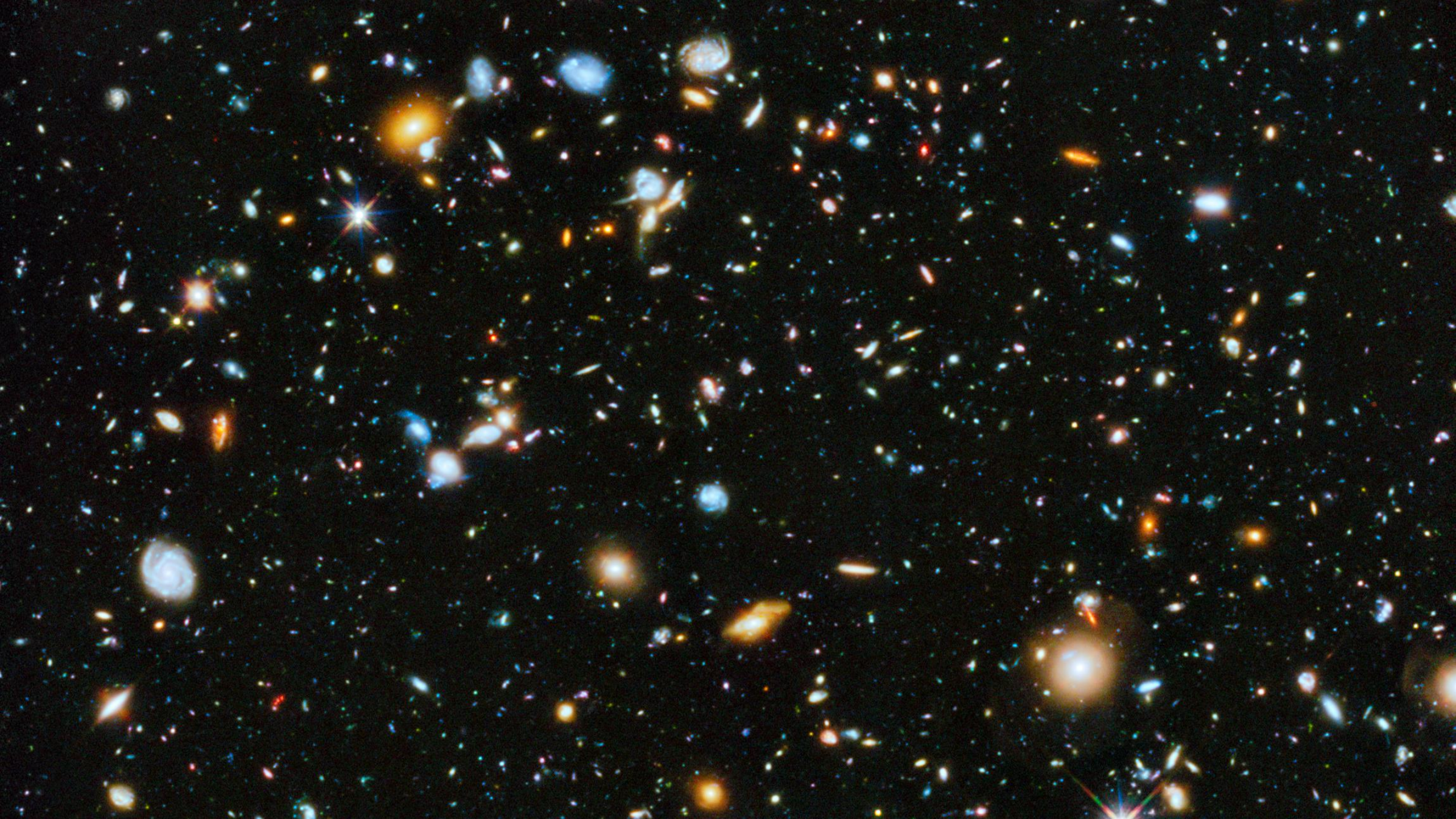
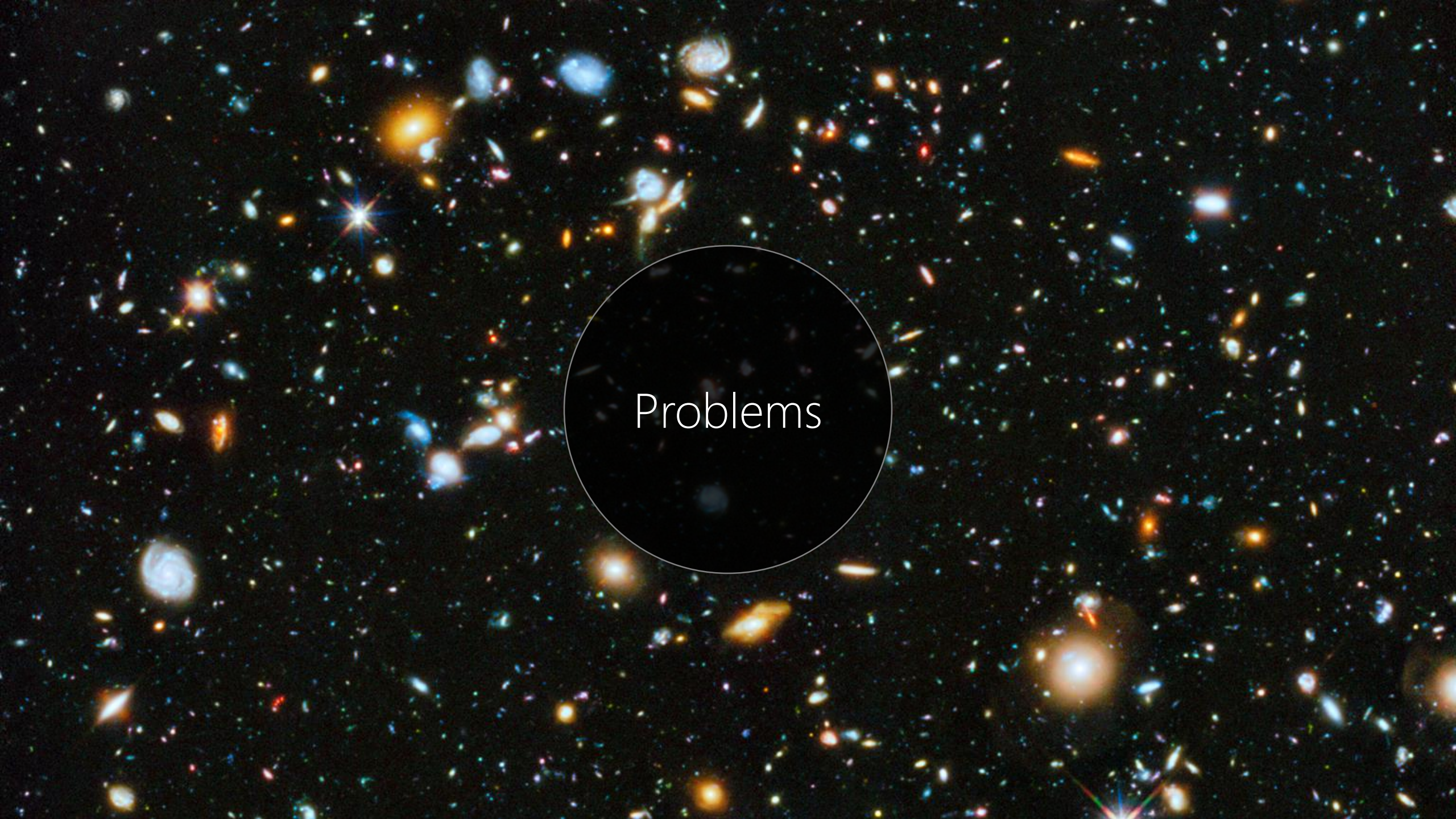
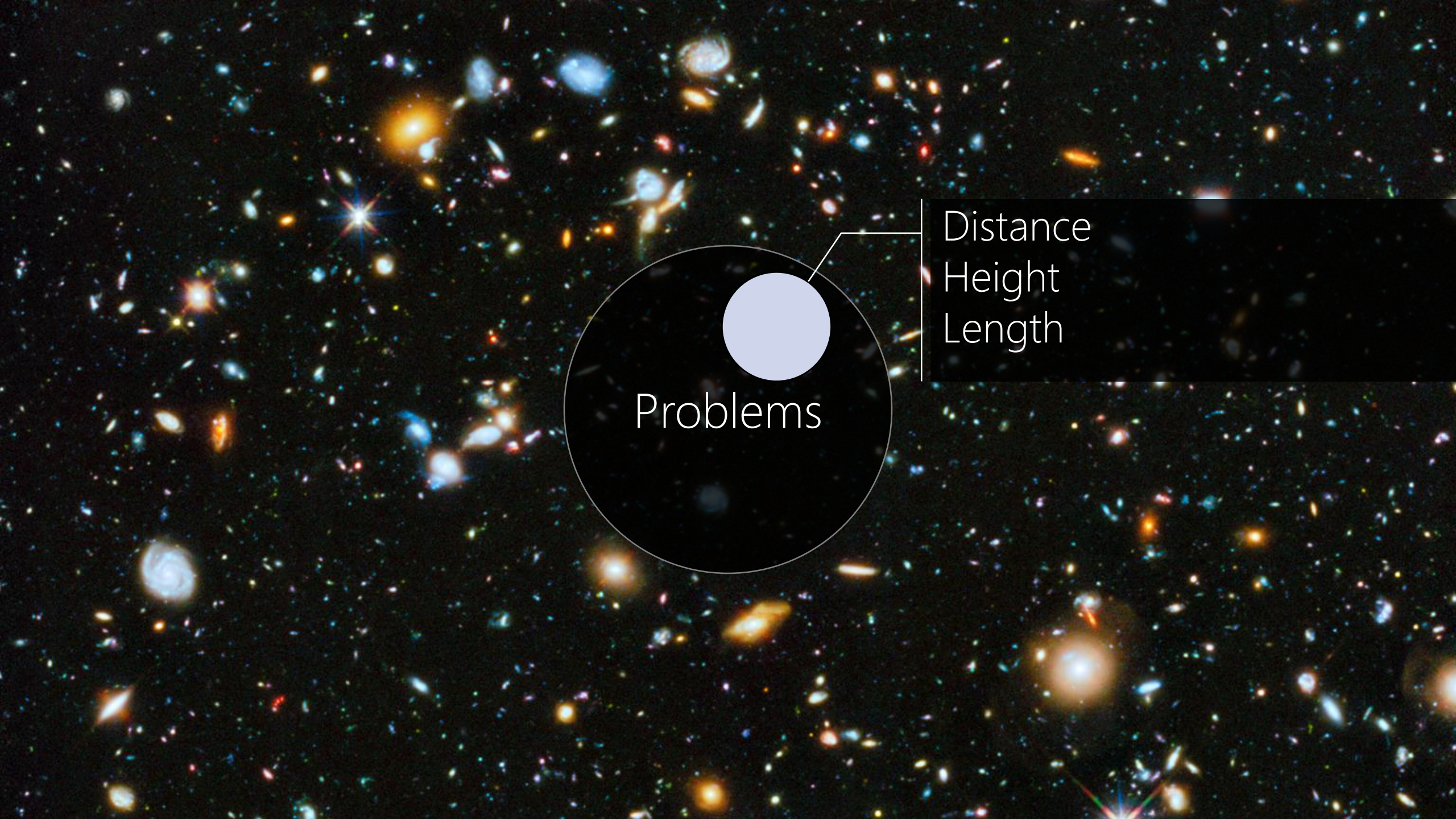
