

Building The Cosmic Web



Abstract

These are the corresponding notes and theory for the “Building The Cosmic Web” Tutorial. Enjoy!

Theory

- The Cosmic Web is primarily composed of dark matter. The web was formed out of fluctuating energy levels from The Big Bang. This was when space was literally “boiling”.
- As the universe expanded and cooled, it created discrepancies in the density of the universe.
- All matter attracts other bits of matter through gravity. This is important when it comes to The Cosmic web, because it can expand how dark matter first clumped together. But gravity can’t explain how all matter was formed in one way. There are other factors. At the start of the universe all matter was plasma, and as it clumped together it formed pressure that counteracts gravity. This created ripples through space-time that were called Baryon Acoustic Oscillations.

Baryon Acoustic Oscillations: These ripples are made of both regular matter and dark matter. Dark matter is only affected by gravity, and it will always stay at the center of these ripples. The pressure that is created by these ripples is released in a process called Photon Decoupling.

- Since most of all the dark matter in a nebulae or a galaxy is located at its core, the visible matter is pushed outwards in other corresponding rings. Sometime visible matter breaks free and sinks to the center of the ripples and the nebulae can look as if it contains a visible center. For Example, nebulae NGC 2022:



Here you can see the visible rings of matter holding the nebulae together. (Courtesy NASA images) This is a small example of a larger phenomena.

- This ripple effect also accounts for how galaxies are formed, and how they are clustered about the universe. These clusters are a ring of visible matter and the spaces between them is a ring of dark matter. Fun fact dark matter ripples create an average distance between galaxies. This distance is 500 million light years.

You can think of the pattern these ripples create as a global fractal pattern.

Other Facts About The Cosmic Web

Hercules-Corona Borealis Great Wall: This one of the longest masses of filaments of The Cosmic Web in the universe.

Keenan, Barger, and Cowie (KBC) Void: This is one of the largest voids in the universe that contains no filaments from The Cosmic Web. It is over 2 billion lightyears long. The Earth and part of our galaxy; the Milky Way, actually exist in this void.

- There is a simulation that you can already view of The Cosmic Web. It is called The Millennium Simulation, and it will be the reference for this tutorial.
- NASA has also tried to create physical models of The Cosmic Web with mold and mushroom growths as their structure resembles the web's structure.

Goal of The Tutorial

- We will build a small scale version of The Cosmic Web, and render it to match current models that NASA has done with slime growth.
- When building the model, it is important to keep in mind that the "webs" do not spawn from one location, rather from "clumps of matters scattered around the universe/box. It may have a centered location, but it will clump and have bigger areas than others.
- Color Palette will match NASA images, infrared Blue/Yellow/Red/Purple.
- We will need to set up a good color transfer system. As well as optimize materials, and camera setups.
- Let's render an image that can/will be confused with an actual Image of The Cosmic Web.
- Finish by making the entire setup more procedural, and controllable.
- We will be aiming for a 3D model rather than a 2D still.
- Since it is still a mystery about which shape the universe is. (More on that in a later video) We will focus on how to create a procedural version of the web so boundaries and containers can be swapped out to better contain the web.