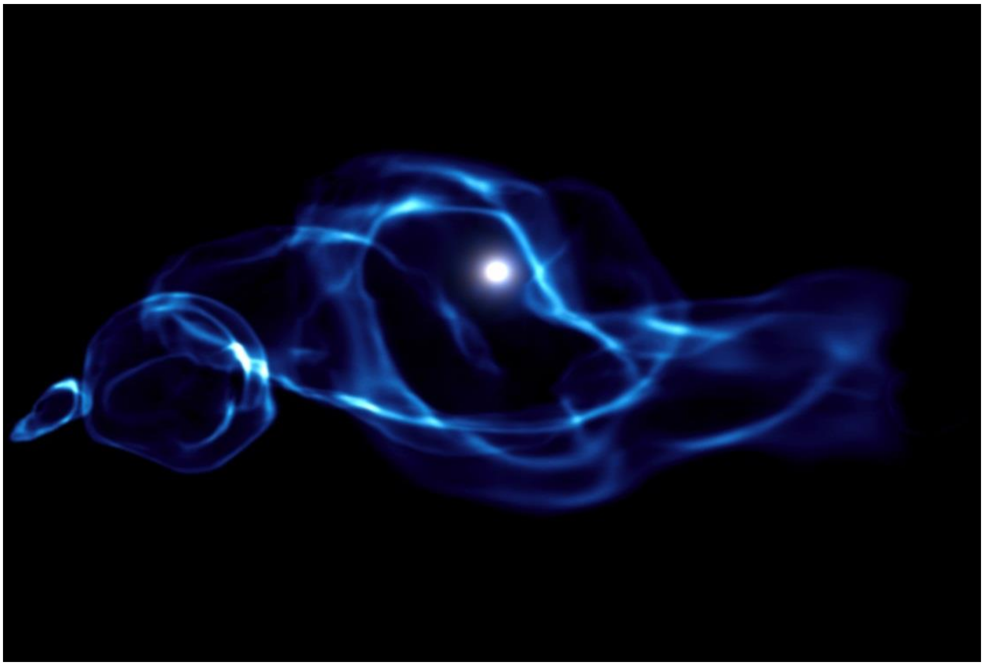
AL KITAB
The Renaissance Project

Chapter 5

Oh Thy Stars Vary!



Mohamed Al Qadi

Neutron Stars and Black Holes

When I was a young boy, I fell on the stairs while playing in my backyard. I was fortunate though; the sharp corner of the step had missed my eye by no more than an inch. The incident left me with a scar above my left eye, the sight of which always reminds me of how invaluable the gift of sight really is.

As we grow up, we not only learn to appreciate the importance of our sight, we learn to put our utmost faith in it. At times, this can be foolish if not dangerous. If you've ever watched a magic show, or walked through a desert, you must know that your eyes can play tricks on you. Whilst a magic show might be entertaining, following a mirage helplessly may lead to your demise. Trusting your sight when looking into the far reaches of space can be just as futile, for space it seems is the trickiest of all matters. This is most evident when discussing Black Holes.

Black Holes, like other ideas, were regarded as no more than science fiction by many. Part of the problem was that they couldn't be seen. It would take another great mind in 1971 to prove their existence. This discovery added more evidence to the theory of the Big Bang. Before investigating what these marvelous entities are, let us investigate how they are formed.

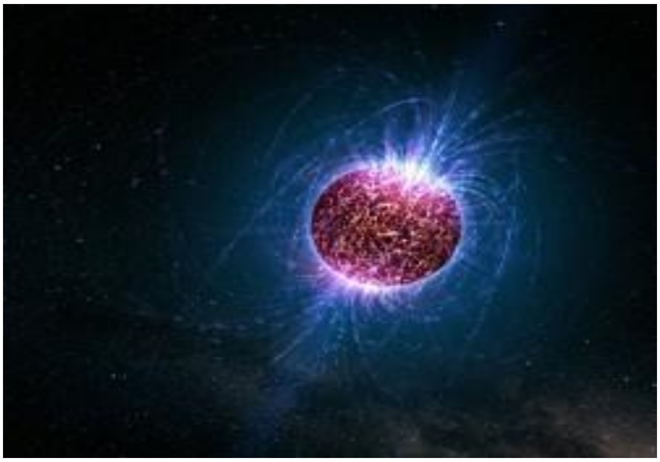
When a star's initial weight is 8 times[(1)] the mass of the Sun or more, it follows a violent path towards the end of its life cycle. We have already detailed how large stars such as Population III stars (see Chapter 4) start fusing heavier elements at the end of their life cycle. We have also seen how the iron core becomes large enough to force the star to implode, blasting much of its outer layers outwards in a gigantic explosion know as a supernova. What we need to investigate next is what happens to the remnant of the star?

