Pi is a Rational Number in Physics

(Version 3)

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Abstract

It has been mathematically proved that pi is an irrational number, mathematics has infinitesimal but there is a minimum in physics. The Planck length is the smallest length that can be measured, and a size smaller than it doesn't make sense. By comparing the circumference of a circle with the Planck length, the significant decimal places of the circumference of the circle are determined, with formula: Pi = circumference / diameter, calculate the number of significant decimal places for pi. Therefore, pi is a finite decimal and is a rational number, according to this, set up the physical pi table. In the same way we get: The square root of 2 is a finite decimal and is a rational number, and has an exact place on the real number line, resolved the square root crisis of 2. This paper argues that, mathematics and physics are different, Irrational numbers are all rational numbers in physics. There is infinity ($n \to \pm\infty$, $n \to \pm 1/\infty$) in mathematics, but not in physics; Length, quality and time all have definite values. Our universe is certain and limited.

Key words: Circumference, Pi, Planck length, Physics, √2, Rational Number, Dimension

It has been mathematician proved that pi is an irrational number(Niven 2000), calculating pi by split regular polygons, can be divided infinitely; use the infinite series formula to calculate the pi, can be calculated indefinitely, infinitely increasing decimal places. As of June 8, 2022, it has been calculated to 100 trillion digits(Emma 2022).

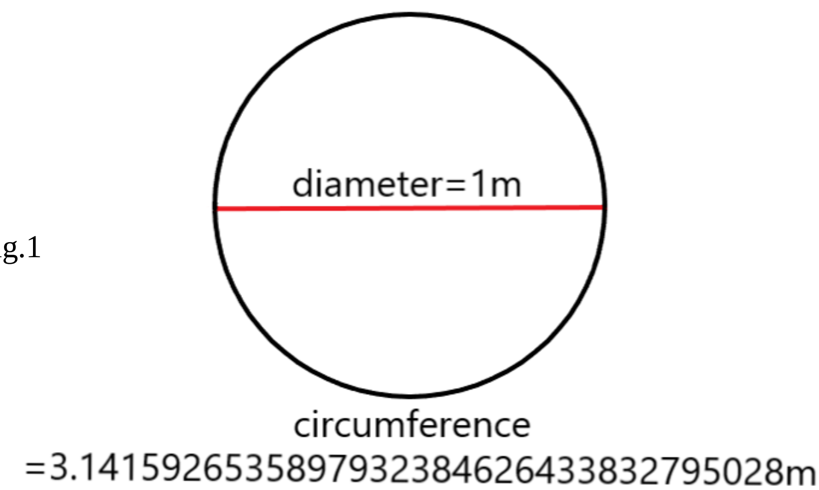
1 Pi in physics

Mathematics has infinitesimal but there is a minimum in physics. “present-day physical ideas about gravitation, together with the uncertainty principle, imply the existence of a fundamental length of order $\sqrt{G}$. This fundamental length applies to macroscopic as well as microscope measurements;” (Mead 1964), the Planck length is the smallest length that can be measured, and a size smaller than it doesn't make sense (Carr et al. 2005), the measurement accuracy can only reach Planck length and can no longer go down(Hossenfelder 2012).

Calculate the pi, you can't go down exceed the Planck length, the decimal places of pi stop here and no longer grow, if more than it, and the part beyond it is invalid.

1.1 A circle with a diameter of 1 meter (Fig.1)

Fig.1



Circumference of circle = π d = 3.1415926······m.

Is space continuous or discrete? There is no definitive answer.

1.1.1 If the space is continuous,we compare the circumference of a circle with Planck length, they are decimal rules.

Circumference: 3.1415926535897932384626433832795028~~84197~~······m

Planck length: 0.000000000000000000000000000000000016162······m

Because the Planck length is the smallest length that can be measured, theoretically, the measurement accuracy can only reach Planck length(Hossenfelder 2012).

We take 3.1415926535897932384626433832795028, that is, 34 decimal places can make sure it is within the valid range.