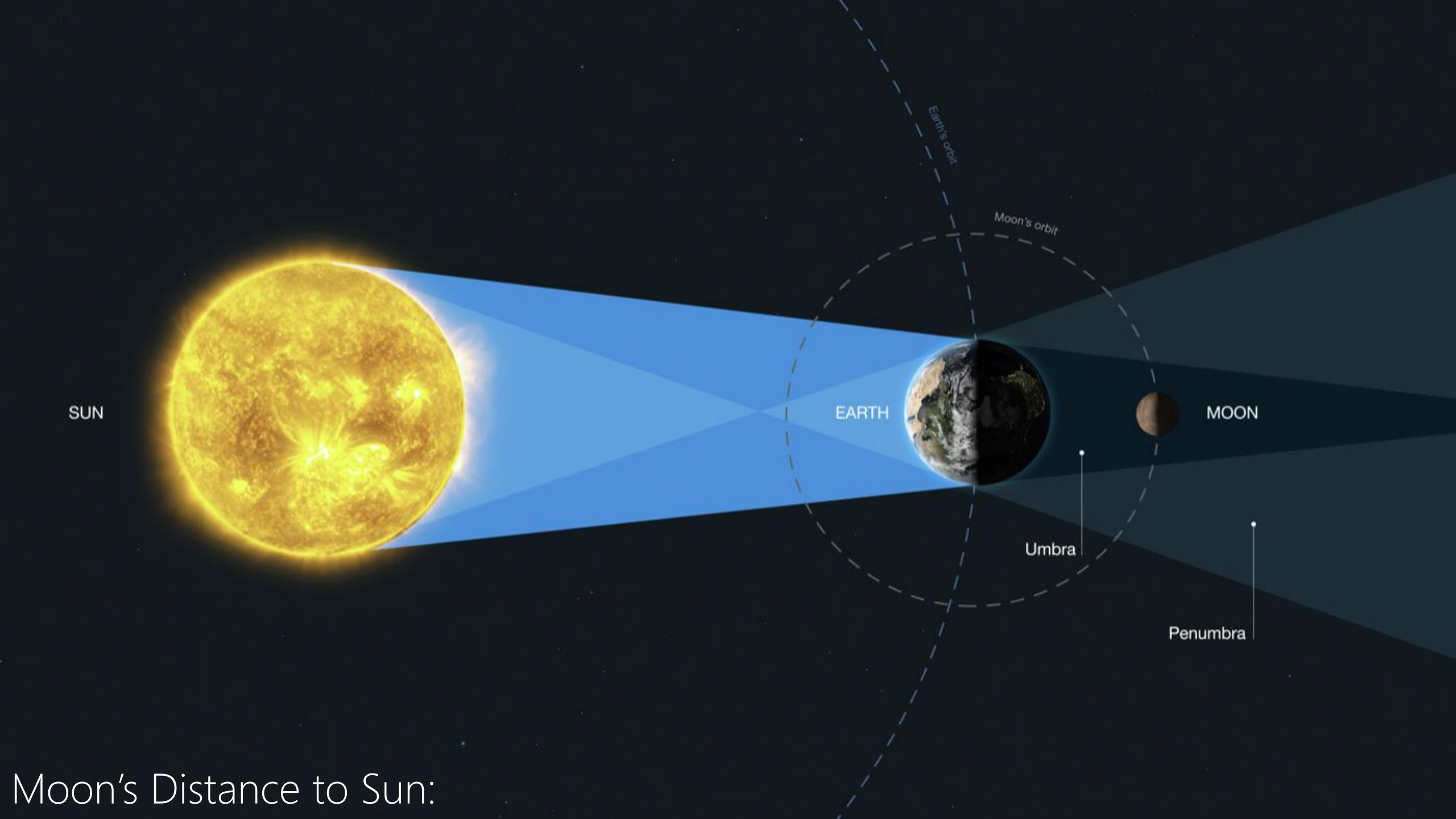
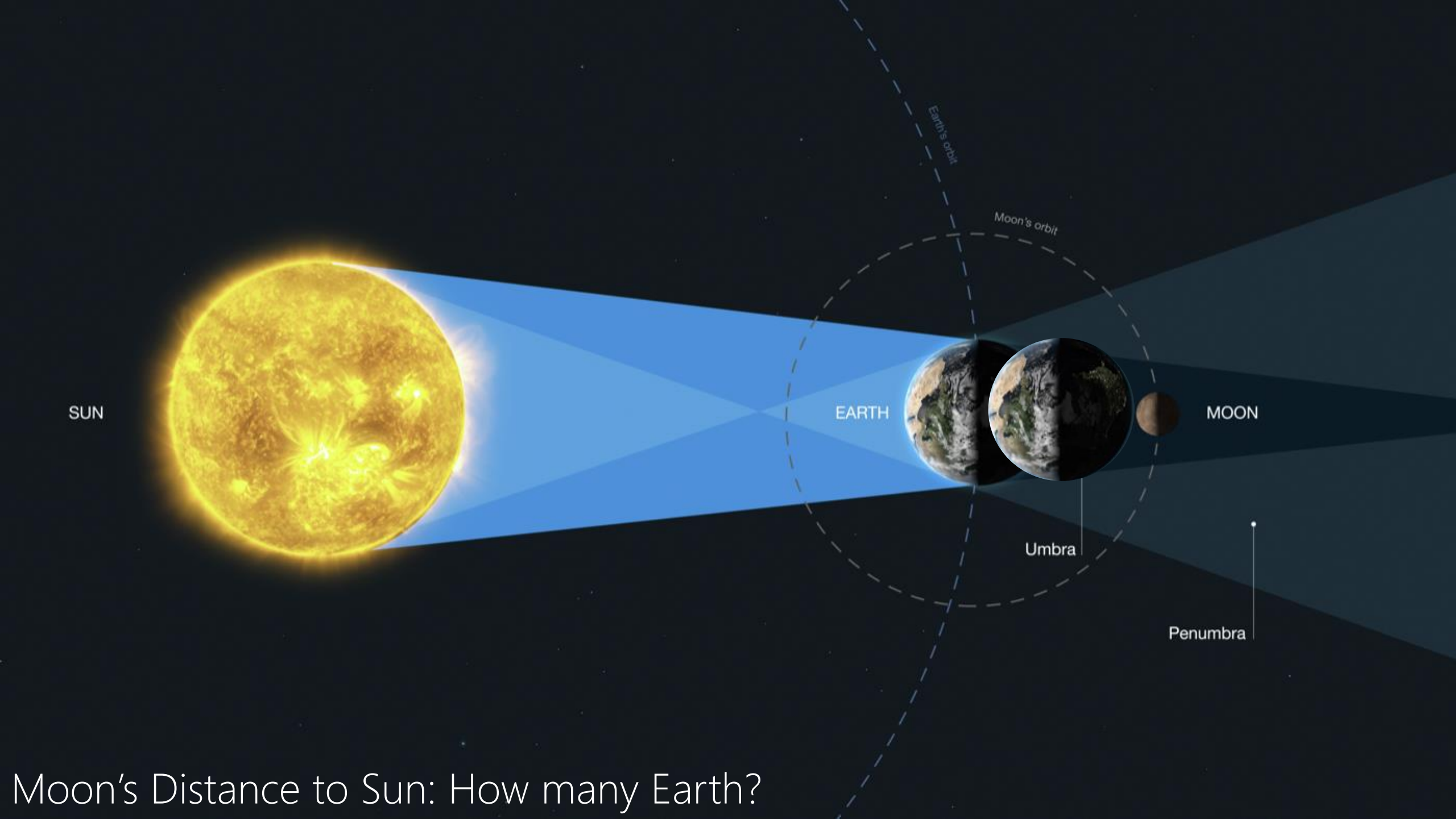



