

High Performance Optical Planetarium

Orpheus – GOTO’s Premium Instrument for Domes 8 to 21 meters

GOTO HYBRID PLANETARIUM **ORPHEUS**

| | | |
|--|--|--|
| 9500 Fixed Stars | 299 Accurate Color Stars | Stars Visible Down to Mag. 6.55 |
| 48 cm Compact Starball Size | LED Lamp 30,000 Hour Lifetime | 3.5 to 6.55 Visibility Cutoff Control |
| 56 Deep Sky Objects | 8 Million Milky Way Stars | Accurate Moon Phases and Details |
| Realistic Sunset Color | Scintillation All Fixed Stars | 5 Realistic Planets |
| Optical Coordinate Lines | 41 db Quiet Operation | Digital Variable Shutters |

SUN, MOON on the main star ball

Sunset color, lunar phases,

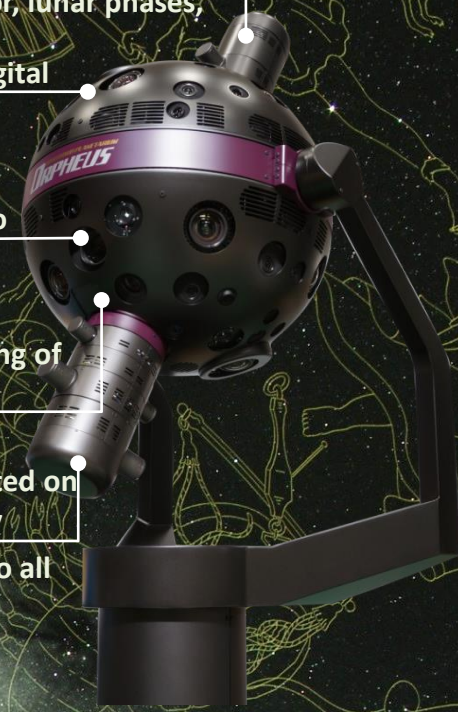
Controllable digital
shutters

9500 Stars down to
Mag. 6.55

Independent dimming of
Milky Way

Planets mounted on
the main body

corresponds to all
latitudes



9500
Fixed stars

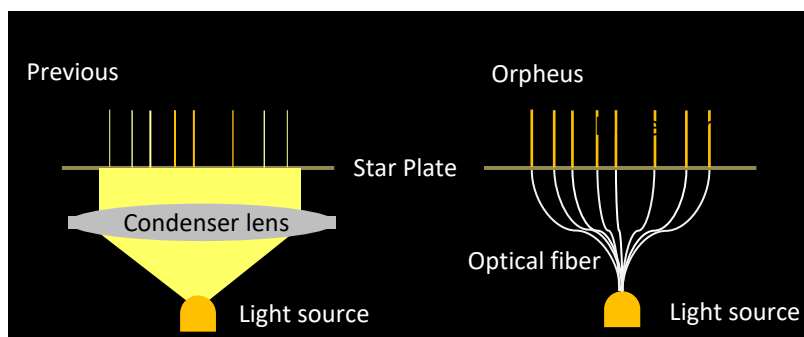
Orpheus a realistic, accurate sky designed with education in mind

- 9500 Fixed stars down to 6th magnitude, mag.3.5 to 6.55 controllable in half mag. steps.

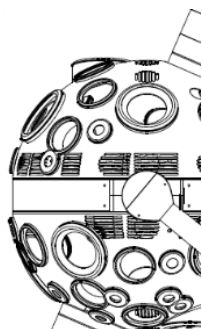


LED Lamp
30,000 Hour
Lifetime

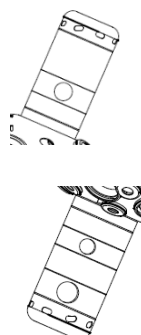
Efficient brightness from long-life LED light source.



Unlike the old method of guiding the light from the source to the star plate by way of a condenser lens, our new method efficiently guides the light from the lamp to the star plate by using optical fibers. This accomplishes the **equivalent or greater brightness with only 1/10th the power consumption** of previous methods.



Main starball
Fixed stars 9500
Bright stars 27
Variable stars 10
Light source : LED
Life-time : 30,000h

