AL KITAB
The Renaissance Project

Chapter 4

From Dust to Star?

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Star Formation

It was a bullet; the catalyst that would ignite one the biggest follies of our time. The assassination of Archduke Franz Ferdinand will always be remembered as a tragedy, not because of his death only, but because of the events that would transpire soon after. World War One would bring the world to its knees; an estimated 17 million(1) people would meet their death.

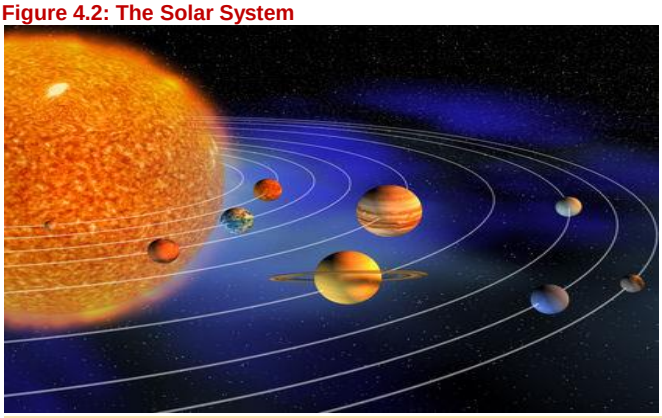
It is amazing how a small sequence of events can alter history. A simple look into the past will provide plenty of similar instances. Take an apple falling from a tree as an example; a common occurrence by any standard. Yet on one particular day, the apple that would land on Newton's head would drastically alter our World.

Figure 4.1: Newton's Apple

The concept of gravity is common knowledge to all. It is an attractive force, the strength of which is proportional to the object's weight. The heavier the object, the stronger its gravitational force and hence, its ability to attract other bodies nearby. If the object is heavy enough, as big as a Planet or Star, it will be able to pull surrounding objects towards it. We experience this force at any particular moment in time. This is what keeps us grounded here on Earth.

It would be very hard to imagine the world without gravity. In fact, it might not even exist. Gravity is not only responsible for keeping us grounded, it is also a critical element in the formation of stars, and consequently, our Universe.

Figure 4.2: The Solar System



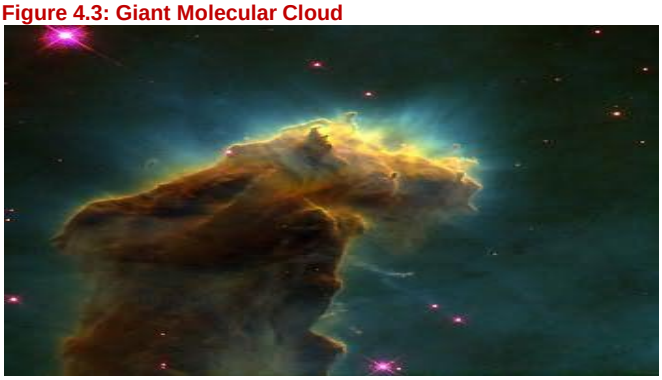
Did you know?

Did you know that Gravitation is responsible for the Earth's orbit around the Sun?

We have investigated The Big Bang and its aftermath in Chapter 2. As discussed, the Universe eventually reached a stage where it was one big hot cloud of elementary elements (Hydrogen and Helium predominantly) and its continued expansion and cooling down finally made it transparent.

The cloud of elementary elements predicted by The Big Bang Theory (Figure 4.3) would go on to produce millions and millions of stars. What was the process you might ask?

Figure 4.3: Giant Molecular Cloud



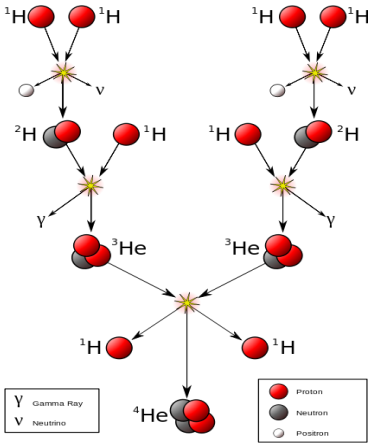
The process of any star formation begins with a giant molecular cloud. The cloud is usually composed of gas and dust particles. In the case of the first stars formed, "Population III Stars", the clouds were composed entirely of elementary gas particles such as Hydrogen and Helium. These clouds, if big enough, eventually "collapse" under the force of their own gravity and the process of star formation begins.