Problems

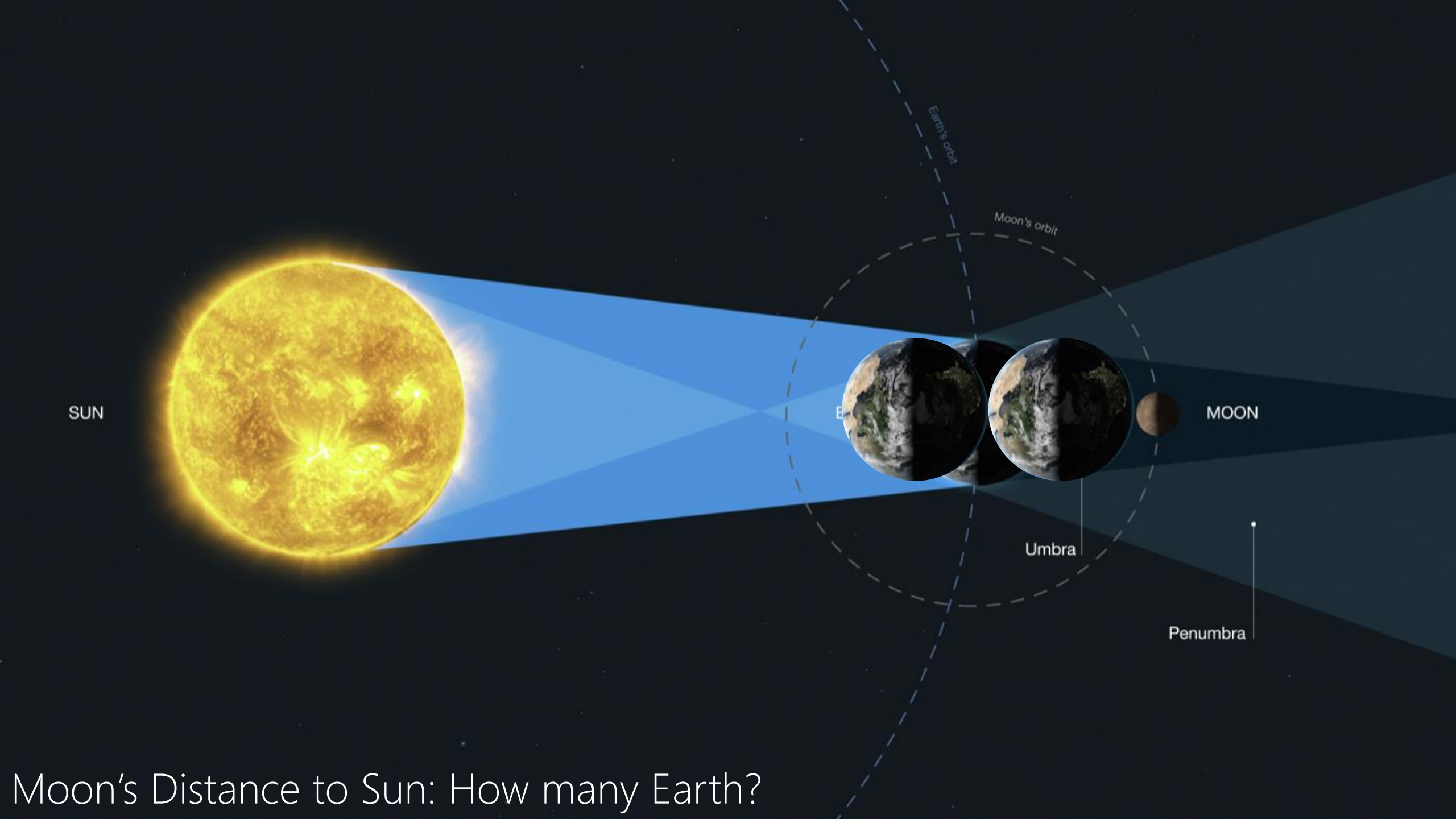

Problems
Distance
Height
Length



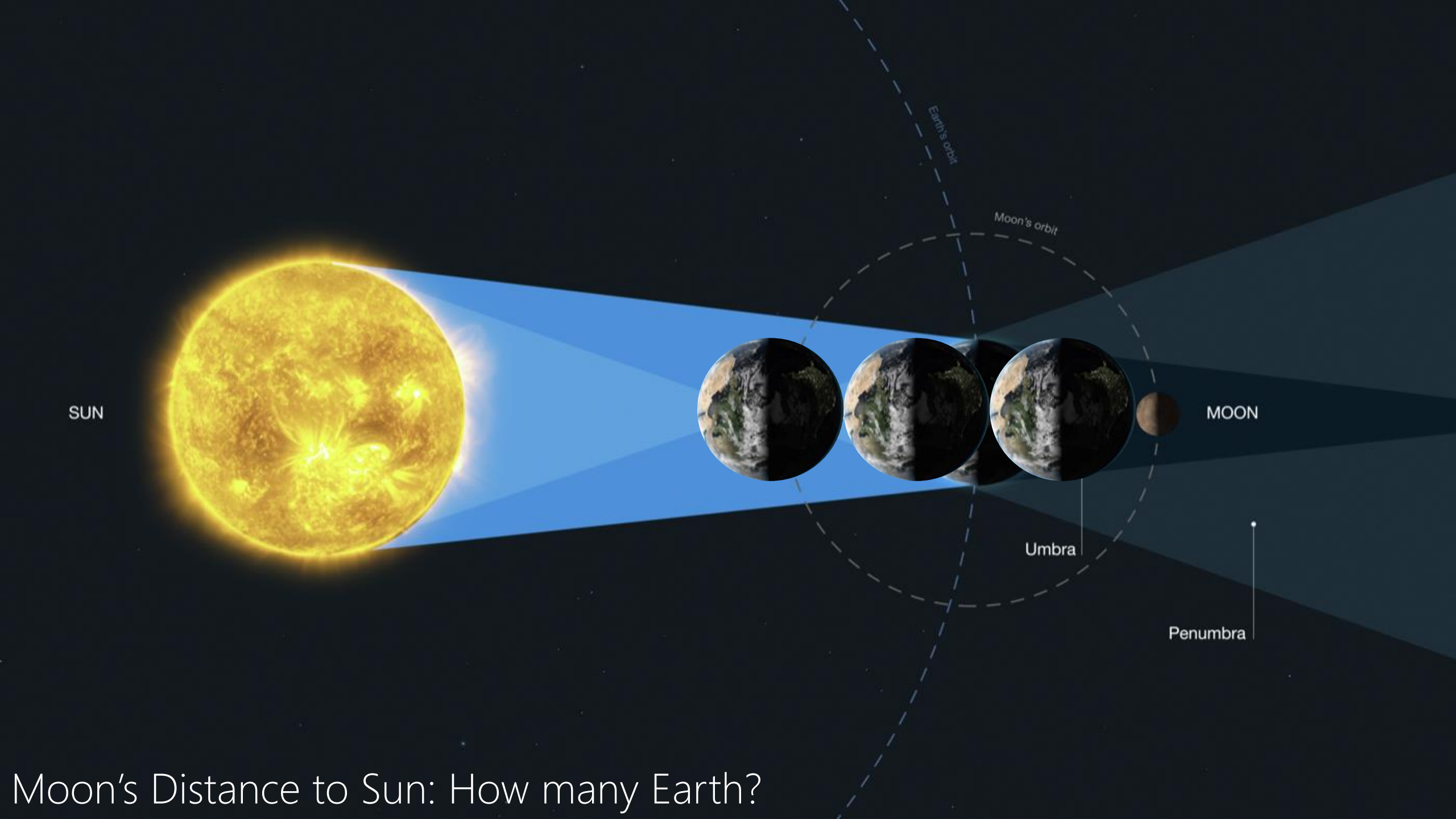
Moon's Distance to Sun:



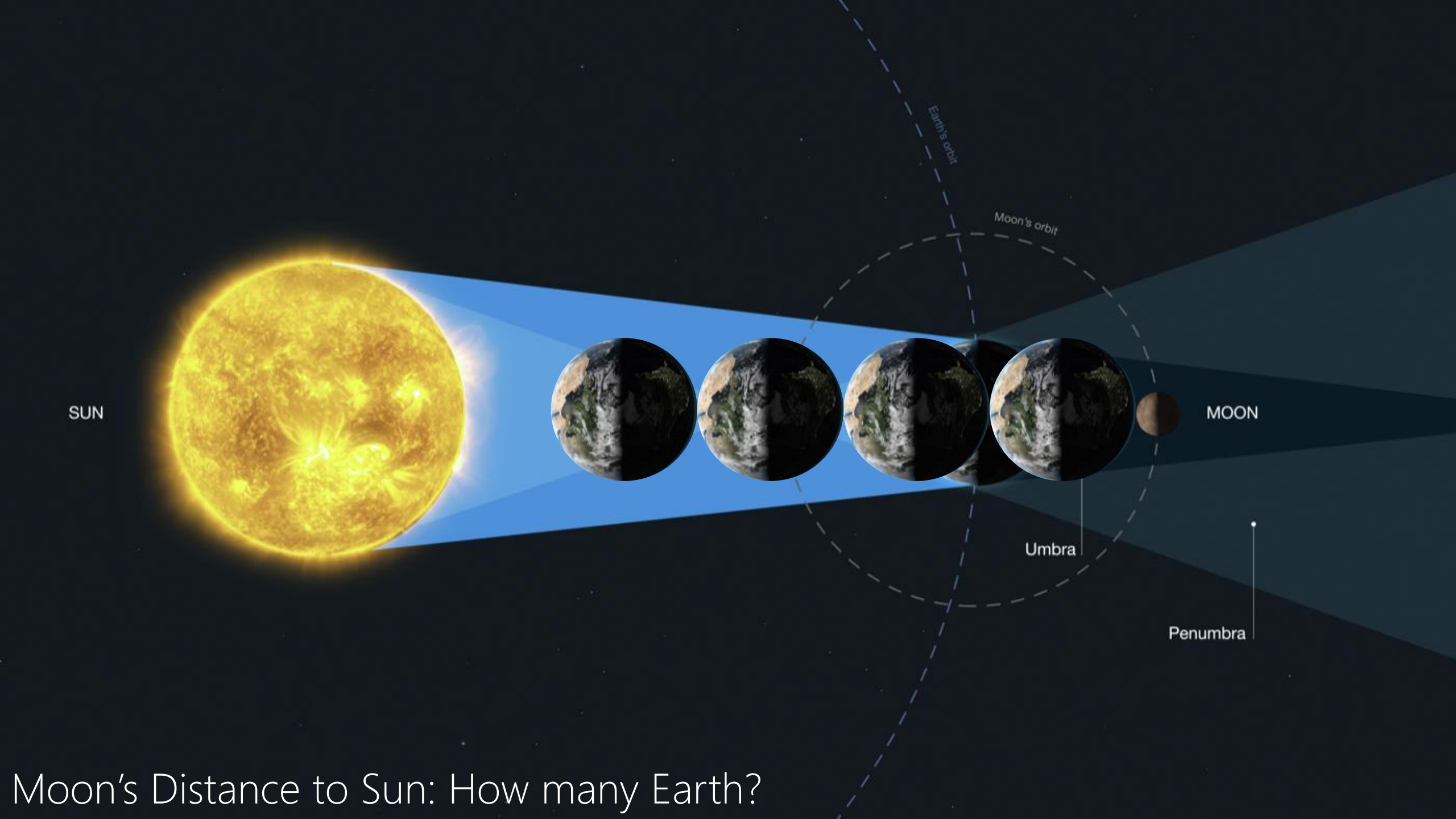
Moon's Distance to Sun: How many Earth?



