CHAPTER TWO
THE BIG BANG

The most incomprehensible thing about the universe is that it is comprehensible. [84]

The popular theory among astrophysicists and cosmologists is that the universe started with a phenomena called the Big Bang, the term itself coined rather cynically by its opponent, the esteemed astrophysicists Fred Hoyle. The whole story of the universe, from start to present can actually be broken up into two parts: the agreed and the speculated.

The Standard Model

The agreed part of the universe's life story is encapsulated in The Standard Model. It tells us how the universe became populated with stars and galaxies and the origin of sub-atomic particles. When astronomers probe deeper and deeper into space, they found that matter is evenly distributed. The galaxies may look like individual islands of stars drifting in the velvety darkness of space without any discernible pattern. But when the view is panned out, the individual galaxies dissolved into some smooth pattern covering the whole expanse of the observable universe. Zooming out from Earth to the farthest star, the universe can be described as thus:

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[84] See: rescomp.stanford.edu/~cheshire/EinsteinQuotes.html

> We know that on the scale of the Solar System we see planets and a star: a lot of empty space with a few heavy bodies. As we look on larger scales, we find that we are embedded in the Galaxy, with 100 billion other stars. From further away, we will see that the Galaxy is embedded in a cluster with many other galaxies. From even further away, this cluster is seen to be one of many clusters making up a massive network of filaments, walls and nodes of light, permeated by vast expanses of emptiness. If we look from sufficiently far away, all these irregularities will blend into one faint, smooth texture, just like a large piece of fabric.[85]

When astronomers talk about a galaxy or a star is of such and such age, it does not mean that the star or galaxy is literally that old. On the contrary, it means that the light from the star or galaxy has travelled that long to reach us. The farther the star is from us, the longer it takes for its light to reach us.

The light from the farthest observable galaxy currently took 13 billion years to travel across the vast expanse of space before reaching the eye[86]. Our galaxy, the Milky Way galaxy, was formed some 11 billion years ago. It therefore means that the light from that farthest galaxy left it when Milky Way was not born yet.

It seems that the universe has always been this large and at least as old as the oldest galaxy. In fact, the Greek philosophy is ingrained on the belief that the cosmos is eternal.

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[85] Pedro G. Ferreira, *The State of the Universe* (London: Weidenfeld & Nicolson, 2006), 228.

[86] This galaxy is designated as LAEJ095950.99+021219.1. It was first observed in 2011 through the Magellan Telescope.

This is the simple picture that is conjured up if it is assumed that the universe has always been this large. Unfortunately, the universe is much more complicated than that. The universe, according to the Standard Model, came from an infinitely dense and hot singularity. It then expanded exponentially, forming stars and galaxies. The question is: what is it that is expanding? The Standard Model's answer is that it is the space-time fabric that is expanding, and not the galaxies flying away due to the momentum gained from the Big Bang explosion.

The expansion of space-time fabric is akin to the expansion of a balloon's surface as it gets inflated. Points on it will get further apart because the surface gets bigger. Similarly, the galaxies are observed to recede from each other not because they are flying away from each other, but because the space between them is expanding.

Going back to the analogy of the balloon, two points that are on the opposite side of it will recede from each other faster than two points that are close with each other. This is because the balloon's expansion stretches more surfaces when the two points are further apart.

When space expands between two objects, observers on each of them will notice the other party receding from it. As it expands further, the receding velocity increases. Thus the general rule is that the further a celestial object is from Earth, the faster is its receding velocity.

Similarly, two galaxies further apart will recede from each other faster than two galaxies that are near to each other. The galaxies in this universe are connected through light that travels from one galaxy to another. As space between them expands, the light wave that connects them is stretched to accommodate greater distance. There will be gradual shift to longer wavelengths. This process is called red shift.

When this phenomena was first discovered by Edwin Hubble in 1930s, red shift of galaxies in excess of 40,000 $^{km}/_{sec}$ were discovered. By 1950s, the record receding velocity was 100,000 $^{km}/_{sec}$. Now it is normal to observe quasars with velocity in excess of 270,000 $^{km}/_{sec}$ or 90% of the speed of light!

As time goes by and more space appears between the two galaxies, the stretching will force the wavelength to shift into the region of microwave and later radio wave. With more expansion, the electromagnetic wave is stretched its limit. Not even the longest radio wave will be able to cover the vast distance created by the expansion. The receding galaxy will now disappear from the observable horizon forever. There will be absolutely zero communication with that galaxy[87].

If space appears out of nothing, then surely Earth and the stars will get bigger because the space inside them expands too and eventually there will not be any solid matter left. Everything will eventually explode into sub-atomic particles.

The reason that is not happening lies in the fact that the expansion of space is not the only force in the universe. There is also gravitational force. And gravity acts strongly on concentrated masses. It pulls them together and cancels out the effect of the expanding space inside the mass.

The thought of expanding space naturally leads us to the logical conclusion that if we reverse time, space will shrink to a point of nothing. Mathematically, mass equals to density multiplied by volume. Rearranging the formula, we get density equals to mass divide by volume. Now if volume approaches zero, density will approach infinity because anything divided by

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[87] This is the main reason we cannot observe the moment of the Big Bang. The distance between it and present Earth is too vast for any electromagnetic wave to transverse.