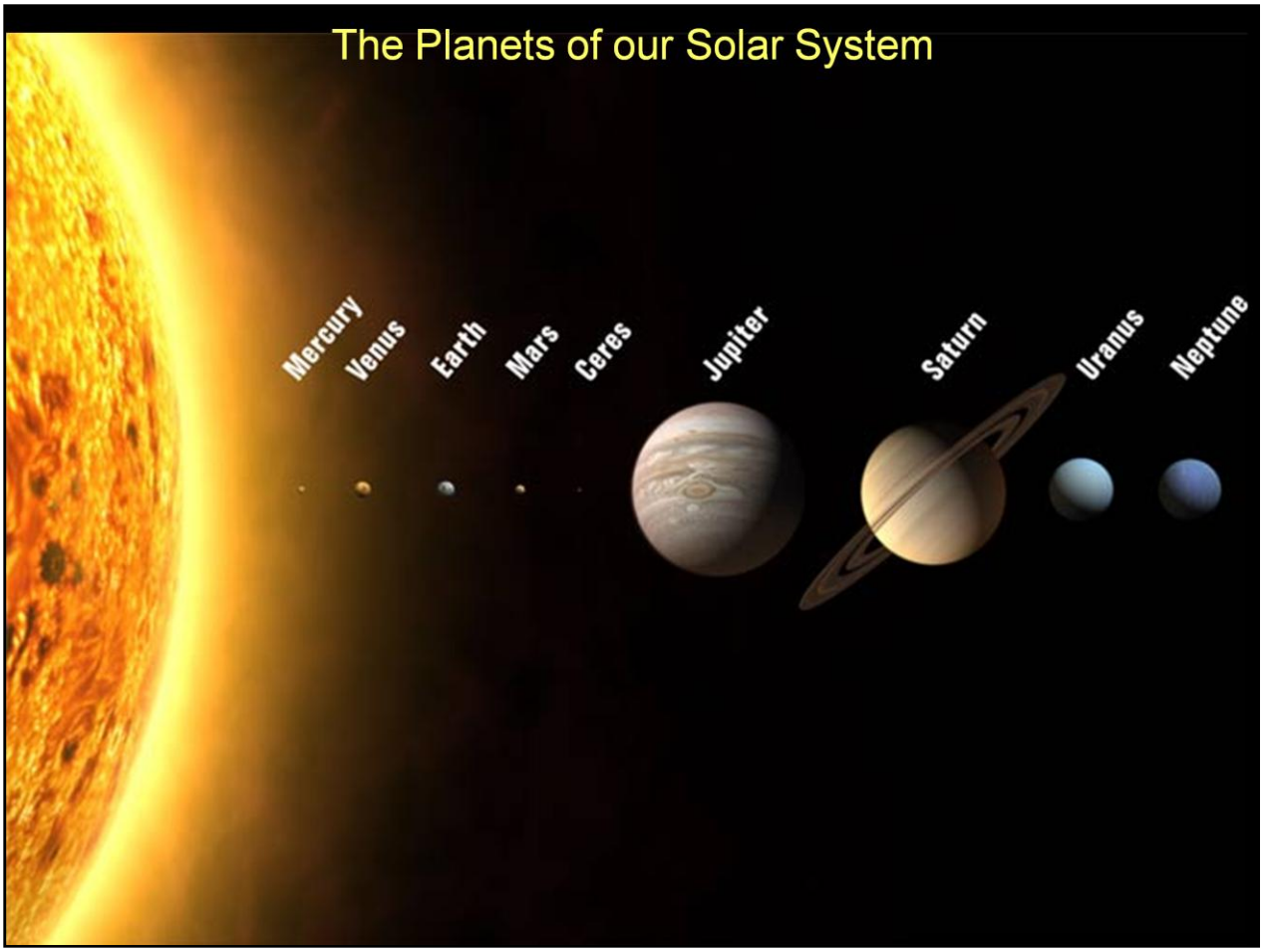
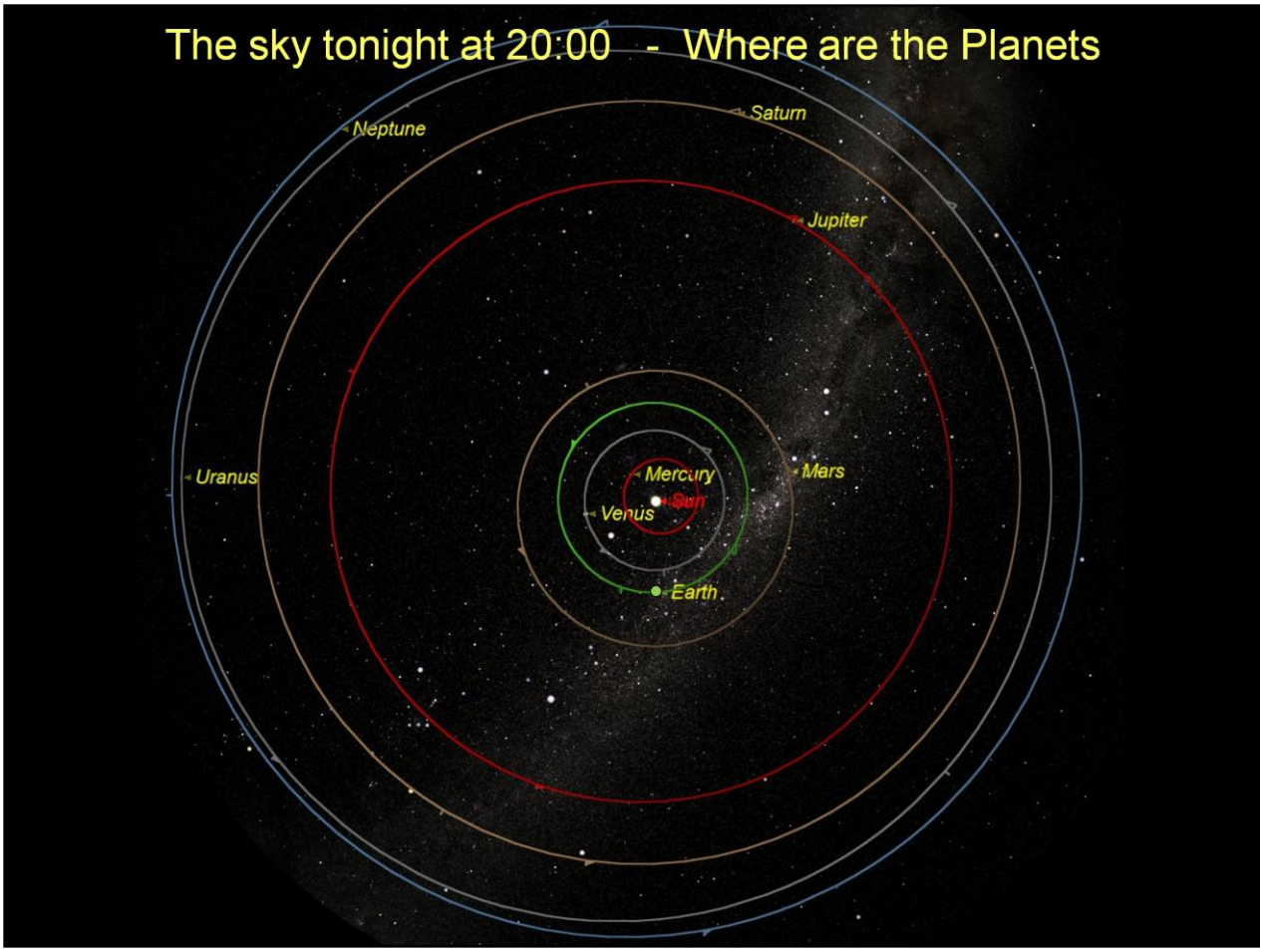
This session 2019 -2020 we intend to present talks designed to provide an introduction to some of the skills that are needed when starting astronomy as a hobby. This month (February 2020) the presentation is another beginner's guide to the night sky. This month we will be taking a journey through the vastness of our Universe.

