

Golden Ratio and Beautifulness in Nature: Beauty of Astronomical Objects in a Layman’s Eye

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Abstract

Philosophers and scientists have tried to understand but science can not yet tell us what beauty is. Beauty is confined to the beholder, i.e. observers enjoy the beautifulness of the real/physical objects ranging from micro-scale to macro-scale, through eyes that make observer’s brain active, then decoding finally make the actual image inside the brain that finally help the beholders to enjoy the beauty of natural objects. Golden Ratio exists everywhere in the beautiful world, i.e. beauty in real object means its association with Golden Ratio and/or Fibonacci sequence. So far observed the most distant/furthest area with the help of advanced space observatory, modern radio telescope, hints that Golden Ratio is also exist there. The hyperbolic model of the universe hints that Golden Section also exists in the form of Fibonacci and Lucas functions in the hyperbolic Universe. So, the question arises—“Is the Golden Ratio a universal constant for self-replication?” Is the Golden Ratio a subtle creator of the beautiful objects in the beautiful worlds? The author introduces, within the article, the role of the Golden Ratio for making the astrophysical objects beautiful in the Universe.

Keywords

Golden Ratio; Fibonacci Sequence; Spiral Galaxy; Hyperbolic Universe

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1. Introduction

1.1 Truth vs Beauty

“Truth is beauty, Beauty is truth” means whatever may be, the “Truth” is always beautiful, simultaneously beauty, in fact, physically true, i.e. physically real that can not be touched, tasted or other means, except that can be observed through eyes. This means that beauty which is real, true is confined within our human eyes. This raises a question in our mind — What is beauty? In the physical sense “Beauty” is commonly described as a feature of objects that makes them pleasurable to perceive. Such objects include landscapes, sunsets, humans and works of art. In the philosophical sense “Beauty” is an art and taste of aesthetics i.e. a combination of qualities, such as shape, colour, or form, that pleases the aesthetic senses, especially the sight. For example: a beautiful woman means — “she was considered a great beauty in her youth” implying that the quality or group of qualities in a person or thing that gives pleasure to the eyes as well as in mind. If we look into the Logo of Institute for Advanced Institute, Princeton Universe, USA it will be much easier to understand what is a physical beautifulness (see Figure 1). In other words it can be said that the beauty is nothing but a covered “Truth” or uncovered (see the art “David”) which can be unraveled only by our human eyes only.

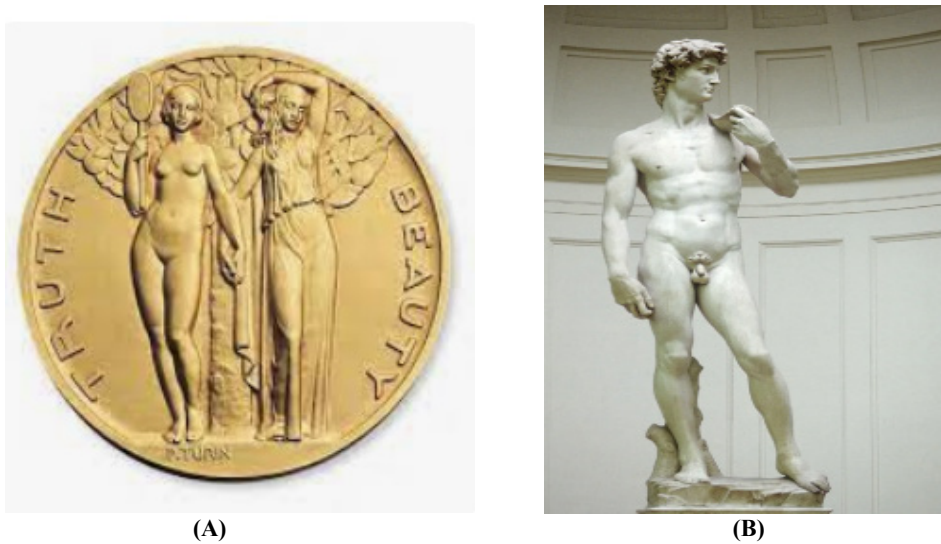


Figure 1. (A) represents the Logo of Institute for Advanced Studies, Princeton University, USA, and (B) “David” by Michelangelo (courtesy: Wikipedia).

1.2 Nature vs Astronomy

If we look into the mid-night sky in a clean weather night one can see billion diamonds are placed in the sky wall in a twinkling mode, so called “Indrajaal” in one’s eyes. One can get a taste of beautifulness that exists. He can be surprised while enjoying the beautifulness of the “mid night” keeping a question in mind — “How beautiful the night sky is”? “Who creates this beautifulness in nature”? “Does this beauty confine within the eyes of the observer only”? “How this beautifulness is created in nature”?, etc.

Again in an open ground field when we look to see what is around us we can see a beautiful natural scenery created by different objects in nature i.e. sky, trees, other objects including groundfield itself combinely (see Figure 2). The same questions spontaneously arise in our mind — who is the creator of this natural beautifulness (which is beyond of touching) that we are enjoying throughout day and night.



Figure 2. A natural beauty what an observer views in his/her eyes in an open space surrounding us.

Initially, scientists were in puzzle mood in explaining how nature spontaneously creates this natural beauty. Ultimately, they unravel this secret what is now known as “Golden Ratio”. Scientists, astronomers are still in puzzle by observing the fact that this Golden Ratio exists in each beautiful objects everywhere in our universe ranging from microscopic scale, such as RNA, DNA, Nuclear Structure, to the macroscopic scale like surrounding environment,

galaxy, a group/cluster of galaxy, including our whole universe as an entity of single Universe (?). This implies that the Golden Ratio exists in all fields i.e., say physics, astrophysics, biology, chemistry, mathematics, arts, architect, economics, etc.

