

# Big Hero 6 : Into the Portal

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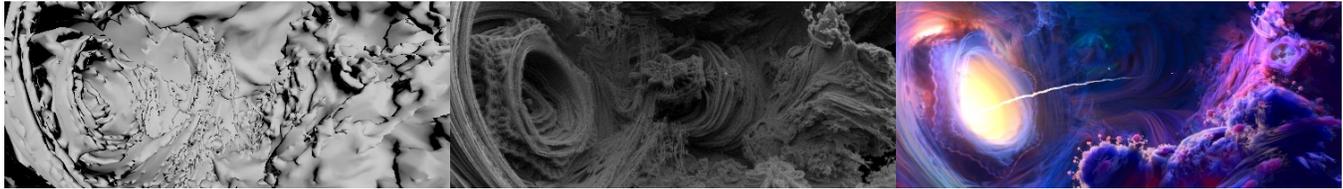


Figure 1: Left: Proxy geometry scene layout. Middle: Effects artist reference render. Right: Final lighting and materials

## 1 Introduction

In the climactic sequence of Big Hero 6, Hiro pilots his robot Baymax into the out-of-control teleportation device which has just destroyed the Krei-tech corporation campus. Once we pass through the portal, our challenge was to visualize a gap between the folds of spacetime fabric—we imagined a realm of fractal forms inspired partly by theories of spacetime structure found in an approach to quantum gravity known as causal dynamical triangulation.

## 2 The Fractal Algorithm

Originating from an extension of the classic Mandelbrot fractal expressed in polar coordinates, our algorithm was a variation on the “Mandelbulb” algorithm and featured parameters that made possible a large variety of three dimensional forms and animation options to build and bring life to this unusual realm. To allow for flexibility of lighting and shading, it was decided early in development to generate and render volumetric data.

## 3 Scene Layout

A low resolution isosurface was generated from the algorithm with a wide range of fractal variations baked into a sequence of frames. This proxy geometry was passed to the layout department as a rig which they could use to populate the environment. Each instance of the rig could be set to one of a large variety of forms giving the layout artist latitude in designing the space. This proxy set passed through animation and on to effects, where the final layouts were generated for each shot. The proxy geometry could not display the level of detail desired for the final renders, so additional tweaks to the layout and adjustments to the algorithm parameters was required in effects, where preview renders were generated that more closely represented the final result. At this point the proxy geo from layout is replaced by new elements generated by fx: these new volumetric assets are published and passed downstream to lighting and stereo. A new low resolution proxy geometry set is derived from the volume data generated, reflecting the changes made in fx. These proxies can be used by lighters to set lights and view interactively, while the volume elements only activate when renders are initiated.

## 4 Authoring Fractal Volume Data

The fractal generator rig was packaged as a Houdini digital asset for ease of distribution. The asset first ran the algorithm in a low resolution frustum volume to find regions of interest, this was then used to activate voxels in a high resolution frustum VDB and the algorithm was run again. Initially we were outputting a float density field but once color started to factor in options were added for vector fields in the flavor of extinction, albedo and emission. Internally the asset would generate a length field by taking the magnitude of the vector that the fractal algorithm returned, then this field could be used to directly control color ramps or be put through further analysis (curvature, Laplacian, gradient or curl) and the resulting fields would be used to drive ramps. After extensive wedging we determined that mapping length to color gave the best results and the asset was modified to output the raw length field.

## 5 Lighting and Rendering

There were many challenges in developing an approach to lighting the fractal environment, but primarily we had to support the story. Color, composition and value structure play an important storytelling role and help us navigate the line between the familiar and the unexpected. Initial tests concentrated on colors solely derived from the fractal algorithm mapping to a fixed palette and baked into the volume data. Lighting artists focused strictly on tonality and form to define the space, and had no control over the color mapping. This limited creative options during lighting that were critical to achieve our storytelling goal. In order to facilitate more artistic control, additional features were added to our volume shader which allowed us to store a single float field in the vdb data but amplify the data to two color fields at render time. The mapping of the float to color fields was exposed as a color ramp that lighting artists could adjust as needed and achieve artistic control over the spectrum of both reflected and absorbed light. Our newly-developed renderer, Hyperion, using residual ratio tracking [Novák et al. 2014] for unbiased rendering of volumetric data was able to efficiently handle very large data sets of up to 2.5 billion voxels in a single render pass using path-traced single scattering full global illumination.

## References

NOVÁK, J., SELLE, A., AND JAROSZ, W. 2014. Residual ratio tracking for estimating attenuation in participating media. *ACM Trans. Graph.* 33, 6 (Nov.), 179:1–179:11.

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