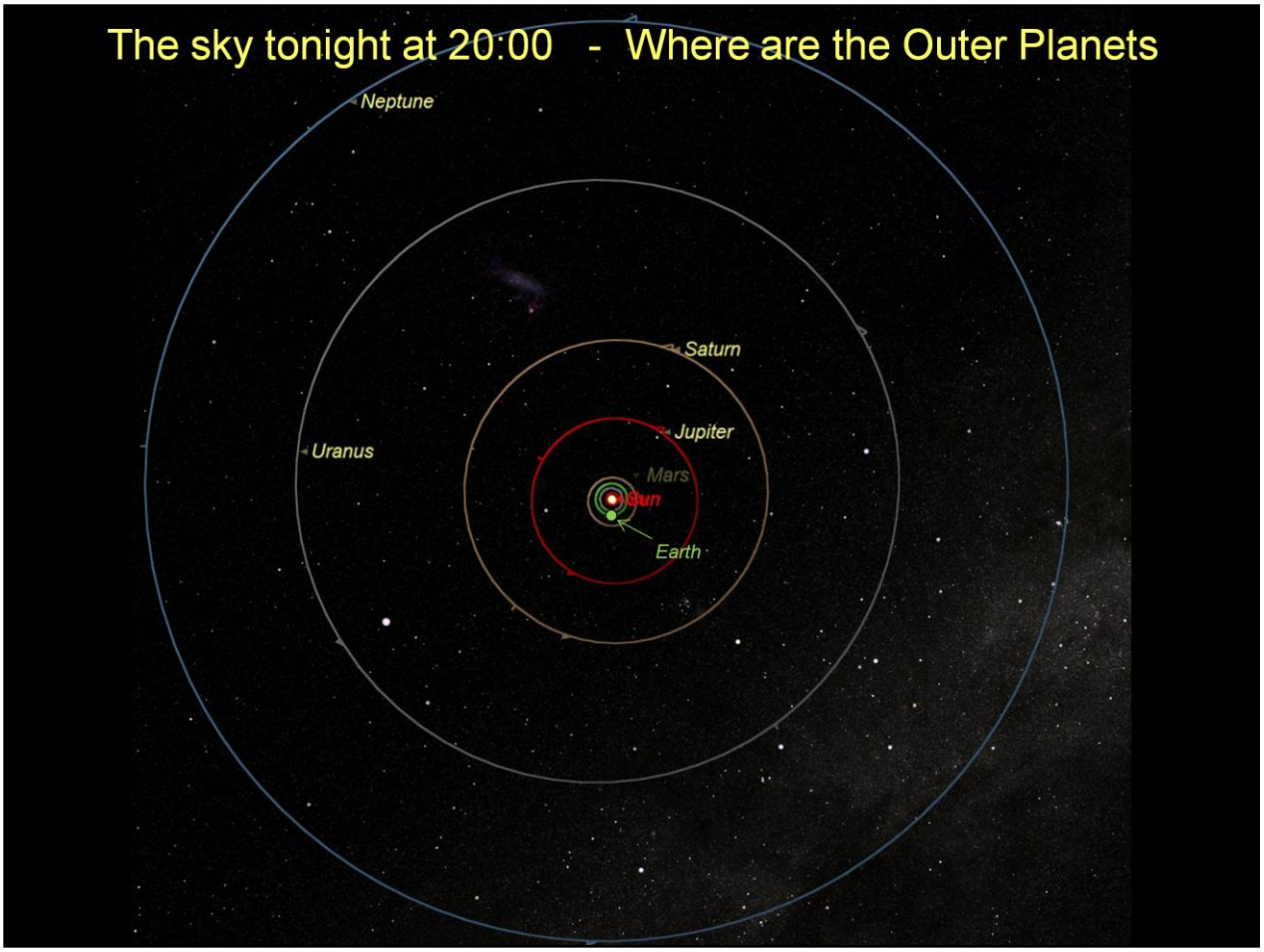
The starting point for our journey through the Universe is our home on the planet Earth. The arrow on the image above shows the location of our Newbury Astronomical Society Beginners Meeting in Newbury, Berkshire in Britain.



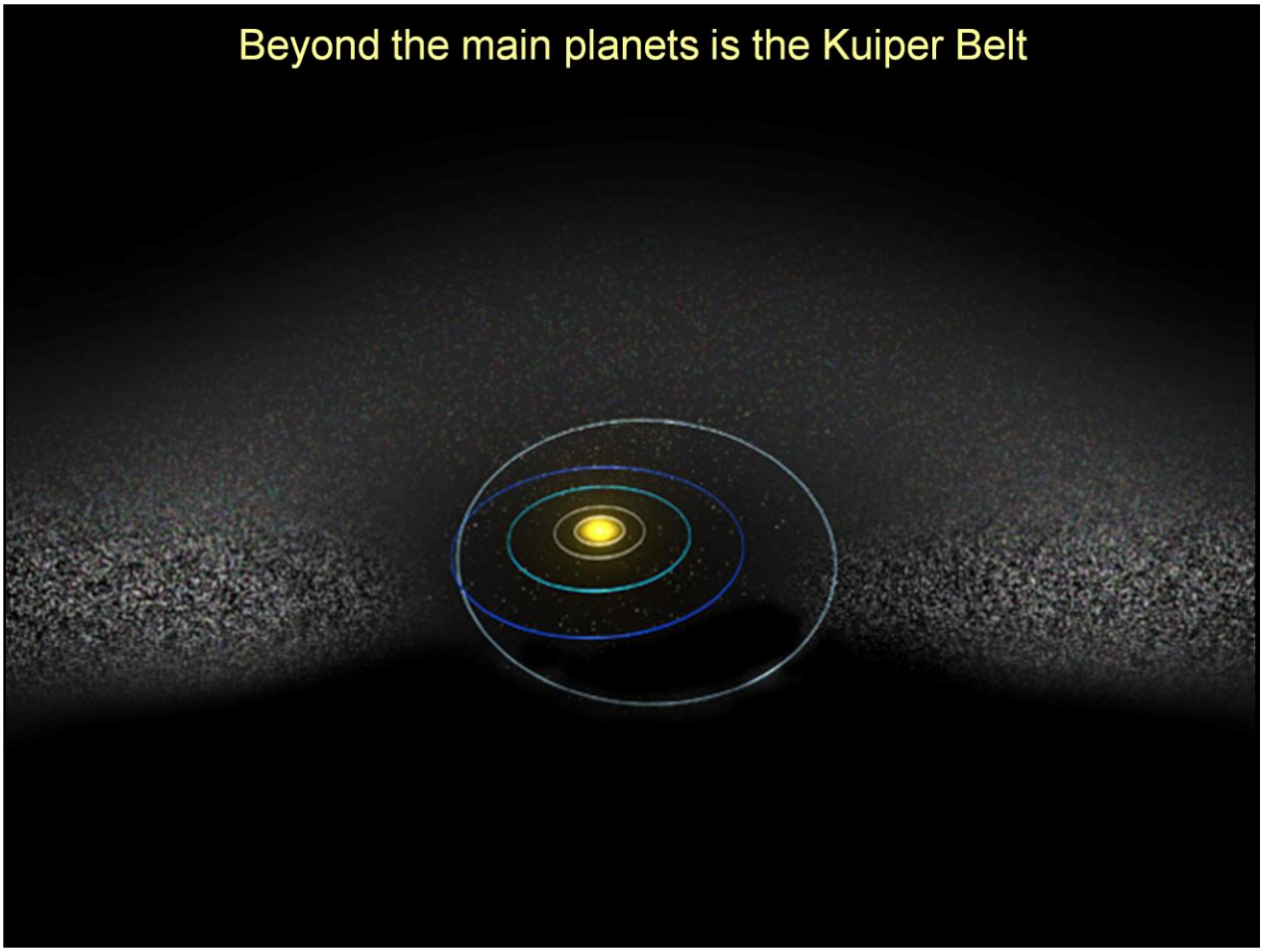
Our Planet is the third of the eight main planets that orbit our star that we call ‘the Sun’. Our Sun is a normal small star that is about half way through its life (about 4.3 billion years of its expected lifetime of 9 to 10 billion years).