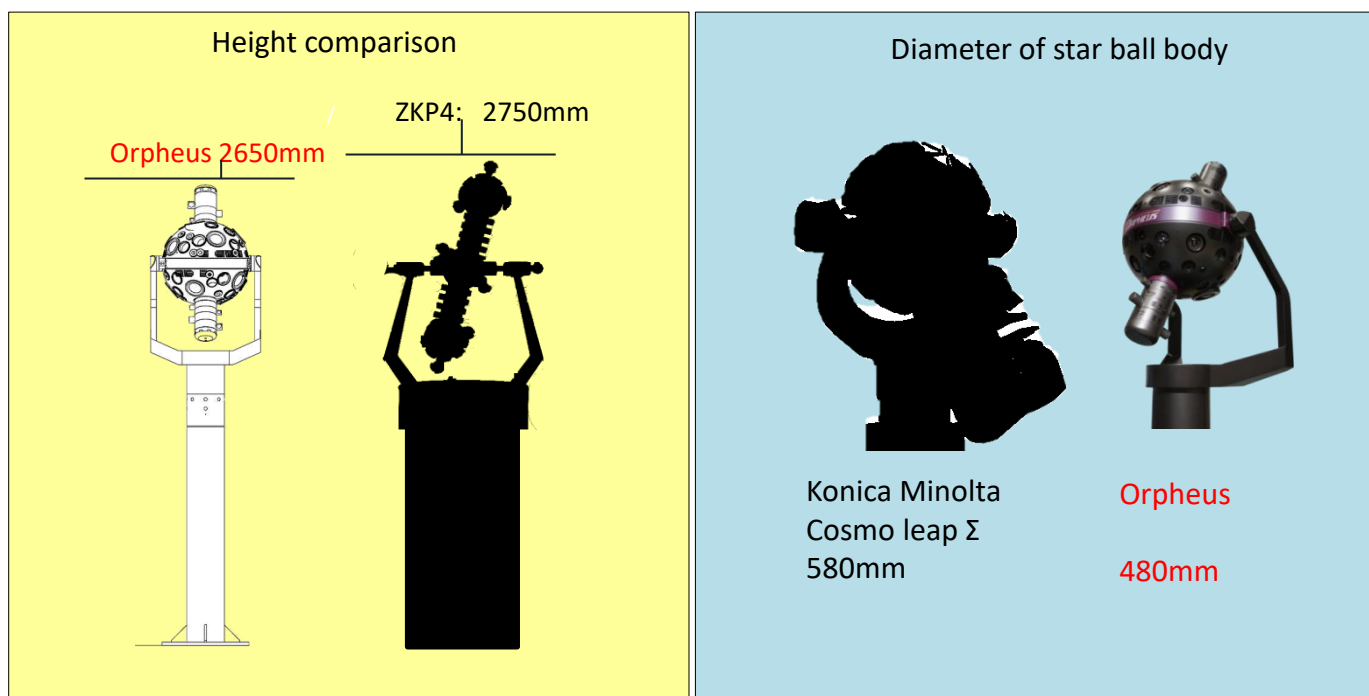


Planet projectors
Sun, Moon, Mercury,
Venus, Mars, Jupiter
and Saturn.
XY mirror system
Ultra-long life LED illumination

48 cm
Compact
Starball Size

Innovative technology combines miniaturization and high accuracy

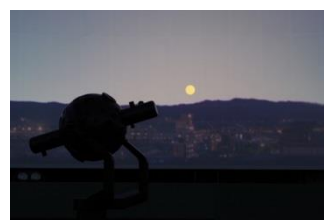
Achieving “you are there” realism in your planetarium sky requires minimizing the presence of the projector, while still maintaining a scientifically precise starfield. **Older star projector designs require 32 separate star plates** to produce the entire night sky. GOTO’s achievements in precision manufacturing and superior engineering reduces **the number of star plates needed by Orpheus down to 12, resulting in a significant reduction in the size and footprint of the system. The processing precision of an Orpheus star plate is about 2.7 times higher than a projector with 32 divisions.** It is necessary to create an extremely small hole with high precision to properly project a small star. GOTO meets this technology challenge by successfully adapting both miniaturization and high precision in a method that cannot be matched by previous technology. Star plates, lenses, and other optical components are still made by expert craftsmen and then assembled by hand for each new customer.



41 db
Quiet
sound

Extremely quiet during operation.

Orpheus suppresses the sound **during operation to less than 41 db.** This ensures no unwanted noise in the dome.

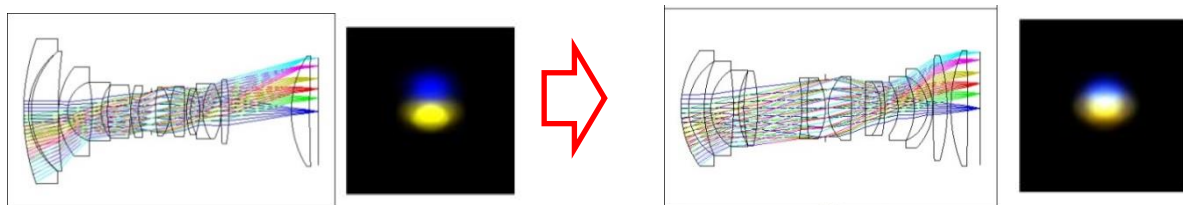


- High performance optical technology with “pinpoint” exactness



- Reproducing a beautiful starry sky with 12 fixed star fields

In the optical design of the GOTO Orpheus, chromatic aberration is removed by using special low dispersion glass (ED glass) and anomalous dispersion glass. The high refractive index glass combination corrects spherical aberration, coma aberration, astigmatism, the curvature of field, etc., and realizes a faithful star image to every part of the dome. **This optical design realizes a sharp star image of only 4 arc minutes diameter.** Our technology succeeds in creating a beautiful starry sky while still only requiring 12 projection fields. The quality of the sky produced by the Orpheus optics meets or exceeds what was achieved in previous projectors with 32 projection fields.



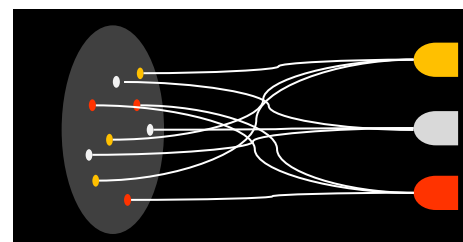
The star image at the edge of the dome by a conventional 12 split optical planetarium.

The image at the edge of the dome produced by Orpheus.

299
Accurate
Color Stars

299 stars with accurate color reproduction.

Like real stars, the color of the Orpheus bright stars is determined by the star's spectral type. The color of 299 separate stars (down to magnitude 3.5) is reproduced by a unique propagation method of optical fibers (right fig.). **This technique also supports variable scintillation on all stars.**



【How to decide star color】

- ① Calculate the color temperature from the B - V color index.
- ② Based on spectral type, stars are color-coded into seven colors.

