

TASC Talk – A New Cosmology

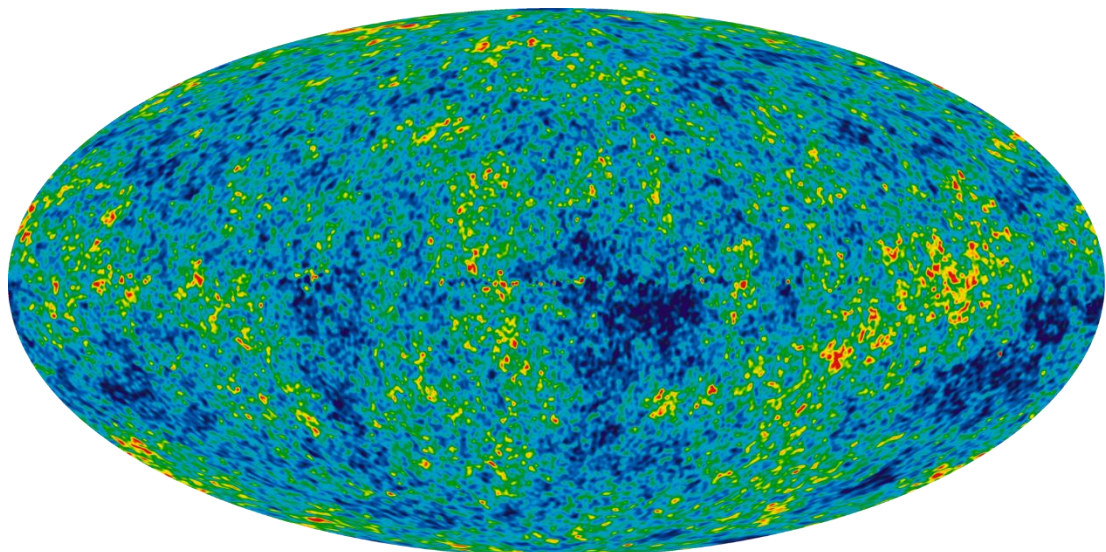
By Professor Andrew Norton – Thurs 20th Nov, 2016

The Talk “A New Cosmology” presented by Professor Andrew Norton covered topics and concepts I have tried to outline below. It was a fascinating insight into current thinking about how “it all started” and continues to provoke questions the more one thinks about it.

From the earliest of times man has asked the question “where do we come from, how did everything begin”? He looked up to the heavens and saw signs of powerful beings who in their ultimate wisdom and power created the Universe and all within.

