SDSS DR16 available in SkyExplorer brings together the galaxies and QSOs from the DR7 catalog, the BOSS mission and the eBOSS mission. The location of 3 millions of galaxies can be viewed in real time. The galaxies from each mission are viewed using a different color code.

- **Animated superclusters of Laniakea, Perseus-Pisces, Shapley**



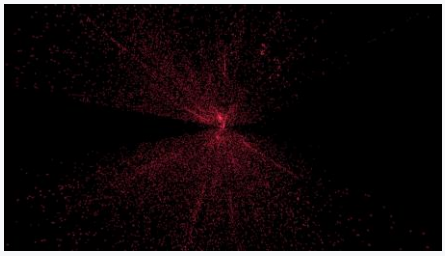
The animated superclusters of Laniakea, Perseus-Pisces, Shapley were developed with scientists of the Cosmicflows Collaboration: Hélène Courtois, Université Lyon 1, and Daniel Pomarède,CEA Saclay, with the data from Cosmic-flows 3 catalog.

For each supercluster, 3 versions are provided:

* Fixed streamlines

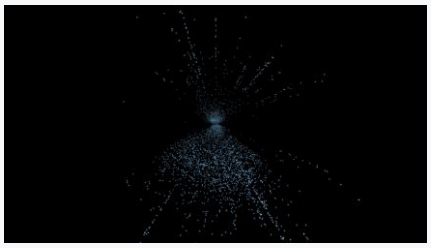
* Waving streamlines

* Animated dots



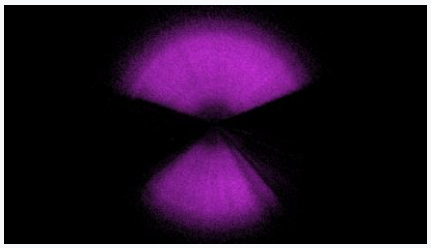
- **Cosmicflows-3**

This dataset includes over 17,000 galaxies of the Cosmicflows 3 catalog, from the Cosmicflows Collaboration.



- **Supernova Catalog**

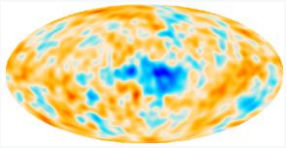
This dataset includes more than 10,000 Supernovae from the Open Supernova catalog.



- **QSOs**

SkyExplorer combines the datasets of the 2dF, 6dF and SDSS datasets in one single catalog giving access to the location of over 700,000 quasars in real time.

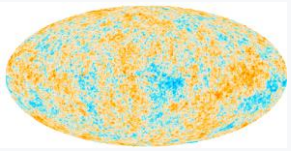
COBE



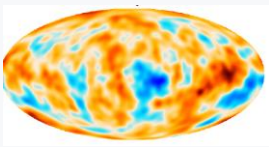
- **CMB Maps (COBE, WMAP, Planck)**

The images of the cosmic microwave background (CMB) captured by COBE, WMAP & Planck can be viewed in SkyExplorer.

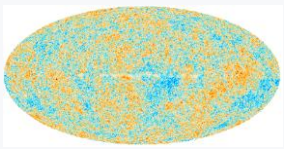
WMAP

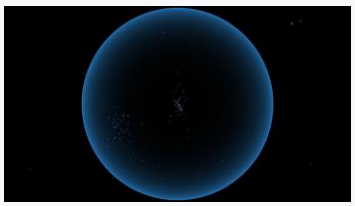


WMAP degraded



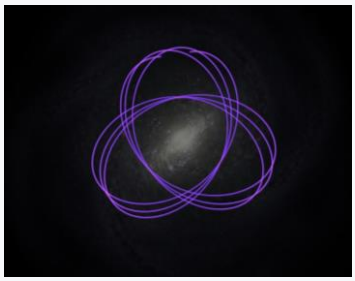
PLANCK





- **Boundaries**

SkyExplorer provides a spheric spatial representation of the size of the stellar halo of the Milky Way, the local groups, Virgo and Lanikea thanks to the boundaries feature.



- **Star orbits**

Users have access to the orbits of 8 stars and of the Sun. The orbits were calculated using the Besançon Galactic Model.

