HDRI Size and Projection

How large an HDRI can be rendered as a sharp backdrop depends on the HDRI size and the field of view (FOV) the camera is set to. Bryce 7.1 Pro accepts RGBE HDRI in the Angular Map and Spherical projection. How the two projections compare is shown.

Introduction

When HDRI light probes were introduced in 2001, they were made by photographing a mirror ball. Although the quality does not suffice for a sharp backdrop, light and direction for image based light (IBL) are both good and accurate. The angular map projection looks similar to a mirror ball (see https://horo.ch/docs/mine/pdf/Mb-Am-Sph.pdf) but it is not the same.

Light Probe

"Light probe" and "angular map" are often used as synonyms but they are not the same. A "light probe" (a misnomer) is a photograph that includes the full environment at the place it was taken and retains most of the light energy. An angular map is just one of many possible projections how a full three-dimensional sphere can be represented on a flat surface.

IBL

Bryce was one of the first 3D applications that got IBL with version 6.0 in October 2006. By March 2007 in version 6.1 it worked perfectly. The HDRI panorama had to be in the angular map projection. With Bryce version 7.1, an additional projection is accepted for the light probe: equirectangular also called spherical or latitude/longitude.

Projections

Habit has it that light probes for Bryce are usually made in the angular map projection because the preview in the IBL tab of the Sky Lab is square and displays the angular map with the correct aspect ratio. If a spherical light probe is loaded, its 2:1 aspect ratio is compressed to 1:1. As far as the light created and the direction it shines from is concerned, the projection does not matter; neither does it for the backdrop if rendered as such. It does matter for how sharp the backdrop appears for a panorama with the same amount of total pixels and memory used.

Size Matters for the Backdrop

The size of the light probe does not matter as far as light is concerned. It does matter when rendered as background. If DOF (depth of field) is used, there is a separate DOF control for the HDRI backdrop to match the blurriness with the objects. Obviously, in this case the size of the HDRI is not overly important. If the background should render sharp, then it matters.

HDRI Size, Camera FOV and Document Size

To get a sharp background the three parameters must be set right. The narrower FOV is set, the higher resolution the HDRI must be. The same applies for the document size: the larger the render, the larger the HDRI must be.

Assuming the HDRI size in the spherical projection is 3600 pixel wide and 1800 pixel high.

3600 px / 360° = 10 px/°

With a horizontal FOV of 90°, the maximum document width can be 90° x 10 px/° = 900 px.

If you want to render this HDRI as backdrop in a document 1200 pixel wide, the camera FOV must be set to 120° because

3600 px / 1200 px = 3 and 360° / 3 = 120°

This gives one rendered pixel for one pixel in the background. Rendering two pixels for one backdrop pixel may still be acceptable but after that blurring gets too obvious.

Angular Map versus Spherical

How is the width of a 3840 pixel diameter angular map? The table below will answer the question and also how much total memory is used to load and tone-map an HDRI. An empty Bryce scene occupies just after loading 35 MB. Those could be subtracted from the values in the table but the table shows the total memory used.

Probe Size (px)	Loading (MB)	Tonemapping (MB)	Ready (MB)	Equivalent (px)
Ø 1280	59	97	68	1604 x 802
Ø 3840	110	448	169	4812 x 2406
Ø 6400	209	1,120	368	8020 x 4010
2048 x 1024	61	109	71	Ø 1634
4096 x 2048	87	279	118	Ø 3268
8192 x 4096	181	953	313	Ø 6536
Ø 800	56	60	60	1002 x 501
512 x 256	54	56	56	Ø 408

The colours identify the probes with approximately the same amount of pixels in the probe; green is the exception, the angular map is 22% smaller than the spherical one. The memory usage is not dramatically different, however. The orange lines are for the specular convolved ones where size does not matter.