Orpheus star diameters for the Owen's Science Center planetarium

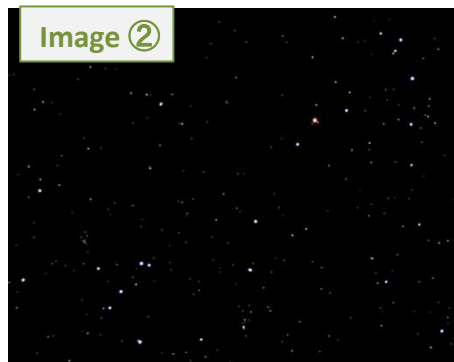
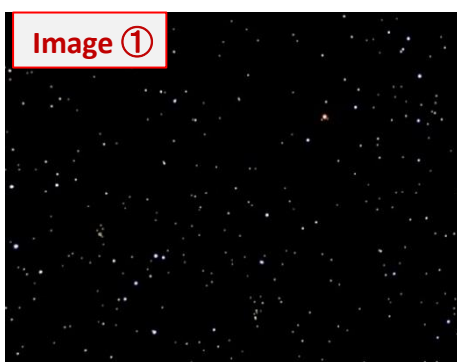
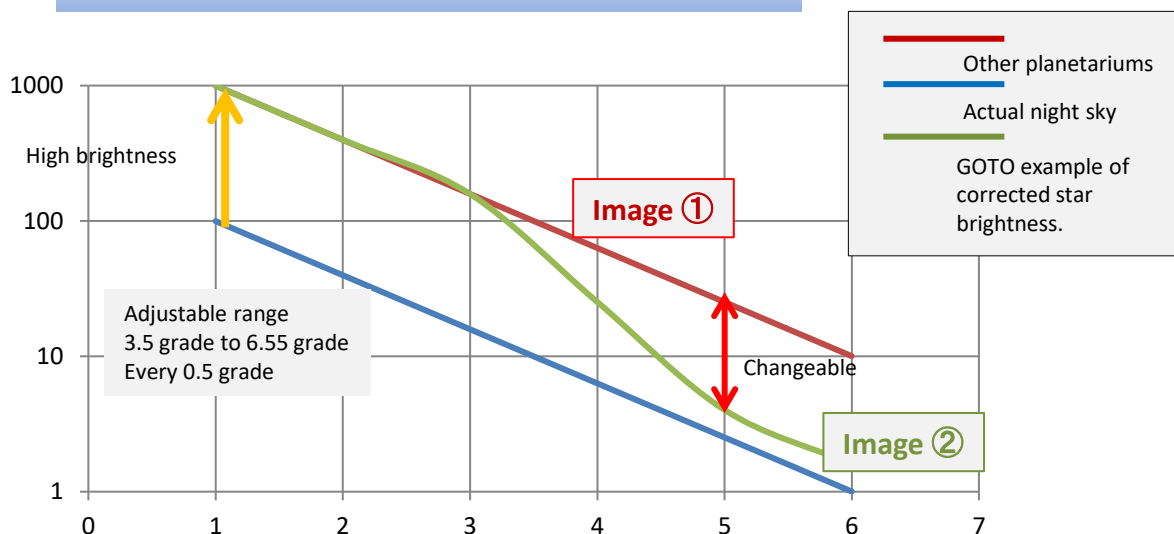
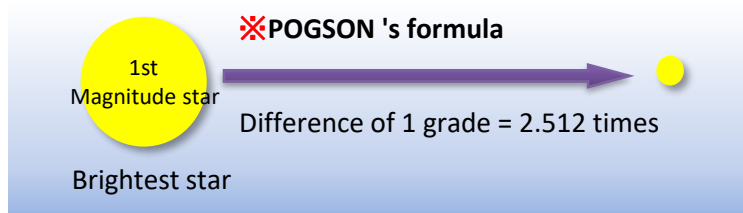
| By Star Magnitude | |
|-------------------|--------------------------------------|
| Magnitude | Apparent diameter |
| -1.5 mag | 4.8 arcminutes (separate projection) |
| 0 mag | 4.8 arcminutes (separate projection) |
| 1 mag | 4.8 arcminutes (separate projection) |
| 2 mag | 3.3 arcminutes |
| 3 mag | 2.1 arcminutes |
| 4 mag | 1.3 arcminutes |
| 5 mag | 0.8 arcminutes |
| 6 mag | 0.5 arcminutes |
| | |
| Maximum size | |
| Pollux | 5 arcminutes |
| Canis Major | 5 arcminute |
| Fomalhaut | 4.875 arcminutes |
| Cygnus | 4.875 arcminutes |
| | |
| Planets | |
| Mercury | 4.9 arcminutes |
| Venus | 8.6 arcminutes |
| Mars | 6 arcminutes |
| Jupiter | 7.6 arcminutes |
| Saturn | 7.4 arcminutes |

3.5 to 6.55
Visibility
Cutoff Control

Adjustment function allows for reproduction of star magnitudes - comparable to real sky observation.

The dynamic range of star brightness is faithfully reproduced based on POGSON's formula. By using the proprietary optical fiber light guides, combined with software control, it is possible to dim and turn ON/OFF low brightness stars under 3.51 mag in 0.5 magnitude increments.

Previous planetarium systems had difficulty with low brightness stars. A star that appeared faint in the real sky would be clearly visible, creating an unnatural look for the planetarium sky. With Orpheus, the shape of a constellation emerges realistically by reproducing dimmer stars as only slightly visible, the way they look naturally, eliminating the artificial appearance. Any night sky, from an inky black mountaintop observatory to a city sky flooded with artificial light, and everything in between, can be reproduced accurately.