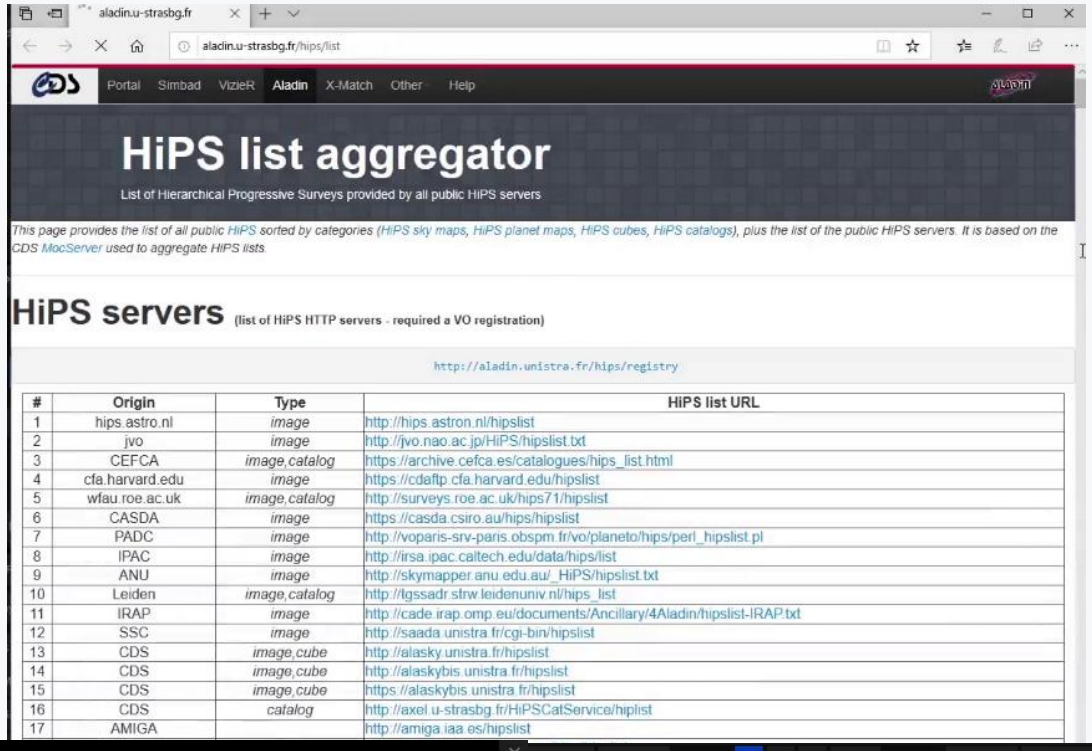
- **Uncertainties**

It is possible to visualize the uncertainties of 100 Hipparcos and Gaia stars' position.

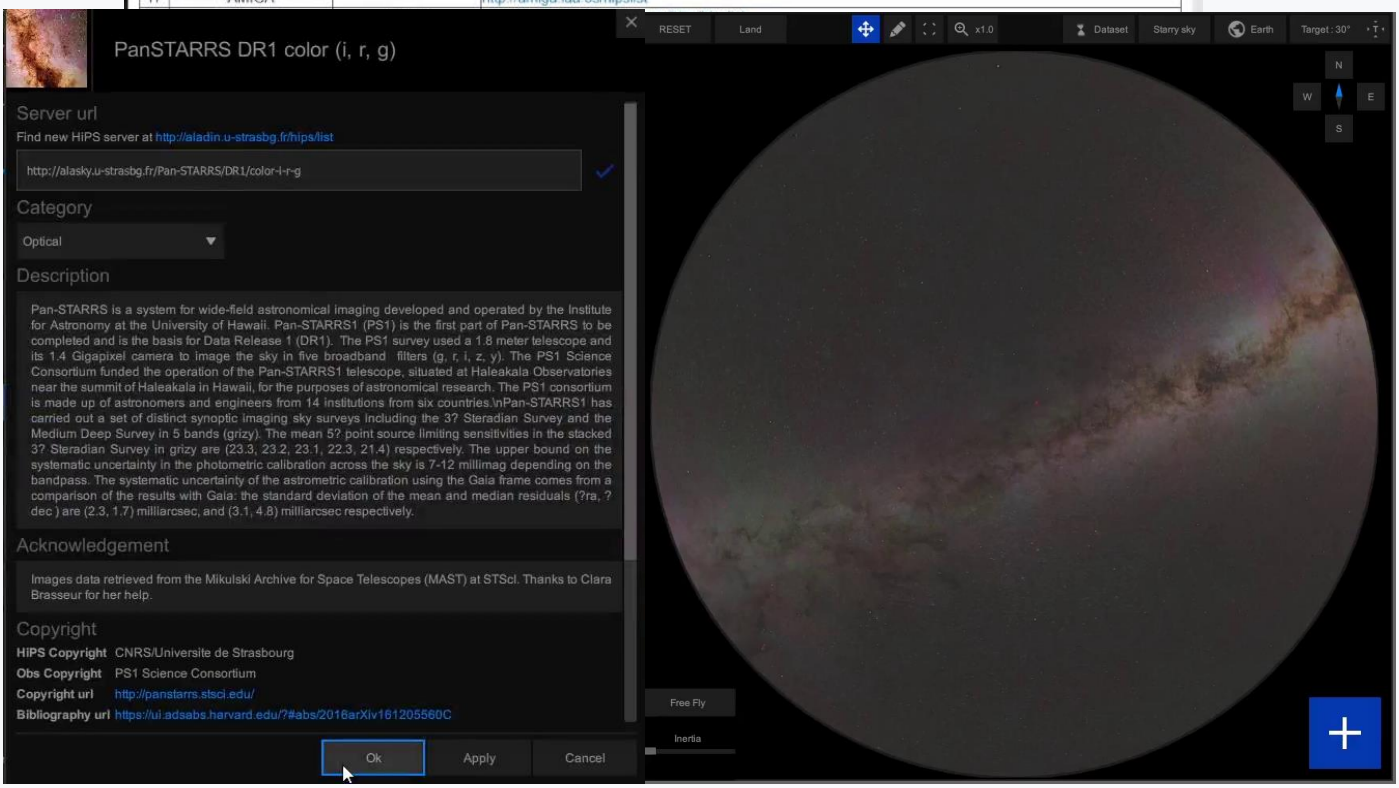
- **Sky Surveys**

SkyExplorer provides a great number of high-resolution sky maps directly integrated from the HiPS (Hierarchical Progressive Surveys) servers registered by the CDS (Centre de Données Astronomiques de Strasbourg)- (http://aladin.u-strasbg.fr/hips/list). Maps of all the sky are available in several wavelengths, i.e. in Gamma Ray, X-Ray, UV, Optical, Infrared, Radio, Gas lines, such as EGRET, Fermi, INTEGRAL IBIS, ROSAT, GALEX, DSS2, SDSS9, PanSTARRS, TESS, HST-V, 2MASS, AllWISE, IRAS, Planck.

More HiPS sky maps can regularly be added into SkyExplorer through SkyExplorer Live Atlas.