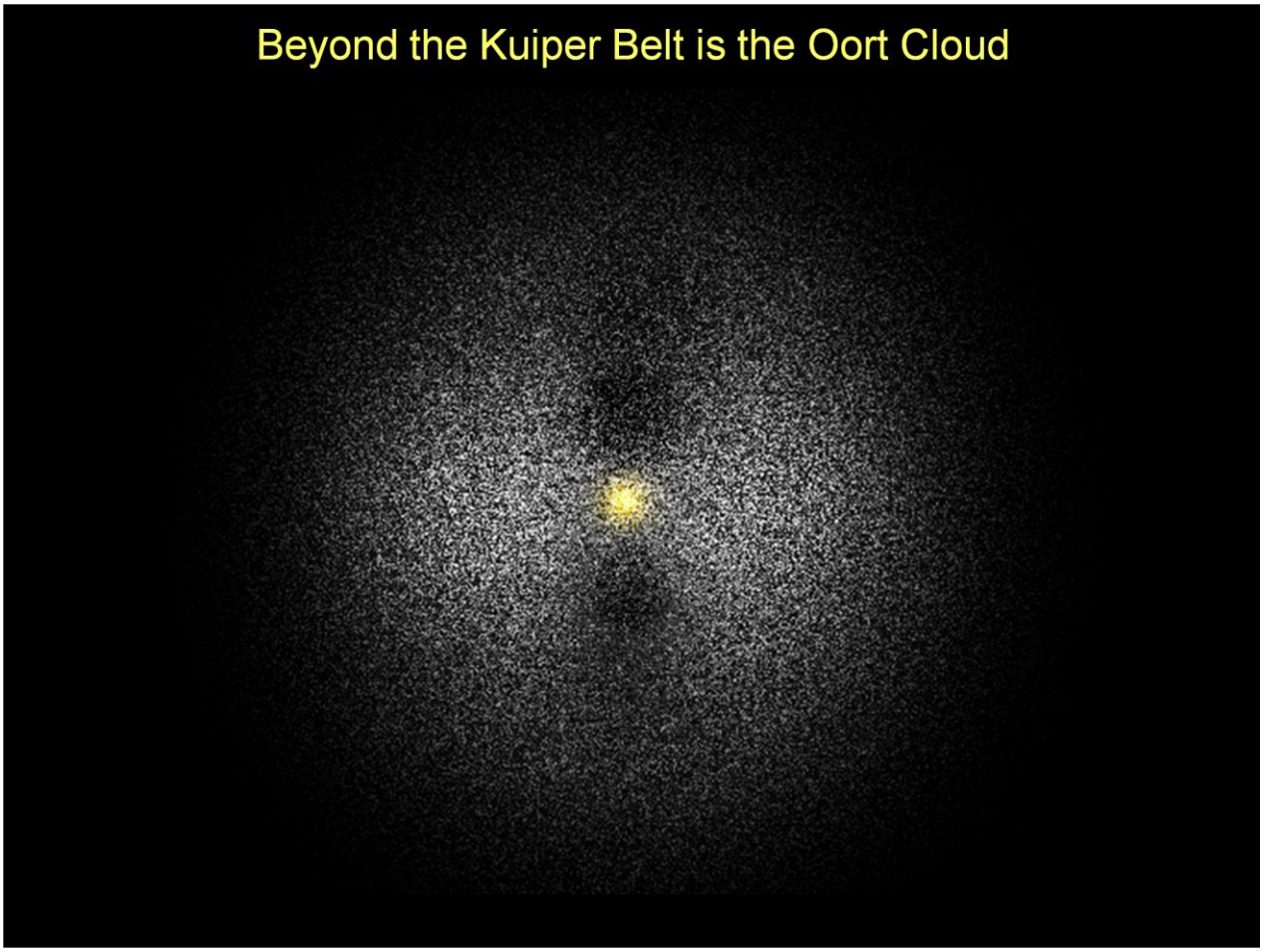
The chart above shows the inner Solar System with the inner planets, Mercury, Venus, Earth and Mars in their relative positions compared to Earth on the evening of the February 2020 Beginners Meeting. The much larger orbits of the outer planets have been compressed to allow all the planets to be included.



The chart above shows the whole Solar System with the smaller orbits of the inner planets, Mercury, Venus, Earth and Mars in the centre. The orbits of the outer planets are shown as their relative size compared to the much smaller orbits of the inner planets. This chart shows the orbits of the outer planets Jupiter, Saturn, Uranus and Neptune in their relative positions to Earth.



Beyond the outermost planet, Neptune, is a vast cloud of minor planets that we call ‘the Kuiper Belt’. This is a toroidal (doughnut shaped) ring of dwarf planets composed mainly of water ice. These range in size from the size of Pluto (which is thought to be the closest and one of the largest of these bodies Kuiper Belt objects) to boulder sized lumps and there are millions of them. Although there are millions they are spread over such a large area they are mostly hundreds to thousands of kilometres apart. (Pluto is shown as the outer white orbit.)

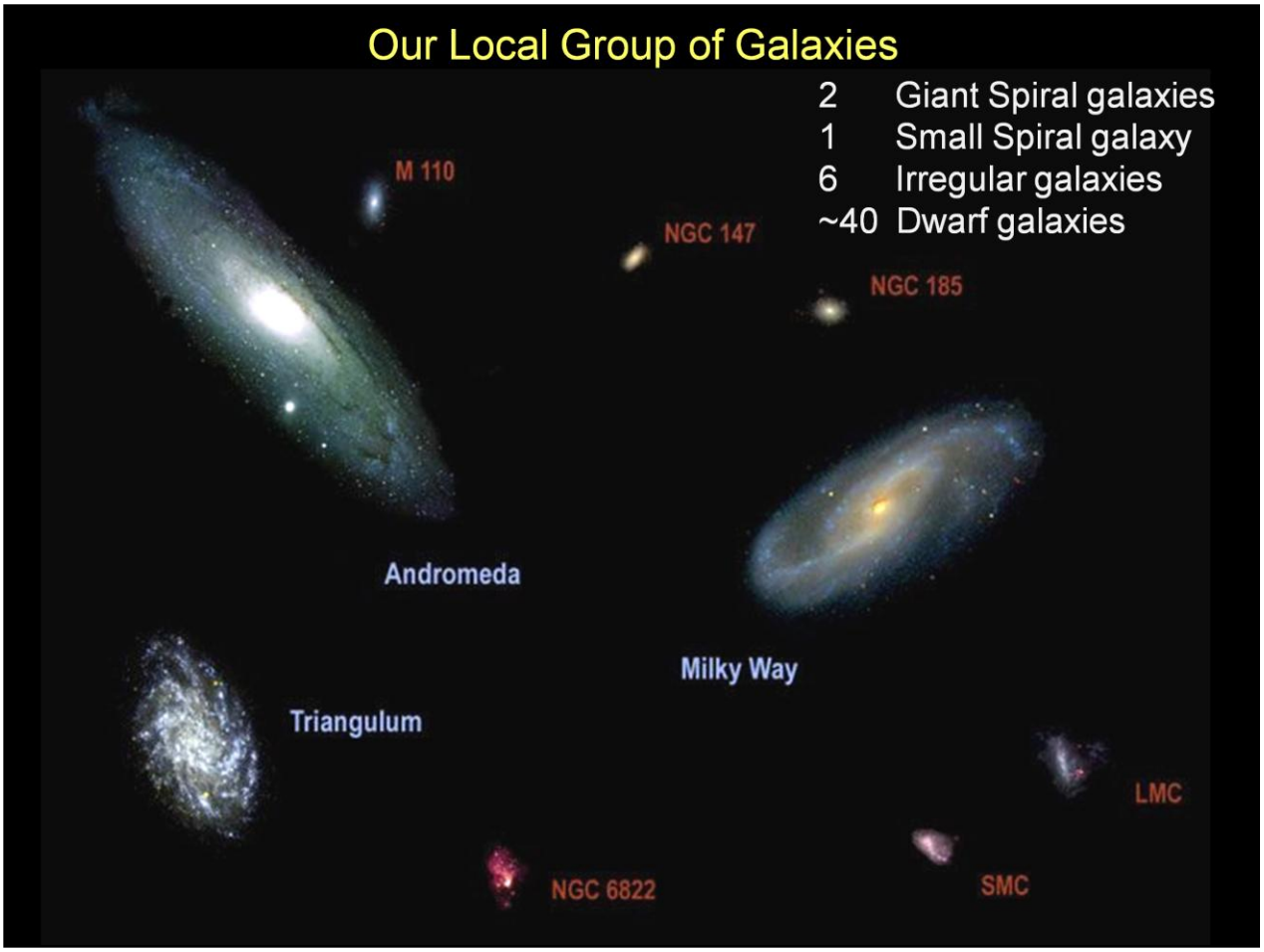


Beyond the Kuiper Belt is a vast halo of icy bodies that surround the Sun out to the very edge of its gravitational influence this area is called the Oort Cloud. These are thought to be similar to the members of the Kuiper Belt but much further from the Sun. They are thought to have orbits that may be up to 2 light years and possibly 2.5 light years from the Sun. This means that the outer orbits may reach more than half way to our nearest star system, known as Alpha Centuri, that is about 4.3 light years away. So the outermost Oort Cloud members may be exchanged with Alpha Centuri Oort Cloud members, if there is one (it is very likely that there is).