Digital
Variable
Shutters

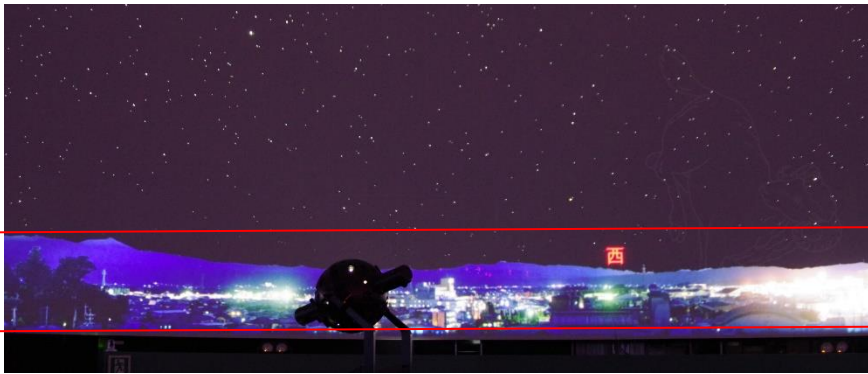
Multipurpose digital shutters are capable of projecting stars to any location on the dome.

The digital shutters on Orpheus can set the overall cut-off to any height in 0.1° increments.

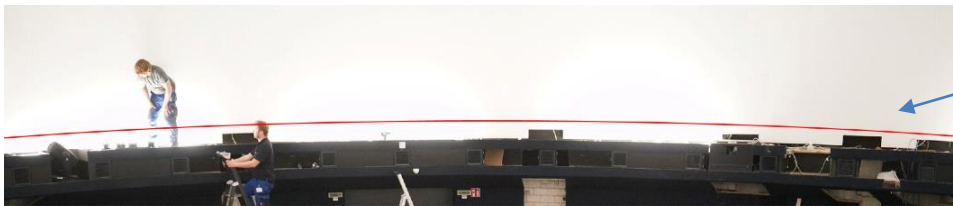
Fixed stars, the Milky Way, and bright stars, are all terminated in the same position. The flexibility of digital shutters is suitable for creating the following scenes.

- 1) Preventing stars from overlapping a panoramic skyline image.
- 2) Customizing the cut-off to match the shape of the cove in the dome.
- 3) Correct termination for domes measuring less than a 180° hemisphere. (165 ° etc.)
- 4) Projecting stars beyond the dome, even onto the audience or floor for an event.

For maximum flexibility you can change the value of the setting while executing a script or assign different height settings to buttons on the console.



Cut-off position can be set freely depending on the scene.



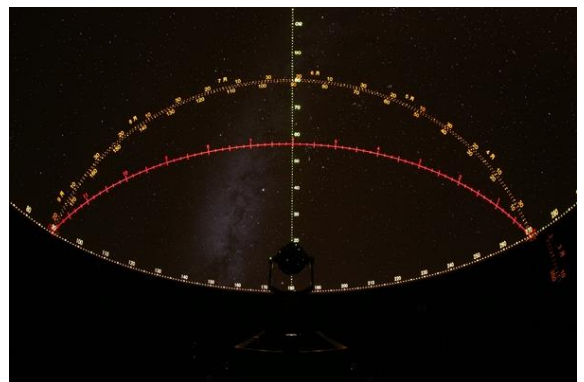
Cut-off line for avoiding projection of the star image on equipment positioned in the cove.

The optimal position for the default cut-off position is determined by consultation with the customer during installation.

Optical
Coordinate
lines

Project astronomy coordinates, essential to education, without using digital.

Orpheus implements optical coordinates such as Equator, Ecliptic, Meridian, Precession circle, Polar location, and Cardinal directions - without interference from video projector backgrounds. Optical coordinates are useful to determine the position of small stars, and to maintain an optimal environment for navigating the sky. You can also incorporate lighting effects to simulate sunrise or sunset.

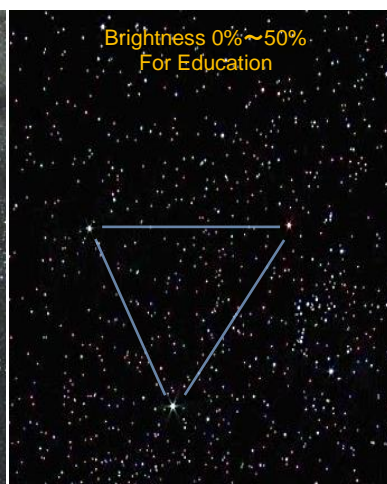
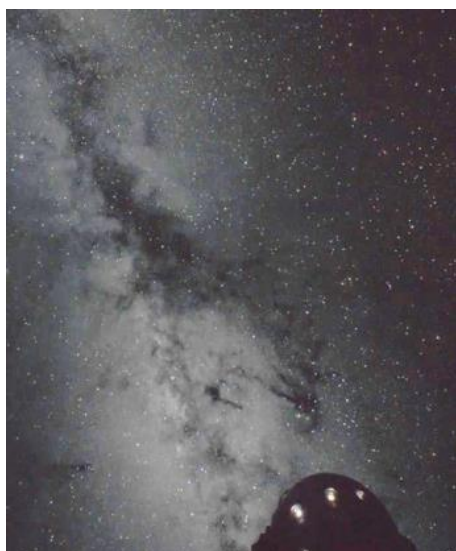


8 Million
Milky Way
Stars

The Orpheus Milky Way, reproduced with approximately 8 million stars, creates a natural and accurate appearance for any location on Earth.

The Milky Way projectors of Orpheus are composed of 6 divisions (± 50 degrees of galactic latitude) produced separately from the main fixed star fields. **The Milky Way is based on the UCAC star table published by the US Naval Observatory (USNO), with about 8 million distinct stars.** The shading at the Milky Way's boundary has been reproduced very smoothly.

