

Magic Planet Display Calibration

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The following documents the development of three approaches by which content may be correctly displayed on the Magic Planet display. The approach taken depends on the graphics software/tools being used.



Figure 1.

It is assumed the display has been mechanically aligned, the main controls for this are accessed from the side opening, they are

1. Manual lens shift knob (found on the top of the projector about 10cm back from the lens)
2. Two metal screw that provide a 2D tilt of the mirror.

Note that once disassembled and reassembled it is likely that the mechanical calibration will need to be redone. For example, there is variability in how high the lens yoke is to the mirror.

Since the system is radially symmetric, a suitable mechanical alignment pattern might just be 2D rings. The image should be presented full screen and at 1400x1050 aspect, the native resolution of the projector.

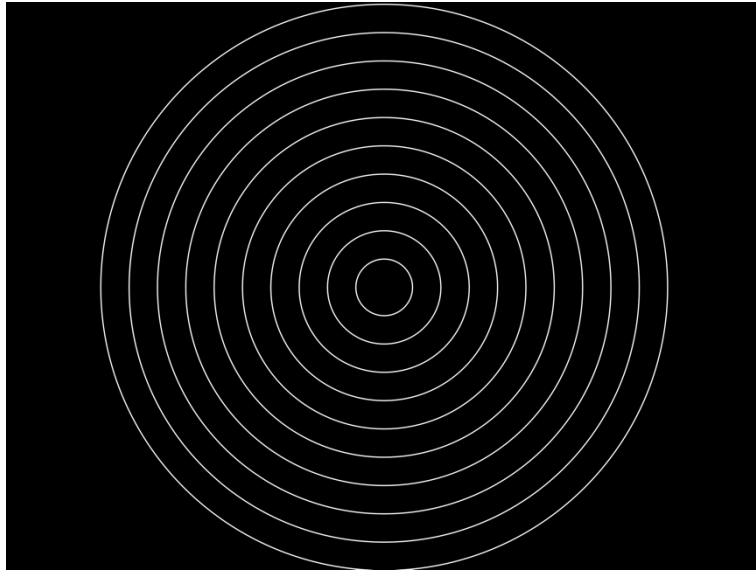
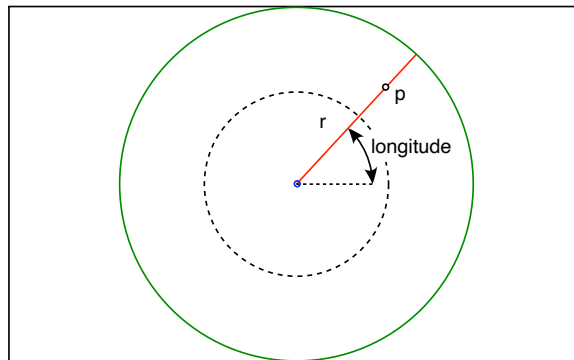


Figure 2.

It is assumed that the input image for such a display will most naturally be an equirectangular projection, that is, 0 to 360 degrees in longitude and -90 to 90 degrees latitude. Creating the image to be sent to the projector involves determining where any pixel in that image is located in the equirectangular. This is illustrated below, to determine the RGB value at position p in the output image one needs to find the equivalent position q in the input equirectangular image.

Output projected image



Input equirectangular

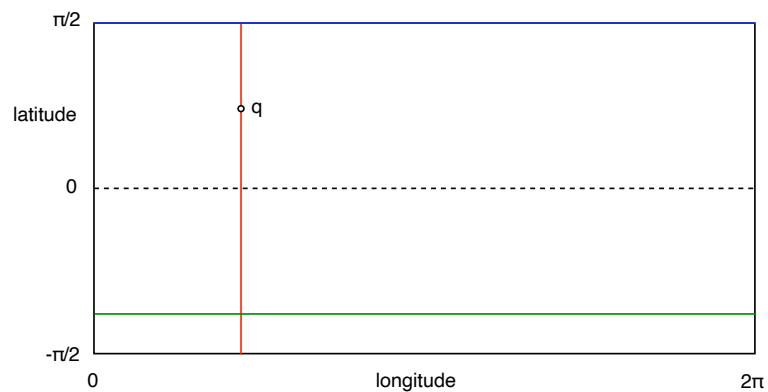


Figure 3.

From the above it can be seen that since the display is radially symmetric then the longitude is a simple mapping from the angle to the pixel in the output image to the horizontal axis of the input equirectangular. The latitude on the other hand is some a function of r (distance from the center of the image to p). It is not a linear function and depends on the geometry and optics of the Magic Planet display.

To determine this relationship the image in figure 2 is displayed, two distances are measured for each white circle; first the distance in pixels from the center of the calibration image to the circle, the second is the arc length from the north pole of the display to the circle as it appears on the dome.