The main aim of this paper is to give a broad view of Golden Ratio to the readers so that they can get an essence of Golden Ratio that exists within our own body itself, its surrounding environments as well as far away beyond our imagination.

2. What Is Golden Ratio

The Golden Ratio, also known as the “golden proportion” or the “divine proportion” is a ratio between two numbers that equals approximately 1.618.... Usually, it is written as the Greek letter “phi” (ϕ). It is also associated with the “Fibonacci Sequence” i.e. a series of numbers wherein each number is added to the last. The Fibonacci numbers are 0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55.....and so on, such that the ratio of each number and the previous number gradually approaches to 1.618 or phi (ϕ). For example,

$$2 = 1 + 1, 3 = 2 + 1, 5 = 3 + 2, 8 = 5 + 3, 13 = 8 + 5, \text{ and so on.}$$

For ratio,

$$3/2 = 1.500000$$

$$5/3 = 1.6666666667$$

$$8/5 = 1.6000000$$

$$13/8 = 1.62500000$$

$$21/13 = 1.6153846154$$

$$34/21 = 1.619047619$$

$$55/34 = 1.6176470588$$

and so on.

Mathematically, the Golden Ratio represents a mathematical connection for the shape of the objects portraying from longer side to the shorter side.



$$\text{i.e. } A / B = (A + B) / A = 1.618....$$

The value of this golden ratio (ϕ) can be expressed in another form, i.e.

$$\Phi = \lim_{n \rightarrow \infty} \frac{F_n}{F_{n-1}} = \frac{1 + \sqrt{5}}{2} = 1.618033$$

where Fibonacci numbers $F_n = F_{n-1} + F_{n-2}$ with $F_1 = F_2 = 1$.

In fact, as this ratio is apparently found in all the objects throughout the nature [1] such as the stems of plants, skeleton of animals, eggs, whirlpool Galaxy, the shape of Nautilus, shells, Hurricane, distribution of planets, moon, asteroids, rings of solar system, geometric shapes of the universe, etc. scientists believe that the reason behind this ratio ϕ is so ubiquitous that it is actually a property of space-time.

2.1 History of the Golden Ratio

According to the available, old historical records indicate that the first known mention of the Golden Ratio is from around 300 BCE in Euclid’s book “The Elements” and his other works on mathematics and geometry written in Greek language. Although the mathematician Pythagoras mentioned the term “proportion” in many of his works but not use the term “Golden Ratio”. However, in 1509 Italian mathematician Luca Pacioli in his book “De Divina Proportione” [2] praised the Golden Ratio as a representation of divinely inspired simplicity and orderliness through illustration drawn by Leonardo da Vinci (see Figure 3). This joint form, i.e. book written by a great mathematician Pacioli and Leonardo’s illustration i.e. art designed by world famous artist, play crucial role for gaining fame among the circle of mathematicians and artists.

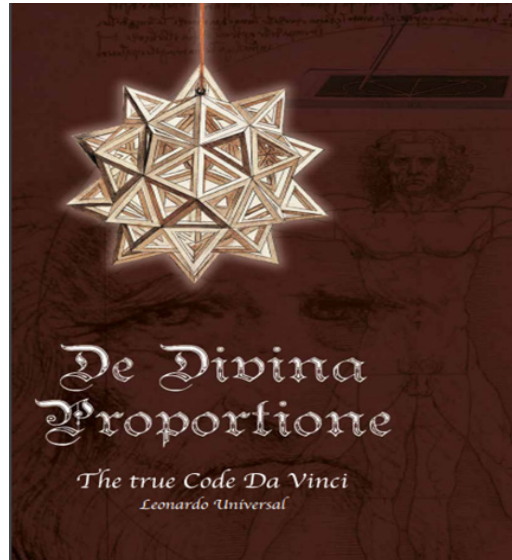


Figure 3. Shows the illustrated page of the book written by Luca Pacioli (adopted from Patrimonio Ediciones; <https://patrimonioediciones.com> > 2018/02).

2.2 What Makes the Objects Pleasant the Eyes?

Initially, around 300 BCE the uses of ratio in mathematics and geometry were known from the works of Euclid, especially Pythagoras recognized prop (not in the name and norm of Golden Ratio). Later in 1509, using Leonardo Da Vinci's art work as illustration in his book "De Divina Proportione" Italian mathematician Luca Pacioli [2] first praised the "ratio" stating as representative of divinely inspired simplicity and orderliness. Since then the term "Golden Ratio" created an enthusiasm among the artists and mathematicians with a claim that this ratio is simply a number that mathematically pleasuring to our eyes but it a mathematical distillation of beauty through golden ratio line segments, golden rectangle tune side lengths and golden triangles. Not only that, it is also argued that the golden ratio is aesthetically pleasuring because of it's commonness in the natural world.

Now question is — "How the brain response to Beauty"? According to the scientists origin of beauty is an enigmatic in our brain as it is in the real or physical world. Again, question is — "What part of our brain responds to beauty"? The answer is very difficult but in general the answer depends on whether we see the beauty as a single category at all. This means the idea of a "Beauty Center" which have hypothesized that it may live in the orbito-frontal cortex, the ventromedial prefrontal cortex or the insula. If the idea of "Beauty Center" is correct, then we need what actual part or origin inside the brain which is responsible for decoding the beauty images.