1.1.2 If the space is discrete based on the Planck length (Fig.2)

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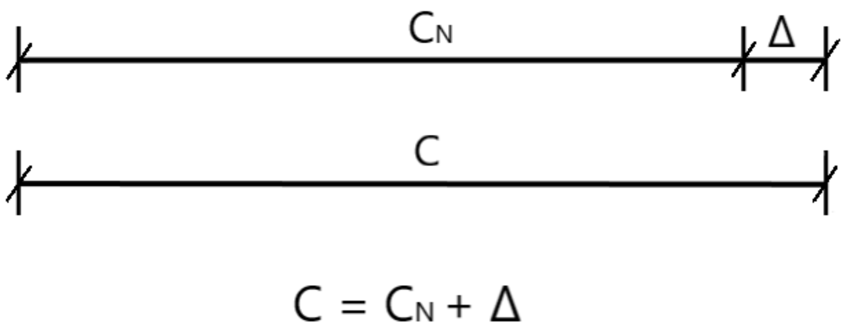
Fig.2



$$C = C_N + \Delta \qquad (1)$$

$$C_N = C - \Delta \qquad (2)$$

$$C = \pi \times D \qquad (3)$$

$$C_N = N \times \ell_P \qquad \{N \in N^+\} \qquad (4)$$

C — Theoretical circumference

D — Diameter

C_N — The circumference of discrete space (integer multiples of the Planck length)

ℓ_P — Planck length

$$\because \quad \Delta = n \times \boldsymbol{\ell}_P \qquad \{ 0 < n < 1 \} \tag{5}$$

$$\therefore \quad 0 < \Delta < \boldsymbol{\ell}_P \tag{6}$$

Δ does not exist in discrete space, it is only used to calculate.

Because the Planck length is an empirical value, the value of CN cannot be accurately determined with the equation(4), we use equation(2) to determine its effective value.

$$C_N = C - \Delta = C - n \times \boldsymbol{\ell}_P \qquad \{ 0 < n < 1 \}$$

$$C_N = \underline{3.1415926535897932384626433832795028}84197\cdots\cdots m$$
$$- n \times \underline{0.0000000000000000000000000000000000}16162\cdots\cdots m$$

We still take 34 decimal places, it is within the valid range (after calculation keep the pi value accurate or needs to be rounded).

1.2 Summary

The effective value of the circumference of a circle with a diameter of 1 meter is 3.1415926535897932384626433832795028m, it is a finite decimal and is a rational number.

According to the formula:

Pi= circumference/ diameter=3.1415926535897932384626433832795028

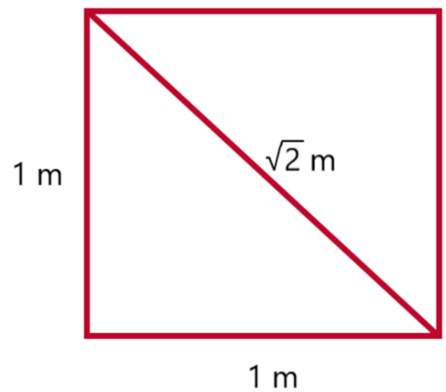
That is, the pi of 1 meter diameter is 3.1415926535897932384626433832795028, take 34 digits after the decimal point of pi.

Therefore, pi is a finite decimal and is a rational number.

The same, the effective value of the circumference of a circle of 10 meters in diameter is 31.415926535897932384626433832795028 8m, its corresponding pi is 3.14159265358979323846264338327950288, take Pi 35 places after the decimal point.

2 The square root of 2(Fig.3)

Fig.3



Geometrically, the square root of 2 is the length of a diagonal across a square with sides of one unit of length .

Figure 3 is a square with a side length of 1 meter, the length of the diagonal is √2 meters, the length of the diagonal line in the figure is fixed, but √2 is an infinite non-repeating decimal and not a fixed value. The crisis came into being.

Now let's compare the square root of 2 with the Planck length:

Square root of 2: 1.4142135623730950488016887242096980~~78569~~⋯⋯m
Planck length: 0.000000000000000000000000000000000016162⋯⋯m

We take 1.4142135623730950488016887242096980m as the diagonal value, it is a finite decimal, a fixed value. The length of the line segment is consistent with the numerical value, the crisis is lifted.