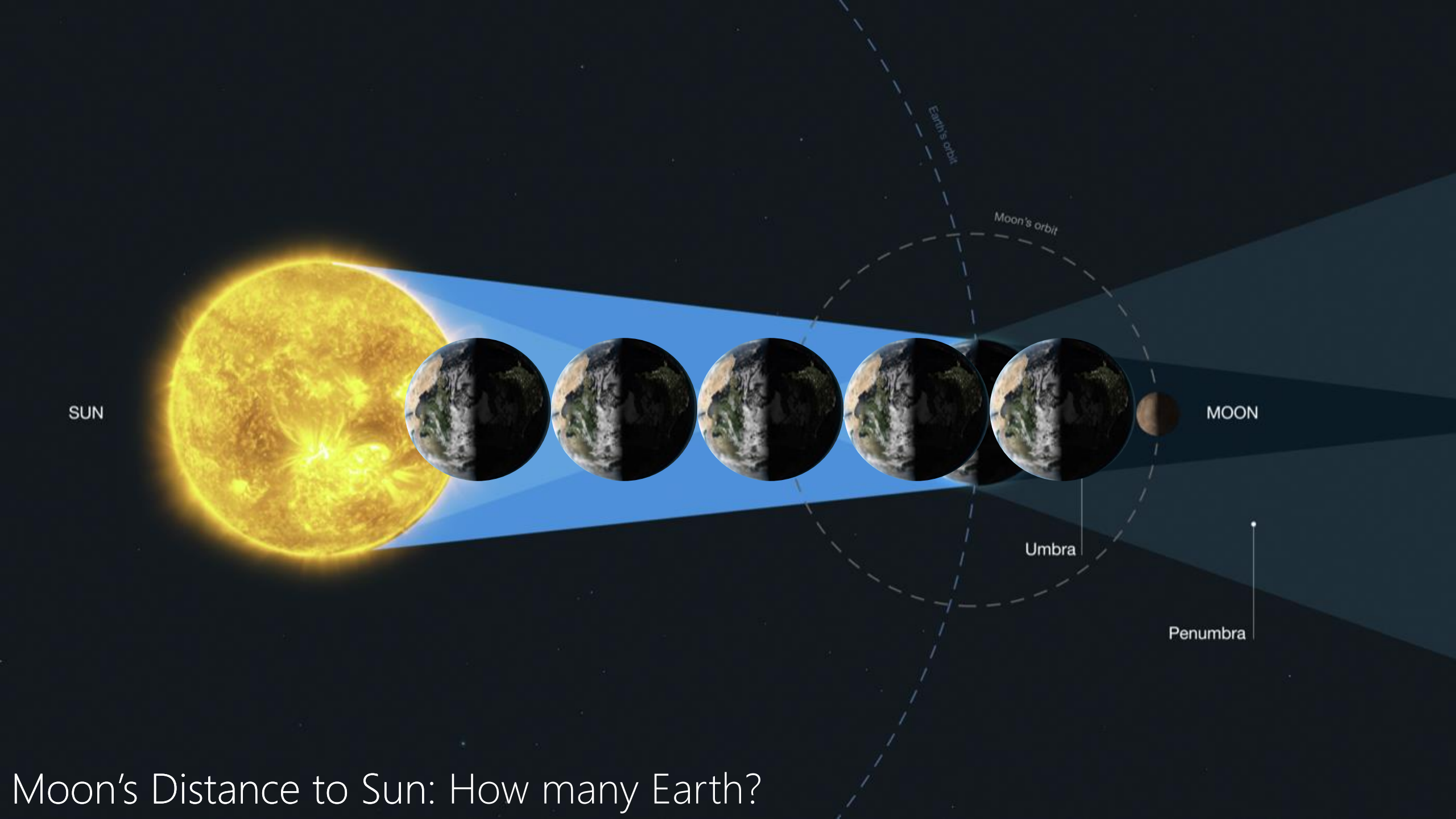
Moon's Distance to Sun: How many Earth?



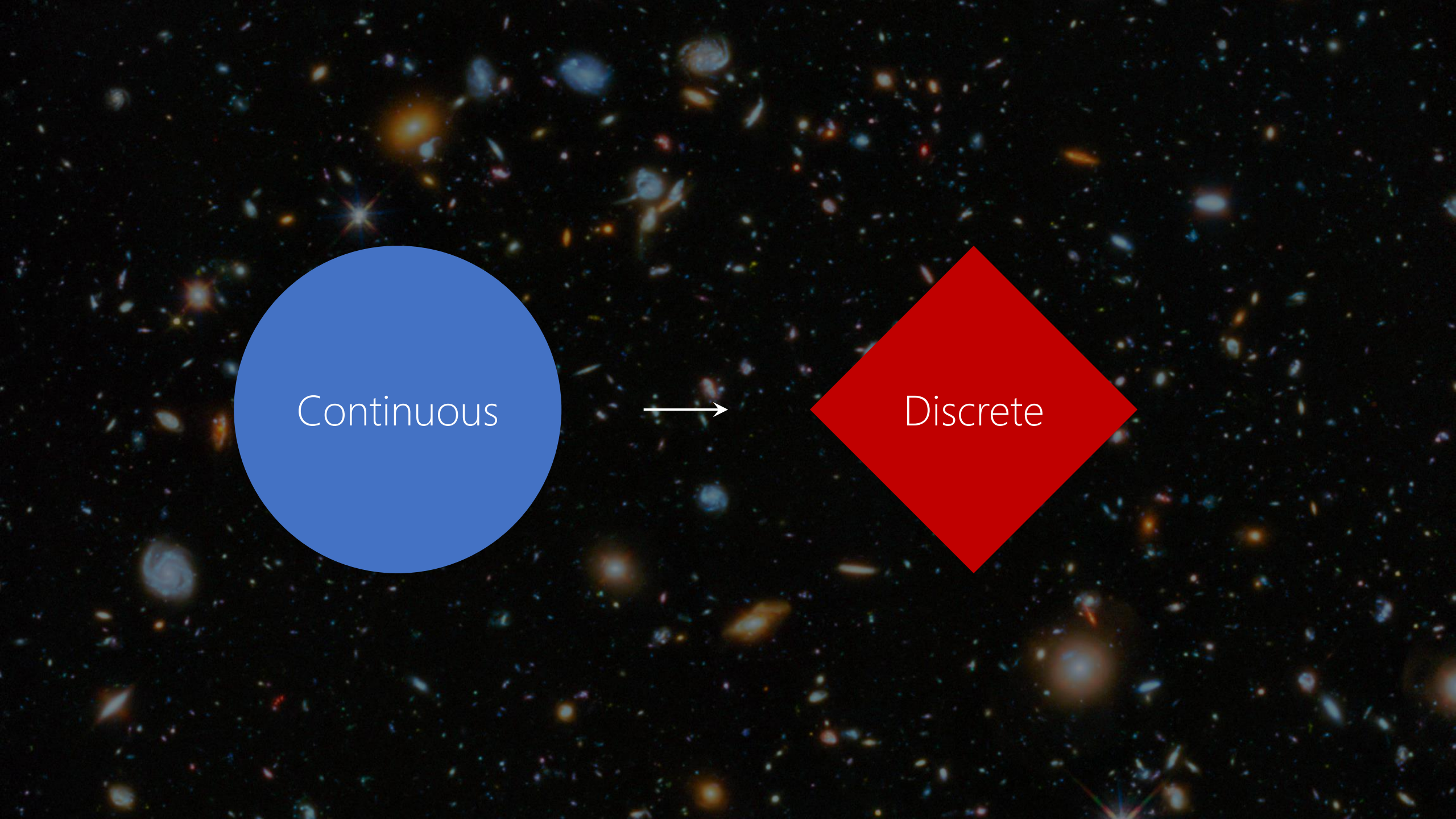
Moon's Distance to Sun: How many Earth?