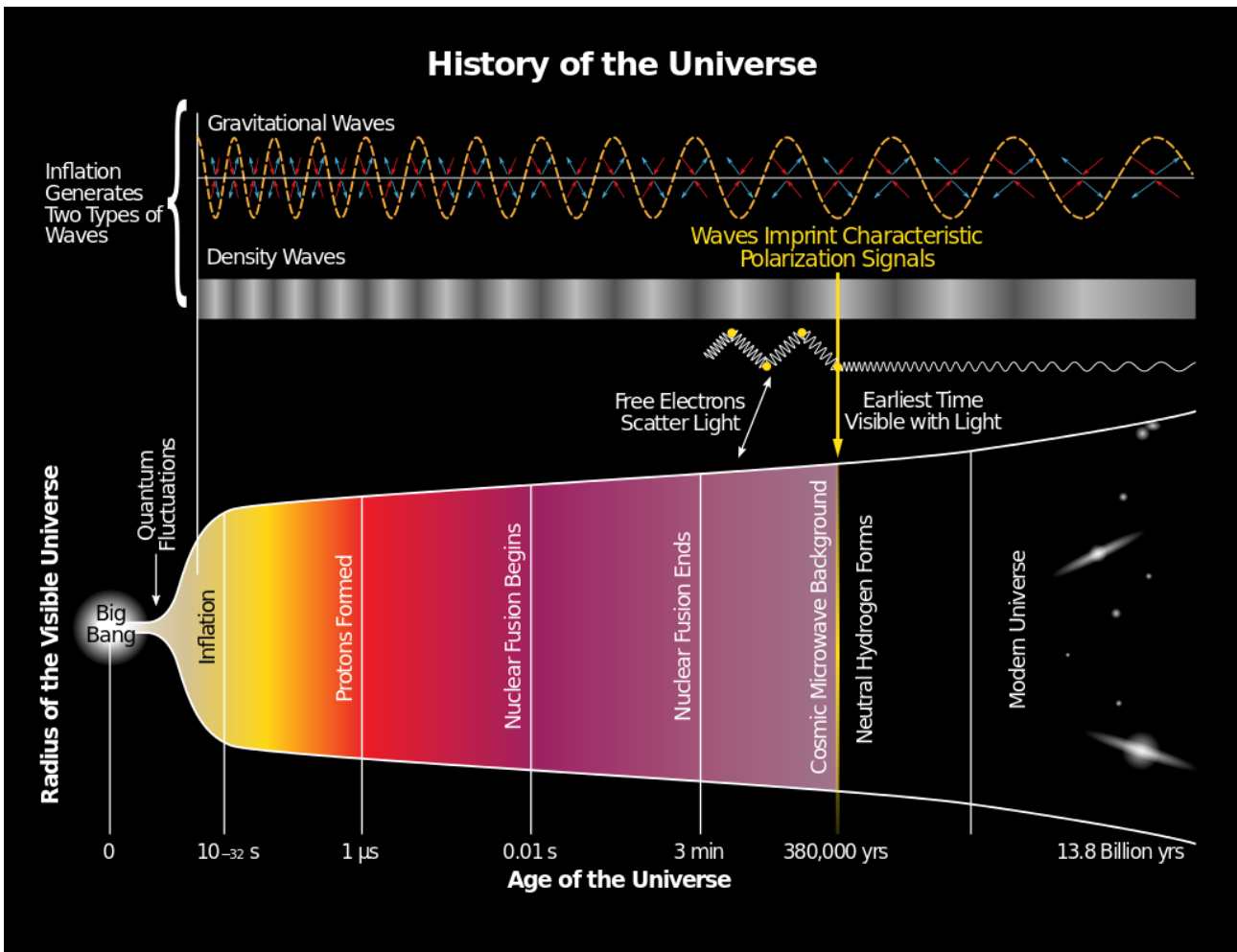


Lately however man has had to review some of those ideas, though questions still arise which ultimately may prove impossible to answer. Man now looks up to the sky and sees not only moons, planets, stars and constellations, but with his ability to invent new instruments and telescopes, he also sees interstellar dust clouds, other galaxies, pulsars, quasars and the Cosmic Microwave Background or CMB.



The Cosmic Microwave Background

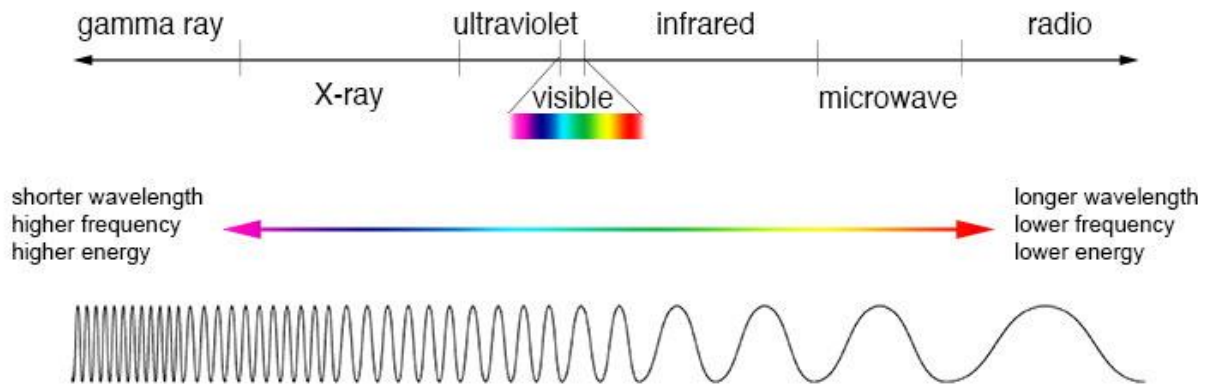
The discovery of the CMB by Arno Penzias and Robert Wilson in 1964 revolutionised cosmology. This discovery above anything else confirmed what cosmologists had been edging towards, that our Universe began in what became known as the “Big Bang” around 13.8 billion years ago when through as yet some unknown mechanism it appeared from nowhere. A point smaller than an atom expanded at a speed greater than that of light to a hot opaque plasma which filled a huge volume of space in the blink of an eye. Following the Big Bang a number of things happened, the initial fast inflation slowed down to a steady expansion, and around 380,000 years on the universe cooled enough for atoms to form. At this point the Universe became less opaque which allowed light to escape its’ “prison” giving it the freedom to travel anywhere it pleased and around 1.6 million years later on stars and galaxies formed, and the rest, as they say, is history.



