Dundee Astronomical Society Meeting Minutes 2019/2020 Season

14th February 2020 at the Mills Observatory

Committee Present

David Paterson	Secretary
Graeme McAteer	Treasurer
Graham Young	Librarian
Tony Hayes	Website Developer
Phil Rourke	Minutes Secretary
Ken Kennedy	

Apologies

June Gilchrist, Jim Barber, Ed Fraser, Andy Heenan

David Paterson chaired the meeting standing in for June Gilchrist, and introduced the guest speaker Joachim Harnois Deraps. Joachim has been working as a post -doctoral researcher at the University of Edinburgh for the past four years and the title of his talk is “Mapping Dark Matter with Millions of Galaxies”

Joachim presented a mosaic of M31 (Andromeda Galaxy) images which highlighted observations taken in radio, infrared, visible, ultraviolet and X-ray by way of showing how different wavelengths can be used to explore different properties of a galaxy. For example, infrared is useful for showing how much dust exists in the interstellar medium.

However, focusing on any one particular galaxy does not reveal much about the universe at large so a 3D movie which had been generated by a powerful computer numerical simulation was shown depicting a flyby of galaxy clusters in the universe at large. This simulation flyby running faster than the speed of light served to show local and large-scale clustering of galaxies. Further simulations on a very large scale were shown which explained the idea of the cosmic web. Despite varying various parameters in these simulations, they always produce a cosmic web with filaments and voids.

The mass of any object will bend space time but massive galaxy clusters for example will bend space time to the extent that objects that would otherwise be hidden behind intervening objects and the observer on earth will be revealed. This spacetime curvature acts like a convergent lens. There are many examples of the Einstein Ring phenomena where distant galaxies appear slit like in a circular pattern around foreground objects.

Measuring redshifts of the lensed object allows calculation of the mass of the cluster creating the lens. This mass must necessarily include dark matter.

Studies of the rotation curves of galaxies, where the orbital velocity of stars around the galaxy centre is compared with distance from the centre indicate that there is not enough visible matter to account for the gravitational force required to keep the stars within the galaxy. They should be flying out into intergalactic space. It has been estimated that about 80% of the required mass is invisible, the so-called dark matter.

An observation of the Bullet Cluster where galaxies collided showed stars passing through, gas pushed towards the centre as it interacts but dark matter also passing unimpeded indicating it is weakly interactive unlike the gas. The dark matter was indirectly observed with gravitational lensing. So, what is the dark matter?

The CMB (Cosmic Microwave Background) has miniscule apparently random variations but this variation has been shown to have structure. The simulations carried out to explain these variations seem to require dark matter.

Fundamental questions arising about dark matter. Where is it? How much? How clumpy? How did it evolve? What is it?

One method to try and shed light on this problem is to use a statistical technique analysing millions of galaxies and the gravitational lens effects.

By way of an analogy a picture of an optical bench was shown with multiple light sources and multiple lens systems. However, the analysis by earth-based systems is hampered by the atmosphere.

The CHFT (Canada France Hawaii Telescope) located on Mauna Kea completed a survey of 12 million distant galaxies using a camera with one-degree squared field of view in 2009. This generated a dark matter map showing the density of dark matter throughout the universe. This map is similar to the cosmic web map where galaxies are found in the dense regions of dark matter and much less so in the voids.

Since then further studies have been carried out. The KDS (kilo degree survey) has mapped 450 degrees squared covering 15 million galaxies using the VLT (very large telescope) in Chile. The DES (Dark Energy Survey) has mapped 1321 square degrees covering 26 million galaxies. The HSC (hyper suprime cam) has mapped 127 degrees squared covering 9 million galaxies with very large redshifts.

These have all produced dark matter density maps and have been used to make comparisons with computer simulations. The simulations specify initial conditions and cosmology and are run with variations to see which models fit the current dark matter observations.

By surveying large numbers of galaxies, the shear caused by lensing can be distinguished from shear caused by the orientation of galaxies not subject to the lens effect. The distribution of elliptical shapes should be random so any systematic alignment between multiple galaxies can be shown to be due to the gravitational lensing. Statistics of dark matter distribution then follow.

Further more advanced surveys will be carried out by the Large Synoptic Survey Telescope which has the ability to cover 14300 square degrees with the ability to image 27 galaxies / arcminute squared. This will probe more deeply weak gravitational lensing and improve the statistical analysis of dark matter distribution in the universe.

There followed a question and answer session which indicated the keen interest of the members to follow up on this very interesting area of cosmological research. It was apparent that everyone would really like to know what dark matter actually is.

David Paterson then gave a vote of thanks to Joachim and thereafter refreshments were served.