#	Origin	Type	HiPS list URL
1	hips.astro.nl	image	http://hips.astron.nl/hipslist
2	jvo	image	http://jvo.nao.ac.jp/HiPS/hipslist.txt
3	CEFCA	image,catalog	https://archive.cefca.es/catalogues/hips_list.html
4	cfa.harvard.edu	image	https://cdaftp.cfa.harvard.edu/hipslist
5	wfau.roe.ac.uk	image,catalog	http://surveys.roe.ac.uk/hips71/hipslist
6	CASDA	image	https://casda.csiro.au/hips/hipslist
7	PADC	image	http://voparis-srv-paris.obspm.fr/vo/planeto/hips/perl_hipslist.pl
8	IPAC	image	http://irsa.ipac.caltech.edu/data/hips/list
9	ANU	image	http://skymapper.anu.edu.au/_HiPS/hipslist.txt
10	Leiden	image,catalog	http://lgssadr.strw.leidenuniv.nl/hips_list
11	IRAP	image	http://cade.irap.omp.eu/documents/Ancillary/4Aladin/hipslist-IRAP.txt
12	SSC	image	http://saada.unistra.fr/cgi-bin/hipslist
13	CDS	image,cube	http://alasky.unistra.fr/hipslist
14	CDS	image,cube	http://alaskybis.unistra.fr/hipslist
15	CDS	image,cube	https://alaskybis.unistra.fr/hipslist
16	CDS	catalog	http://axel.u-strasbg.fr/HiPSCatService/hiplist
17	AMIGA		http://amiga.iaa.es/hipslist



VARIOUS DATA COLLECTIONS

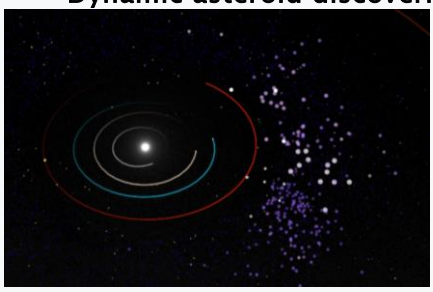
- **Stellar Black Holes**

This dataset produced by the planetarium of la Cité des sciences et de l'industrie in Paris shows the location of 20 Stellar black holes.

- **Exoplanet pointers**

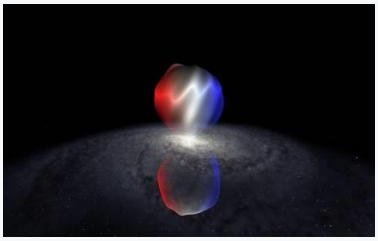
Pointers are available to identify more than 400 systems with exoplanets. The color of each pointer relates to the number of exoplanets discovered.

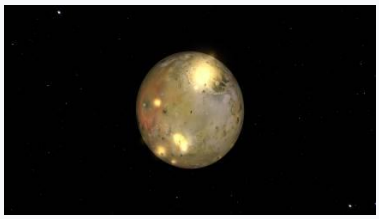
- **Dynamic asteroid discoveries**



A representation is available with asteroid points appearing dynamically at their date of discovery.

- **Data from California Academy of Sciences**



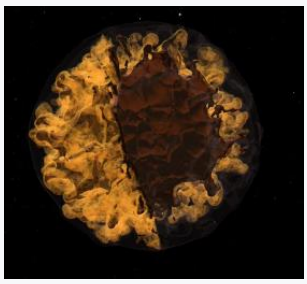
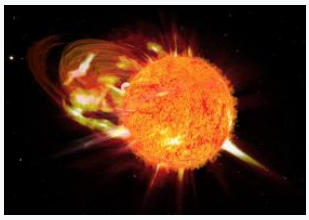
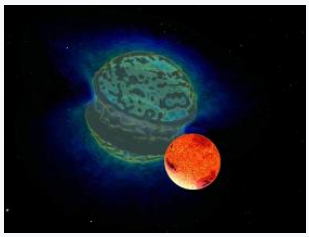


Various data were integrated into SkyExplorer for Ryan Wyatt's "Data to Dome" presentation at LIPS 2017.

Most of these datasets and models are redistributed to SkyExplorer's users, including:

- 3D models and orbits of binary asteroid (90) Antiope
- Exoplanet pointer dataset
- 3D model of the Milky Way's Fermi Bubbles
- Dynamic dataset of hotspots on Io (2013-2015)
- Juno's 3D trajectory to Jupiter
- 3D models of Jupiter's magnetosphere and radiation belt
- 3D model of Io's torus
- 3D model of KIC 9832227 eclipsing binary system
- Rogue planet pointer dataset
- 3D models of Trappist-1 exoplanets
- Earth terrain patches of crop and pasture land use
- Earth terrain patch of agricultural water use
- Point dataset and orbits of trans-neptunian objects (TNO)

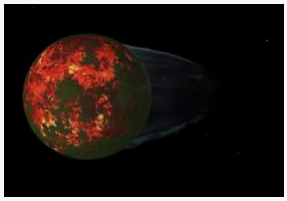
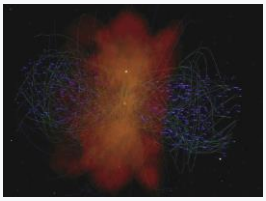
CALIFORNIA ACADEMY OF SCIENCES

- **Data from the Italian National Institute for Astrophysics (INAF)**

  Various data from Salavatore Orlando of INAF were integrated in SkyExplorer including:

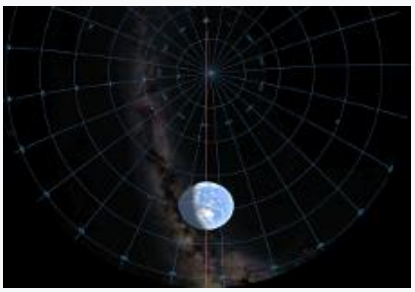
  - 55 Cancri-e, a fiery volcanic extrasolar planet
  - A stellar nursery in the interstellar space
  - The blue supergiant Sanduleak-69° 202a (SN 1987A)
  - The nova outburst of U Scorpii observed in 2010
  - Giant coronal mass ejection in an active star
  - The dramatic explosion of a type Ia supernova


EDUCATIONAL & CORE PLANETARIUM FEATURES

SkyExplorer gives access to advanced educational features & hardware solutions in order to deliver the most precise & qualitative sessions.

