Chapter 2
Stabilizing the Universe

The universe was born restless and has never since been still.
— Henri Rousseau

Intelligence is the ability to adapt to change.
— Stephen Hawking

2.1 The Universe Made of Matter, Energy, and Space Out of Nothing

The universe we live in is a general term for the vast space and the various celestial bodies with diffused matter that exist in it. Although the origin of the universe is an extremely complex issue, people have been persisting in exploring when and how the universe came into being. Until the twentieth century, there were two influential cosmological models of the origin of the universe appeared: one is *the Steady State Theory*, and the other is *the Big Bang Theory*.

On one hand, according to the Steady State Theory, the past, the present and the future of the universe are basically in the same condition, which is equal and constant in terms of structure and has no beginning or end in terms of time.

On the other hand, the Big Bang Theory believes that the beginning of the universe and the time are originated from a huge explosion in the universe. It is the explosion that caused the major galaxies. Meanwhile, the major galaxies and the entire universe are always in a process of constant change and development.

In the Big Bang Theory, around 13.8 billion years ago, the entire universe, in all its mind-boggling vastness and complexity, ballooned into being out of the nothingness that preceded it. Of course the critical question is raised: did God create the Big Bang to occur? We have no desire to offend anyone of faith. So we leave this question out of the scope of this book.

In 1927, the Belgian cosmologist and astronomer Georges Lemaitre firstly proposed the Big Bang hypothesis [1]. In the late 1920s, Edmin Hubble discovered the phenomenon of redshift, indicating that the universe is expanding. In the mid-1960s, Arno Penzias and Robert Wilson discovered the cosmic microwave background radiation. Those two discoveries give strong support to the Big Bang

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theory [2], mainstreaming the Big Bang theory into the formal recognition of the origin of the universe.

In the Big Bang theory, the entire universe, about 13.8 billion years ago, with its incredible vastness and complexity, expanded from its previous nothingness. When the explosion happened, there was a point, where the volume was infinitely small, the density was infinitely high, the temperature was infinitely high, and the curvature of space-time was extremely infinite, called the singularity. At the beginning of the explosion, matter can only exist in the form of elementary particles such as electrons, photons and neutrinos. The continuous expansion after the explosion of the universe caused a rapid drop in temperature and density. As the temperature decreased, atoms, nuclei, and molecules were gradually formed and recombined into ordinary gases. The gas gradually condensed into nebulae, which further formed into various stars and galaxies, eventually forming the universe we see today.

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Despite the vastness and complexity of the universe, it turns out that to make one you need just three ingredients: matter, energy, and space [3]. Matter is the stuff that has mass. Matter is all around us, in our rooms, beneath our feet, and out in space. Water, rock, food, and air on Earth. Massive spirals of stars, stretching away for incredible distances.

The second ingredient we need to build a universe is energy. We encounter energy every day, although you have not thought about it. We use energy to cook food, charge phones, and drive cars. In a sunny day, we can feel the energy produced by the Sun 93 million miles away. Energy permeates the universe, driving the dynamic, endlessly changing processes.

The third one we need is space, lots of space. Wherever we look at our universe, we see space, stretching in all directions.

According to Einstein's theory of relativity, mass and energy are the same physical entity and can be changed into each other in his well-known equation, $E = mc^2$, where E is energy, m is mass, and c is the speed of light. This reduces the number of the ingredients in the "cosmic cookbook" from three to two.

Although only two ingredients, energy and space, are needed to make a universe, the big question is where these two ingredients come from. At the heart of the Big Bang theory, it explains that energy and space are positive and negative, respectively. In this way, the positive and the negative add up to zero, which means that energy and space can materialize out of nothing.

A simple analogy can be used to explain this crucial concept. Imagine we want to build a hill on a flat land, and we don't want to carry soil or rock from other places. To build this hill, we can dig a hole on this fat land, and use the soil from the hole to build it. In this example, we make not only the hill, but also the hole, which is a negative version of the hill. The hill was in the hole, and it perfectly balances out in this process. In other words, the hill and the hole can materialize out of a flat land.

This is the principle behind what happened for the energy and space at the beginning of the universe. When the Big Bang produced a massive amount of energy, it simultaneously produced the same amount of negative energy, which is the space. The positive and the negative add up to zero.

2.2 The Restless Universe

After the universe flashed into existence, it is not as static as it appears. Everything in the universe is endlessly changing to make it more stable. Figure 2.1 shows the timeline of the universe evolution after the Big Bang.

Scientists believe that, in the first moments after the Big Bang, the universe was extremely hot and dense, with a lot of energy. As the building blocks of matter, the quarks and electrons were formed. These fundamental particles roamed freely in a sea of energy. Quarks and electrons had only a fleeting existence as a plasma because the annihilation removed them as fast as they were created. As the universe cooled, the quarks condensed into protons and nucleons after about one ten-thousandth of a second after the Big Bang. Within a few minutes, these particles stuck together to form atomic nuclei, forming the first atoms, mostly hydrogen and helium. The 73% hydrogen and 25% helium abundances that exists throughput the universe today comes from this period during the first several minutes.