Weiss and Weiss [3] attempted to understand the principle of information decoding by the brain from the data of EEG (electroencephalogram). They found a strange result which indicates that the metric of brain waves as a superposition of 'n' harmonics times 2ϕ where half of the fundamental (i.e. ϕ) represents the point of resonance (i.e., golden mean). This means that the golden mean act as important clock cycle of brain waves.

Regarding aesthetical effect it is true and known to us that golden ratio is tuned in all the aesthetically pleasuring images. Question is — Why is the golden ratio so pleasing? Scientists believe that this structure, based on this proportion is the easiest for the eyes to scan, and for the brain to process the important actions and finally to recreate the image, especially when the longer side is horizontal. When one scan left to right, the left eye will take over when what one is looking up right eye's field of vision. But when one is looking up and down, on that time both eyes work at the same time simultaneously and this takes longer time to scan the area. Therefore, golden ratio associated shape or structure is easiest for the eye to process.

According to the scientists —

- (i) 'soft', 'round' shaped objects are more, more aesthetically pleasing than sharp objects;
- (ii) Our eyes and brain perceive 'soft' and 'curvy' items as being similar to living organisms, implying that the brain perceives these objects friendly, food, or something else appealing.

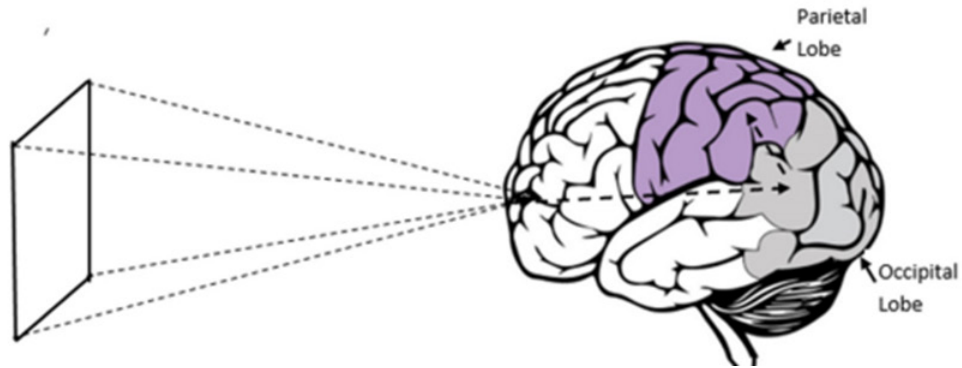


Figure 4. Schematic diagram showing the responsible part of the brain to observe a dimension or shape (adopted from ref. [6]).

Therefore, looking objects if they are more appealing means that are more aesthetics, whereas less appealing indicates the objects are sharp, dangerous or inedible i.e. non-attractive. In other words, Golden ratio possesses an innate appreciation for the aesthetic harmony while Fibonacci pattern transcends disciplinary boundaries for beauty, aesthetic creation [4, 5].

3. Golden Ratio in Astronomy

3.1 Connection Between the Numbers Phi (ϕ) and Pi (π)

Egyptians were aware regarding the use of the golden ratio (ϕ) when building the temples and also places for the dead. So, they called this golden ratio (ϕ) as the “sacred ratio”. Around 2560 BC they faced a problem during the design of “Cheops Pyramid” in Egypt. It was geometrical problem in calculating the actual dimensions of the shell used in Pyramid. The outer part of the shell turned to smooth while inner part remains rough-shaped — thus, difficulties in calculating the original dimension.

To overcome this difficulty, they inscribed circle in the square pyramid and before the construction of the Pyramid they determined the side length (d) of the square pyramid on the ground and then found the inscribed circle of a circumference (C) which is equal to Pi times the side length i.e. $C = \pi d$. From careful measurement they were finally able to approximate the value of π close to $(\pi) = 3.1415927$.

Therefore, three mystic numbers ϕ , π , and 3 arose. The significance is that it established a geometrical and mathematical bridge between the universal constant π and the golden ratio ϕ by interrelating the construction of the area of a circle [4].

3.2 Golden Spiral

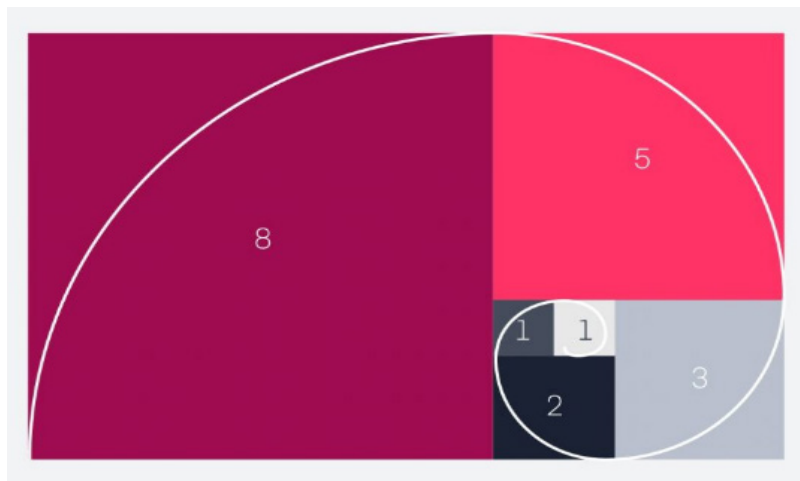


Figure 5. Schematic diagram of Golden Spiral in “approximation” method.