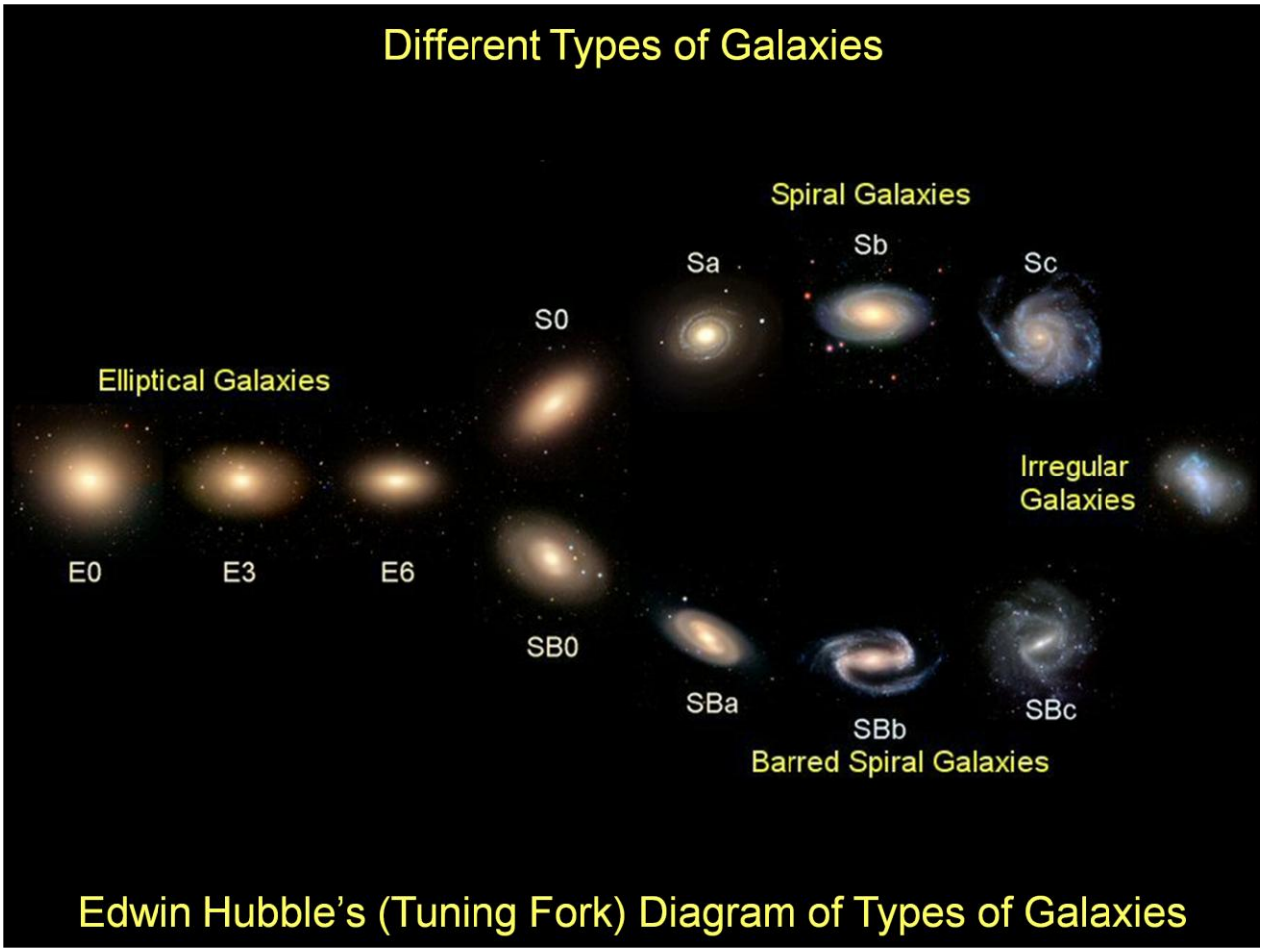
Our Sun is a member of a Giant Spiral Galaxy that we call the Milky Way Galaxy. Our Sun is one of about 200 billion stars in this giant galaxy. Our Galaxy has its spiral arms attached to a central bar so the Milky Way is classified as a Giant Barred Spiral Galaxy. The Milky Way is about 100,000 light years across from edge to edge.

Our Sun is located on the outer edge of the Sagittarius Spiral Arm. So when we look towards the constellation of Sagittarius we are looking to the centre of our Galaxy. When we look towards the constellation of Orion we are looking towards the outer edge of our Galaxy in the direction of the Orion Spiral Arm. The Sun is about 30,000 light years from the centre and about 20,000 light years from the outer edge.

So when we look towards the constellation of Sagittarius we are looking to the centre of our Galaxy.



The Milky Way is in a group comprised of two Giant Spiral Galaxies, one smaller Spiral Galaxy, six Irregular Galaxies and up to about 40 very small Dwarf Galaxies that make up our 'Local Group' of about fifty closest galaxies. These are gravitationally linked to each other. It is thought that the smaller Galaxies might be pulled into the two Giant Spiral Galaxies and consumed. The two Giant Spiral Galaxies are currently 2.3 billion light years apart but are being pulled towards each other and will merge into one larger Elliptical Galaxy in about 5 billion years time.

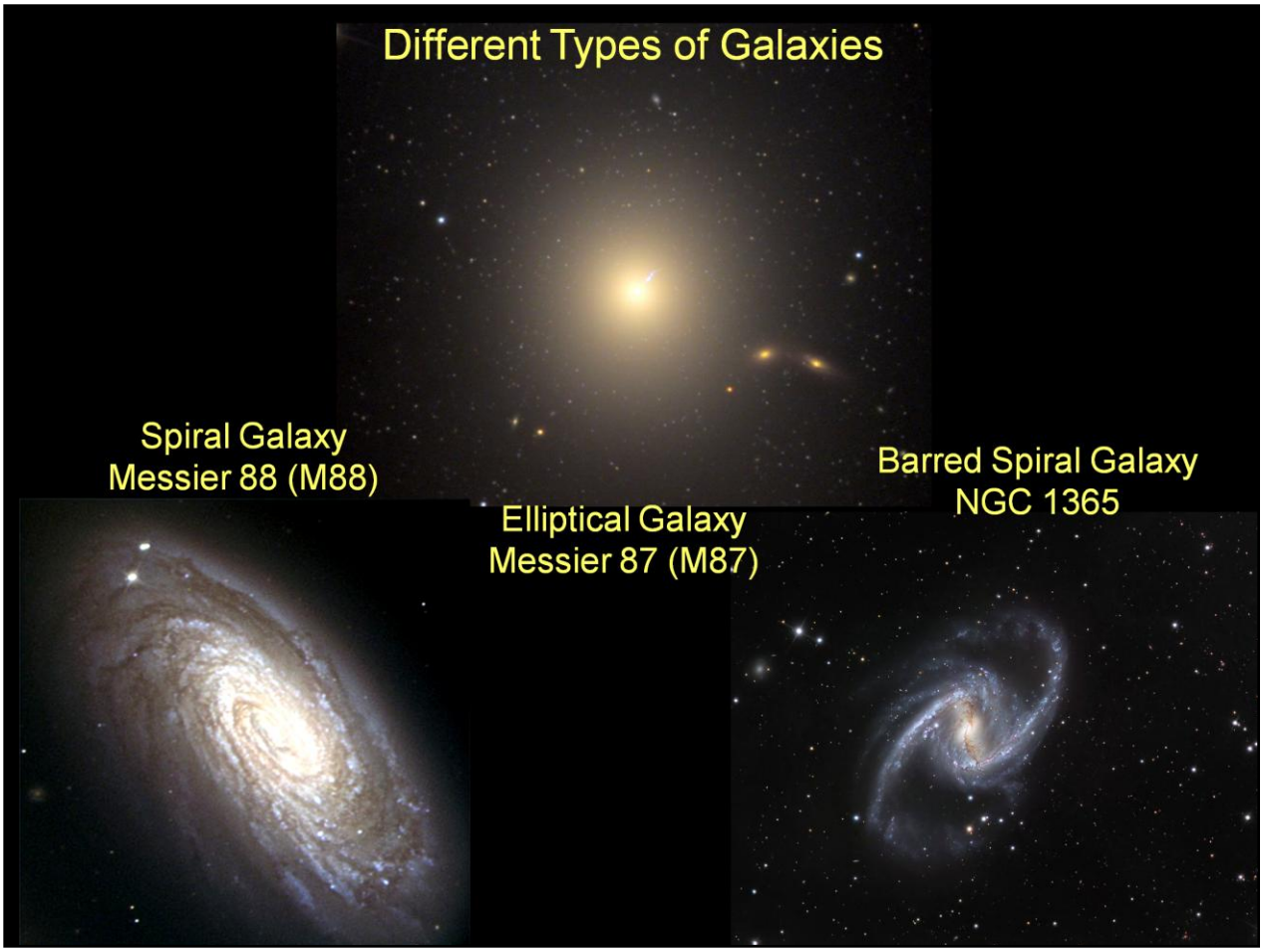


The diagram above is known as the 'Hubble Tuning Fork Galaxy Diagram' and was devised by Edwin Hubble to show the how galaxies develop. He initially thought Elliptical Galaxies develop spiral arms as they matured and become Spiral Galaxies.

As our understanding of galaxies increased it was realised that if galaxies were large enough they would become spiral galaxies. Some Spiral galaxies develop a bar structure in the central core. The mechanism of the formation of the bar is not fully understood but it is probably a gravitational effect.

Giant Elliptical Galaxies are thought to be the result of the merging of Spiral Galaxies but some may have formed as Elliptical Galaxies. So if two or more spiral galaxies merged due to their gravitational attraction they may become a larger spiral or may become an Elliptical Galaxy.

Irregular galaxies are a separate group that are too small to develop a recognised shape.

