Stellarium and Planetarium Spherical Mirror Projection

With Stellarium it's very easy to project the sky on a dome and create your own planetarium.

360° PROJECTION
You can use either a very expensive fisheye lens projector - or a standard projector with a spherical mirror. Not only is spherical mirror projection less expensive, but it produces a higher resolution image on the dome[1], and it's very easy to upgrade the projector.

A planetarium spherical mirror is curved like a security mirror (convex safety mirror) - with the important difference that it's 'first surface' ie. the reflective silver is not protected by a transparent acrylic or polycarbonate layer. This allows light to be *reflected* without being *refracted*. Spherical mirrors are therefore very delicate and should never be touched with fingers or wiped with a cloth. A powerful dust blower is all you need to keep it clean.

There are two types of spherical mirror projection boxes: compact 'Newtonians' (spherical mirror with an additional small mirror)[2]; or full-length boxes (spherical mirror only)[3]. The former take up less space in the planetarium (but a little less light reaches the dome); whereas the latter produce a slightly brighter image (but require more space in the planetarium).

Although commercial projection boxes are quite expensive (mainly due to the cost of the first-surface spherical mirror); it's quite easy to build your own[4] - and you can use a cheap convex safety mirror for testing before investing in a first-surface mirror.

PROJECTOR SPECS
A major challenge with digital planetariums (360° cinemas) is the cross-reflection of light on the dome. This is why projector **contrast ratio** and **colour saturation** are more important than brightness (lumens). Light 'bouncing' around the dome causes the planetarium image to 'wash out' (lose colour) - so the higher the projector colour saturation, the better. Similarly, the higher the contrast ratio, the sharper and crisper the planetarium image will be, especially the night sky.

4K projectors are now very affordable, allowing you to deliver the same high-quality visuals in your small dome as large planetariums!

COMPUTER CONFIGURATION
The best way to operate a planetarium is with a dual display arrangement ie. computer as the primary (main) display, and projector as the secondary (extended) display.

This way the Stellarium remote control window, desktop shortcuts, other applications, etc, will only be visible to you. The audience will only see what you want them to see. To ensure there's always something nice on the dome (even with no application open), use a high-resolution image of stars as your desktop wallpaper.

To function as a planetarium, Stellarium should be configured to open in full screen mode on the extended display (see below).

SYSTEM CONFIGURATION
To minimise image distortion at the back of the dome, it's worth carrying out the slightly complex *Meshmapper* configuration[5]. This creates a custom distortion file for your specific system (ie. your dome diameter, stand height, spherical mirror dimensions); and the image improvement will be remarkable[6]. This custom distortion file ('warp mesh data file') can then be used with dome applications like Stellarium.

STELLARIUM CONFIGURATION
To enable planetarium spherical mirror projection, the config.ini file needs to include the following:

```
[navigation]
init_fov = 180

[projection]
type = ProjectionFisheye
auto_zoom_out_resets_direction = true
```

```
[video]
fullscreen = true
viewport_effect = sphericMirrorDistorter
screen_number = 1

[spheric_mirror]
distorter_max_fov = 180
dome_radius = 5.0  (note: regardless of your actual dome radius)
image_distance_div_height = 2.67
mirror_position_x = 0
mirror_position_y = 5
mirror_position_z = 0
mirror_radius = 0.37  (note: regardless of your actual mirror radius)
```

Stellarium also has built-in options to help you project the best possible planetarium night sky.

In a planetarium, removing the Stellarium atmosphere results in a much darker (and more beautiful) night sky. Yet without the atmosphere, the stars stop twinkling and meteors (shooting stars) disappear - which is correct for the real sky, but not what you require in the planetarium. To maintain twinkling and meteors even without the atmosphere, manually add the following lines to the config.ini file:

```
[stars]
flag_forced_twinkle  =  true

[astro]
flag_forced_meteor_activity = true
```

Another useful configuration for planetariums is to completely hide the vertical and horizontal toolbars on the dome:

```
[gui]
flag_show_gui  =  false
```

The following are also recommended (adjust the values to your preference):

```
[viewing]
flag_moon_scaled = true
moon_scale = 8.00

[astro]
meteor_zhr = 3000

[landscape]
flag_fog = false

[stars]
absolute_scale = 6.00
flag_star_twinkle = 1.00
flag_star_spiky = false
relative_scale = 0.70
star_twinkle_amount = 0.50
```

References

1 - https://domeclub.com/#PxComp
2 - https://www.eplanetarium.com/projector_newtonian.php
3 - https://myplanetarium.com/projection-dome-system
4 - https://docs.worldwidetelescope.org/diy-planetarium-dome/1/dome/#setting-up-the-projector-and-mirrors
5 - https://paulbourke.net/dome/meshmapper
6 - https://domeclub.com/images/Meshmapper-1152w.jpg