If a star doesn't exceed 15-20 times[(1)] the mass of the Sun, the remnant turns into a Neutron Star. There are many kinds of Neutron Stars, the most fascinating of which are Pulsars. They spin at amazing speeds, rotating up to several hundred times per second![(2)] Furthermore, Pulsar stars release radio and x-ray emissions. When the Pulsar's poles are directed towards Earth, radio emissions, like a beam of light, sweep over our plant. We can detect these regular "pulses" (radio signals) since ultra-short radio waves can penetrate the Earth's atmosphere and are not impeded by it.

Did you know?

The most rapidly rotating Neutron Star currently known, PSR J1748-2446ad, rotates at 716 rotations per second[(2)]

Figure 5.1: Artist Impression of Neutron Star



Neutron Stars - The Science

A Neutron Star is ~20 km in diameter and has the mass of ~1-2 times that of our Sun. The Neutron Star is so dense that a teaspoonful would weigh a billion tons. It possesses a surface gravitational field about 2 x 10^{11} times that of Earth and a magnetic field that is a million times stronger. Neutron Stars are born after a supernova which forces the core of the star to collapse on oneself.
Unlike white dwarfs, electron degeneracy is not strong enough to stop this. The force of gravitational collapse is so strong that electrons and protons combine to form neutrons, hence why they are called Neutron Stars. The degeneracy pressure produced by neutrons finally stabilizes the star

Notes (1): Estimates of initial sizes of stars vary. The TOV limit estimates are taken here
(2): Different Neutron Stars spin at different speeds
(3): National Radio Astronomy Observatory; June 12th 2006

Neutron Stars and Black Holes

If however, a star's initial mass is 25 times or more larger than our Sun[(4)], the remnant of the star turns into a Black Hole. To explain what is so special about Black Holes, we must revisit the concept of gravity. As discussed in Chapter 4, gravitation is what keeps us grounded here on Earth. To escape Earth's gravitational pull, one must travel at a sufficiently high speed to do so. This is called "escape velocity" (the speed needed to escape the gravitational pull of a particular object). All objects have an escape velocity, the value of which is proportional to the object's mass. For example, because Neutron Stars are very heavy, their escape velocity may reach 100,000 km/s! Black Holes however, are so heavy and dense that their escape velocity exceeds the speed of light. This means that not even light can escape their gravitational pull, hence why they are invisible. Since nothing can travel faster than light, once an object enters a Black Hole, it can never escape. In effect, Black Holes are like vacuum cleaners that suck everything in their presence, never to be seen again.

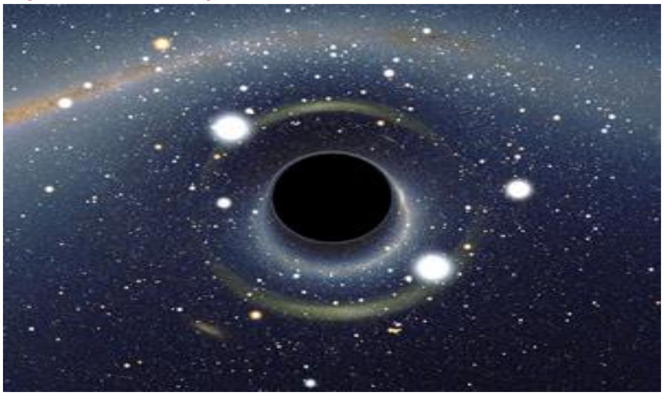
How do we know these phenomenal remnants exist? Beyond their borders, called event horizon, Black Holes continue to pull other stars, objects and planets into their orbit. By observing the orbits of stars and planets, one can detect the presence of a Black Hole and the impact it has on surrounding objects.