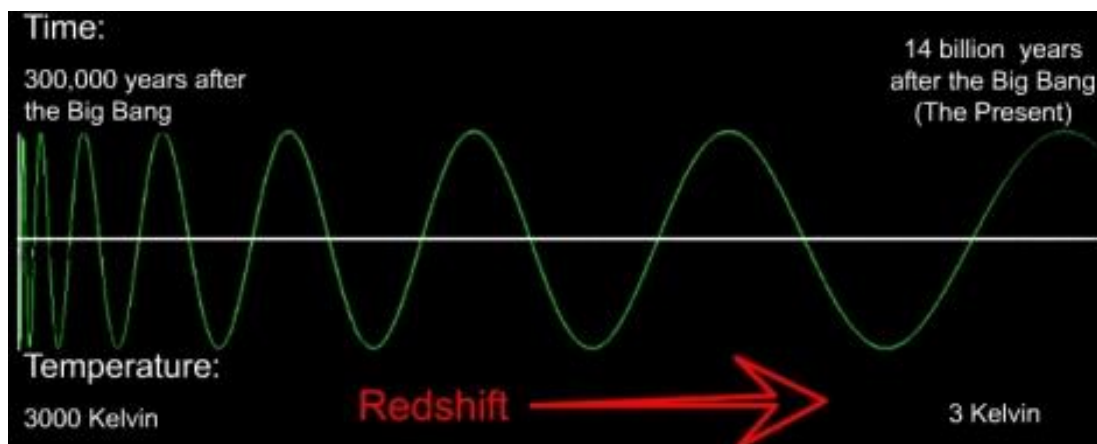
One of the interesting things about stars and galaxies forming is that by all accounts this should not have happened. Relatively recent analysis of the amount of matter and energy contained in the universe shows that there is not enough normal matter for this to actually happen. Scientists such as Vera Rubin back in the 50's and 60's discovered that stars within the outer arms of many spiral galaxies were moving much faster than they should have been. This led to the revelation that there must be something contained within these galaxies which was holding these errant stars in place, but no matter how hard anyone looked no one could see what was stopping them from flying off into inter-galactic space. This is when the concept of Dark Matter first came to prominence. Dark Matter is some kind of, as yet, unknown type of matter which seems to only be detectable by the effect of its gravity on the passage of light and by affecting normal matter; other than that it cannot be seen directly. It appears that most, if not all, galaxies are surrounded by a Dark Matter halo.

Going back to the CMB, when first viewed by Wilson and Penzias with their crude microwave receiver the CMB seemed to have the same intensity no matter where their antenna was aimed. However, now with newer and more sensitive equipment such as the “Cosmic Background Explorer” or COBE satellite which was launched in 1989, minute differences in intensity throughout the CMB have been discovered and mapped.

The reason for the existence of the CMB is put down to those particles of light, called photons, from the early Universe escaping and eventually reaching us. At the time there was a lot of them, however as the universe was expanding their overall density fell. Now as photons are particles of light, they can only travel at one speed and that is at the speed of light, 186,000 miles per second or around 300,000 kilometres per second. When the universe was young these photons were “Hot” but as the Universe grew older they “Cooled”. The amount of energy contained within a photon is not measured by how fast it is going, as it can only travel at light speed, but how high its frequency is, the higher the frequency and the shorter the wavelength is the more energy is contained within the photon. If you didn’t already know photons have a strange duality, not only can they be considered as particles but they also act as if they were waves and therefore have properties such as frequency and wavelength.