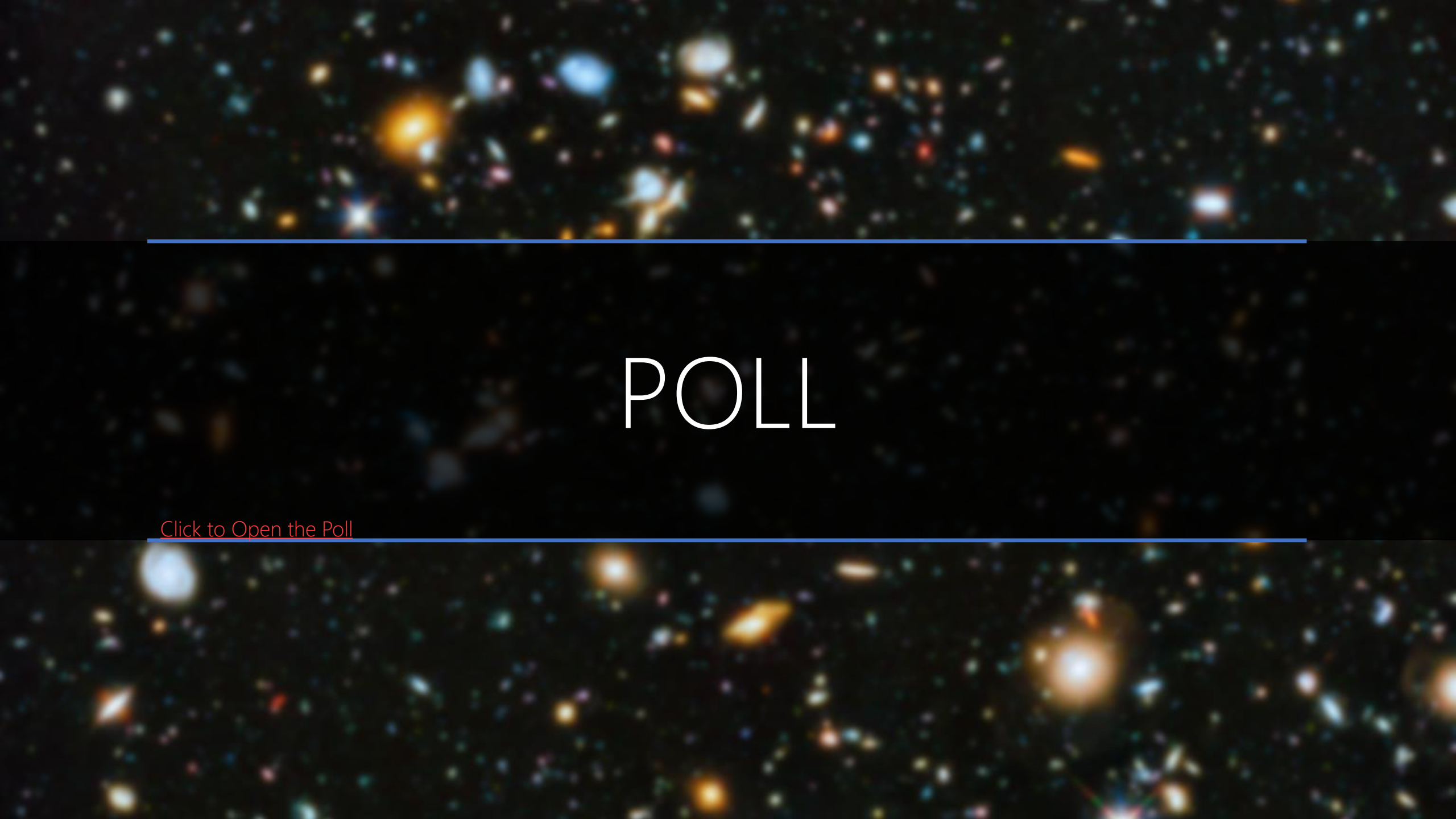
Moon's Distance to Sun: How many Earth?



Moon's Distance to Sun: How many Earth?


Continuous
Discrete

DISCRETE SYSTEMS



POLL

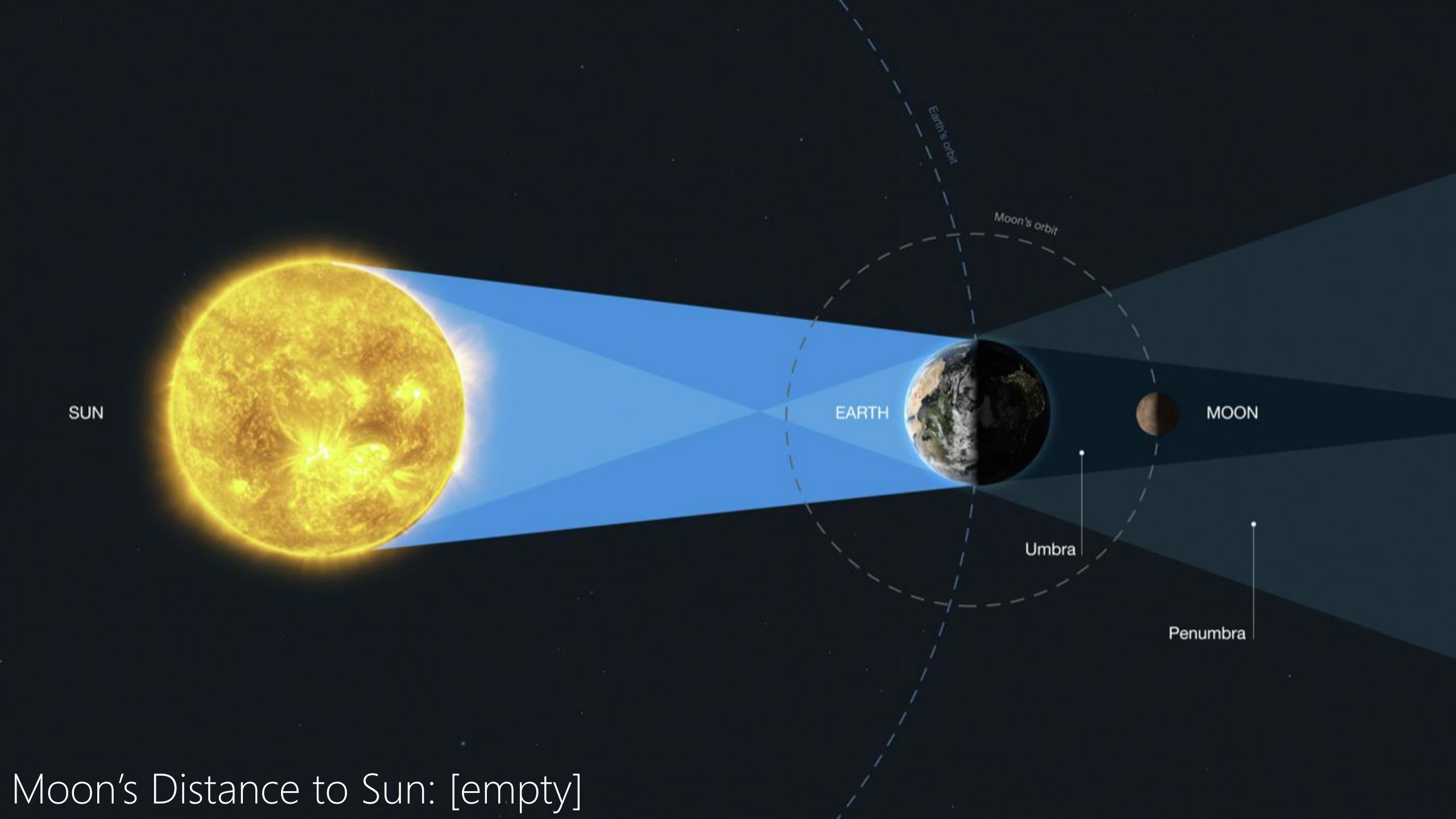
Click to Open the Poll

STAR	CONTINUOUS	DISCRETE
TEMPERATURE	CONTINUOUS	DISCRETE
ELECTRON	CONTINUOUS	DISCRETE
TIME	CONTINUOUS	DISCRETE
WEIGHT	CONTINUOUS	DISCRETE
SPEED	CONTINUOUS	DISCRETE
STUDENT	CONTINUOUS	DISCRETE
SOUND	CONTINUOUS	DISCRETE
IMAGE	CONTINUOUS	DISCRETE
PAIN	CONTINUOUS	DISCRETE
LIGHT	CONTINUOUS	DISCRETE
WAVE	CONTINUOUS	DISCRETE

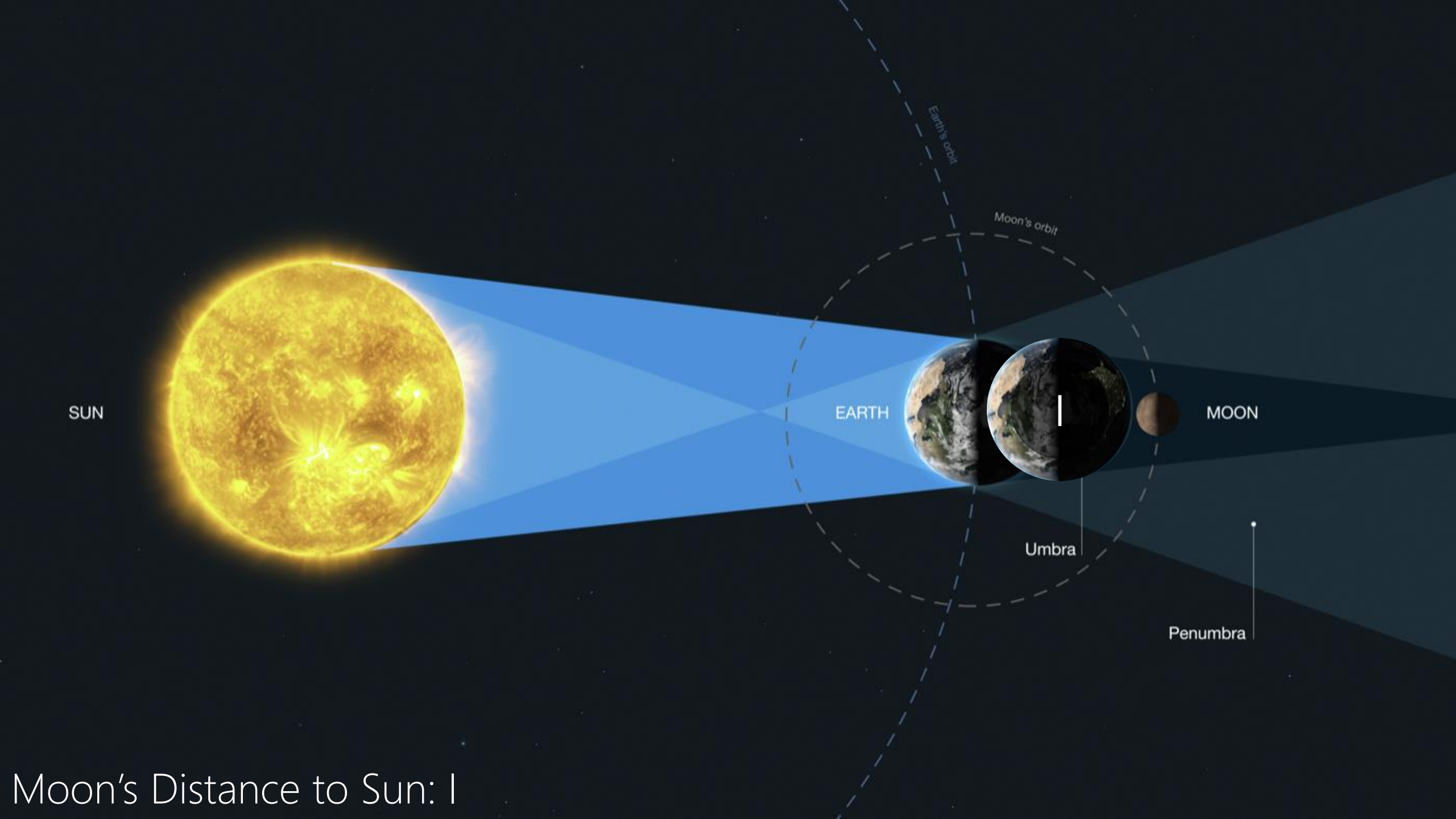
STAR		DISCRETE
TEMPERATURE	CONTINUOUS	
ELECTRON		DISCRETE
TIME	CONTINUOUS	
WEIGHT	CONTINUOUS	
SPEED	CONTINUOUS	
STUDENT		DISCRETE
SOUND	CONTINUOUS	
IMAGE	CONTINUOUS	DISCRETE
PAIN	CONTINUOUS	DISCRETE
LIGHT	CONTINUOUS	DISCRETE
WAVE	CONTINUOUS	