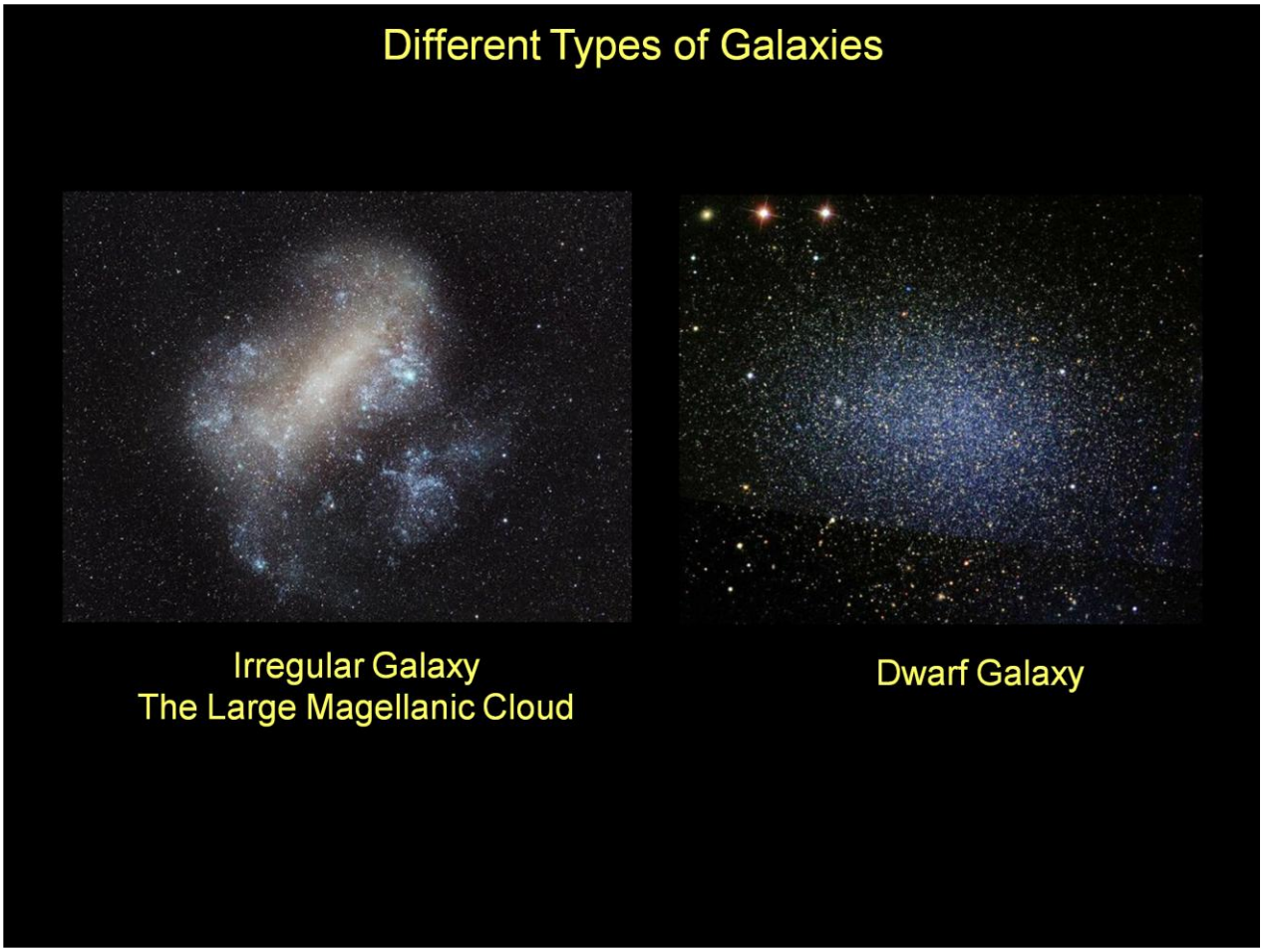


Generally Elliptical Galaxies are the largest and Spiral Galaxies can range from small up to giant in classification.

Elliptical Galaxies are classified as E1 (spherical) to E7 (more flattened and elliptical)

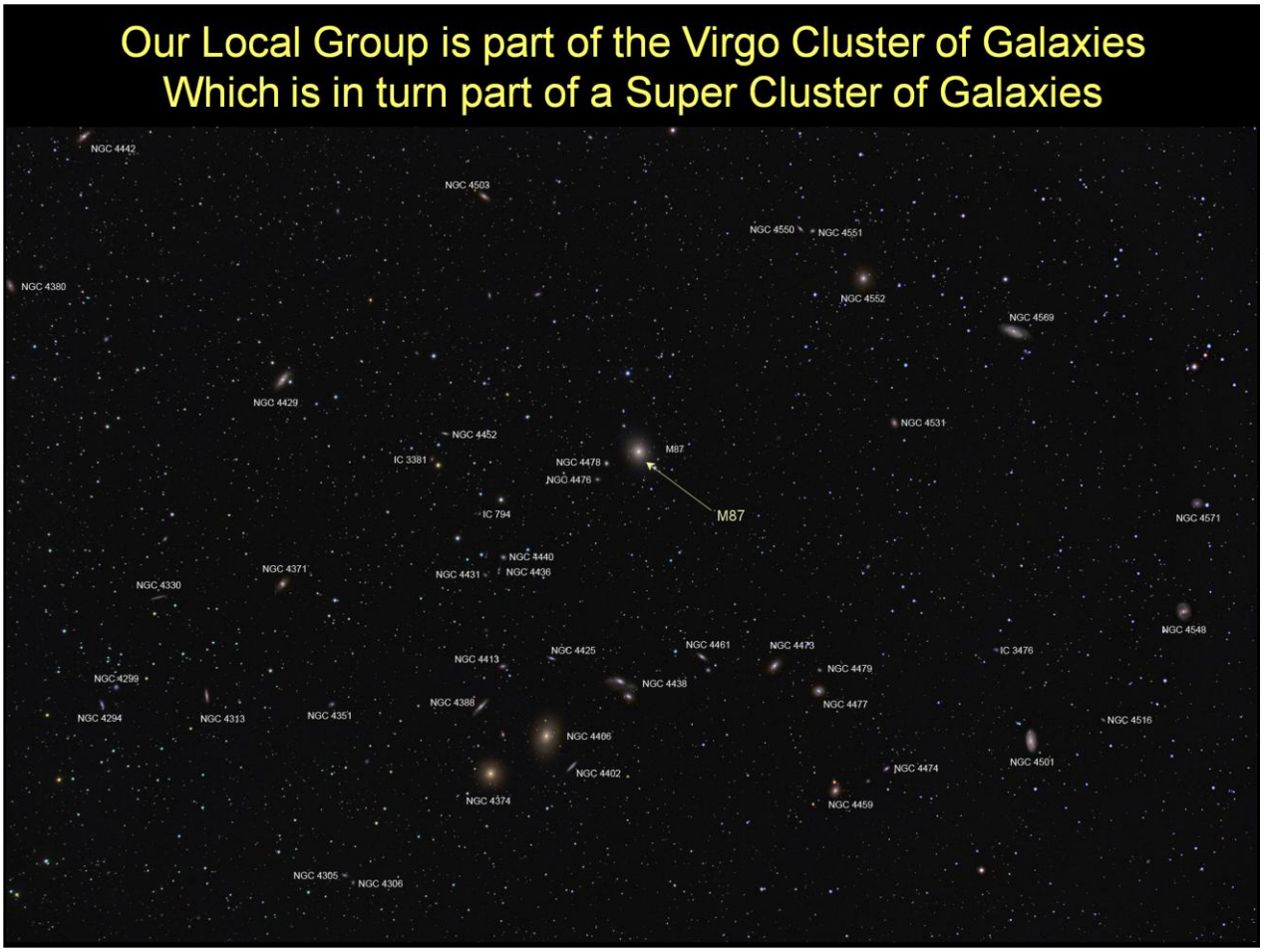
Spiral Galaxies are classified S0 (partially formed arms) and Sa to Sc depending how developed and tightly wound the spiral arms are.

Barred Spiral Galaxies are classified SB0 and SBa to SBc similarly to plain spiral galaxies.



Irregular Galaxies are normally too small to develop spiral arms but some (like the Large Magellanic Cloud) can show signs of the partial development of spiral arms.

There is another class of very small galaxy called Dwarf Galaxies. These resemble Open Clusters but their stars are old and gravitationally tied to the group that is stable. Open Clusters are young stars that have formed from a Nebula and will gradually disperse.