A Golden Spiral in geometry is a representation of a “logarithmic” spiral whose growth factor is (ϕ) such that when a golden spiral gets wider or further from the original then it follows a factor ϕ for every quarter turn it makes. This means that a “golden spiral” is that approximate one among several comparable spirals but don not exactly equal (see Figure 5).

3.3 Approximation of the Golden Spiral

This golden spiral can be approximated by first starting with a small rectangle such that the ratio between its length and width is the golden ratio. Then this rectangle can be partitioned into a square and a similar rectangle and again this rectangle can be split in the same way. Continuing this process for an arbitrary number of steps, the obtained result will be an almost complete partitioning of the rectangle into a number of squares such that the corners of these squares can be connected by quarter circles. This final result, though not a true logarithmic spiral, but one closely approximates a golden spiral.

4. Golden Ratio, Golden Spiral in Astrophysical Objects

The letter “ ϕ ” has a special property i.e. its decimal representation is equal to “never repeating”, “never ending” number $\phi = 1.6180339887\dots$. Looking back into the past, we see that first this (ϕ) appeared in astronomical symbol, known as “Pentagram”—the five pointed star (see Figure 6a) as a symbol for a star. In fact, each one of the five side triangles in this Pentagram the ratio of the side to the base matches precisely equal to ϕ . Not only that, to represent the cosmos as a whole Plato used the symbol “Dodecahedron” (see Figure 6b) which he thought it as “God used embroidering to express the Constellation as a whole heaven” [2]. Note that if one considers an edge length of a dodecahedron of “1” unit then its total volume = $5\phi / (6 - 2\phi)$ units. Not only that, in some observation of the “afterglow of creation” via the Cosmic Microwave Background Experiment (COBE) astronomers found that the observed results could be explained if the Universe is, in fact, finite and shaped like a dodecahedron.

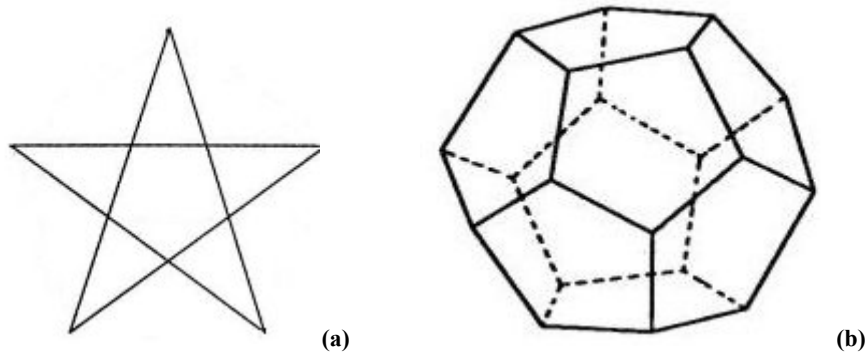


Figure 6. Represents (a) a Pentagram, and (b) a Dodecahedron.

From our daily life observation we know that golden ratio manifests in:

- (a) Plants → through the pattern and structure of leaves, flowers and seeds;
- (b) Animal bodies → through the measurement from the tip of an animal’s head to the beginning of its tail, such as fish, birds, certain animals like ram, cats.
- (c) Human faces and bodies → through the proportions of their own bodies and faces. In such a way what is considered aesthetically pleasing or harmonious in human proportions. For example, the ratio of the distance between the eyes to the width of the mouth, length of the face to width, etc.
- (d) Natural structures → related to Fibonacci patterns not for just aesthetically pleasing but also represent solutions to various natural optimization problems. i.e. the arrangement of leaves or seeds in certain patterns that can minimize exposure to sunlight, air, and nutrients. For example, in the case of honeybee hives, the hexagonal packing of cells where a pattern is associated with Fibonacci numbers which provides a highly efficient use of space and building materials.
- (e) Natural design (reproduction) → presence of Golden Ratio as a factor in aesthetic appeal that influence mate selection (i.e. indirectly natural selection) implying that features or organisms that approximate for more likely

for successful reproduction.

- (f) Astrophysical objects → related to Fibonacci patterns in large scale measurements such as Saturn's ring, solar system, galaxies.

Due to limitation we shall discuss the presence of Golden Ratio or Fibonacci pattern exists in different astrophysical objects, systems, etc.

4.1 Golden Ratio in Solar System

It is believed that formation of our solar system took place with the explosion of unknown supernova. Explosion of that supernova produced the stardust that would eventually form planets, asteroids, and also other celestial bodies. Our present knowledge indicates that the amount of matter in each section of the solar system was proportional to the Golden Ratio (GR). As a result, our solar system is a harmonious and efficient system.

It is also argued that our Solar System was formed from the remnants of multiple supernovae. Whatever may be, the possible fact is: the explosion of supernova releases vast amount of energy as well as scattered residual matter into space. This scattered materials contain heavy elements including gold, platinum, and Uranium resulting which we observe that our earth is a rocky planet.

As mentioned earlier that the existence of Golden Ratio or golden proportion is intrinsic in nature in different forms or design. Many papers and texts focus on this Golden Ratio in our Solar System and also in the Universe.

4.1.1 Dimensions of the Earth and Moon Are in Golden Ratio

As per observational available data,

Radius of Earth (A) = 6378.10 km and radius of Moon (B) = 1735.97 km.

The total length of the radii (Earth + Moon) (A + B) = 8114.07 km.

Thus, the hypotenuse (C) (see Figure 5), where $C^2 = A^2 + B^2$, i.e. $C = \sqrt{A^2+B^2} = 10,320.77$ km.

Proportion of Hypotenuse to Earth radius (C / A) = 1.618157445.