Notes (1): Estimates range from 8 to 20 million and vary by source

Star Formation

The collapse of a molecular cloud, now called Protostar, increases its density and heat. As the gravitational freefall continues, the Protostar becomes so hot that Hydrogen atoms react with one another to form Helium in a process known as “Nuclear Fusion”. The reaction releases an immense amount of energy which counteracts the gravitational pull exerted on the particle. In other words, while gravity pulls particles to the center of the Protostar (collapse) the energy produced by the nuclear fusion of Hydrogen atoms pushes particles outwards. Inside a star, billions of Hydrogen atoms go through this process. The star eventually stops collapsing and stabilizes when the energy released by Hydrogen Fusion is strong enough to counteract the gravitational collapse of a star. This is called the **Main Sequence Stage** of stars and it is often the longest phase in a star’s life cycle.

Figure 4.5: Nuclear Fusion

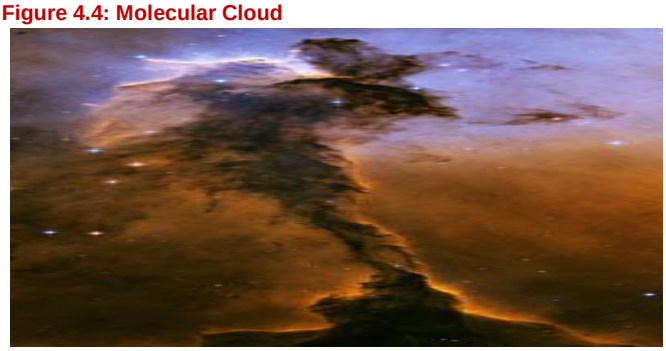


Did you know?

One can think of Hydrogen atoms as the star’s fuel. The star “burns” Hydrogen atoms to release energy that will prevent any further collapse. Our own Sun burns up to 620 metric tons of Hydrogen in one second!

But when a star eventually runs out of Hydrogen atoms, what happens then? At this point, Post Main Sequence Stage, a Population III Star starts to collapse again until its dense core is hot enough to fuse and produce heavier elements, the heaviest of which is Iron.

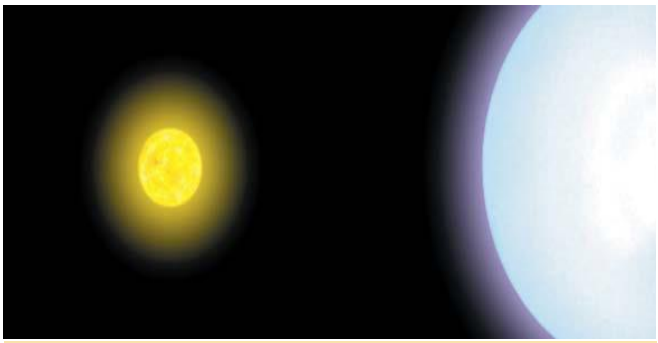
Figure 4.4: Molecular Cloud



Gravitational Freefall – The Science

As a cloud grows in size, gravity starts pulling particles into its center. Clouds often spin as well adding more pressure on particles. The combined force of gravity and cloud movement (driven by electromagnetic forces) pushes particles closer and closer together . Gradually, this tight clump of gas continues to fall on itself, a process known as gravitational freefall. The inner most regions of the cloud fall the fastest as the force of gravity is strongest there. The outer regions take a longer time to succumb. This would eventually lead to the formation of a new star.

Figure 4.6



It is estimated that (Population III Stars) were anywhere between 35 to 1000 times the mass of our Sun!

Fusion of Elements and Star Size – The Science

Average sized stars (such as our Sun) do not fuse elements larger than Helium. They eventually settle down as white dwarfs.
On the other hand, Population III Stars were massive. This allowed them to fuse much larger elements such as Carbon, Oxygen, etc.

Supernova

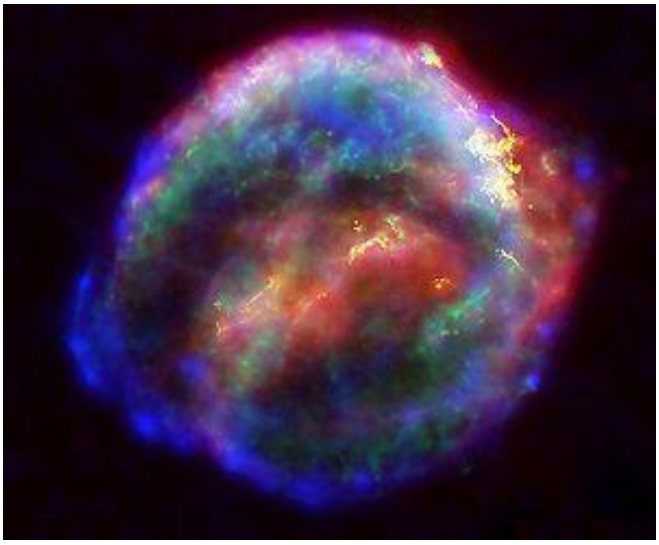
At this stage, the star's resilience will not stop the inevitable; the star collapses. This is because Iron's nuclei is the most stable among elements. Fusion of Iron would require an immense amount of energy that cannot be generated within a star.