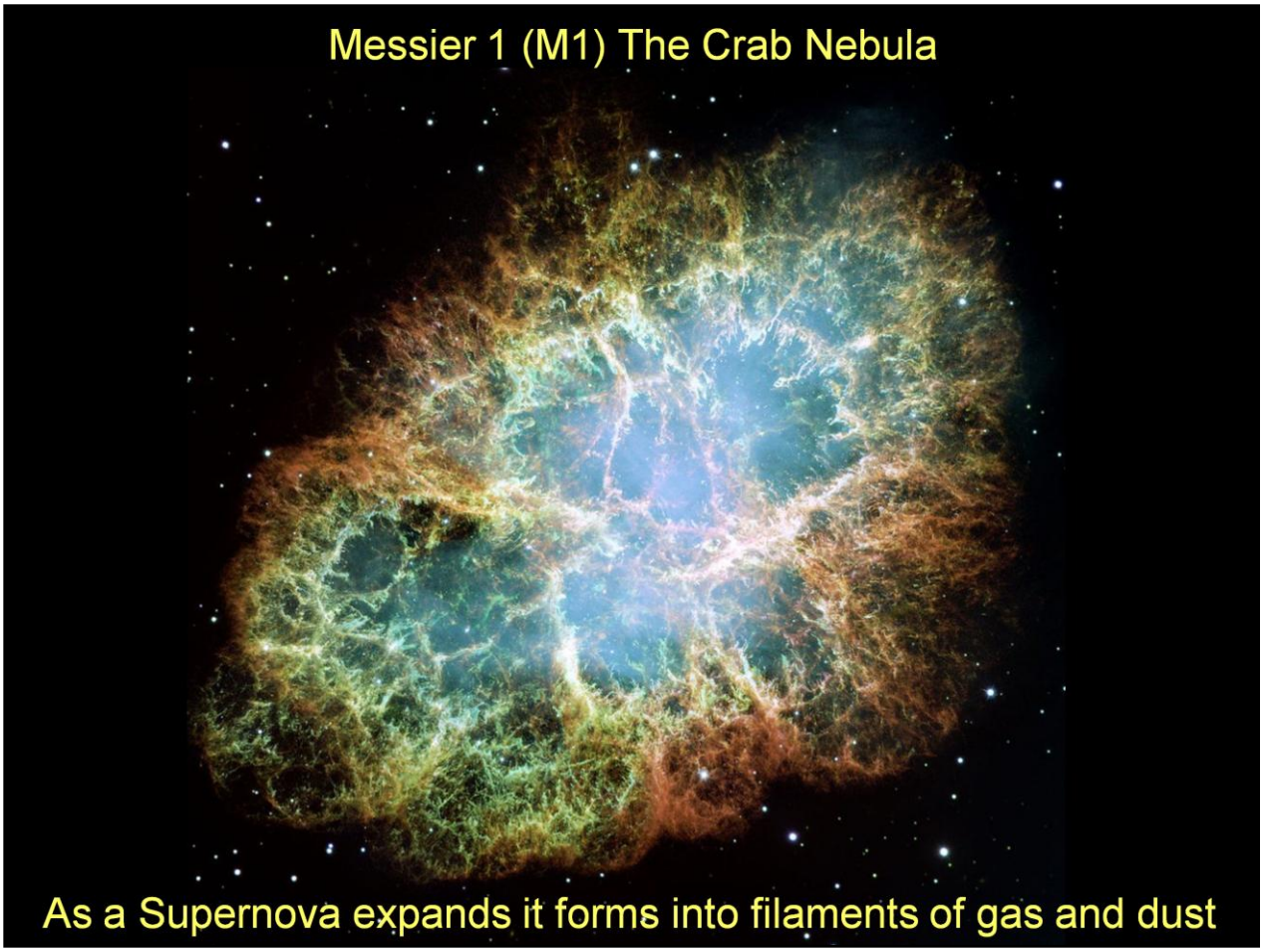
Our Local Group of galaxies is part of a much bigger cluster of galaxies called the Virgo Cluster. This cluster does overlap into the neighbouring constellations of Coma Berenices and Leo. All stars at these vast distances reside within the galaxies. There are a few exceptions of stars that been thrown out of their galaxy by some traumatic event. These 'Wandering Stars' cannot be detected in the vastness of the distant universe so all we can see are the galaxies.

Our Local Group appears to be gathered around a Giant Elliptical Galaxy known as Messier 87 (M87). It is thought to contain well over a trillion stars and has powerful jet.

Our Universe came into existence about 13.7 billion years ago. Somehow there was an unimaginable powerful release of energy that we call the Big Bang. This is not a good description because this occurred within a microscopic space that is called a 'Singularity'. This Singularity had an infinitely small volume but an infinitely high mass, temperature and pressure. The Singularity rapidly expanded as a spherical ball of very hot energy and continued to expand and start to cool.

After a period of about 100,000 years the ball of energy had cooled sufficiently for atoms to form. The energy was converted to Mass (Hydrogen and Helium atoms with a small amount of Lithium) in accordance with Albert Einstein's famous equation $E = Mc^2$ transposed as $M = E/c^2$. This means that (M) was the Mass of atoms, created from the Energy (E) at a rate divided by the speed of light (c) squared (c^2). At this point a massive flash of electromagnetic radiation (in the form of Gamma and X-Rays) was released.

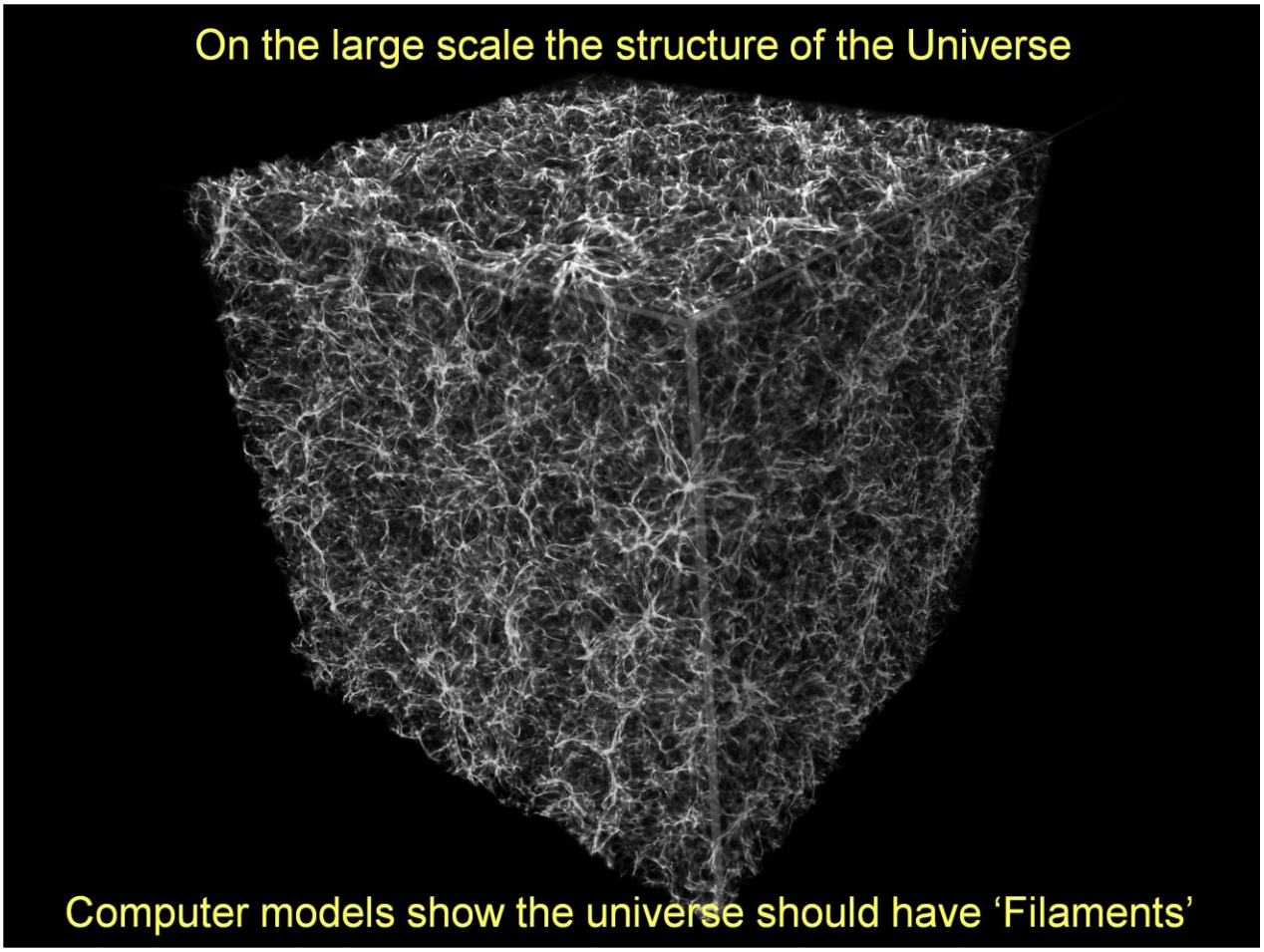
In actual numbers of the atoms produced in the Big Bang there was (92%) Hydrogen and (8%) Helium. As the Helium atoms are heavier, the Mass (weight) was 75% Hydrogen and 25% Helium. The atoms continued to cool as the young Universe continued to expand. Gravity pulled the atoms together creating dense filaments and empty voids. Gravity in the filaments caused the gas to be compressed into huge dense clumps, within the filaments, that became galaxies and within the galaxies stars formed from the gas at a smaller scale.



The nearest example that we have of a very large explosion is the final moments of a giant star that was 10 or more times the mass of our Sun. We can see the remains of these tremendous explosions in the sky we call them a Supernova or Supernovae in plural. The closest and best known of these Supernova Remnants is Messier 1 (M1) also known as the Crab Nebula in the constellation of Taurus (the Bull).

A massive star that was just 6000 light years away from Earth exploded about 7000 years ago as a Supernova. It was seen and recorded as a very bright star in the year 1054 AD. The Supernova was bright enough to be seen in daylight for about three months then faded. Its remnants can still be seen as a 'fuzzy' patch of light using a 150mm telescope. The image above was taken, in great detail, using the Hubble Space Telescope.