“The world's first photograph—or at least the oldest surviving photo—was taken by Joseph Nicéphore Niépce in 1826 or 1827. Captured using a technique known as heliography, the shot was taken from an upstairs window at Niépce's estate in Burgundy. As heliography produces one-of-a-kind images, there are no duplicates of the piece, which is now part of the permanent collection at the University of Texas-Austin.” 18 Famous First Photographs in History: From the Oldest Photo Ever to the World’s First Instagram

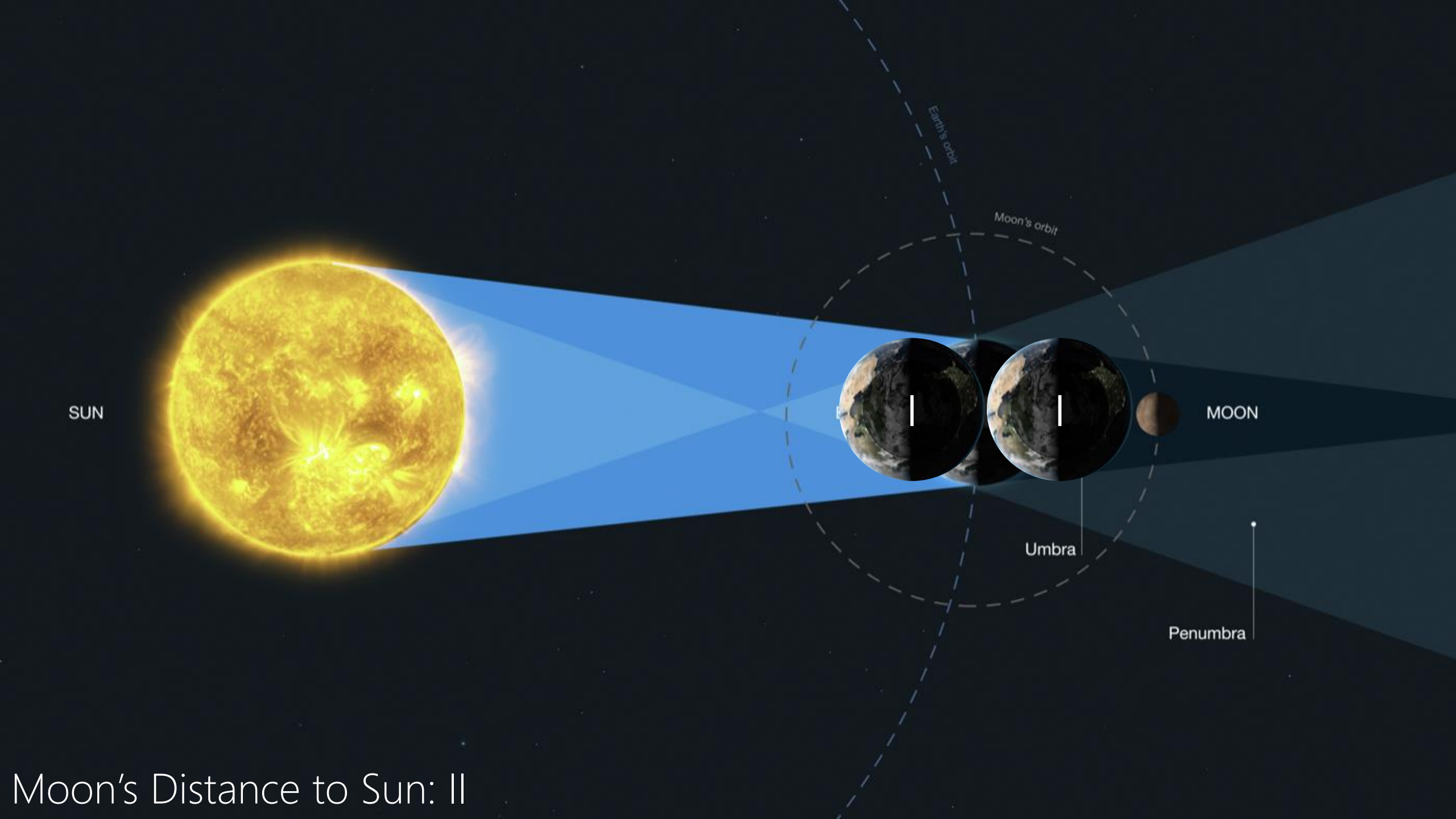
“We may be used to selfies now, but it's Robert Cornelius's 1839 image that lays claim to the first self-portrait. Taken in Philadelphia, Cornelius sat for a little over one minute before covering the lens.” 18 Famous First Photographs in History: From the Oldest Photo Ever to the World’s First Instagram



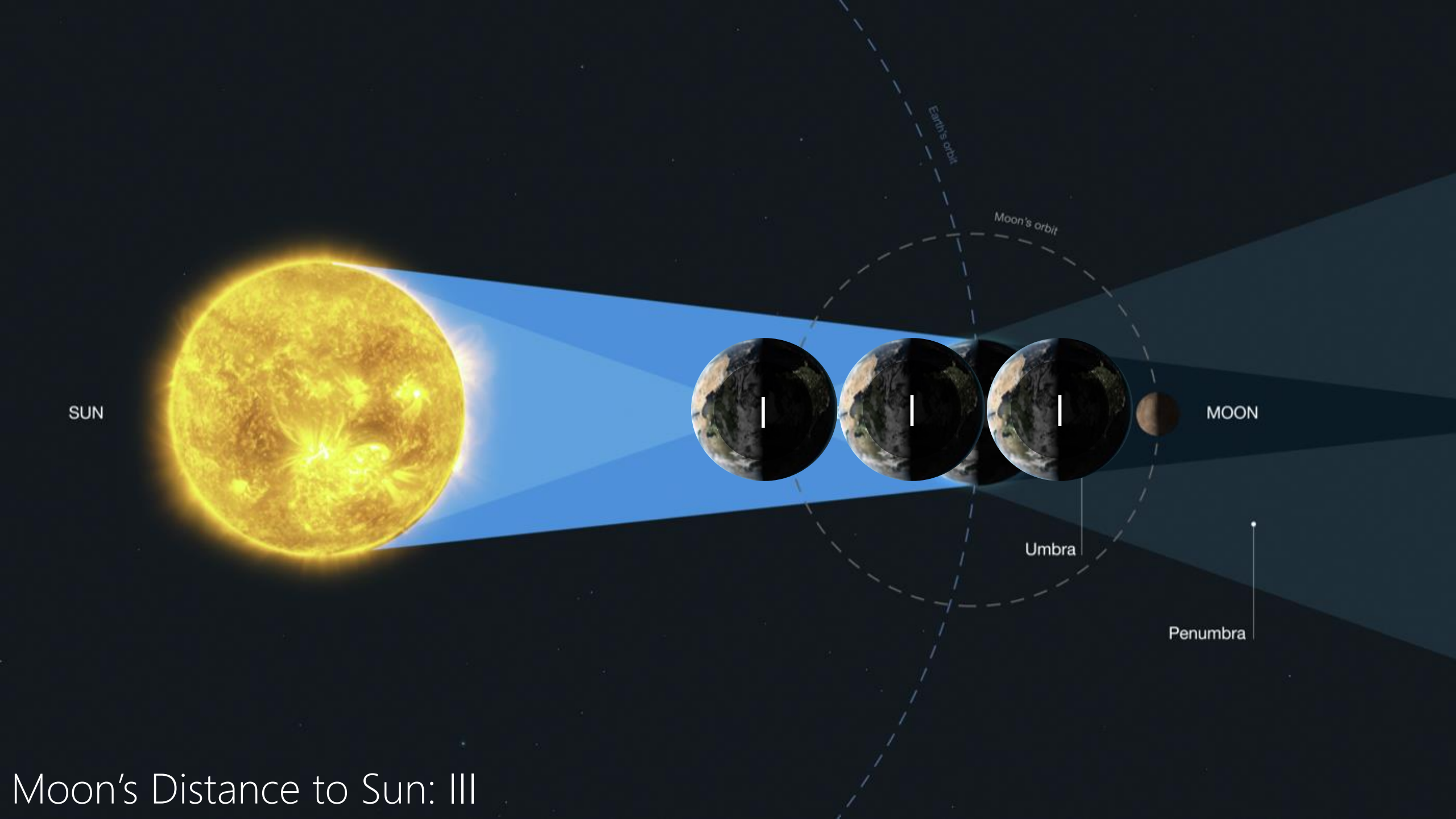
Moon’s Distance to Sun: [empty]