The idea that these objects suck anything in their proximity, including light, never to be seen again is utterly fascinating. What is even more wondrous is that Black Holes mimic the singularity point of which our Universe was born from. What this means is because a Black Hole is so dense, time and space do not exist inside it; the gravitational force is so strong that time comes to a stop.

Did you know?

An event horizon is the point of discontinuity in space and time. It marks the border of a Black Hole and anything that ventures past this point is lost forever. Furthermore, any information on the object's shape and size is also lost to the outside observer. Black Holes have different sizes as seen in table 5.1

Figure 5.2: Artist Impression of Black Hole



Black Hole – The Science

Figure 5.2 is an illustration only

Black Holes, like Neutron Stars, are formed after a supernova when the remnant of the star continues to collapse on its self. However, the main difference between Neutron Stars and Black Holes are their respective masses. While Neutron Stars stabilize because of the neutron degeneracy principle, a star forming a Black Hole is so massive that not even neutron degeneracy can stop it from absolute collapse. According to the Tolman-Oppenheimer-Volkof limit, any remnant of a star that has at least 3-4 times the mass of our Sun will continue to collapse and turn into a Black Hole.

Table 5.1[(4)]

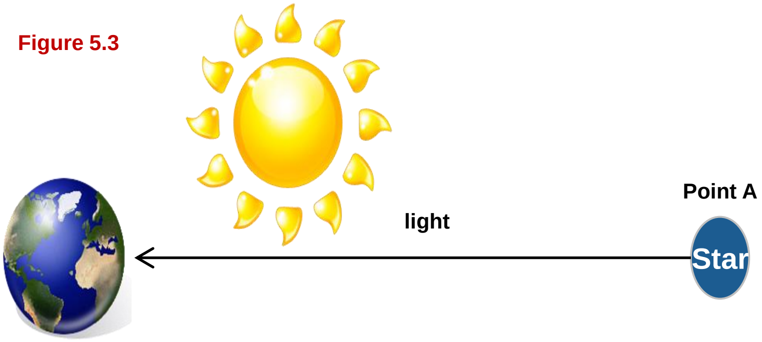
Class	Mass	Size
Supermassive Black Hole	~ 10^5–10^9 Mass of Sun	~0.001–10 AU (the distance between Earth & the Sun)
Intermediate mass Black Hole	~ 10^3 Mass of Sun	~ 10^3 KM (radius of Earth)
Stellar Black Hole	~ 10 Mass of Sun	~ 30 Km
Micro Black Hole	up to ~Mass of Moon	Up to 0.1 mm

Notes (4): Estimates and classification of sizes vary between sources

Stars – where are they?

I have claimed that space is the culprit of many illusions, the invisible Black Holes are a perfect example of this. However, a Black Hole is not the only phenomenon that fools the human eye; in fact, most stars do.

Figure 5.3



A star is visible to an observer on Earth based on the light it emits. By observing the light's source, one can determine where the star is located in relation to Earth's current bearing. For example, in the figure above, the observer tracks light back to its source and is able to determine the location of "star" at Point A.

By doing so, the observer makes the assumption that light travels in a straight line. This however, is not true. We know the gravitational fields of large objects such as the Sun bend light[(5)]. In reality, the Star's perceived position might be at Point A, but its real position is at Point B. Thus, it is quite difficult to determine the correct position of stars although we are becoming increasingly good at it.