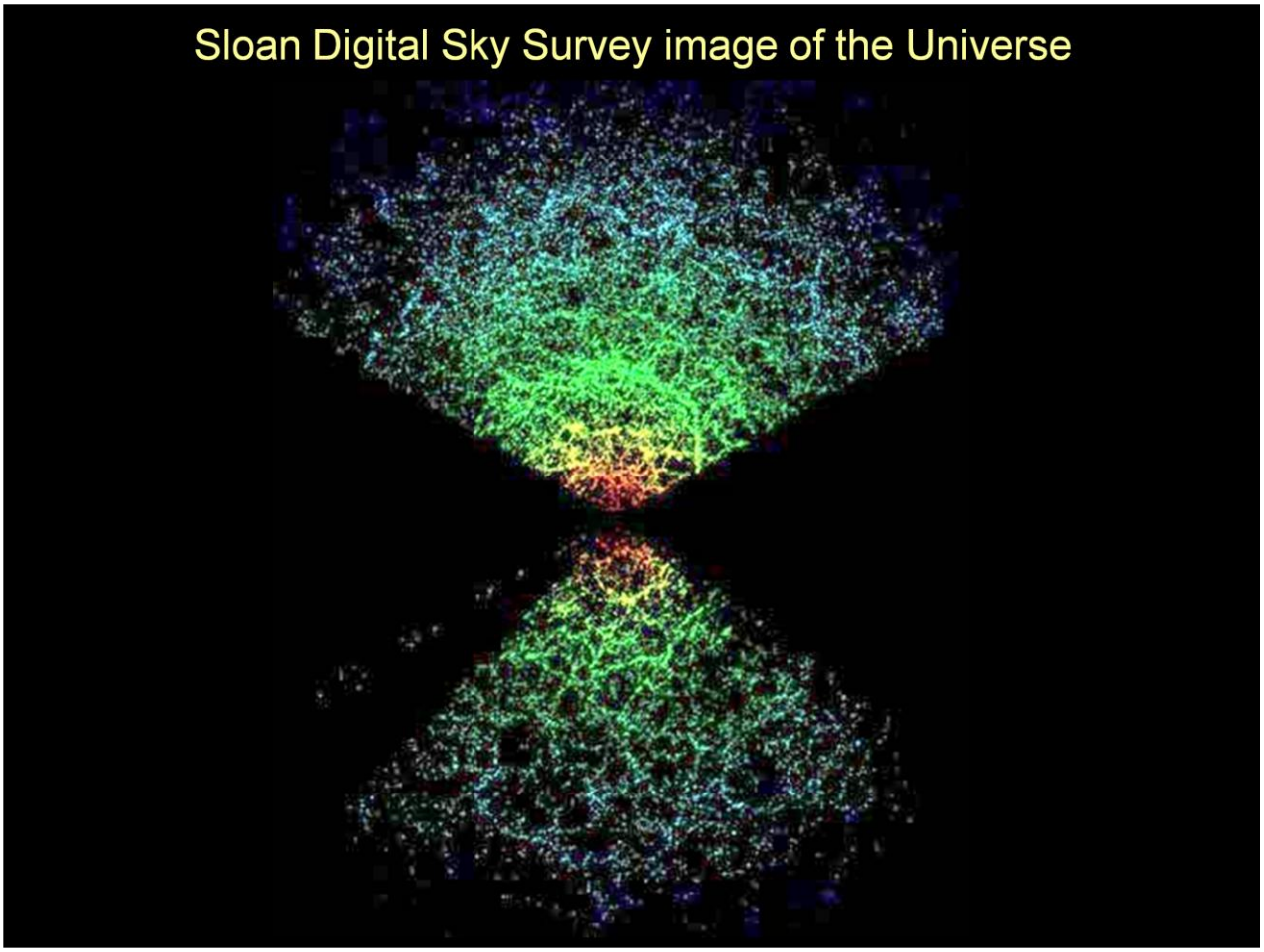
The filamentary structure and voids resulting from this tremendous explosion can be clearly seen in this image.



Modern super computers can be programmed to calculate how the Universe might have developed using all the known data we have. The image above is a computer generated picture of what the computers nearly always predict as the most likely structure of the Universe. It shows filaments of material and empty voids looking very much like the structure we see in the remnants of a Supernova explosion of a giant star.

The Sloan Digital Survey Telesope

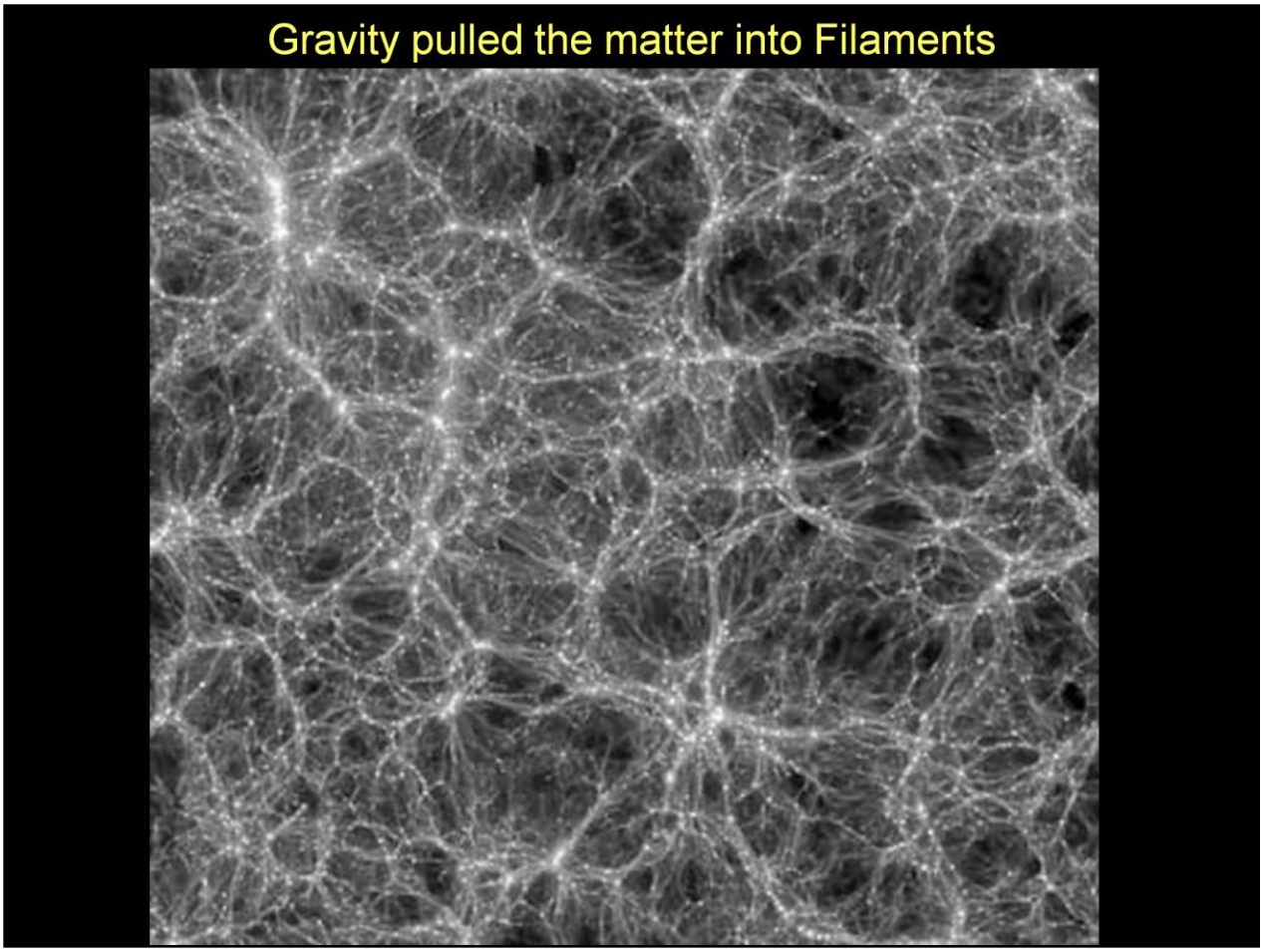
We now have telescopes, cameras and instrumentation that enable us to map the universe around us. One of the first instruments to embark on this task was the Sloan Survey (deep space) Digital Telescope. It is able to record details of thousands of galaxies in each image it produces. From this a detailed map of the universe around us can be produced.