Considering the calculation to 12 significant digits $\phi = 1.61803398875$ which is different from ϕ by only 0.007% only.

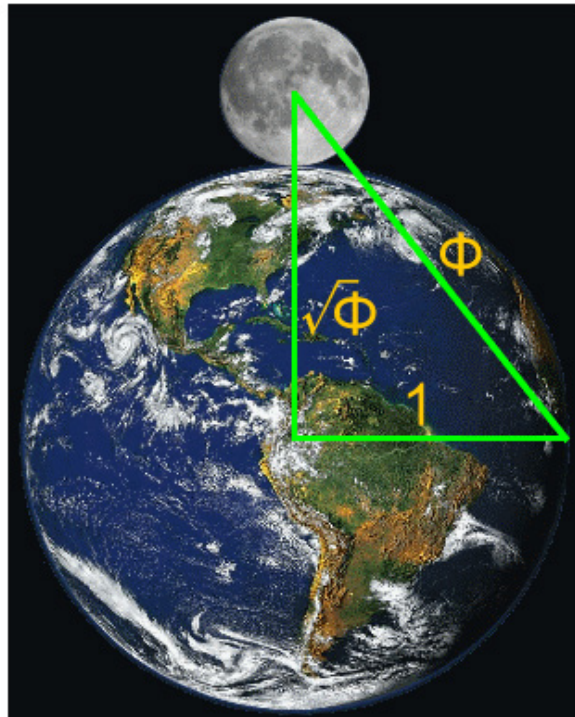


Figure 7. The illustration shows the relative sizes of the Earth and the Moon to scale (courtesy: Wikipedia).

4.1.2 Sun and the Orbit of the Moon

Mercury orbits the Sun in 87.968 earth-days, i.e. it creates a conjunction with the Earth in every 115.88 days. Our

Earth takes 365.24 days to complete one orbit around the Sun. Therefore, there are $365.24 / 115.88$ conjunctions in a year which is 22 conjunction in 7 years. The means that conjunction per year = $22 / 7$ which is equal to π .

4.1.3 Average of the Mean Orbital Distance of Each Planets w.r.t. Mercury

Ceres (minor-planet designation: 1 Ceres) is a dwarf planet in the middle main asteroid belt between the orbits of Mars and Jupiter. Note that it was the first known asteroid, discovered on 1 January 1801 by Giuseppe Piazzi at Palermo Astronomical Observatory in Sicily, and announced as a new planet. Ceres was later classified as an asteroid and then a dwarf planet, the only one inside Neptune's orbit. The total number of planets then becomes 9.

Table 1 shows the relative mean distance of planets relative to Mercury =1. The average value obtained for 9 planets is 1.61874 which is equal to the value of $\phi = 1.61803398875$ with a degree of variance = 0.00043.

Table 1. Show 9 planets with their relative mean distance w.r.t. Mercury

Planet	Mean distance in million kilometers (as per NASA)	Relative mean distance where Mercury = 1
Mercury	57.91	1.00000
Venus	108.21	1.86859
Earth	149.60	1.38250
Mars	227.92	1.52353
Ceres	413.79	1.81552
Jupiter	778.57	1.88154
Saturn	1,433.53	1.84123
Uranus	2,872.46	2.00377
Neptune	4,495.06	1.56488
Pluto	5,869.66	1.30580
Total		16.18736
Average		1.61874

4.1.4 Golden Ratio in Planetary Distances

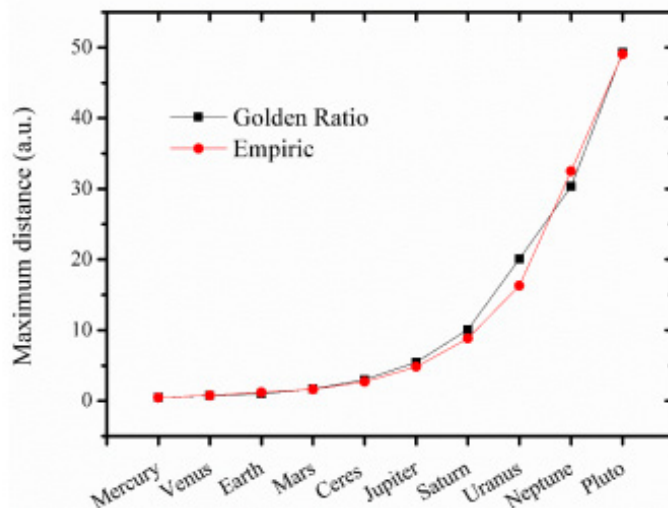


Figure 8. Comparison of maximum planetary distances as obtained by Cordeiro et al. [7].

In a recent study of searching the Golden Ratio in planetary distances Cordeiro et al. [7] calculated the minimum and maximum distances using the known astronomical distance (a. u. = astronomical unit) of the concerned planets, with respect to the Sun, in our solar system. In this method they considered two concentric circles C_1 and C_2 such

that $A(0,0)$ represents the center of the two circles with $B(x_0, y_0) \in C_1$ and $C(x, y) \in C_2$ so that segments \overline{AB} , \overline{BC} , \overline{AC} obey a golden ratio. The relative error they estimated through the relation $r_2 = 0.618034 r_1$, where r_1 and r_2 are the radius of the concentric circles C_1 and C_2 , respectively.

Figure 8 shows the comparative results obtained by Cordeiro et al. [7] which clearly indicates that planets in our solar system follow the Golden Ratio.