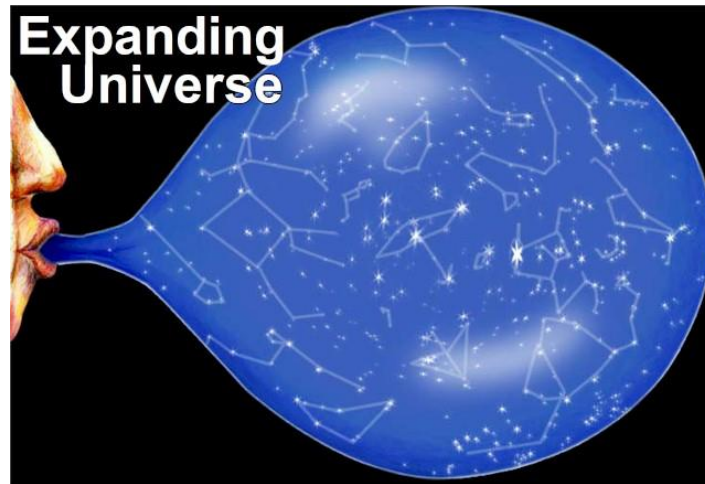


This is all well and good but what has it got to do with anything. Well, it was estimated that the temperature of the Universe shortly after the Big Bang was 100 nonillion, or 1 followed by 32 zeros, Kelvin (273° Kelvin is the same as 0° Centigrade) but now the average temperature is nearer to 2.7 Kelvin or -270.45 Celsius, that’s cold. So you can see that the early Universe was extremely hot but the current Universe is extremely cold and this is what the CMB shows. Why? Scientists now believe that unlike an explosion where everything is shot out from the centre of the “Bang”, the Big Bang was, and still is, an expansion of space itself and as such is causing the wavelength of the photons from the CMB, as it travels, to expand or stretch lowering their temperature. The overall affect is similar to the Doppler affect where the pitch of a siren passing a stationary observer appears to change from high to low as it passes. This affect is also detectable with light; the spectrum of a receding star or galaxy appears to be shifted to the red end of the visible spectrum, and is called its “Red Shift”, and to the blue end when approaching, its “Blue Shift”.

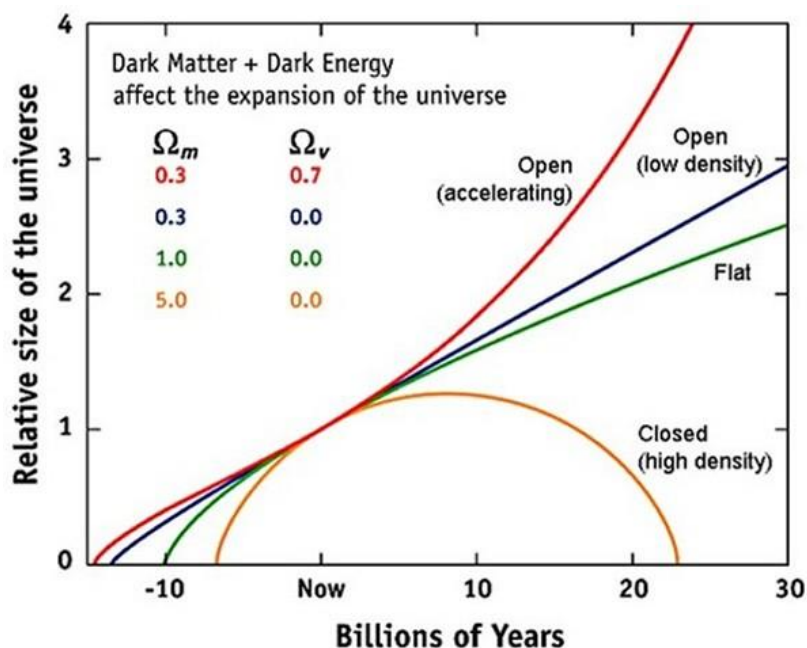


Back in 1922-23 an astronomer named Edwin Hubble discovered that we were not alone, that in fact galaxies other than our own existed and even more astoundingly they were all, except for a few close ones in our “local group”, were moving away from us. He later discovered that they were not just moving away but were in fact accelerating away from us. How could this be? What was fuelling this acceleration? A theory arose

which seemed to explain this odd behaviour and one key element within it was the existence of what has come to be known as Dark Energy. Are you seeing a trend here? If we don't know what anything is, give it a name beginning with "Dark". Funnily enough Einstein had sort of already predicted the existence of this but considered his idea to be flawed and therefor fudged his equations of General Relativity to compensate only to find that his fudge, if tweaked a little bit, perfectly matched this accelerated expansion being seen by the world of astronomy. Even his "Greatest Mistake", as he called it, proved to be pure genius.