ASTRONOMICAL BEARINGS



- **Constellations Images, IAU Boundaries and Videos**

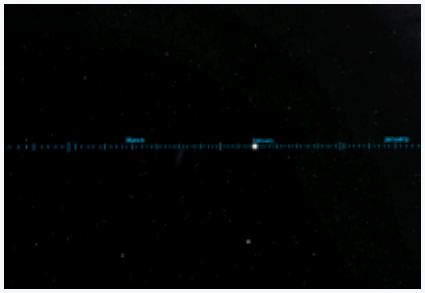
  SkyExplorer allows the display of 88 constellations: the line patterns (connecting stars in 3D), graphic representations, the IAU boundaries and the names of the constellations. Most constellations also have cartoon images adapted for children. Several of them can be animated using videos.
  Several common asterisms are also included, such as the big dipper and the summer triangle. All representations of the constellations can be customized. It is also possible to build and/or load all new constellations such as constellations from another culture or your own custom asterisms.

- **Astronomical Marks**

  SkyExplorer can show several astronomical marks. All these marks can be customized to show graduations, texts and lines.

  It is possible to show:
  - Earth Ecliptic and Equatorial (J2000 and true equinox) lines, poles, axes, bands, grids, equinoxes and prime meridians
  - Earth Precession circle
  - Earth Circumpolar circle
  - Earth Equatorial synchronous marks: equator, prime meridian, tropics, polar circles, graticules
  - Earth magnetic poles with location data animated from 1590 to 2025 using IGRF and WMM models
  - Horizontal grids: cardinal points, horizon line (azimuth), meridian, prime vertical, zenith
  - Supergalactic and Galactic band and grid
  - Hour Angle – Declination grid

In addition to the predefined astronomical marks, SkyExplorer offers users the possibility to create their own grids by defining the shape and number of meridians and parallel lines for example. The other adjustable parameters are: intensity, color, thickness of lines, font used.



- **Dynamic Astronomical Marks**

  SkyExplorer can show the ecliptic line with graduations that dynamically change depending on the year. With this ecliptic mark, the position of the Sun on the ecliptic line as seen from Earth is exact whatever the date, even in leap years.

  SkyExplorer allows to identify the circumpolar stars and constellations thanks to the relative circle they lie within. The circumpolar circle is dynamically adjusted regarding the latitude of the observer on Earth.

- **Linking Lines** Exclusive

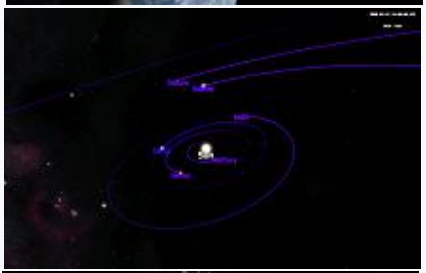
  It is possible to draw a straight line between two objects. This line can be drawn on the dome or in the 3D simulation. The line can be graduated, and it is also possible to continue the line after it reaches the targeted object. A label with the distance (for 3D lines) or angular distance (for 2D lines) between the two objects can be displayed, evolving in real time.

- **Power Cubes** Exclusive

  “Power cubes” can be centered on any object, showing the closest power of ten length unit.

- **Pointers**

  All astronomical objects can now display a 2D or 3D pointer showing their position. The 2D pointer can be selected from a list of images. It is also possible to show a 2D pointer at any position on the dome.



- **Labels**

  SkyExplorer is able to display labels for all objects (Sun, Planets, Dwarf Planets, Satellites, Hipparcos Stars, Milky Way, Messier catalog, etc.).

  The size and the number of displayed labels are automatically handled by SkyExplorer in order to keep a visible number of labels displayed on the dome as well as to keep a relevant size for these labels.

  Labels can be used as simply as using on/off switch, but can also be customized.

- **Internationalization**

  All the texts that can be displayed in the simulation have been translated into: French, English, Latin, German, Flemish, Romanian, Ukrainian, Russian, Spanish, Italian, Portuguese, Greek, Arab, Korean, Japanese, Chinese, Swedish and Thai.