Milky Way brightness can be dimmed separately from the main stars - from 0% to 100%. Whether you want a view from Earth orbit unhindered by atmosphere, or no visible Milky Way to clearly study the local stars in its path, you have control over the type of sky to depict.



If the number of Milky Way stars are small ...

The image will not be able to reproduce a smooth transition at the edges of the galactic plane, this creates an unnatural impression at the boundary.

If the Milky Way can not be dimmed individually from the main stars ...

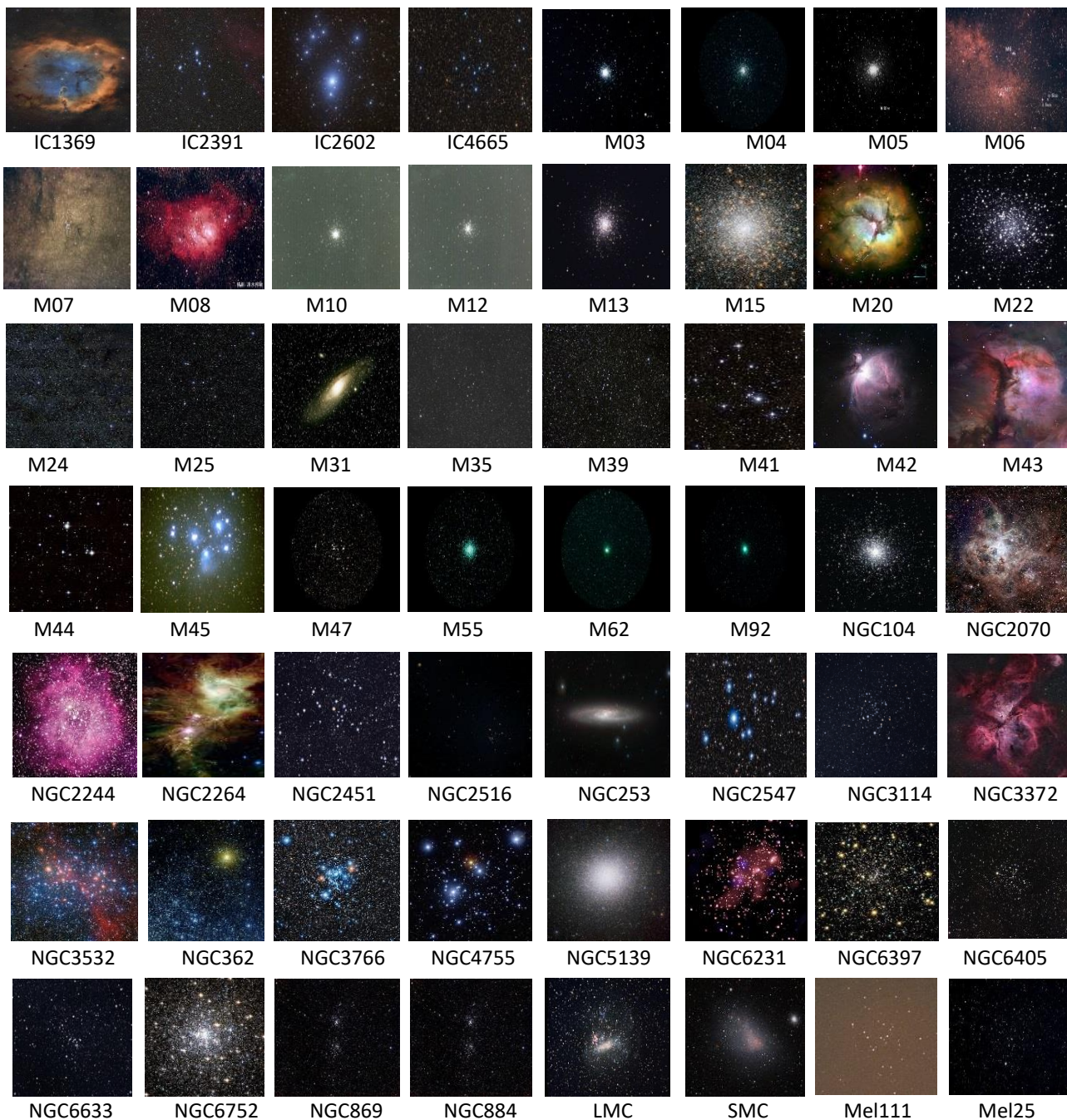
The night sky that is reproduced will be limited and unable to capture the differences visible in skies that are observed from various locations.



Faithfully reproduce 56 nebulae and clusters.

56 nebulae and star clusters are rendered based on actual star data. This intensifies realistic experiences and enhances the projection to meet the diverse needs of educational and entertainment applications.

List of deep sky objects (Photos are for reference only)



List of individually projected variable stars and bright stars

| Variable Star | | Name |
|---------------|--------------|-------------------|
| 1 | γ Cas | Gamma Cassiopeiae |
| 2 | μ Cep | The Garnet Star |
| 3 | β Pe | Algol |
| 4 | α Cet | Mira |
| 5 | δ Cep | Delta Cephei |
| 6 | χ Cyg | Chi Cygni |
| 7 | L2Pup | L2 Puppis |
| 8 | Rdra | R Dra |
| 9 | δ Sco | Antares |
| 10 | α Ori | Betelgeuse |