Moon's Distance to Sun: I



Moon's Distance to Sun: II



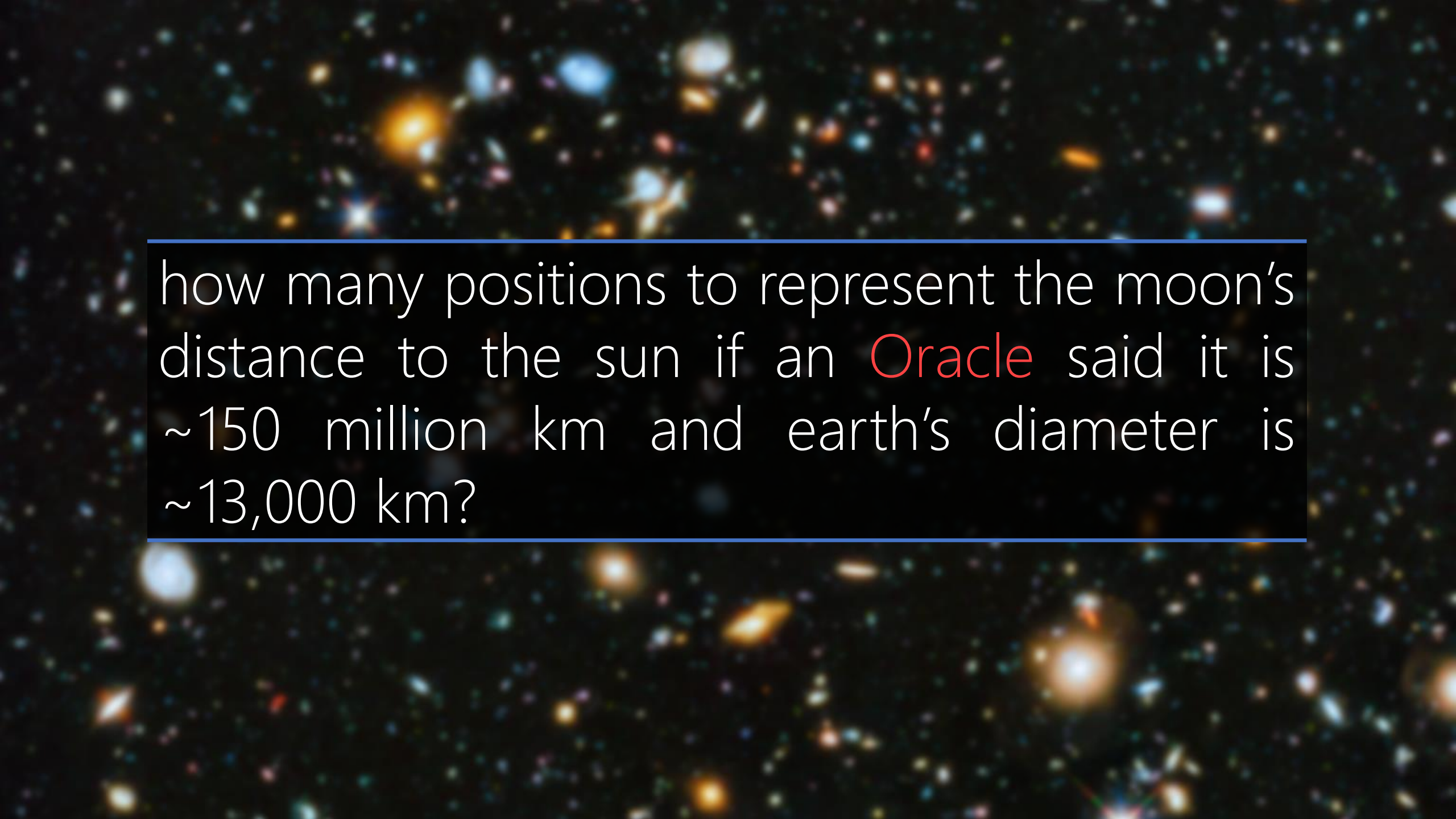
Moon's Distance to Sun: III

Quantization

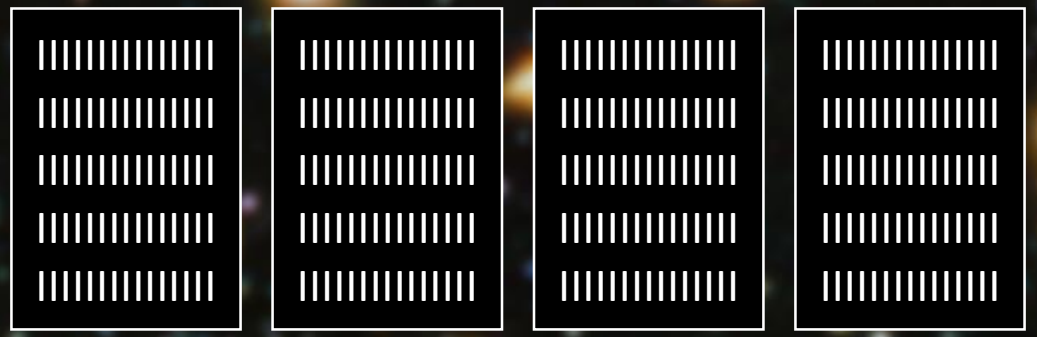
Roman Numerals
Originated in Ancient Rome
8th Century BC

UNARY SYSTEM

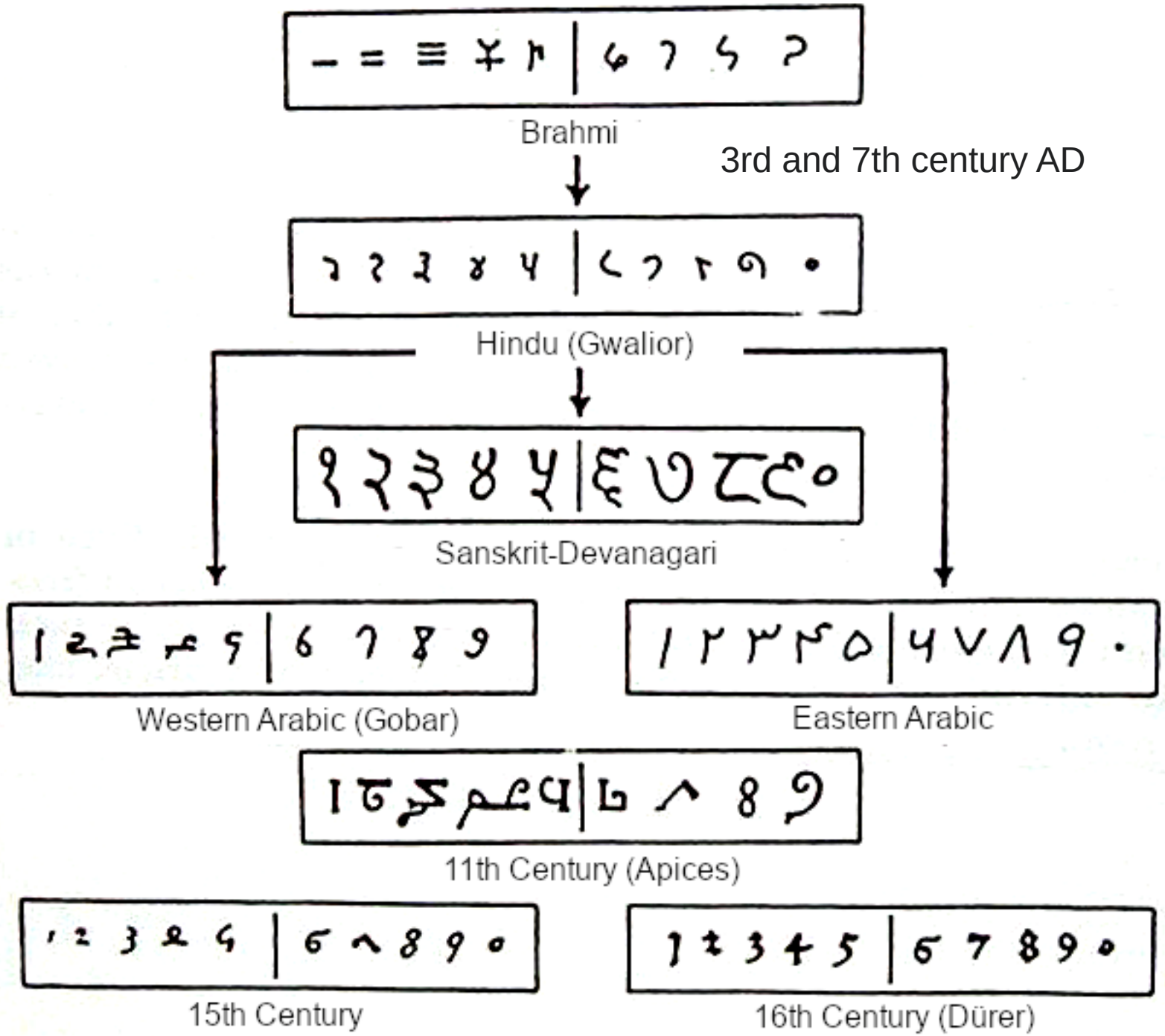
aka. Base-1


how many positions to represent the moon's distance to the sun if an Oracle said it is ~150 million km and earth's diameter is ~13,000 km?

~150 million km ÷ ~13,000 km = ~12,000 Earth
paper = ~3,000 positions
12,000 ÷ 3,000 = 4 pages!

