Diary of my Ogden Internship
A new view of the Cosmos

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This summer I spent 6 weeks working in the ICC (Institute of Computational Cosmology) at Durham Physics Department. Before I started this internship I did not know what to expect but I was looking forward to starting. When I arrived I had a meeting with my supervisor Dr. Mark Swinbank who explained the aim of the 6 week project - To produce a number of videos from preliminary ALMA (Atacama Large Millimetre Array) sub-mm imaging and MUSYC (Multiwavelength Survey by Yale-Chile) optical imaging of the ECDF-S (Extended Chandra Deep Field South). ALMA is an interferometer which is an array of telescopes in the Atacama Desert. The ECDF-S is an area in space about the size of a pea held one meter away in the sky. MUSYC is a collaboration of researchers who carried out a multiwavelength survey of ECDF-S.

To produce the videos I used a piece of data visualization software called Partiview. To produce the videos I was given a computer which was running the Scientific Linux operating system. Initially I was given the MUSYC optical data in the form of three images that were taken through different light filters along with a catalogue of all the galaxies in the images. This catalogue contained the information about every galaxy in the image such as its redshift, its location in the images and its angle in the sky. The first task was to combine these images to make a single colour image, to do this I wrote a program using the programming language IDL. Prior to the internship I had never used IDL so before I could begin to write the program I read an IDL tutorial book Mark had provided me with. I then edited the program to crop around and make a thumbnail of each galaxy using the provided catalogue. There was a problem with some of the thumbnails due to stars that had been captured in the original 3 images that I did not want in my final thumbnails. To overcome this problem and to remove any noise around each galaxy in the thumbnail I used a segmentation map. I used this map after combining the 3 original images to set every pixel in the image that was not a galaxy to black. This removed the

noise caused by the stars and any very dim galaxies.

I then loaded the thumbnails into Partiview which plotted them based on X and Y co-ordinates calculated from the angles of each galaxy in the sky and a Z coordinate based on its redshift. Partiview then crashed because of the 30,000 galaxies that I had loaded into it. I then scaled down the data set down to 30% of the original number of galaxies. Using Partiview I was then able to move the camera and fly around this 3D visualization of the ECDF-S. The next step in making the videos was to take a series of screenshots along a predefined path through this 3D visualisation. To do this I made a script and ran it in Partiview. This moved the camera along a predefined path. I set the camera to stop at every frame along the path and take a screenshot.

Figure 1: A screenshot produced by Partiview from the MUSYC data

The script was run in Partiview overnight to take the initial screenshots, this process took a number of hours to complete due to the significant amount of galaxies in the MUSYC data. Once the screenshots were taken I encoded them into a video. This first video of the optical data alone was a test to make sure that the scripts and programs were working properly and that the data produced enabled me to create a video. I then showed this video to Mark who then gave me the ALMA data to use in the next video. The ALMA data was more difficult to process as the images provided were of individual galaxies. To process the ALMA data I wrote a program that extracted the thumbnails of each galaxy.

While doing this I met with Mark and we discussed the possibility of making a 3D model of the ALMA array to use in the videos. We decided to use the 3D modelling software 3DS Max to make this model. I started by reading up on how to use the software's modelling and animation features. While searching and reading documentation I found a website

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that had prebuild models of many different objects. Given the timeframe I had to make a 3D model I decided to download an existing radio telescope model. I then began working on the single telescope model, eventually making an array of telescopes. I animated the array and the camera in 3DS Max to fly around the array while the telescopes rotated to look at a point in the sky.

