

# Presentation on the expansion of the universe



Good morning/afternoon, today I will be talking to you about the expanding universe. The topics that I will be covering today would be: thesis statement, Background to the Universe Expansion, what causes it to expand? what evidence are there to support it, did it start from the Big Bang? And what happens to the galaxies as it expands? These topics will be supported through the key idea; how gravity is related to the expansion of the universe? I would like to begin with my thesis statement, the universe is expanding and as the universe expands the galaxies are all moving away from each other in all directions and the once that are the farthest are moving the fastest. Does this mean that no matter what galaxy we are in, everything is expanding?, is our galaxy the milky way also expanding? Does this mean that the entire solar system is expanding? What about the things on earth? And also does the amount of matter present also increase through the expansion? The answer to all these question relates back to the year of 1929 when an astronomer at named Edwin Hubble discovered that the universe is expanding through the biggest telescope that was available in his time. He pointed the telescope at distant galaxies and for the first time we could see those distant galaxies and he noticed something very funny about the light from them. The light from those galaxies were red shifted which means those galaxies were moving away from us.

#### Redshift – Hubble constant

Now like sound, light travel out from its source as a wave, different colours have different wavelengths, blue light have a relatively short wavelength whereas red light have a relatively longer wavelength. Consider an object that moves away from you, as it continues to move then the wavelength of

its light get stretched and moves towards the red end of the spectrum and so we call this a red shift. Every galaxy that Hubble looked at was rushing away from our galaxy Milky Way. He realised that the further away the galaxy was, the bigger the redshift of the light and that meant those galaxies were moving away from us at faster and faster speeds. It's not that the galaxies are moving apart but it's the fact that the entire universe is expanding, the whole of space is getting bigger. This discovery led us to an astonishing conclusion that all the matter that we see today must at one time have been in a very dense and hot region of space and that is the phase we call the Big Bang.

#### The fate of the universe

It is taken around 13 billion years for our visible universe to get to where it is today, but what does the future hold and tell us about ten years ago, cosmologist have three theories for what would happen to our universe: one the open universe – if there wasn't enough gravity, then the universe would keep slowly expanding for ever and become infinite. Two – the closed universe – that the amount of gravity in the universe would slow its expansion down until it collapses back in on itself, And three the flat universe – that there would be just a perfect amount of gravity so that the universe grows to a particular size and then stops. But then astronomers discovered something completely unexpected. The expansion of the universe is accelerating and they realised that there must be something pushing on it and we don't know what it is, but we know it is there.

In early times of 1900s, astronomers presumed that the universe was slowing down and that the gravity would hold everything down and maybe will come back and explode again and people expressed this idea with a mathematical expression that the universe is flat meaning that the universe will continue to expand slowly without ever stopping. But relatively now in this 21<sup>st</sup> century, astronomers were trying to find out that at which rate is the universe slowing down using extraordinary technologies like telescopes all around the world and observing the dark night sky and the supernovas referring to the standard brightness that relates to the distances. But what they actually discovered was that the universe is not slowing down. But it is accelerating; the universe is accelerating at its expansion and do you know why? No one knows why, no one knows why but what you hear these days is the expression dark matter or dark energy and these are mathematical concepts which explain the gravitational attractions of galaxies, clusters of stars and their expansion. Doesn't it seem logical that something is out there that is causing the universe to expand, it can be considered here also on Earth but it's the fact the we don't know how to detect it.

### The Hubble diagram

Now days we have the distance that Hubble measured using the sapphires and the velocity he measured using the red shift and the blue shift of the spectra. So we as scientists we like to make charts and graphs so let's graph these two things, the galaxy velocity versus the galaxy distance and this is the chart that Hubble made. Each of the point on this graph is a unique galaxy and what you can see here is that many, in fact most of the galaxies are redshifted. Moreover, galaxies that are further away are higher

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redshifted than galaxies that are close. Now yes there are couple blueshifted galaxies on this plot if you look closely, and that's alright because these are galaxies that are actually very close to us such as the Andromeda galaxy and it turns out that we are gravitationally attracted to one another, we are pulling each other in and we will in couple billion years slam into the Andromeda galaxy and will make one big new galaxy. Now we can ignore those local effects but the general overwhelming effect is that galaxies that recede faster from us, the more distant they are and this is the Hubble law. And this of course, is another change in our understanding of the universe because what it suggests or supports is that instead of living in just a universe with the galaxies that are sort of hanging out and not doing much, we are actually living inside an expanding universe.

#### The grid expanding universe representation

This grid represents space and each little square is a bit of space and these little dots are the galaxies that recede in space and now galaxies are free to move through space, they do that too like I said that we are going to hit Andromeda and that's because both galaxies are moving through space at one another. But the other thing that happens is that the galaxies move away from one another because space itself is expanding between them. so here is space at some beginning time and here is space at a later time when the space itself has expanded. You can see that the galaxies haven't moved relative to the grid of space but they've moved from one another because the space itself has gotten much larger and no matter where you are, no matter which galaxy that you are in, if you look at all the other galaxies they all appear to be moving away from you with a velocity that is proportional to

their distance, so things that are moving away faster are more distant from us.

### The balloon example

You can also think of the example of a balloon being blown up, just imagine the surface of the balloon and there are little dots that are little galaxies all over the surface of the balloon and as you blow it up the surface itself increases and so all the little dots representing galaxies move away from all the other little dots on the surface and are accelerating in their expansion and this is the universe that we live in now. This agency that is causing this accelerating expansion is called the dark energy, so it appears that although we answered all of the big questions, we are still left with many more. We don't know what the dark matter is but we know that it is there. What happened in the early stages of our universe? We don't know the answer to that either. We haven't got any clue to as what our universe is going to be doing billions of years of now, we just don't know because we don't understand it but with the astonishing technologies that are available to us today and through the discovery of Edwin Hubble, we know one thing for sure, the universe is expanding.