Figure 5.4

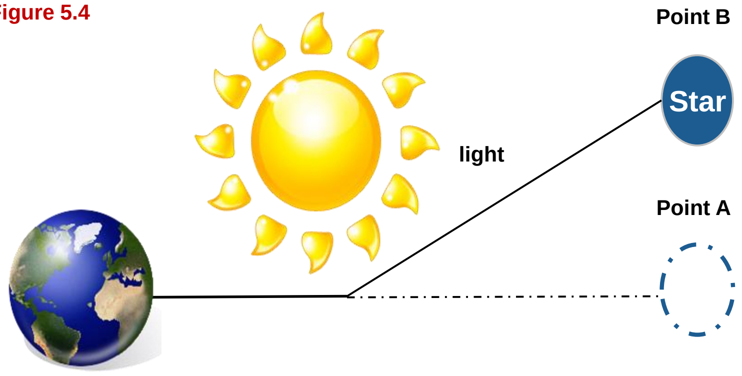
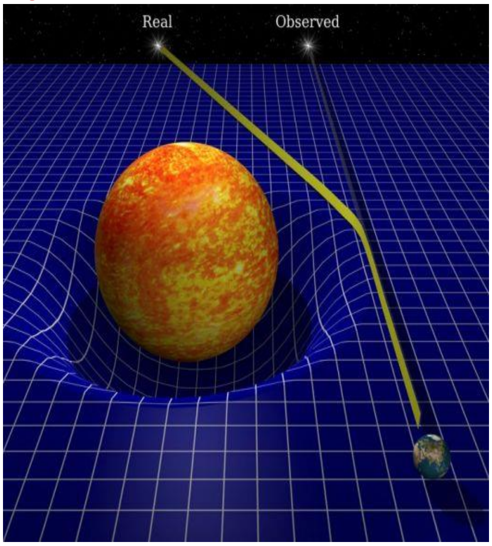


Figure 5.5



Why light bends – The Science

One of the outcomes of General Relativity (1905 AD), Einstein's masterpiece, is the phenomenon known as gravitational lensing. Light bends when it passes through the gravitational fields of a large object. The reason for this is that large objects cause curvature in the space-time continuum, a concept we will explore in Chapter 6.

To conclude, stars pose many problems to an observer here on Earth (though technology is beginning to remove such hurdles). Visible stars for instance could "fool" the observer, while others such as Black Holes are completely invisible. These challenges and the descriptions of different types of stars are found in the Quran.

Notes (5): When discussing bending of light by Gravity, one must remember that this is just a three dimensional way of speaking. In four dimensional space-time, light continues to move along the straightest possible path

Oaths

Oaths are meant to be taken seriously, especially when they are given by God. The Quran contains several instances where Allah swears by a particular entity or phenomenon. Suffice to say, when the Almighty swears by something, it magnifies it. It is as if God is pointing us towards something spectacular for He will only swear by something that is truly marvelous.

As discussed, some Neutron Stars such as Pulsars emit regular pulses that are observed here on Earth. These pulses are usually radio waves that are not hindered by the Earth's atmosphere. If one were to listen to these pulses, they would hear a sound similar to a beating heart or drum. It is perhaps nothing short of extraordinary that the Quran describes the existence of these stars in similar fashion

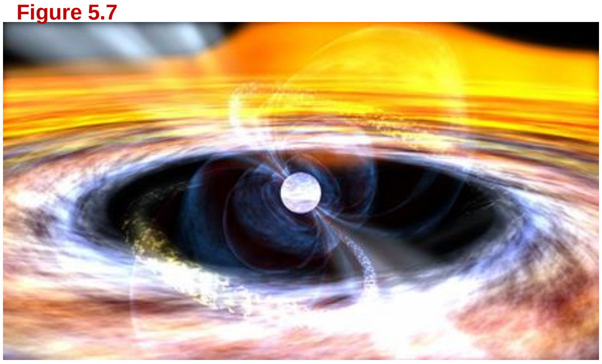
"وَالسَّمَاءِ وَالطَّارِقِ ◌ ومَا أَدْرَاكَ مَا الطَّارِقُ ◌ النَّجْمُ الثَّاقِبُ" (86,1-3)

"By The Heavens and the Tariq(1) How would you know what is the Tariq? (2) It is the piercing star (3)"

The word Tariq in Arabic is derived from the word "Matraqa" which is a hammer. Tariq is thus used to describe the person who uses a hammer or who hammers something. It is also used to describe a visitor because a visitor knocks on the door. Consequently, the word Tariq is used to describe something or someone that hammers / knocks; a knocker. It is a very accurate description of a Neutron Star whose radio waves "hammer" earth on regular time intervals (Listen at **http://www.youtube.com/watch?v=gb0P6x_xDEU**). Furthermore, the description of it being a piercing star adds more weight to this claim since a Neutron Star's emissions are radio waves that penetrate our atmosphere without much hindrance.