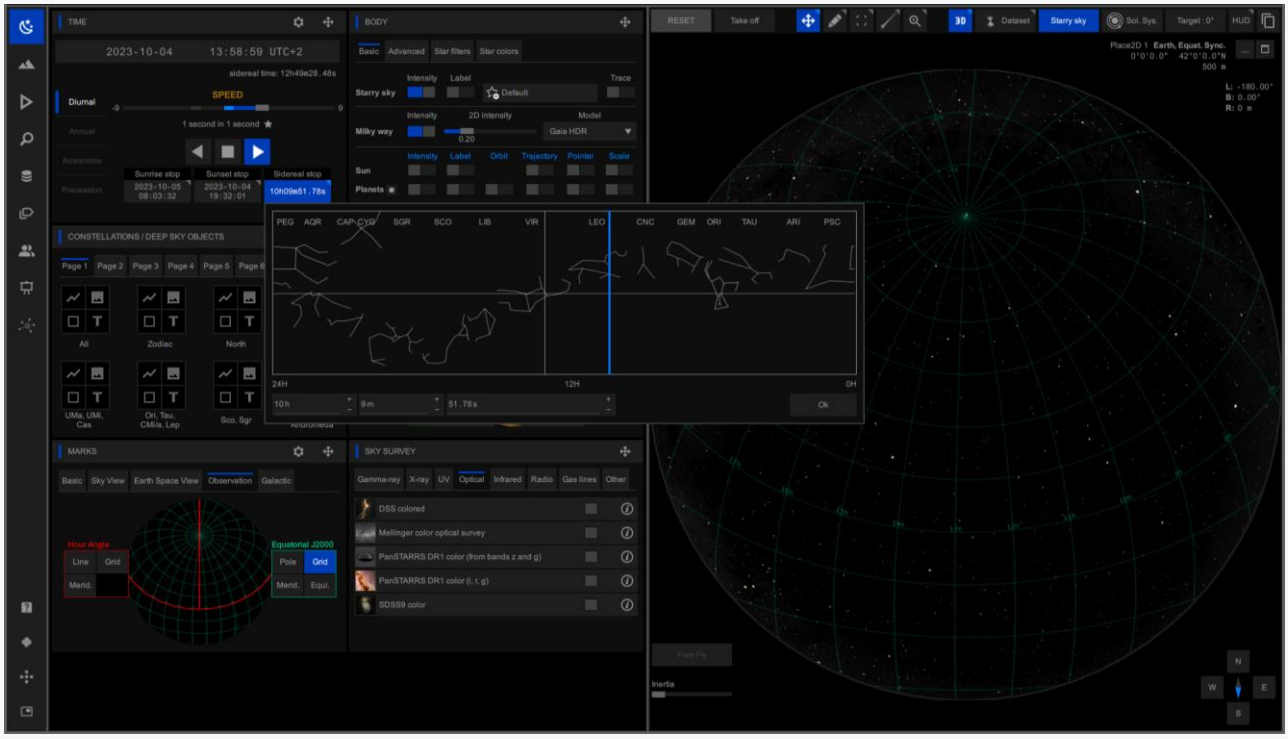
  In addition, units can be switched between metric/SI and imperial/USC systems.

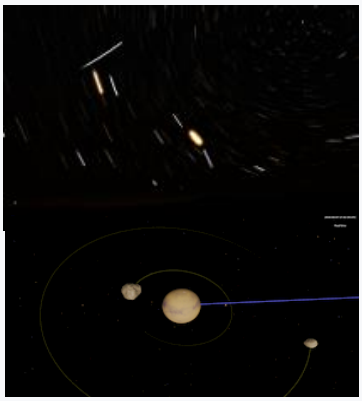
SCENOGRAPHIC TOOLS

- **Simulation time control**

SkyExplorer provides full control of simulation time:

- reach a given date/time
- reach next sunset/sunrise (with a customizable offset in hour(s) or degree(s))
- reach a given sidereal time
- run the time (instant, diurnal, annual, analemma, precession)
- adjust the time speed on the fly (while a time motion is already running)
- display information (date, time, sidereal time) on the dome





- **Trace Mode**

  Activating this mode is like taking a photo leaving the shutter open. This mode is provided for instance to see the trail left by the stars during a diurnal motion or to track the artificial satellites in the sky.

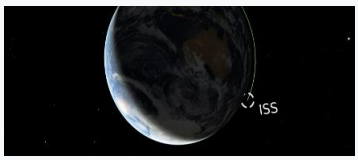
- **Modification of Astronomical Parameters**

  SkyExplorer allows for individual control of the parameters of each celestial body:

  - Size factor
  - Rotation factor
  - Factors of revolution and distance for all planets and satellites relative to their orbited body
  - Precession factor for the Earth.

- **Complex Trajectories**

  This function is designed to show the movement of an object from the observer's point of view. This function is particularly useful when showing the shape of a retrograde motion of a planet or an analemma.

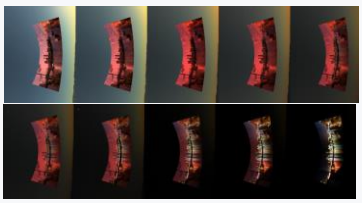


Exclusive

- **3D Paths & Orbital Paths**

  Using timed keys of 3D position and orientation, it is possible to create complex trajectories for 3D objects and for the observer. Existing paths (such as JPL Horizons data) can be imported to precisely follow the trajectories of spatial probes.

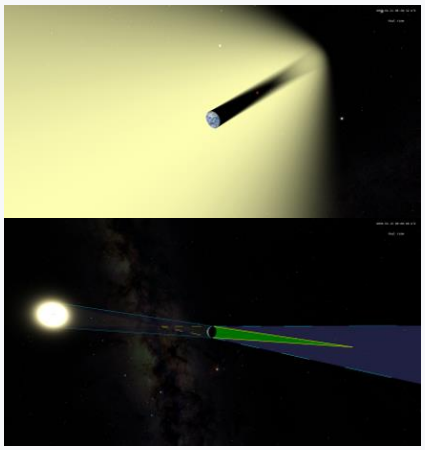
  Similarly, objects can be positioned on arbitrary orbits by defining orbital elements. These parameters can either be set manually or, for Earth-orbiting objects like the ISS, imported from TLE (two-line element sets).



- **Parameterization**

  This feature allows to dynamically change an attribute based on another variable from the simulation. For example, the user can play on the opacity of a panorama to simulate day/night cycle by fading between two overlaid images based on the height of the Sun.

