3D Immersive Visualization of Large Astronomical Data

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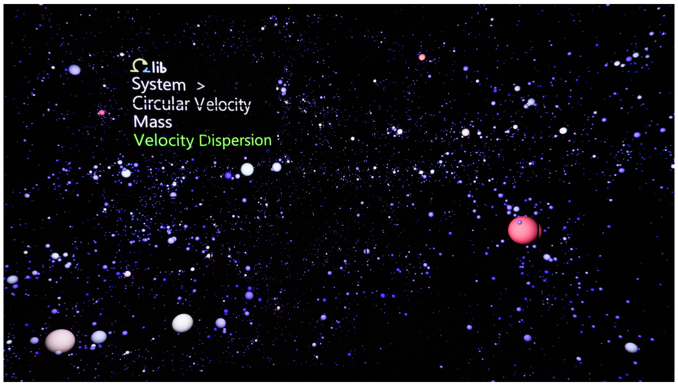

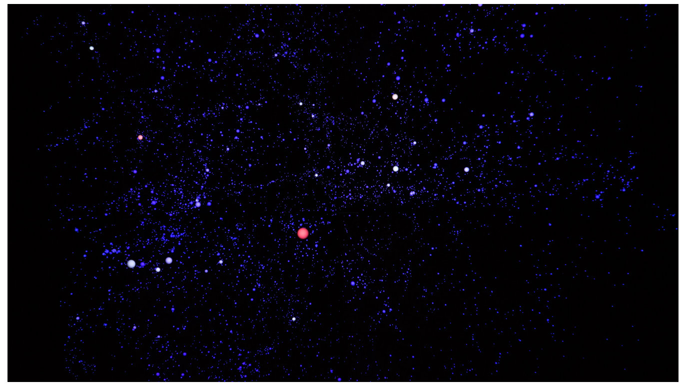

Figure 1 (left) shows a 3D visualization of halos and the menu where the user can interact with some of the halo's properties. Figure 2 (right) shows a zoom out view of the halo mass representation.

1 Introduction

Thanks to increasing advancements of high performance computing, cosmologists are able to model the formation of the universe via n-body simulation, from the Big Bang to the present. These simulations make up a core part of our understanding of the known universe. However, the volume of data generated by these simulations is enormous, with the largest simulation to date [1], having produced data on the order of petascale. The task of analyzing and disseminating this level of data has, unsurprisingly, proved to be a major challenge. The need for visualization tools which can accurately represent the complex interactions of these simulations in addition to scaling has only grown.

The main objective of this project is to visualize large amount of cosmological data in a 3D environment. One of our main focus was to allow users to be able to explore and analize the data in real time, we implement menu where the user can change the visualization and compare the data. We use GPU acceleration to improve the interaction times.

2 Methods

We used the 11G 128^3 particle dataset provided through the IEEE SciVis 2015 website. In the pre-processing stage, we ran a python [2] script to parse the raw particle and halo catalog datasets, using yt [3] and thingking [4] respectively. After integration and processing (described below), the spatial particle and halo data are displayed and manipulated in our immersive environment using OmegaLib [5].

The raw particle data and the halo data are specified in different coordinates, and need to be cross-registered before displaying. After parsing the necessary initial parameters (XYZ coordinates, acceleration, velocity, and potential for raw particle data; XYZ coordinates, mass, radius, and circular velocity for halo data), we converted the data to the format used by OmegaLib [5]. The Point Cloud module of OmegaLib was used to load and handle point cloud data. In total, 178 files were loaded into memory in order to be further processed by our python program.

To take full advantage of GPU acceleration, we further normalized halo parameters such as Halo Mass, Circular Velocity, and Velocity Dispersion to a define range of [0: 300]. We did this because the maximum number of halos is around 7000, and choosing a bigger range it would it make it difficult to understand the image displayed.

Halos can be colored by any parameter specified by the user via an interactive menu. By default, all halos are the same color, making it easier to distinguish between particles and halos. However, when the particles are toggled off, the halo colors can be mapped to halo quantities of interest, for example, the halo mass, circular velocity, velocity dispersion as show in picture 1. The Halos are color coded in the visualization to make then easier to analyze. The colors go from blue to white to red, which correspond to values that range from low to medium to high in that order.

In order for the user to interact with the visualization and be able to switch the halo properties at 60 frames per second we first have to load all the 87 time steps into memory and by using the shaders in Omega Lib we were able to switch between halo properties smoothly.

3 Results and Conclusions

Figure 2 shows the halo representation on time step 99, on tis time step there are more that 7000 point loaded, we can clearly see the red halo on the lower middle part of the figure. This represent the halo with the greatest mass the clear halos are the ones with average mass and the blue ones are the halos with the less mass.

Our results and domain expert evaluation show our halo visualization application is useful and effective. The domain experts were pleased with the menu interaction, they seem to like the ability to switch the properties of the halos and be able to point the areas where significant changes were occurring. Al so they recommend us to implement a way to show how the halo properties change over time, also if the user can load two or more properties at the same time.

In conclusion, we introduced a unique tool for the exploration of large scale cosmological simulation data. That also allows the user to interact with the dataset and to point where in the space the halo properties are changing.

Acknowledgements

This research was supported by a grant from the Computing Research Association's Collaborative Research Experience for Undergraduates (CREU) program. We are also thankful for our advisor Professor G. Elisabeta Marai for her support and guidance throughout this research experience. Also want to thanks everyone at the Electronic Visualization Lab for their continuous support by answering our questions and sharing their knowledge with our group.

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