Bright Stars

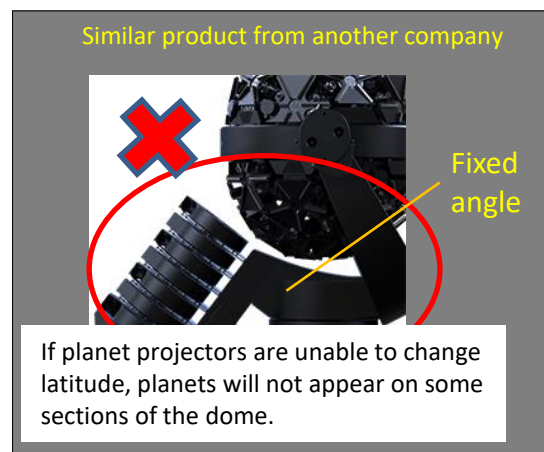
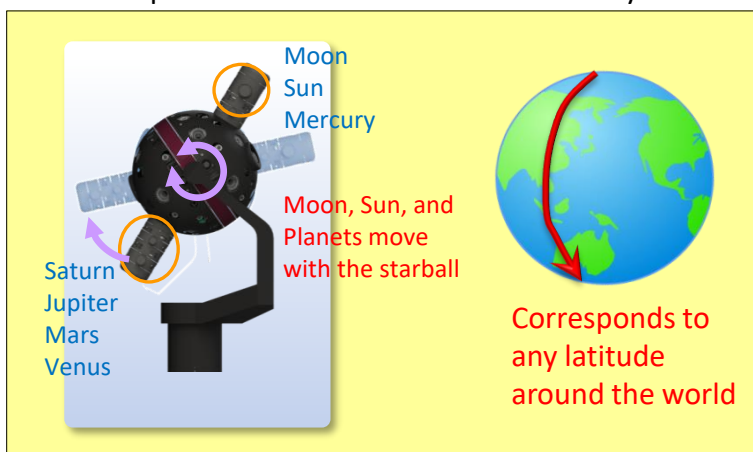
| | | | |
|----|----------------|----------------|------|
| 1 | α CMa | Sirius | A1 |
| 2 | α Car | Canopus | A9 |
| 3 | α Boo | Arcturus | K2 |
| 4 | α Cen | Alpha Centauri | G2 |
| 5 | α Lyr | Vega | A0 |
| 6 | α Aur | Capella | G8 |
| 7 | β Ori | Rigel | B8 |
| 8 | α CMi | Procyon | F5 |
| 9 | α Ori | Betelgeuse | M2 |
| 10 | α Eri | Achernar | B3 |
| 11 | β Cen | Hadar | B1 |
| 12 | α Cru | Acrux | B0.5 |
| 13 | α Aql | Altair | A7 |
| 14 | α Tau | Aldebaran | K5 |
| 15 | α Sco | Antares | M1.5 |
| 16 | α Vir | Spica | B1 |
| 17 | β Gem | Pollux | K0 |
| 18 | α PsA | Fomalhaut | A3 |
| 19 | β Cru | Mimosa | B0.5 |
| 20 | α Cyg | Deneb | A2 |
| 21 | α Leo | Regulus | B7 |
| 22 | ϵ CMa | Adhara | B2 |
| 23 | γ Cru | Gacrux | M3.5 |
| 24 | γ Vel | Gamma Velorum | WC8 |
| 25 | γ Ori | Bellatrix | B2 |
| 26 | ζ Ori | Alnilam | B0 |
| 27 | α Per | Mirfak | F5 |



Multi-function planet projector implemented on the main body

The planet projector, and its LED light sources, **correctly reproduce the brightness ratio and color for the planets with relation to the fixed stars**, and it also shows effects such as Venus shining brightly at dawn and the reddish coloration of Mars.

- Sun, moon, and 5 planets on the main body.
- Planets appear correctly for the viewing latitude, from Antarctica to the Arctic.
- Planetary brightness ratio with relation to the stars is correctly reproduced.
- The unique color of Mars rendered accurately.



<https://www.konicaminolta.jp/>

Comparison in 2 similar size domes.

Orpheus, with planets on the main projector body, is **very compact requiring a smaller footprint** even with 2 video projectors included.



Similar product from another company

If the planet projectors are mounted separately from the main body, It will occupy much more space in the dome, even without video projectors



Accurate
Moon Phases
and Details

Innovative Moon projector provides improved visual accuracy

The Orpheus Moon projector can accurately reproduce highly detailed lunar phases, lunar eclipses, details from the far side, libration of the Moon, and more. Even earthshine is beautifully reproduced, **creating a Moon image more realistic than any planetarium before it.** The Moon's size can also be changed, from 1 degree at perigee to a Moon 14 % smaller at apogee, precisely following the Earth-Moon distance.

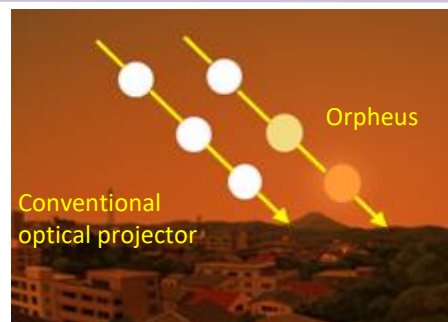


Realistic
Sunset Color

Solar projector reproduces the setting sun

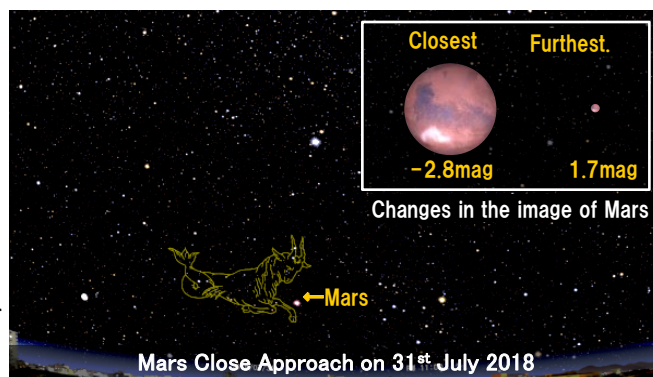
- The real sunset

With the use of multiple LED light sources for the Sun's light source, it becomes possible to reproduce the appearance of **sunlight fading and changing color as it sets.** When paired with Hybrid video atmosphere effects, it becomes possible to produce fantastically realistic sunset scenes.