Once the Iron Core of a star is equivalent to ~1.4 times[(2)] the mass of our Sun, the star suddenly collapses. The shockwave formed from the star's sudden collapse causes it to shed its outer layers through an immense explosion called "supernova" (see Figure 4.8). The explosion is so ferocious it brightens the night sky millions of light years away and can be easily seen by the naked eye. The viciousness of the explosion allows elements heavier than Iron to be synthesized and scattered across the Universe. Thus, most of the elements we see today are the product of stars.

Iron – The Science

The nuclear binding energy is the energy required to break up a nucleus into its components. In essence, it is a quantitative measure of the nuclear stability. Iron has the highest nuclear binding energy of all elements and would consequently require an immense amount of energy to break its nucleus up.

Figure 4.7: Supernova



Rebirth

As we have seen, the first stars formed after The Big Bang would go on to produce many of the elements we see today. These elements would subsequently be scattered across the Universe through Supernova explosions. What is so remarkable is how the process reinitiates itself.

Clouds, composed of Hydrogen, Helium, and newly formed elements such as Carbon, Oxygen and Nitrogen, begin to form once more and the process of star formation repeats itself; from a molecular cloud to Protostar to Main Sequence and the Post Main Sequence stage of a star's lifecycle.

The material produced by these second generation stars (Population II Stars) will eventually be used to form the stars we are most familiar with today such as our Sun (Population I Stars). Recycling not only seems to be inherent in our Universe's fabric, it is essential to the Universe's development and survival.

Notes (1): Known as the Chandrasekhar limit

The Great "Smoke"

Figure 4.8: Molecular Cloud

Looking at Figure 4.8, it is no surprise that scientists have named this lump of gas and dust particles as a cloud; the resemblance is quite evident. As we have seen, these molecular clouds are crucial to the formation of stars and planets such as the Sun and Earth.

There are a number of verses in the Quran that seem to describe the role of molecular clouds in the formation of our universe, the most prominent of which can be found below:

"ثُمَّ اسْتَوَىٰ إِلَى السَّمَاءِ وَهِيَ دُخَانٌ فَقَالَ لَهَا وَلِلْأَرْضِ ائْتِيَا طَوْعًا أَوْ كَرْهًا قَالَتَا أَتَيْنَا طَائِعِينَ" (41,11)
"فَقَضَاهُنَّ سَبْعَ سَمَاوَاتٍ" (41,12)

"He then turned to the Heaven and it was as smoke and said to it and to the earth: "Come both of you willingly or unwillingly." They both said: "We come, willingly." (11) Then He completed and finished from their creation (as) seven heavens"

The word "دخان" (Dukhan) is often translated into smoke. It is sometimes used interchangeably to describe vapour and gas. Whichever meaning one were to adopt, molecular clouds as seen in figure 4.8 resemble to a great degree, smoke, vapour or gas. The verse states that the Heavens and Earth were in such a state and were consequently turned into "Seven Heavens".

Some readers might wonder what these Seven Heavens are. It maybe some sort of configuration that our Universe currently holds, perhaps seven layers. Another question might arise: "if this verse is indeed referring to molecular clouds, which molecular cloud is God referring to?". Is it the first molecular cloud that created the first stars? Or is it the cloud that produced our solar system? Or perhaps it is describing another stage in our Universe's lifecycle. There are many theories but none are decisive.

As much as one's curiosity craves for answers, we must not be taken by such details and forget the remarkable description contained in this verse. We may never know which cloud the Quran is describing, but the suggested description of molecular clouds and their role in the formation of the Universe found here is astonishing.

Allah also makes another apparent reference to molecular clouds when describing Judgment Day. As we have seen, there is Quranic evidence in support of a Second Big Bang that would produce a new Universe. In the following verse, the author states that during recreation, a great smoke will conquer the Heavens. This is presumably a molecular cloud that will be used to create the future Universe or some of its components.

"فَارْتَقِبْ يَوْمَ تَأْتِي السَّمَاءُ بِدُخَانٍ مُبِينٍ" (44,10)

"Then wait you for the Day when the sky will bring forth a visible smoke"

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Editors

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