4.1.5 R R Lyrae Stars Follow Golden Ratio

During the analysis of Kepler Space Telescope data John Linder and his group found a typical variable star called R R Lyrae stars. The specialty of these stars have variability in their Brightness (see Figure 9). These stars brighten and dim as their atmospheres expand and contract due to periodic pressure changes. In particular, each star pulses with a “primary” frequency while shows smaller brightness fluctuations occurring on a secondary frequency. The ratios between these two frequencies are very important because they are characterized by the inner structure of the stars. This means that if a such type star exhibits many modes implying that observation of the frequencies gives very strict constraints to the stellar models. Analysis of the observed data for four of the six RR Lyrae, such as star KiC5520878, showed that the ratio of the primary to secondary frequencies was very close to the Golden Ratio within 2% error in variability [8, 9].

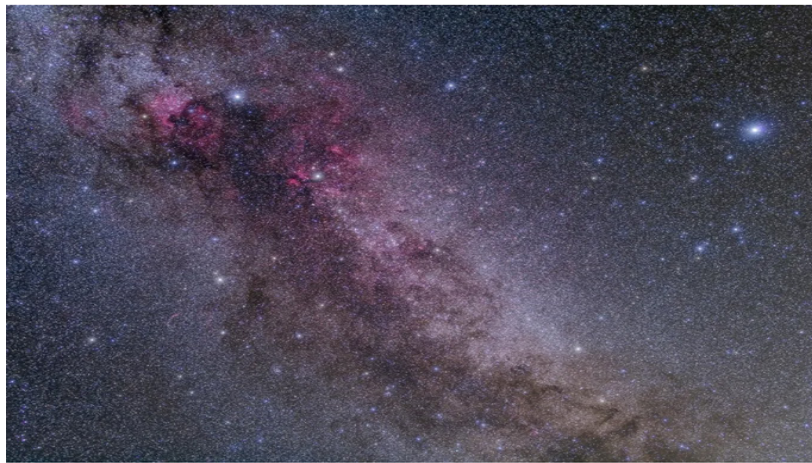
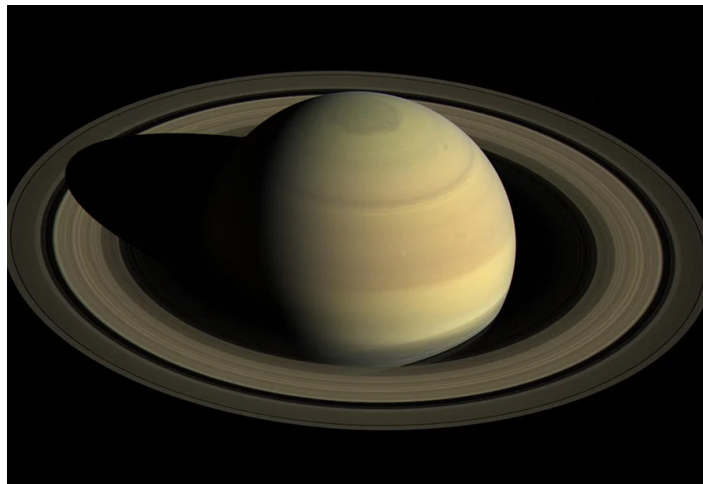


Figure 9. R R Lyrae Stars (which are variable star flickering to the Golden Ratio), bright blue colour, are in Constellation Lyra, bisected by the Milky Way Galaxy (Adopted from Alan Dyer.Inc/visualunlimited/corbis. Photo Credit: Prof. Alan Dyer).

4.1.6 Saturn’s Diameter and Its Rings



(a)

Figure 10(a). Saturn and its rings, as seen by the Cassini spacecraft in 2016 (Photo credit: NASA/JPL-Caltech/Space Science Institute).

Saturn is called the jewel of the solar system because of its magnificent rings (see Figure 10a). Cassini-Huygens satellite was sent in space for precisely observation of Saturn’s ring with measurement. The Saturn’s rings appear golden as the planet’s shadow drapes almost the whole span of the ring.

Scientists found from the analysis of obtained data that the inner ring division follows in a relationship that is very close to ϕ w.r.t. the diameter of the rings outside the sphere of the planet [10]. In fact, Saturn has the most extensive and also complex ring system. Voyager 2 space craft observed the Saturn’s ring very closely and decoded information indicates that Saturn’s ring is basically a system consisting of thousands of rings but this can be grouped into 4 or 5 clusters.

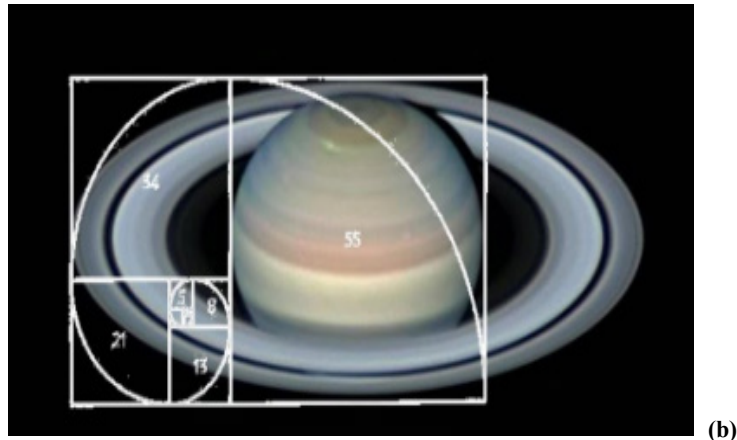


Figure 10(b). Saturn’s diameter and its ring obey the Golden Ratio (Photo credit: Dyslexic Artist Theory on the Physics of 'Time' on you tube).