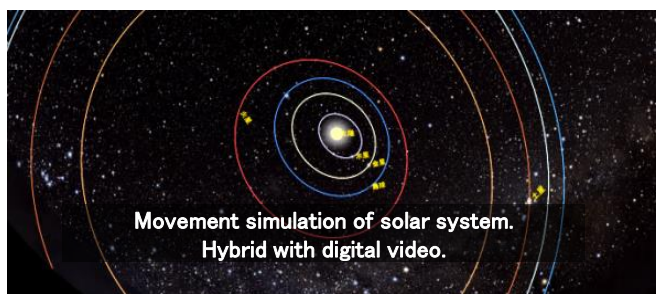
- Planet projectors with varying light intensity

Orpheus correctly reproduces the changes in brightness of the planets depending on their positional relationship with Earth. For instance, Mars changes its luminous intensity more than 3 magnitudes in the actual night sky. Now the difference in brightness is easy to see and understand in the planetarium and is effective for learning the positional relationship between the Earth and the planets.



- Reproduce a bird's-eye view (orrery) of the solar system

With the Moon projector displaying the Earth's position, planetary motion for +/- 5000 years, from any position in the solar system, can be reproduced without using digital images. **It is possible to depict basic solar system mechanics (an orrery) using only optical projection,** or it can be enhanced with hybrid video effects.

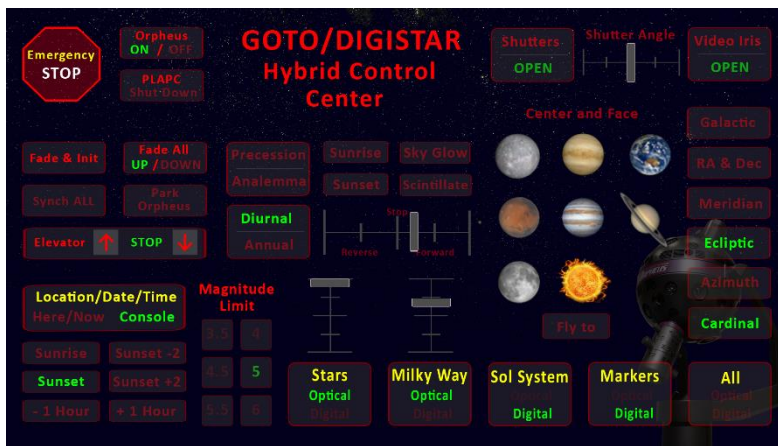


Flexible control

It is possible to control Orpheus through the GUI of the Digistar system as well as from the manual control console. Control functions can also mirrored on a tablet or other remote device.



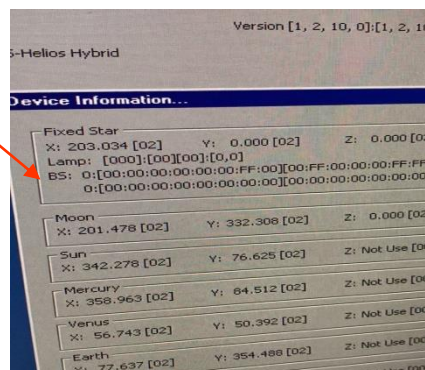
D6 monitors with hybrid console



Digistar control panel
For Orpheus Hybrid operation

System communication

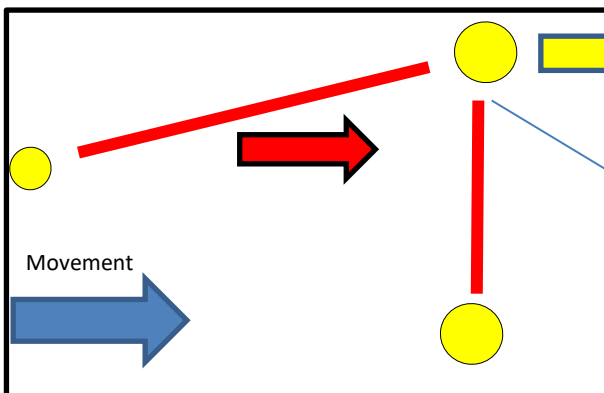
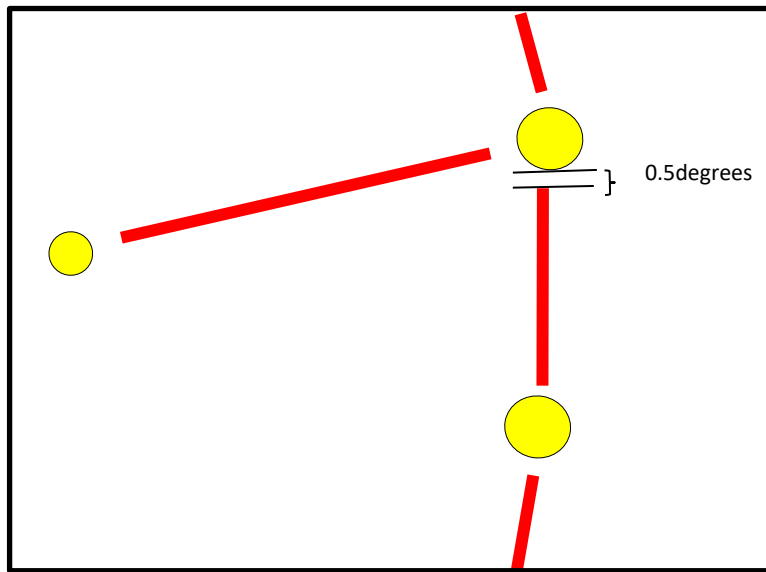
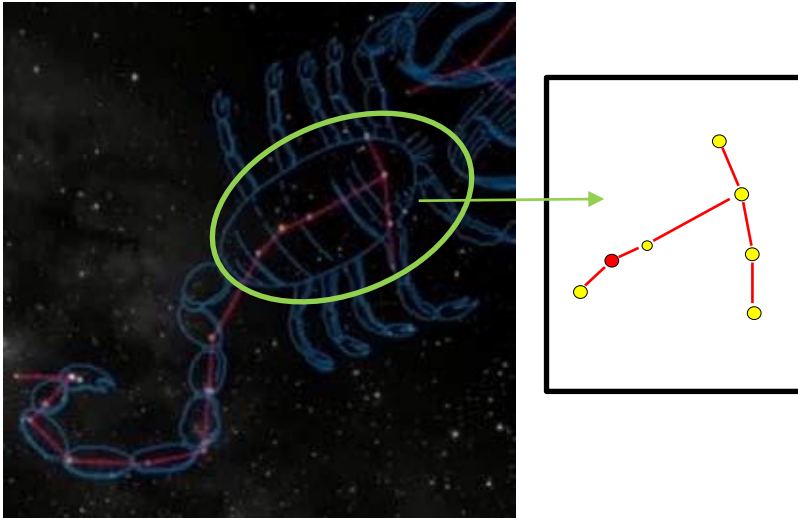
Orpheus communicates status with the Digistar system at a frequency of 30 times per second via a planetarium PC. **Synchronization of commands occurs quickly and smoothly no matter which system is currently controlling the Hybrid system.**