The 2% of nuclei more massive than helium present in the universe today were created hundreds of thousands of years later. Electrons stuck to the nuclei to make complete atoms. These atoms gathered in huge clouds of gas due to gravity, and

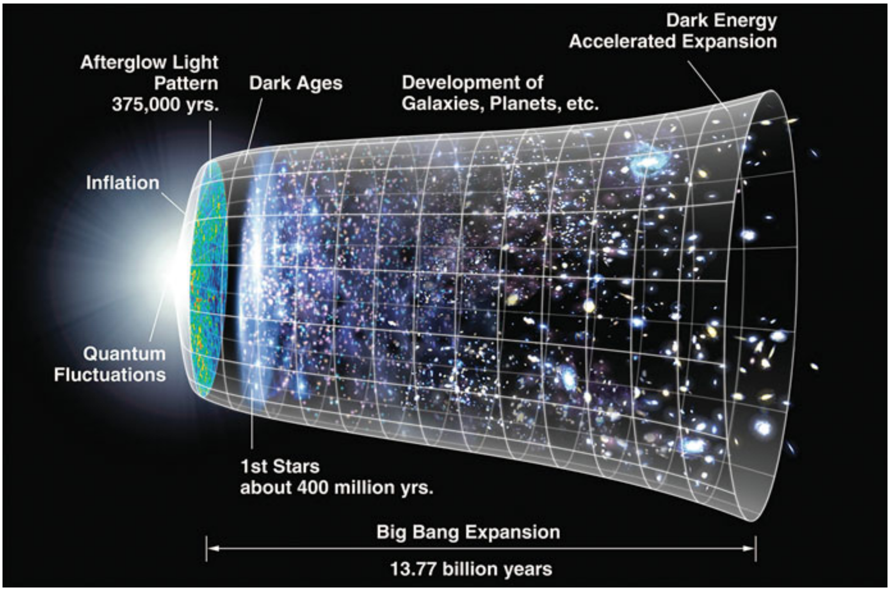

Fig. 2.1 The evolution of the universe after the Big Bang (Courtesy Wikipedia)

galaxies are formed with collections of stars due to gravity, which is the force that pulls any objects with mass towards one another, e.g., that causes falling apples from trees.

Large objects, such as Earth and the Sun, are in motion due to the gravitational force and the electromagnetic force. In addition to motion, the universe has been steadily expanding—increasing distances between galaxies embedded in space. An analogy to explain the expanding universe is a loaf of raisin bread dough. As the bread rises, the raisins on the bread move farther away from each other, but they are still stuck in the dough.

Between the year 1912 and 1922, American astronomer Vesto Slipher observed the spectra of 41 galaxies and found that 36 of them had a redshift, which he believed meant that these galaxies were away from Earth [4].

In 1929, observations by American astronomer Edmin Hubble showed that galaxies were moving away from Earth at a rate proportional to their distance, traditionally known as Hubble's Law. To commemorate Hubble's contribution, in 1990, the National Aeronautics and Space Administration (NASA) invented the space telescope, and named it "Hubble Space Telescope" to commemorate Hubble's great achievements.

In addition, the asteroid 2069 and the Hubble crater on the moon are all named after him. In 2018, the International Astronomical Union (IAU) voted to revise the name of the Hubble-Lemaitre law in recognition of the contributions of Hubble and Belgian astronomer Georges Lemaitre to the development of modern cosmology.

Small particles on the atomic and subatomic level, which are studied in the quantum world, are in motion as well due to the weak and strong nuclear forces. Not only do small particles move, but also they move strangely compared with that seen in our daily lives. Quantum particles can behave like particles, located in a single place; or they can act like waves, distributed all over space or in several places at once. Another strangest aspect of quantum particles is entanglement: if we observe a particle in one place, another particle—even far away—will instantly change its properties, as if these two are connected by a mysterious communication channel.

2.3 Change to Stabilize the Universe

Why is everything in the universe endlessly changing? Although it appears to be demonstrable and fundamental facts, this question is currently not fully answered by science.

One possible reason is that the two ingredients (i.e., energy and space) in the universe make it unstable from the beginning, everything in the universe is constantly changing to make the universe more stable since then. Moreover, due to the space ingredient, energy is vastly distributed in the universe, and it seems that there is no centralized control in this stabilizing process. Therefore, each component is contributing to the stabilizing process in a distributed manner.

This hypothesis can explain why matter in the universe was formed in the first place. Matter was formed to make the universe more stable by spreading energy to relieve the imbalance of energy. This matter-forming process was similar to the way steam condenses to liquid droplets as water vapor cools. The molecules in water vapor are more spread apart than those in water droplets. The change in density is accompanied by spreading energy. In a warm environment, water in the vapor state. The environment and water are in a stable state. When the environment's temperature drops, there is a gradient between the environment and water, and the system is not stable anymore. The environment is in a lower energy state than the water vapor. To make this system more stable, the density of water molecules changes to facilitate energy spreading. Consequently, the water changes from the gas state to liquid state. Similarly, in the matter-forming process, the structures of the particles changed to facilitate energy spreading.

Some other examples including rock rolling and ice melting in our daily lives. More sophisticated examples include living things evolution, collective intelligence, and trending ideas in social networks. We will elaborate this in the following chapters. Particularly, since we are mainly interested in intelligence in this book, we show that intelligence appears naturally in the process of stabilizing the universe, as natural as rock rolling and ice melting.

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