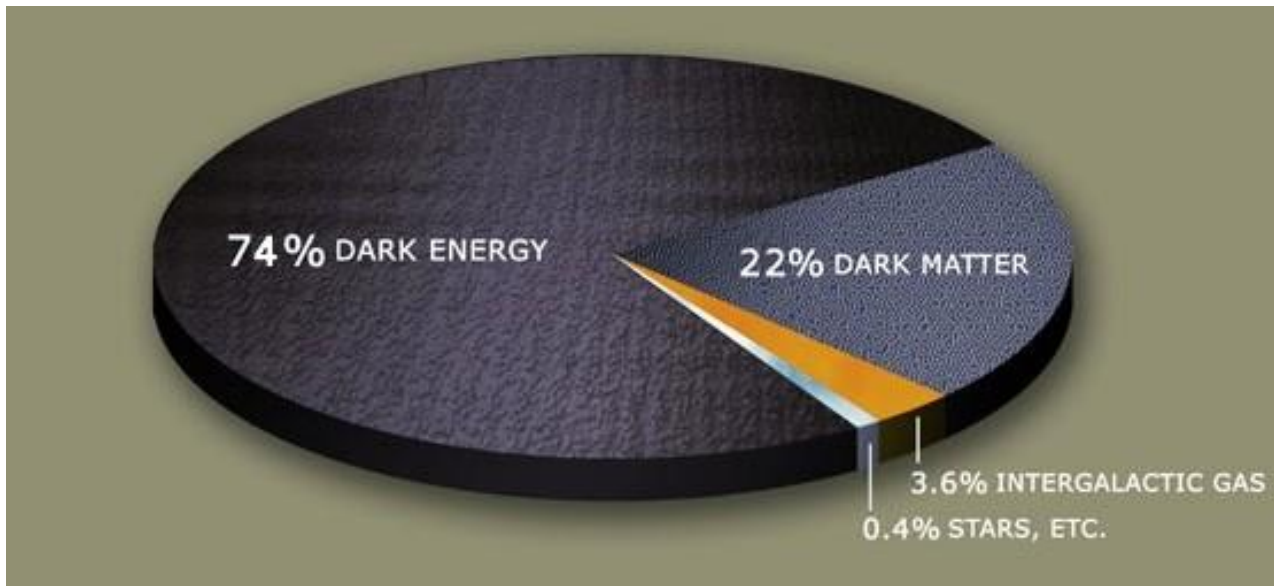


It was thought that our Universe was sitting in the middle of two extreme conditions. One is where it contains an overabundance of matter and because of this, gravity will surely but slowly cause the expansion to stop and sometime in the distant future reverse the flow. The Universe will collapse back to a single point. This version is called the "Big Crunch". The second possibility is called the "Big Rip" where there isn't enough matter for gravity to hold everything together and in fact because Dark Energies power starts to dominate, the Universe is blown apart and indeed for that matter given enough time so are all the atoms which make up normal matter. The last possibility is that, like the Three Bears, our universe sits in the middle, not too much and not too little matter. In this scenario our Universe continues to expand but at an ever slower rate, never actually stopping. This is the "Big Freeze". Not so long ago opinion was leaning towards the "Big Freeze", however following a survey carried out in 1998 by a number of astronomers where they measured the distance to a number of type 1a supernovas and found them to be further away than first thought, they came to the horrifying conclusion that we in fact inhabit a "Big Rip" Universe.



Another way to visualise this situation is to think of space as if it were curved and dependent on how much matter and energy, this includes the Dark variety, is present the Universe has a number of options as mentioned above (see graph on previous page).

One last point before I wind up: our Universe appears to be dominated by Dark Energy. Over 73% of our Universe is made up of Dark Energy around 22% is made of Dark Matter and the remaining 5% is made up of normal visible and invisible (rocks, dust clouds, gas etc.) matter.



From the time of Aristotle through to Copernicus and onto Galileo and Newton, the world in which we live seems to be getting smaller and smaller. It now appears that our whole visible Universe including us and all life, occupies a tiny fraction of what is actually out there. Some scientists now believe that this fraction is getting even smaller. Some current theories consider our Universe, both seen and “Dark” is just one of an infinite number of Universes in what’s called the Multi-verse and not only that but there may be other dimensions called membranes or “Branes” for short, which lie close to the one our Universe is on but unreachable, each of which may contain an infinity of Universes.

Some of you may think a lot of what you read or have seen in Science Fiction books and films is strange. Think again!

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