Hybrid Status displayed on the shared monitor of the Digistar server.

GOTO Technician checking the status of planetarium PC

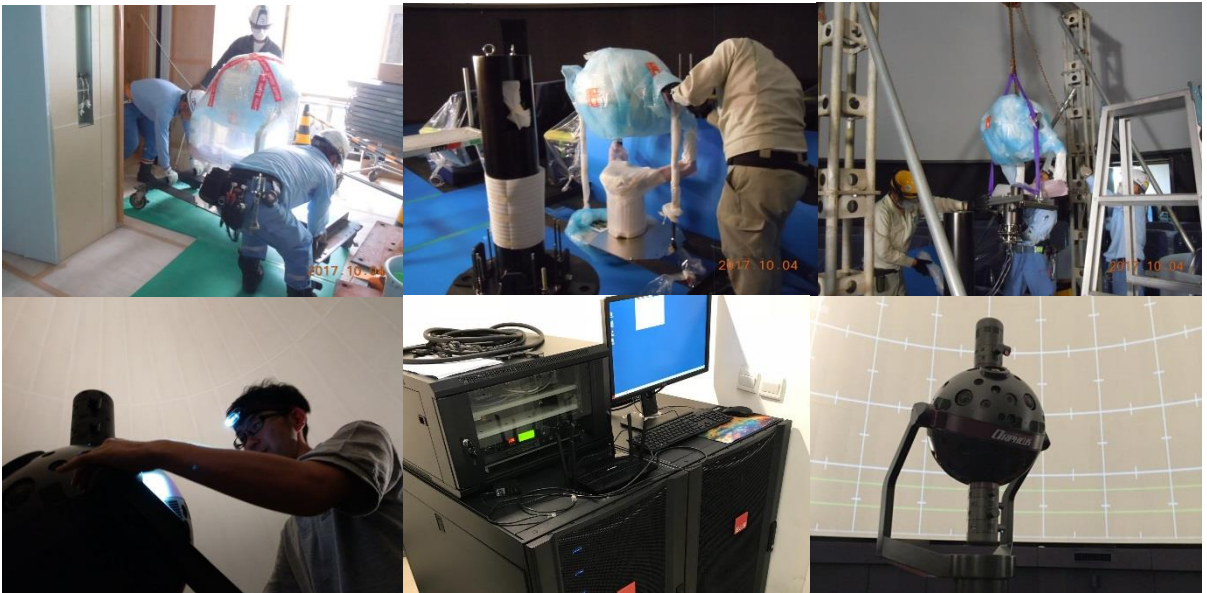
When the operator moves the stars and digital constellation lines together, whether manually, by software command, or through programmed operation, **the optical stars and the digital images will move in unison and maintain a relative distance no greater than 0.5 degrees.**



During movement, The gap between the optical star and the digital constellation line will be kept to a uniform distance.

Once it is installed, the GOTO optical projector is fixed in one spot, often for twenty or thirty years, or more. Therefore, the hybrid planetarium needs to be installed and adjusted for accuracy by professionally trained staff in order to maintain consistent quality over the life of the projector.

The optical projector is installed at the center of the accurately measured dome, and the digital system is then adjusted to coincide with the optical projector placement. Unless there are special circumstances, such as distortion in the shape of the dome screen, it is possible to maintain the positional accuracy of a uniform optical star and its corresponding digital image throughout the entire dome screen area.



Installation flow

Phase 1

- Unpacking & loading.
- Measure to find the center of the dome.
- Optical projector installation.
- Wiring between each system component.
- Check of the electric power
- Check of the motion and function of each equipment.

Phase 2

- Hybrid adjustment.
- Sound adjustment.
- Trial test.
- Maintenance.

Phase 3

- Training

*Elements of the flow may be adjusted depending on the system configuration.

Connection of GOTO equipment