ADVANCED EDUCATIONAL TOOLS

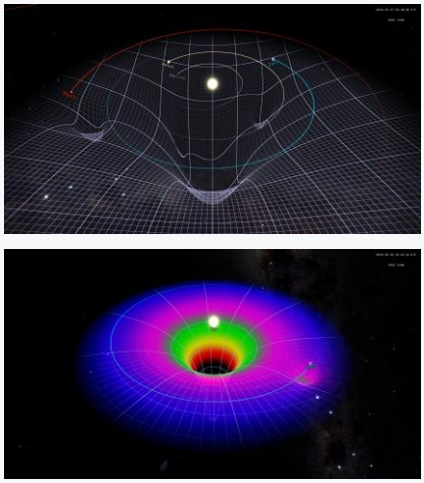


Exclusive

- **Shadow Cones**

To help you explain eclipses, SkyExplorer includes the ability to schematically display the shadow cast by any planetary body. Various representations are available, and can be customized:

- 3D cones showing umbra and penumbra
- 2D cones with lines on the boundaries
- 2D cones showing the amount of occluded light
- Cone sections
- Eclipse projection on the surface of the occluded body

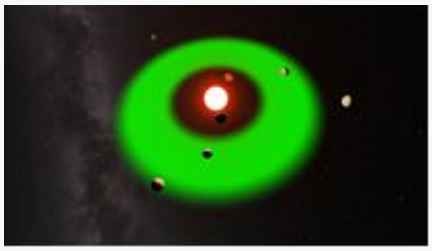


Exclusive

- **Space-Time Curvature Representation**

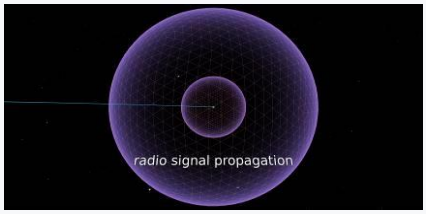
SkyExplorer allows you to represent the curvature of space-time using a distorted plane. This plane can be displayed using several modes to help show the distortion: 2D grid, contour lines, and color gradient.

This object can be positioned anywhere: stars and planetary bodies dynamically affect the distortion based on their position and mass. The size of the plane and the scale of its curvature are automatically updated to match those of the participating objects, and can also be customized by the user.



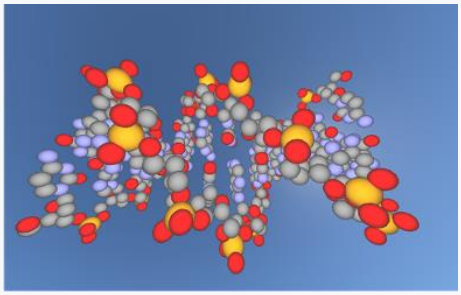
- **Circumstellar Habitable Zone**

All exoplanet systems in SkyExplorer are provided with their own Goldilocks (habitable) zone, computed from the Star's temperature and size.



- **Radio sphere**

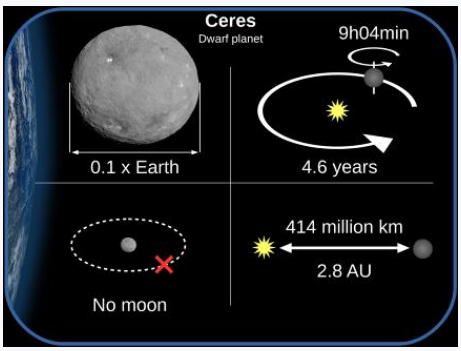
An animated sphere 3D model is available to help visualize radio signal propagation, expanding at the speed of light from customizable position and date.



- **Molecule Models** Exclusive

  SkyExplorer allows you to zoom down to the molecular scale. For example, you can show molecules from the atmospheres of Earth and Mars to compare their composition and proportion.

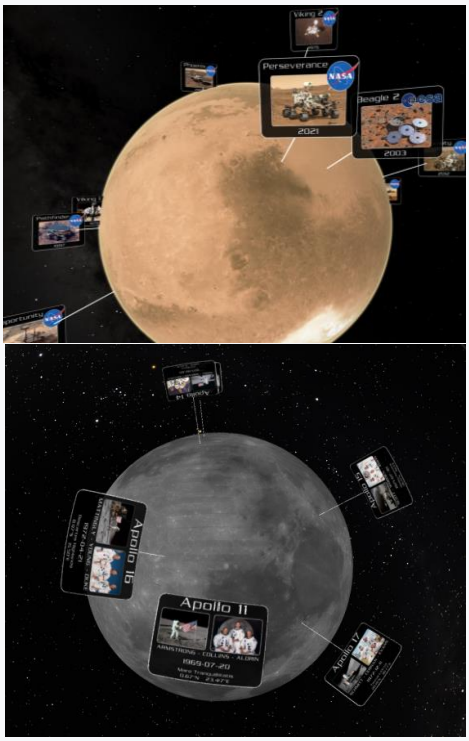
  It is possible to load molecule definitions from files using the standard PDB format. This allows to show any complex organic molecule like proteins and DNA. You can also customize the representation of atoms and their bonds to your liking.



- **Datasheets**

  39 datasheets are available for Solar System bodies. These contain notable information about each body, as a combination of english text and images.

  They have been specially developed for pedagogical purposes for a wide audience.



- **Mars & Moon Landing Sites**

  The location of the most famous landing missions on Mars & on the Moon can be shown in SkyExplorer with a pin and an image of the mission attached to it.

INSERTS

- **Fulldome Video Player**

SkyExplorer includes a fulldome video player capable of decoding video files up to 8K @ 60FPS in real-time. SkyExplorer is stereo 3D compatible at 120 FPS (60 per eye). SkyExplorer can play videos using up to 12 bits per component. SkyExplorer is AFDI compliant (as a founding member) and includes encrypted video capability.