Figure 2: An image from the render of the 3D Model

The ALMA video then became my main task as I continued to work on the thumbnail extraction program. I encountered a problem in that I did not know what colour to assign to the thumbnails as they were taken in sub-mm wavelengths which we cannot see. After talking to Mark about this we decided to use Herschel (the Herschel Space Observatory is a space based sub-mm and infrared telescope) imaging in three different wavelengths to determine the artificial colour of each galaxy. The colour scale I used with the Herschel imaging is that the 500 micron wavelength image has a red colour, the 350 micron image has a green colour and the 250 micron image has a blue colour. Each galaxy in the Herschel and ALMA images was aligned using a pixel mapping of the images as to where each pixel is in the sky. This information was taken from the astronomy data contained within Herschel and ALMA images. A colour thumbnail of each galaxy was cropped from the combined Herschel images. The ALMA image was then used as a segmentation map and combined the Herschel thumbnail. This meant that the thumbnails were actually from the ALMA interferometer but had the colour defined by the Herschel imaging. I then used the catalogue to produce the X, Y and Z coordinates required for Partiview to display the images in the 3D visualisation. Once this was complete I then ran the script used to make screenshots in Partiview and then encoded these screenshots into a video.
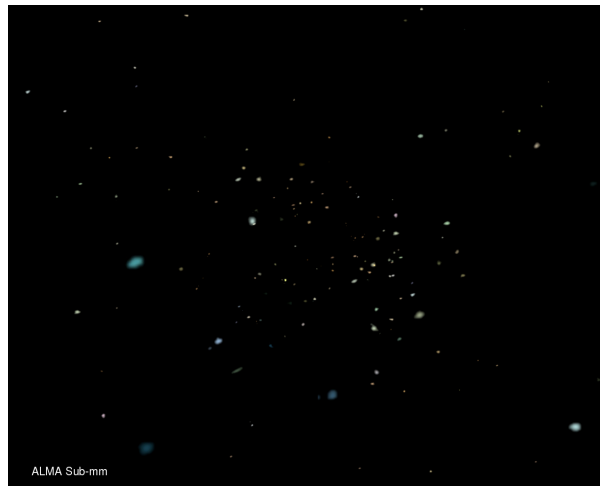
Figure 3: A screenshot produced by Partiview from the ALMA data

I had another meeting with Mark to discuss what videos I should make. We decided on four main videos to be made: A straight flythrough of the ALMA imaging with the z value or redshift printed in the bottom of the screen, A complex path flythrough of the ALMA imaging, A complex path flythrough with crossfade between the ALMA imaging and the MUSYC imaging and finally a side by side view of both the ALMA and MUSYC imaging. I modified the scripts and programs I had written to generate the correct paths for each video. The complex path took some time to make due to its complexity and length.

While setting off the screenshot script in Partiview I continued to improve the 3D model of the ALMA array, adding a ground texture from Google Earth taken of the ALMA site in the Atacama Desert. I talked to Dr. Ben Lowing who was making an iPad app with imaging from galaxy simulations. I discussed with Mark the possibility of making imaging for the app using the MUSYC and ALMA data and we decided that enough time was available. Using Partiview I took six screenshots in both the MUSYC and ALMA imaging. Each image was taken from the central point of the data and is the inside face of a cube. The app displays the view of the ECDF-S in the direction pointed by the iPad.

Once the screenshots for the videos had been taken from Partiview I wrote a number of programs to process the images. These programs added the z values to the bottom of the straight fly through, crossfaded between the images in the crossfade video and stitched together the images from the MUSYC and ALMA imaging in the side by side video. I had a meeting with Mark to encode the screenshots and finish the videos by adding the rendered 3D animation of the ALMA array and the video credits.

Once the videos were finished Mark asked me to make a website to put the videos on. I wrote a website in HTML, CSS and JavaScript which contains the videos and stills available for download. The videos I have made will be used for outreach by the ICC and possibly used in talks about the preliminary ALMA data.
Website: http://astro.dur.ac.uk/~ams/ALMAmovie/

During the internship I improved my computer skills significantly. I was using Linux for most of my work along with Windows which gave me experience in using different operation systems. Before the internship I had never used IDL but after writing a number of programs I gained programming experience and by the end of the internship felt much more confident in using this language. The internship gave me an experience of the independent work and living which will be required at university and in a future career in physics. From a Physics perspective this was my first experience of astronomy and I learned about star formation, redshift, the properties of different galaxies and stars and skills in manipulating telescope data and imaging. I would like to thank the Ogden Trust and Durham University for this internship, it was very rewarding and has provided me with skills that I will definitely use in the future.