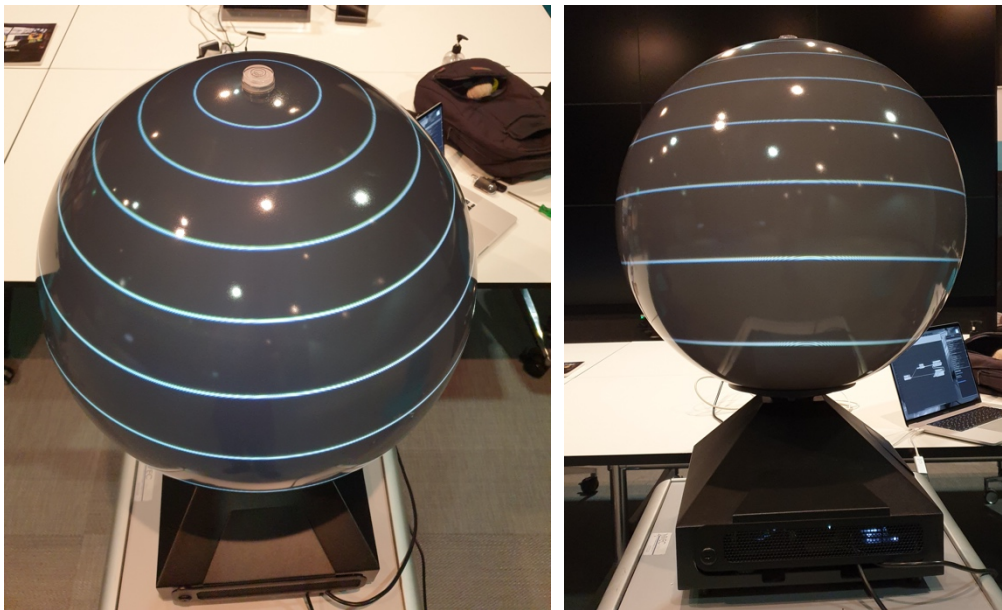


Figure 4.

These, in a spreadsheet may appear as follows, the second two columns are the calculated from the first two columns which are the measured lengths.

Radius (pixels)	Arc length (cm)	Normalised radius	Latitude
0	0	0	1.570796327
102	6	0.097142857	1.361006117
207	12.5	0.197142857	1.13373339
312	19	0.297142857	0.906460662
416	26	0.396190476	0.661705418
523	34	0.498095238	0.381985138
627	42.5	0.597142857	0.084782341
731	53	0.696190476	-0.282350526
835	66	0.795238095	-0.736895981
941		0.896190476	
1045		0.995238095	
	dome radius	28.6	

Table 1.

If one then fits a polynomial through the graph of normalised radius and latitude then this can be used to relate the two in the image warping.

The graph and curve fit are shown below, the resulting polynomial is

$$\text{latitude}(r) = \frac{\pi}{2} - 2.3988r + 1.1575r^2 - 2.2498r^3$$

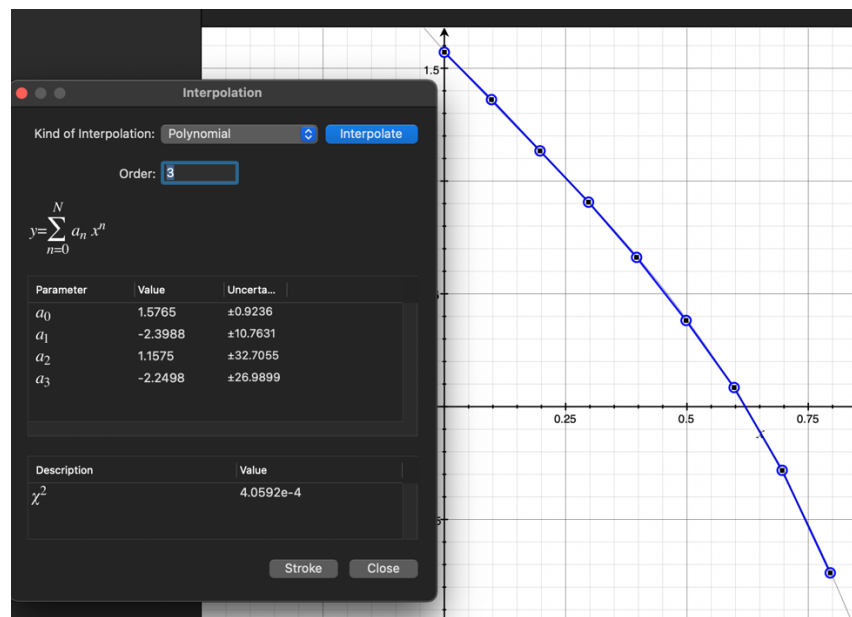


Figure 5.

Given this, three different warping assets can be produced, they are

1. "Pauls warpmesh" as used by various third party software (eg: Vuo) and documented here <http://paulbourke.net/dataformats/meshwarp/>
2. A OBJ style textured mesh. If an equirectangular is applied as a texture to this mesh then the result, projected onto the MagicPlanet, will look correct.
3. GLSL style shader.

Obviously all the above should give the same result on the dome surface.

Example photographs