4.1.7 Moon and the Golden Ratio

The purpose of NASA’s Gravity Recovery and Interior Laboratory (GRAIL) mission was to uncover the moon’s uneven gravity. By analyzing the data obtained from this mission scientists found the locations of large, dense regions called mass concentrations (called “mascon”). The characteristics of this mascons is strong gravitation pull. As a result, this mascons appears in a target pattern on the map of the moon’s gravity field i.e. looks like a bull’s eye (has a strong or gravity surplus) which is surrounded by a ring with a gravity deficit. A pattern is formed like a ring with a ring with a gravity surplus surrounds the bull-eye and the inner ring. This implies that due to variation in its density, precisely, a difference in gravity between the near and far side of the moon.

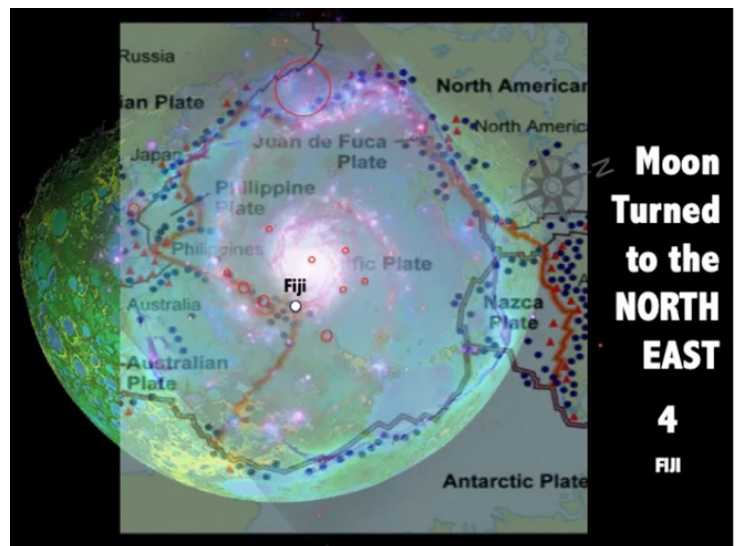


Figure 11. Shows path of the moon over the Pacific Region under Grail Mission operated by NASA (Figure adopted from ref. Beaubier 2022 [8]. Photo credit: NASA).

Scientists found that **moon’s surface shows the presence of Golden Ratio pattern, such as the Fibonacci spiral found in the craters on its surface.**

As the moon’s uneven gravity is not constant and can change over time due to various factors, such as Earth’s gravity, rotation and **the Moon’s own movement.** Scientists expect or speculate that Moon’s own movement may follow Golden Rule (see Figure 11) which needs more investigations.

In a study to track the Moon’s revolution path NASA undertake GRAIL Mission for close observation to the Moon. Figure 9 covers the path when the Moon was over Fiji in the Pacific region. The analysis of the data obtained during the passage of this region hints that Moon follows nearly a path with Golden Ratio.

4.1.8 True Visual Picture of Solar System

In the beginning of this section it is discussed that our solar system was formed from a cloud of gas and dust originated from an unknown supernova explosion or multi-explosion of supernovae and the formation process, i.e. from star dust to Planet through complex and intricate process, took millions of years. It is believed that this process created a swirling disk of material that eventually formed the Sun and the planets. The Golden Stardust, which can be recalled to the abundance of elements like gold and silver in the universe, played a crucial role in the formation of the Solar System. These heavy elements were created in the crucibles of supernova explosions and were dispersed throughout the galaxy, eventually becoming part of the gas and dust cloud that formed the Solar System. Scientists believed that the Golden Ratio principles helped to organize the material into distinct structures. This led to the formation of the Sun at the center, with the planets and other celestial bodies orbiting around it in a harmonious and efficient manner. Figure 12 represents the possible true visual picture of our solar system following the Golden Ratio implying that why Golden Ratio is observable everywhere.



Figure 12. Schematic view of True visual representation of our Solar System in Golden Systems (adopted from <https://medium.com/@cherkashin/from-stardust-to-life-the-golden-ratio-in-the-evolution-of-the-solar-system-da496674cf82>).

4.1.9 Golden Ratio in Galaxy

A galaxy is a system containing stars, stellar remnants, interstellar gas, dust and dark matter bounded by gravity. Galaxies are categorized according to their visual morphology as elliptical, spiral or irregular. In an average a galaxy contains ~ 100 million stars to the largest galaxies (called supergiant galaxy) having ~ 100 trillion stars. It is believed that most of the mass in a typical galaxy is in the form of dark matter. Most of the galaxies are 1,000 to 100,000 parsecs diameter (approx. 3,000 – 300,000 light years). For example, our Milky Way has a diameter of at least 26800 parsecs.

Our Milky Way is a spiral galaxy. “Spiral galaxies” are undoubtedly the most famous among them. In fact, just over half of all known large, nearby, massive galaxies have spiral shapes and very few of them that exhibit a Fibonacci-like pattern (see Figure 13).

Indeed, a Fibonacci-like pattern is what we call “self-similar,” implying that where if you zoom out, and look at it on larger scales, that same structural pattern repeats itself when you zoom in to smaller scales. The spiral structures seen in galaxies don’t do that in two separate ways, as:

- the interiors of spiral galaxies rarely spiral in all the way to the center, but rather terminate in an asymmetric galactic bulge or bar,
- and the exteriors of these galaxies — in which the stars, gas, and dust are largely confined to a disk — are better approximated by the curve of a circle than by any “spiraling-out” structure.