3 Why physics

When we draw a geometric diagram, it naturally has a length dimension and have physical properties, although no units of length are marked, but it has a length value.

All matter and space in the universe have dimensions and have physical properties, we need to explain them with physical rules.

3.1 Figure 4 is a common geometric construction, the irrational number √2 has a position on the OX axis.

An irrational number have an exact place on the real number line, this view is wrong. When we conduct thought experiments or describe with text, it is in the realm of philosophy and mathematics, the square root of 2 is an irrational number, ability to find corresponding points on virtual axes. But when we implement it, it has a dimension and physical properties, √2 is a rational number in physics and have an exact place on the real number line.

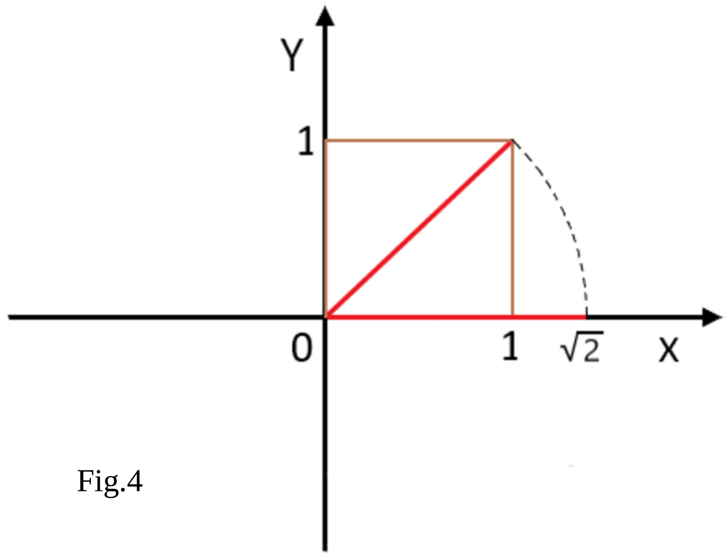


Fig.4

When you draw it out, and is physics,to be explained by physical rules. Although there is no unit of length,but it has a fixed value. we can measure(Kalanov 2013). Theoretically, the measurement accuracy can only reach Planck length and can no longer go down(Hossenfelder 2012).

4 Significance

Mathematics and physics are different, irrational numbers are all rational numbers in physics. There is infinity (n→±∞, n→±1/∞) in mathematics, but not in physics; length, quality and time all have definite values, problems like Zeno's paradox can be solved; we take on new meaning in interpreting physical formulas. For example, Einstein's equations contain pi, pi is a finite decimal, so we can understand that the universe is certain and limited.

$$R_{\mu\nu} - \frac{1}{2} R g_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}$$

5 Conclusion

Pi is a rational number in physics, it is necessary for physics circle to define pi as a rational number, “the physical pi table” is a new standard; √2 is a rational number on the real number line, mathematicians should announce that the crisis of the square root of 2 is over, in this way, we can explain the physical universe more rationally. To distinguish, we use “π_w” to represent the pi in physics.