Figure 5.6

Figure 5.7



As for Black Holes, we have seen that they are invisible. We have also seen that they have a strong gravitational pull; if any object gets close, the star's gravitational force will pull it towards it until the object reaches the event horizon. Once there, an object can't escape and is lost in the Black Hole forever.

"فَلَا أُقْسِمُ بِالْخُنَّسِ ◌ الْجَوَارِ الْكُنَّسِ" (81,15-16)

"No! I swear by the hiding stars (15) the moving sweepers (16)[5]

Once again, traditional translation fails to properly convey the meaning held in this verse. In fact, before the discovery of the Black Hole, no one knew what this verse meant (which made translation very difficult – various translations articulate this verse in many different ways). Most ancient scholars argued that this verse described ordinary stars which hide during the day and appear during the night.

It is thus best to study the meaning of the words before trying to explain or translate the verse. The word خنس "Khunas" means to hide or recede. It is often used to describe Satan (Khanas) because Satan disappears when Allah is mentioned. The word كنس "Kunas" is derived from the word كنس (Kans) which is to conceal. Hence a vacuum cleaner is a Maknasa because it conceals the dirt by sweeping it. By knowing the meaning of these words, it is likely that the verse is describing Black Holes. Allah has described these stars by the word "Khunas" - hiding and "Kunas" because Black Holes suck in any object that comes close, never to be seen again (in effect, concealing these objects).

Notes (5): No I swear by the Khunas. The Jawari Al Kunas
Traditional translations may read "I swear by the receding stars. (15) Moving swiftly, concealing themselves"

And More Oaths…

But perhaps my favorite Oath in the Quran pertains to the location of stars:

”فَلَا أُقْسِمُ بِمَوَاقِعِ النُّجُومِ َ ◌َ وَإِنَّهُ لَقَسَمٌ لَوْ تَعْلَمُونَ عَظِيمٌ“ (56,75-76)

“No! I swear by the location of stars (75) It is indeed a mighty oath if only you knew (76)

Figure 5.8

While oaths in the Quran are not uncommon, seldom does as an oath get expressed in such a powerful way: “it is indeed a mighty oath if only you knew”. Here, God hints that while all things He swear by are special, this particular oath trumps most others. This is because this oath is very effective in providing a glimpse of how infinitely powerful and knowledgeable He truly is:

There are trillions and trillions and trillions of stars, each larger than our Earth, each separated from the next by tens, hundreds, and thousands of light years. I cannot begin to describe how big our Universe really is, nor how insignificant our planet is in the grand scheme of things. To swear by the location of each one of those stars not only represents the mightiness of God for creating such a vast universe, but of his infinite wisdom in being able to pin point the location of each one of those stars. However, this is not the only reason why this oath is important. After all God has sworn by the stars in other verses in the Quran. So why swear by their location? What makes this greater than swearing by the stars themselves?

In Chapter Two, we discussed how light travels at a finite speed. Consequently, when we look at stars that are far away, we are seeing them in the past (see Chapter 2). We can never see how these stars currently look like nor where they currently are as star light takes hundreds, thousands, and sometimes millions or billions of light years to reach us. Though we might be able to identify the location of a star in the past, we can never be certain of its current state or position. This problem is not limited to Earth. Any observer in any part of the Universe will experience the same problem due to the limitations on the speed of light and the vastness of our Universe. The problem is augmented by light’s tendency to bend when passing a strong gravitational field making it harder to identify where the star used to be in the past, let alone its current location. The only conceivable way that any entity could know the exact location of all stars at any given time is that the entity doesn’t abide by the rules of our Universe. God is not limited by any rules, certainly not the ones he created for our world. His presence cannot be related to the Universe for He doesn’t exist within it. It is one of the strongest statements of God’s nature and power, the Almighty indeed. The manner in which this oath is emphasized is indicative of the Quran’s knowledge of the impossibility of such a task; a realization we’ve only come to recently.

I now ask the reader to think about some of the material presented in the first few chapters of this book. Was this was all a big coincidence? Creative thinking by people who want to believe? Or is it more likely that this Quran is truly special?

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Photo and Figure Sources

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- Figure 5.2 Credit: Alan R.
- Figure 5.6 & 5.7 Credit: NASA

Editors

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