SkyExplorer uses the FFmpeg library to play videos, therefore it supports a very wide range of codecs. It comes with fine-tuned encoder presets to produce video files from Dome Masters that ensure the best image fidelity and leverage Nvidia NVDEC GPU-accelerated decoding for the best playback performance. These recommended presets use MPEG-4 codecs (AVC/H.264, HEVC/H.265) in a .mp4 container format.

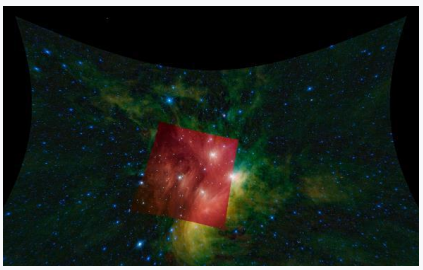
SkyExplorer supports various streaming protocols (NDI, UDP, HTTP, RTP / RSTP) to broadcast videos from a single computer to the dome. When possible, our tools use multicast or broadcast technologies to avoid saturating the network when there are a lot of computers.

You can insert subtitles in SkyExplorer. Subtitles follow the curvature of the dome, to maintain a constant text size and stay parallel to the horizon. Videos and subtitles can be controlled by play, loop, pause, stop, seek and speed.

- **Image and Video Inserts**

SkyExplorer allows for images or videos to be embedded into the simulation on four types of host geometry: “standard” (rectangular shape), “panoramic” (cylindrical shape), “spherical” (equirectangular / fullsky / VR) and “fisheye” (fulldome / dome masters). They can be placed on the dome or in the 3D scene to create many effects and extend the explanations of the presenter.
Opacity, intensity, position, orientation, positioning can be modified, as well as the volume for audio and video files. These parameters can be used to create animations like appearing, moving, disappearing, fading in and out effects, etc.

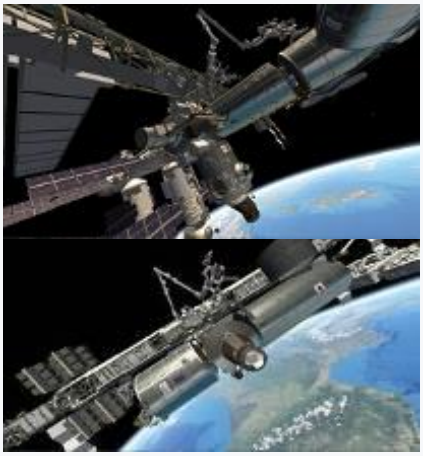
Color grading parameters can be used to adjust the colorimetry: Lift Gamma Gain, Hue Saturation Value (HSV), Vibrance, Brightness Contrast.
Chroma key can be used to define a color for the image or video that will become transparent when displayed in SkyExplorer.



- **AVM – Astronomy Visualization Metadata**

  Any astronomical image which includes AVM metadata can be automatically positioned with the right position, orientation and size, when added to an Insert or Messier object.

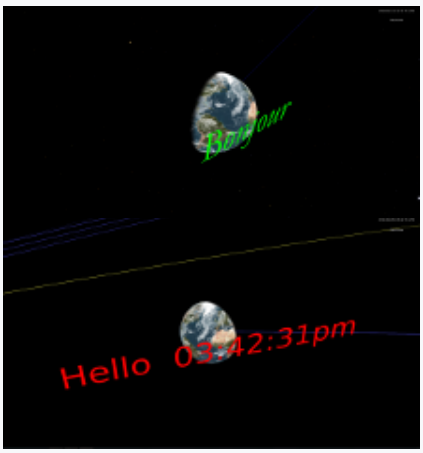
  It is very useful when downloading images with precise coordinates from resource servers such as ESO, Hubble and more.



- **3D Inserts**

  SkyExplorer allows users to incorporate their own 3D models into the simulation. It supports the following formats: FBX, GLTF, 3DS, X, OBJ, DAE, LWO, CMOD, OSG, IVE, DXF, STL, AC3D, PLY, XGL, ASE.

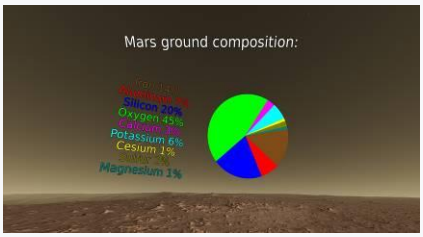
  Standard PBR materials are natively supported and real-time shadows are cast by the objects. Rendering uses the same atmospheric lighting as the terrain allowing for smooth integration and to switch between day and night.



- **Text Inserts**

  SkyExplorer enables users to display text. You can choose:

  - Position in the scene in 3D or on the dome
  - Type of the host geometry (plane or sphere)
  - Contents, including real-time information (such as the current date in simulation, travel speed or distance to a chosen body, in the unit of your choice).



- **Charts**

  Charts can be added in SkyExplorer, using bar chart and pie chart styles. Labels, colors and of course content data can be customized and animated.

  These charts are automatically used by the Audience Response System to display voting results.

- **Clocks**

  Analog clocks can be displayed on the dome. A timezone can be applied to each clock to show the time difference between places.

HARDWARE SOLUTIONS

- **Hybrid Solutions**

  SkyExplorer allows hybrid function with KONICA MINOLTA, GOTO and MEGASTAR starballs. Astronomical calculation shared between SkyExplorer & the starballs using special interpolation allows perfect synchronisation at any time.

  The hybrid solutions are compatible with all manual consoles.

- **Dante Audio Systems**

  SkyExplorer integrates Dante audio systems to deliver superior audio performances & offer the latest technological innovations.