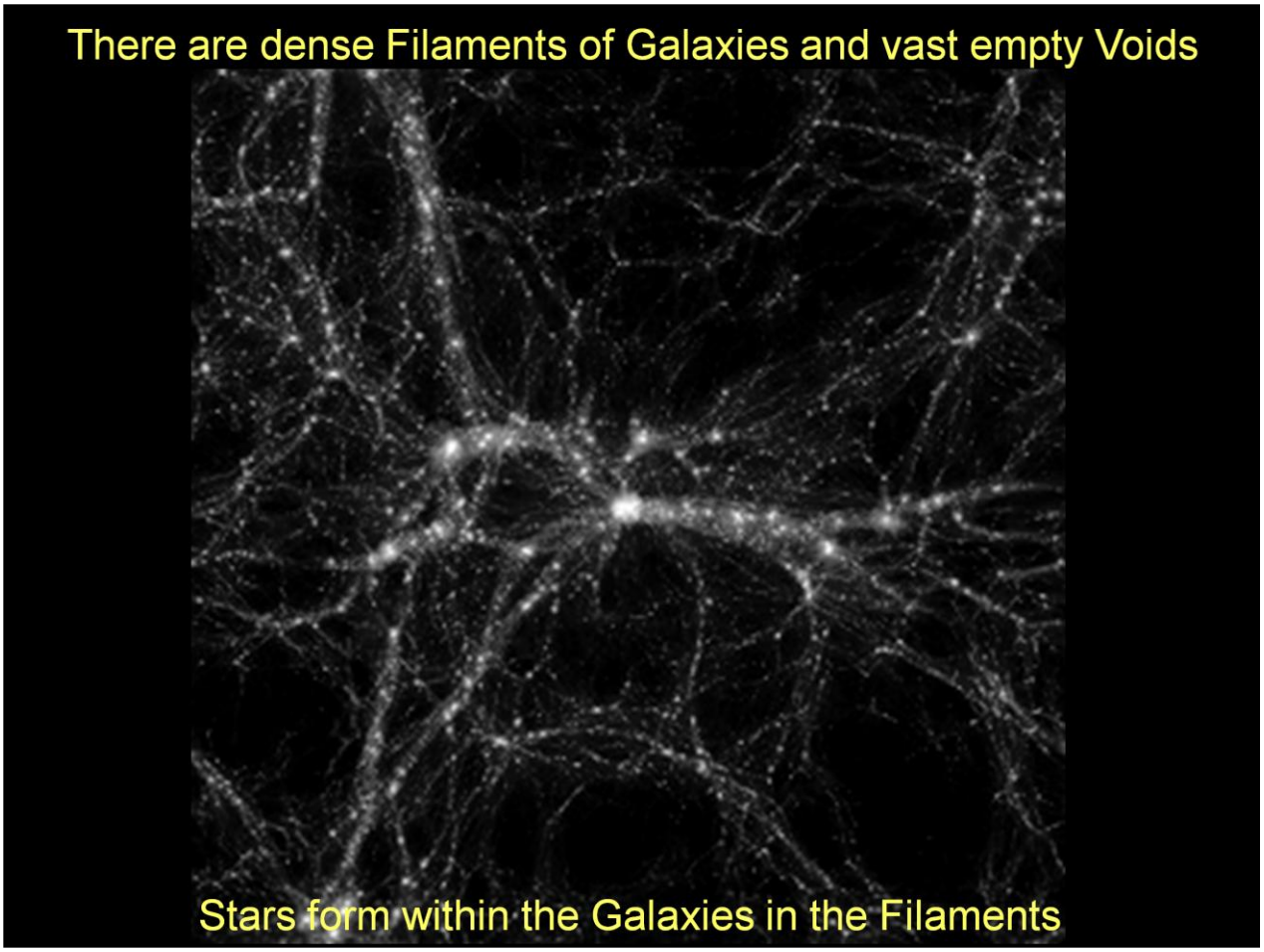
The image above was produced from the data obtained by the Sloan Digital Sky Survey Telescope. It does, as predicted by computer calculations, show a structure of filaments and voids. This structure is on a vast scale that our minds can find difficult to comprehend. The filaments are not comprised of stars they are all comprised of millions of galaxies. Our view in this image is looking above and below our galaxy, the Milky Way. Our view to the sides is obscured by the gas and dust in our own galaxy.

The Sloan camera was also able to measure the Red Shift of the galaxies it imaged. Red Shift is where the colours of the spectrum have been shifted towards the red end indicating the galaxy is moving away from us. If the colours have shifted towards the blue that galaxy would be moving towards us. The faster the galaxy is moving relative to us the further the colours will be shifted.

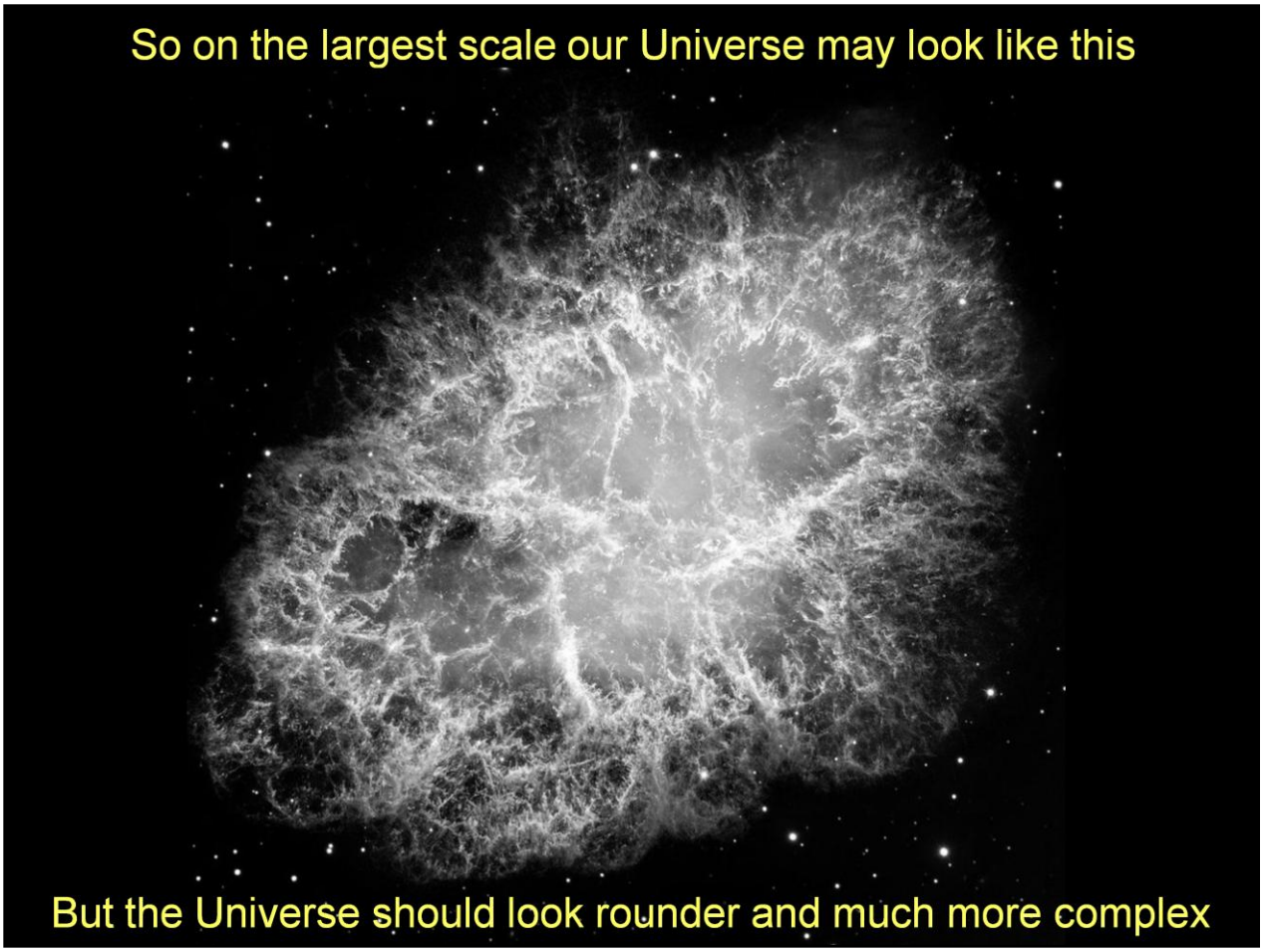
It transpired that all but a very few of the galaxies are moving away from us and the further away they are, the faster they are moving. This is perfectly as predicted by the Big Bang theory. The false colours given the galaxies in the image show red moving away slower through to blue moving away fastest.



So the detailed computer generated image above shows us what the large scale structure of the Universe looks like. Gravity has pulled the original gas from the Big Bang into vast dense filaments. This is where galaxies formed from the swirling mass of atoms of gas (mainly Hydrogen). Within these galaxies individual stars like our Sun formed from the gas. As the gas was pulled into these filaments by gravity it left huge empty areas called Voids where there is almost no matter left.



If we look at these Filaments in more detail we can see the structure of the Universe closer to home. We can see bright spots in the filaments that are Super Clusters of Galaxies containing thousands of galaxies. Within the Super Clusters are smaller clusters like our own Virgo Cluster and within them are local groups like the fifteen or so galaxies that make up our Local Group.



We can never see our Universe from the outside, it is simply too large to even contemplate such a view. So we can only speculate what the Universe might look like. However from what we know, indications are it might look something like the Crab Nebula but probably more spherical, much more complex and unbelievably large. However we do know it is comprised of ‘Filaments’ and ‘Voids’.

This presentation is on our

Beginner's Website:

naasbeginners.co.uk