Remember that the spiral arms within a galaxy are caused by density waves, and by the galaxy “winding up” over time. There are a few notable features that exist in *some* spiral galaxies that exhibit a Fibonacci-like pattern over those in-between regions, but this is not the norm [11].



Figure 13. Schematic diagram shows Galaxy follows Golden Ratio i.e. in the form of Fibonacci sequence (superimposed) (Courtesy: Wikipedia).

4.1.10 Golden Ratio in Blackhole

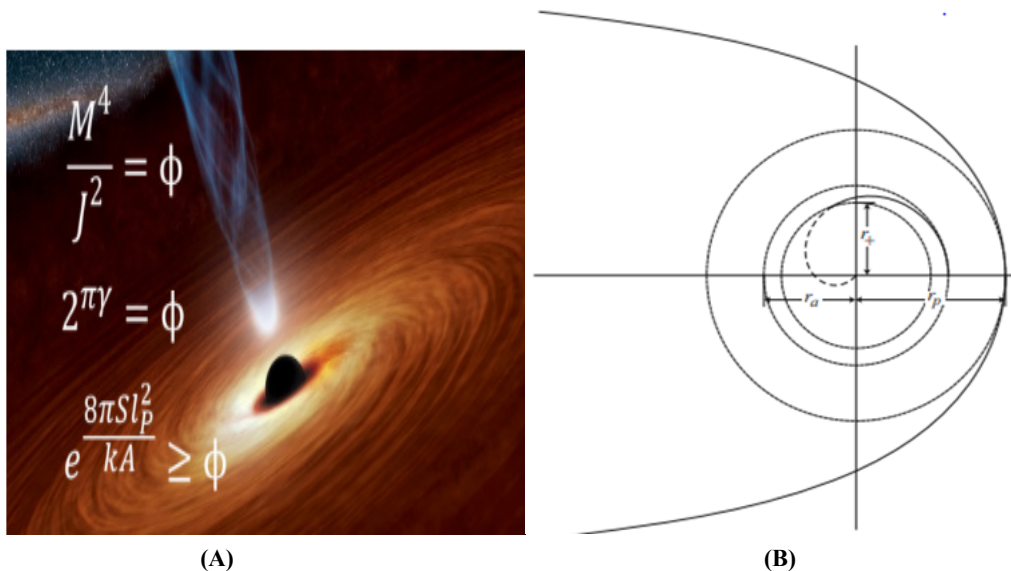


Figure 14. (A) Artist’s view of Black holes (Courtesy: Wikipedia) and (B) Schematic representation of orbits of a Black hole obeying Fibonacci Sequence (adopted from: <https://quantumgravityresearch.org/golden-ratio-in-nature-overview/>).

Black holes are one of the most intriguing phenomena in the Universe in which gravitational pull is so strong that light can not escape. Study of Black hole plays an important role in understanding the behavior of “space-time”. The Golden Black holes, therefore, refers to a special class of Black holes that can be described by the Golden Field Equations through incorporating the principles of Golden Ratio.

In an investigation of space – time associated with the Schwarzschild – Kottler Black holes Cruz et al. [12] calculated the maximal radial acceleration for null geodesics case and found the turning points of the orbits of the Black hole are in the golden ratio $\phi = (\sqrt{5} - 1) / 2$. They also showed that Golden Ratio is present in the Schwarzschild – Kottler metric.

In another investigation, considering validation formalism to describe Black hole solution in higher dimension Nieto [13] shows that this formalism enables to find a surprising link between Black holes and Golden Ratio (Figure 14).

4.1.11 How One Can Apply Golden Ratio to Enjoy Beauty

When one can feel and enjoy the beauty of nature in an open space he/she most probably does not know how Golden Ratio creates such a beauty. As an example, one first try to find an object nearer, make a close distance between you and the object and then try to make an imaginable Fibonacci sequence as shown in Figure 15. In fact, even though it is not yet known how Golden Ratio is created but only it is known that a beautiful scenery exists for beholders.



Figure 15. Schematic diagram indicating how one can make an imaginable Fibonacci sequence in an open space for understanding the Golden Ratio (Photo credit: PISCart).

5. Conclusion

Philosophers and Scientists have tried for centuries to understand beauty. According to the Scientists the origin of beauty is an enigmatic in our brain as it is in our real world. To pursuit this difficulties Scientists tried to relate it with the states of the nervous system as the subjective experiences which accompany them with an idea of “Beauty Center”. If this theory of “Beauty Center” prevails then beauty could really be traced back to a single region of the brain as in other cases like ‘memory center’, ‘vision center’, ‘pleasure center’, ‘beauty center’. Two questions arise: i) Where is the exact location of it in the brain? and ii) “How do we understand beauty differently from other?”

In physical/real state beauty is associated with the Golden Ratio that we observe every day in the areas of biology, physics, astrophysics, chemistry and technology [14] ranging from micro to macro structures, even including the Universe itself in the form of hyperbolic universe [15]. In this context, quality of beauty depends on the Golden Ratio proportion implying that very beautiful means structure proportion is very close to value of the $\phi = 1.618033 \dots$ and for less beautiful it means the value of proportion deviates from the value of ϕ .

So, questions still remain:

(a) Is the Golden Ratio a universal constant for self-replication?

- (b) Why does Golden Ratio exist only in beautiful objects, not in all the objects in the universe?
- (c) Is the Golden Ratio a subtle creator of the beautiful objects in the beautiful worlds?
- (d) How Golden Ratio is created or implemented?
- (e) What is the exact role of Golden Ratio i.e. for self-replica only?

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Competing Interest

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