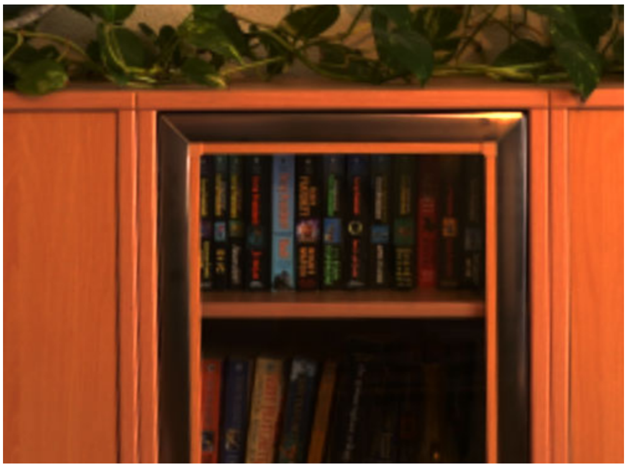
Test Renders

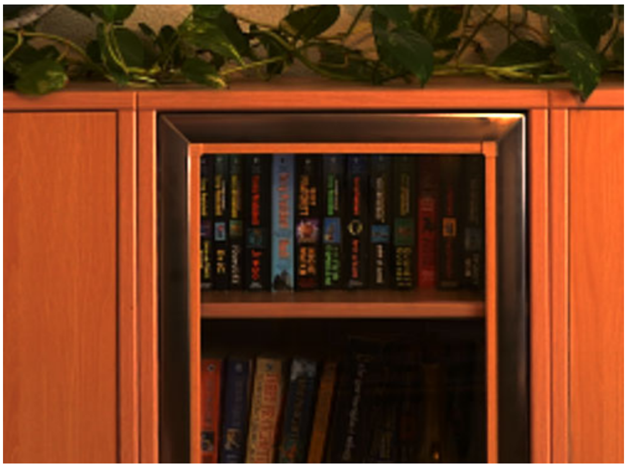
The panorama below at left is used to visualise the difference in sharpness for angular maps and spherical panoramas. The small red frame indicates which part was rendered. This part is shown at right, but not rendered; it is the HDRI from the original 55 photographs that was used to stitch the 16,112 x 8,056 pixel panorama. View the document at 200% or larger to see the details.

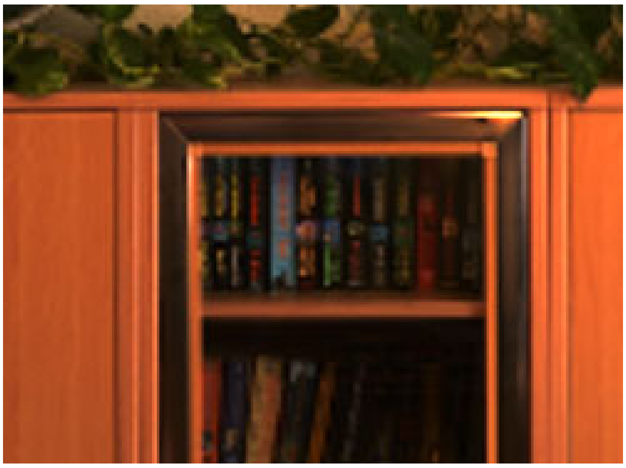
Below the renders made in Bryce are shown. The cabinet size is 47.8 cm (18.8 in). The camera FOV is 22° (FOV=22°, Scale=79.641) and the document size 1000 x 740 pixel. This is double as large as is should be: there are two rendered pixels for one background pixel. Ideally, the document size should be 500 x 370 pixel but we get away nicely with this size.

At left, the 6400 pixel diameter probe was used, at right the 8192 x 4096 probe. When you zoom in, you will notice that the render at right is sharper even though it occupies less memory.

The same can be observed when looking at the top row below. At left the 3840 pixel diameter probe and at right the 4096 x 2048 pixel one. The document size for the render was 500 x 370 pixel — again double the ideal size.







The lower row shows at left the 1280 pixel diameter probe and at right the 2048 x 1024 pixel one. Both were rendered at a document size of 250 x 185 pixel (again double ideal size).

The last example is a bit unfair because the right render has 28% more data than the left one, though it only uses 12% more memory. And, of course, all six renders are shown in the same size here — though are embedded in the document in their original sizes.

The renders with the specular convolved light probes look the same, whether the 800 pixel diameter one is used or the 512 x 256 pixel one and are therefore not shown here.

Conclusion

The spherical light probes are sharper than the angular maps. The panoramas are stitched in the spherical projection. There are not many programs around that can do angular maps. An angular map is round, straight horizontal and vertical lines get bent. If these lines are fine, they tend to get interrupted. To prevent this, transformation from spherical to angular map must use super-sampling; bilinear interpolation alone does not suffice. Super-sampling blurs the result slightly. This could, theoretically, be partially recovered by cautious sharpening, but filtering an angular map can give inconsistent and weird results, and artefacts. A bit of blur is the lesser evil than interrupted lines and irregular sharpening.

Most 3D rendering programs that feature image based light accept the HDRI panorama only in the spherical projection with an aspect ratio of 2:1. Because Bryce was one of the first programs sporting a working IBL, the angular map was the logical choice at the time.

As the tests show, the spherical projection gives the better result for the background and uses a bit less memory for a comparable sized HDRI.

Links to other Documents discussing Bryce IBL

Sky Lab Settings when Exchanging an HDRI. This document shows which controls are automatically altered in the Sky Lab whenever an HDRI is loaded (or created from the sky). 3 pages.

https://horo.ch/docs/mine/pdf/XchgHDRI.pdf

Exporting an HDRI retaining full Dynamic. Study how HDRIs must be exported out of the IBL tab of the Sky Lab to retain the full dynamic range. Compilation of all export possibilities. 7 pages.

https://horo.ch/docs/mine/pdf/HDRIexport.pdf

HDRI Memory Usage. Study what types of HDRI Bryce loads, how much memory they use and what tone-mapping and exporting additionally claim. 3 pages.

https://horo.ch/docs/mine/pdf/HDRI-MemUse.pdf

HDRI Light Sources. From an HDRI point light sources are generated for IBL that work like radial lights. Also, an HDRI can be generated from any sky either as sky dome only or as a full panorama. How many lights are generated is shown. 6 pages, 31 pictures.

https://horo.ch/docs/mine/pdf/IBL-Light-Sources.pdf

FOV Calculator: Calculates the values for the Bryce camera to get the desired horizontal angle of view. An additional calculator permits the same for the fisheye lenses that can be attached to the Bryce camera. (On-line calculator: JavaScript must be enabled in the web browser.)

https://horo.ch/raytracing/know/camcalc_en.html

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