6 The physical pi table

Serial number	Diameter (m)	Pi decimal places[1]	Applicable diameter range(m)	Example
1	10^{-15}	19	3.19×10^{-16} ~ 3.18×10^{-15}	electron
2	10^{-14}	20	3.19×10^{-15} ~ 3.18×10^{-14}	
3	10^{-13}	21	3.19×10^{-14} ~ 3.18×10^{-13}	
4	10^{-12}	22	3.19×10^{-13} ~ 3.18×10^{-12}	hydrogen atom
5	10^{-11}	23	3.19×10^{-12} ~ 3.18×10^{-11}	
6	10^{-10}	24	3.19×10^{-11} ~ 3.18×10^{-10}	atom
7	10^{-9}	25	3.19×10^{-10} ~ 3.18×10^{-9}	base pair
8	10^{-8}	26	3.19×10^{-9} ~ 3.18×10^{-8}	flagellum
9	10^{-7}	27	3.19×10^{-8} ~ 3.18×10^{-7}	virus
10	10^{-6}	28	3.19×10^{-7} ~ 3.18×10^{-6}	bacteria
11	10^{-5}	29	3.19×10^{-6} ~ 3.18×10^{-5}	red blood cell
12	10^{-4}	30	3.19×10^{-5} ~ 3.18×10^{-4}	the steel ball in ballpoint pen
13	10^{-3}	31	3.19×10^{-4} ~ 3.18×10^{-3}	rapeseed, yarn
14	10^{-2}	32	3.19×10^{-3} ~ 3.18×10^{-2}	Coins, buttons
15	10^{-1}	33	3.19×10^{-2} ~ 3.18×10^{-1}	table tennis, football
16	1	34	3.19×10^{-1} ~ 3.18×1	manhole cover, round pipe
17	10	35	3.19×1 ~ 3.18×10	shield machine, hot air balloon
18	10^{2}	36	3.19×10 ~ 3.18×10^{2}	stadium
19	10^{3}	37	3.19×10^{2} ~ 3.18×10^{3}	crater
20	10^{4}	38	3.19×10^{3} ~ 3.18×10^{4}	Large Hadron Collider
21	10^{5}	39	3.19×10^{4} ~ 3.18×10^{5}	rainbow
22	10^{6}	40	3.19×10^{5} ~ 3.18×10^{6}	Moon, Pluto, Triton
23	10^{7}	41	3.19×10^{6} ~ 3.18×10^{7}	Mercury, Mar, Venu, Earth
24	10^{8}	42	3.19×10^{7} ~ 3.18×10^{8}	Neptune, Uranu, geosyn-chronous orbit, Saturn, Jupiter

25	10^9	43	3.19×10^8 ～ 3.18×10^9	Moon orbit, Sun
26	10^{10}	44	3.19×10^9 ～ 3.18×10^{10}	Callisto orbit
27	10^{11}	45	3.19×10^{10} ～ 3.18×10^{11}	Earth orbit
28	10^{12}	46	3.19×10^{11} ～ 3.18×10^{12}	Jupiter orbit
29	10^{13}	47	3.19×10^{12} ～ 3.18×10^{13}	Neptune orbit, Kuiper belt
30	10^{14}	48	3.19×10^{13} ～ 3.18×10^{14}	
31	10^{15}	49	3.19×10^{14} ～ 3.18×10^{15}	
32	10^{16}	50	3.19×10^{15} ～ 3.18×10^{16}	
33	10^{17}	51	3.19×10^{16} ～ 3.18×10^{17}	
34	10^{18}	52	3.19×10^{17} ～ 3.18×10^{18}	
35	10^{19}	53	3.19×10^{18} ～ 3.18×10^{19}	
36	10^{20}	54	3.19×10^{19} ～ 3.18×10^{20}	Small Magellanic Cloud, Large Magellanic Cloud
37	10^{21}	55	3.19×10^{20} ～ 3.18×10^{21}	Hoag's Object, The Sombrero Galaxy, Milky Way, Andromeda
38	10^{22}	56	3.19×10^{21} ～ 3.18×10^{22}	IC 1100
39	10^{23}	57	3.19×10^{22} ～ 3.18×10^{23}	Alcyoneus
40	10^{24}	58	3.19×10^{23} ～ 3.18×10^{24}	
41	10^{25}	59	3.19×10^{24} ～ 3.18×10^{25}	Laniakea Supercluster
42	10^{26}	60	3.19×10^{25} ～ 3.18×10^{26}	Hercules-Corona Borealis Great Wall
43	10^{27}	61	3.19×10^{26} ～ 3.18×10^{27}	Hubble Volume
44	10^{34}	69	3.19×10^{34} ～ 3.18×10^{35}	Maximum universe [7] (Wang 2022)

1. Significant decimal places of pi corresponding to the circumference of the circle, it doesn't make sense to exceed it.

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