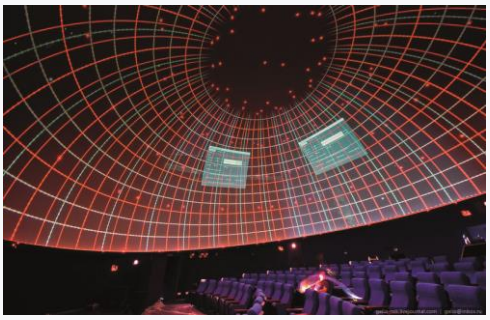
  Dante is probably the most popular protocol used worldwide for digital IP audio networks.

  A Dante audio system guarantees the highest sound quality & digital fidelity by using a network cable rather than analog cables.

  This system also means an easier set up & greater connectivity since over 500 channels can run through one Ethernet cable.

- **Screen Dimmer**

  Users will be able to adjust the brightness of the master computer's screen by connecting a screen dimmer. Dimming the screen lighting will avoid visual pollution & will help in maintaining the highest level of darkness inside the dome.

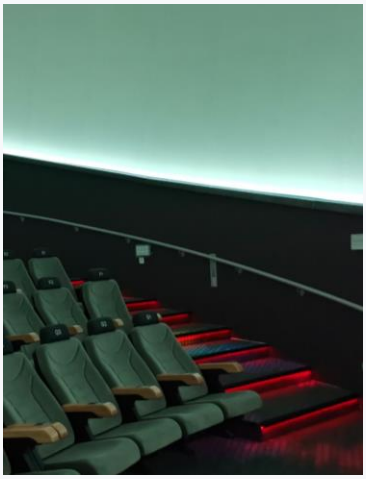


- **Autocalibration**

Autocalibration is a key process for displaying high-quality images with a homogeneous rendering throughout the entire dome.

It is easy to set up as it can be launched directly from SkyExplorer's interface, is connected via wifi to the fisheye lens camera needed during this process & requires no manipulation of the projectors.

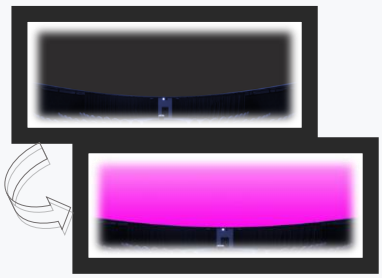
It applies all the necessary adjustments, from the geometric alignment between each image generator, to the levels of brightness & black around the edges, to ensure the best image quality.



- **Light Control**

SkyExplorer enables to control the lights of the planetarium. It is possible to switch on and off different lights such as the cove lighting, the staircase lighting.

SkyExplorer supports DMX and DMX over the network using Art-Net. DMX over Art-Net enables to control lights in 16 bits for a more progressive color transitions.



- **Virtual Cove Lighting**

SkyExplorer offers the possibility to use the projectors for uniform RGB lighting of the dome without the need for physical cove lights.

RSA Cosmos provides another complementary software to go beyond astronomy:

FreeDome MADE WITH Unity

Bring new content beyond astronomy to your audience and open up your doors to new utilizations.

With its ground-breaking software FreeDome, a complementary software to SkyExplorer, RSA Cosmos offers the opportunity to any immersive environment (planetariums, immersive rooms, museums, and more) to open up their doors to new utilizations and bring innovative content beyond astronomy to their audience to learn, and to live fun and innovative experiences.

FreeDome gives access to infinite content beyond astronomy thanks to fun and interactive modules covering a multitude of fields, such as STEAM Education, Architecture, Product Marketing, Cloud Points, Games, and any immersive experience desired. RSA Cosmos' dedicated team adds regularly more modules to bring always more novelties.

FreeDome also enables users to create their own content using the best and most widely used game engine, Unity 3D, and even to co-create content with other planetariums or immersive environments.

FreeDome is ideal for every immersive environment and enables all the content to be broadcasted at the full resolution of the planetariums' or immersive environments' system, to guarantee the best visual experiences.

FreeDome was developed using Unity 3D, the best and most widely used games engine.
By combining Unity 3D's and FreeDome's technologies, a robust, powerful, innovative and flexible solution is offered to our users to offer innovative immersive experiences.

FreeDome's main assets are:

- ACCESS INFINITE CONTENT - FUN AND INTERACTIVE MODULES BEYOND ASTRONOMY:
  - ❖ STEAM EDUCATION (SCIENCE, TECHNOLOGY, ENGINEERING, ARTS AND MATHEMATICS)
    - BIOLOGY
      - HUMAN BODY
      - EYE ANATOMY
      - HEART
      - CELLS
      - BLOOD TYPE INHERITANCE
    - CHEMISTRY
      - PERIODIC TABLE
      - PH SCALE
      - STATES OF MATTER
    - MATHEMATICS
      - BASIC MULTIPLICATION
      - TRIGONOMETRY
      - FOURIER LAW
      - FRACTAL 2D
      - VECTORS
    - PHYSICS
      - BOYLE MARIOTTE LAW
      - MAGNETIC FIELD
      - OPTICAL
      - PROJECTILE MOTION
    - ARTS
      - COLOR THEORY
      - PLEXUS
      - SPIROGRAPH
    - ENGINEERING
      - FOUR-STROKE ENGINE
    - RELATED TO ASTRONOMY
      - TELESCOPE
  - ❖ ARCHITECTURE
  - ❖ DATA VISUALIZATION - CLOUD POINTS
  - ❖ PRODUCT MARKETING
- CREATE YOUR OWN CONTENT USING UNITY 3D
- BROADCAST ALL CONTENT AT THE SYSTEM'S NATIVE RESOLUTION
- IDEAL FOR EVERY IMMERSIVE ENVIRONMENT
- CONNECT IMMERSIVE SPACES TOGETHER
- COMES WITH ADVANCED FEATURES

A full documentation for FreeDome is also available.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