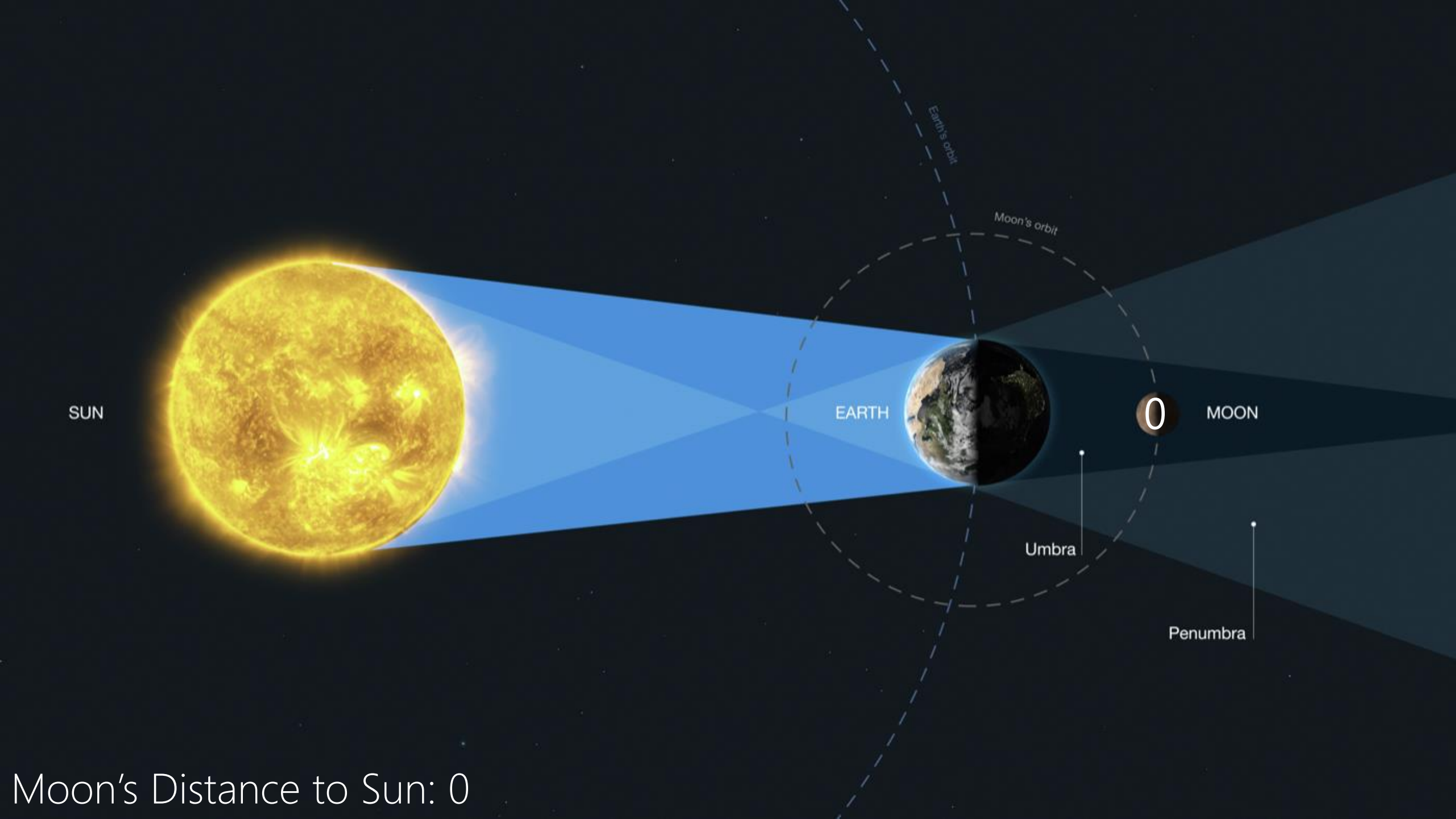


NUMBER SYSTEMS

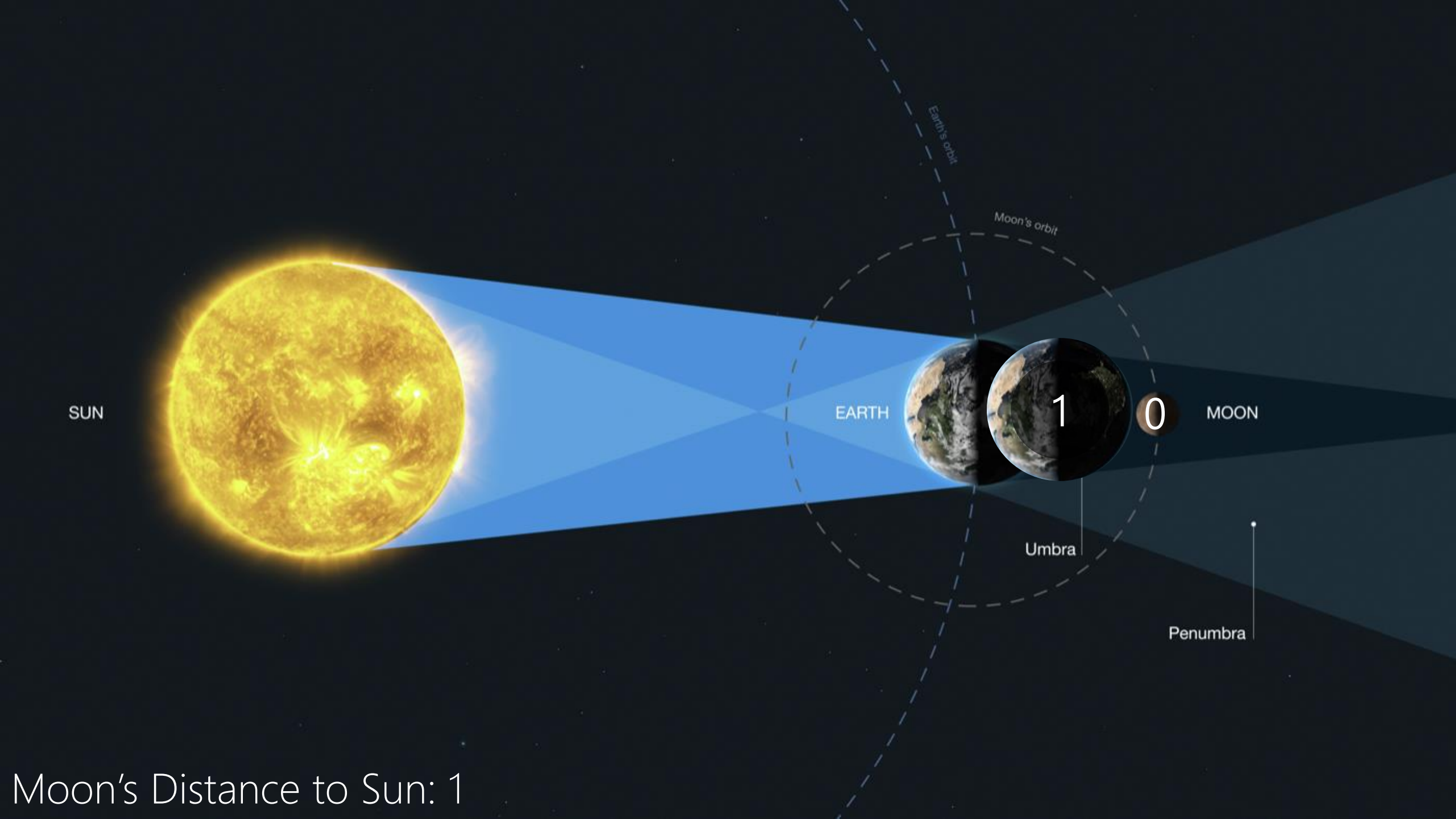

Brahmi
3rd and 7th century AD
Hindu (Gwalior)
Sanskrit-Devanagari
Western Arabic (Gobar)
Eastern Arabic
11th Century (Apices)
15th Century
16th Century (Dürer)

0123456789

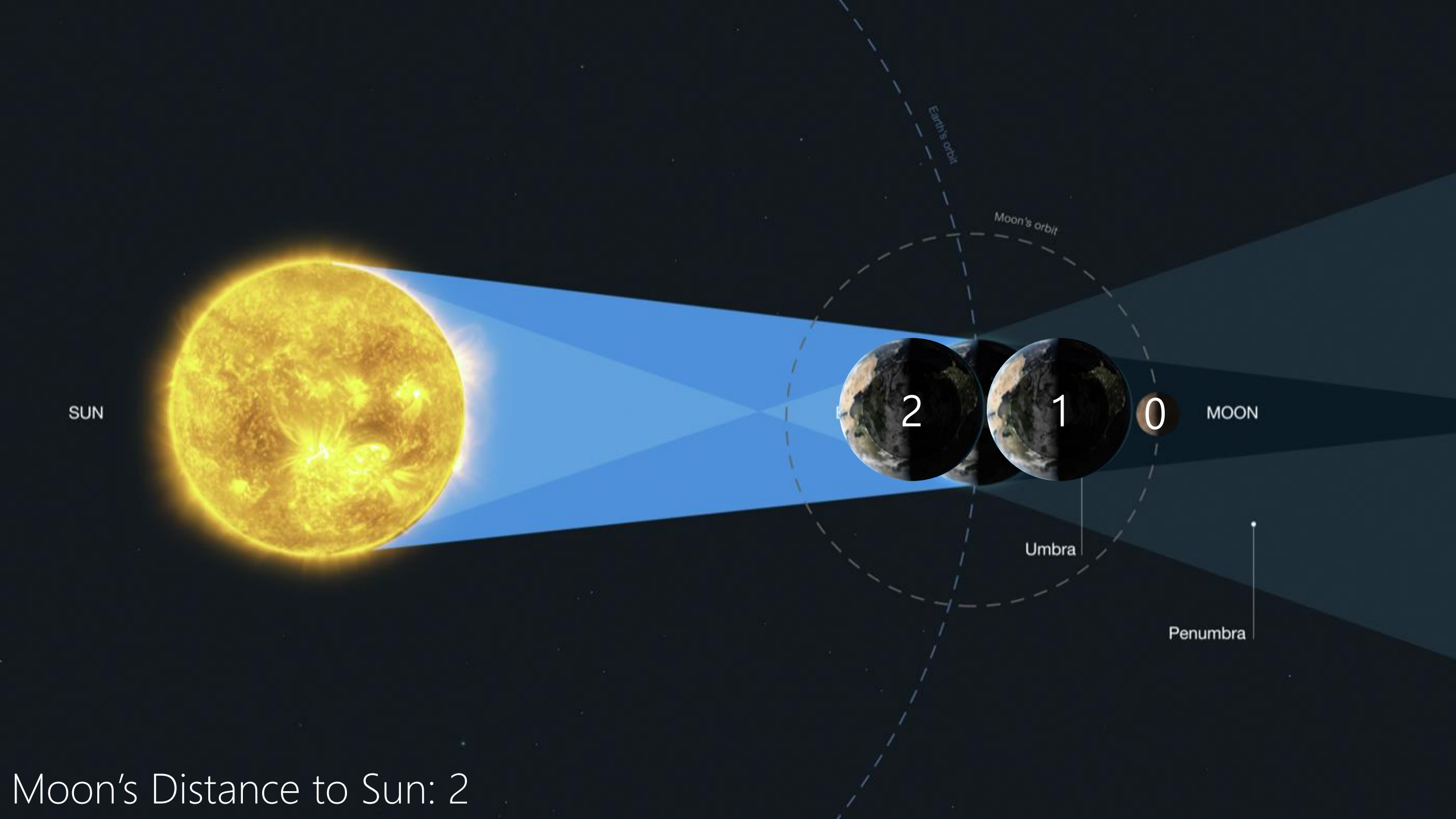
Hossein's Number System



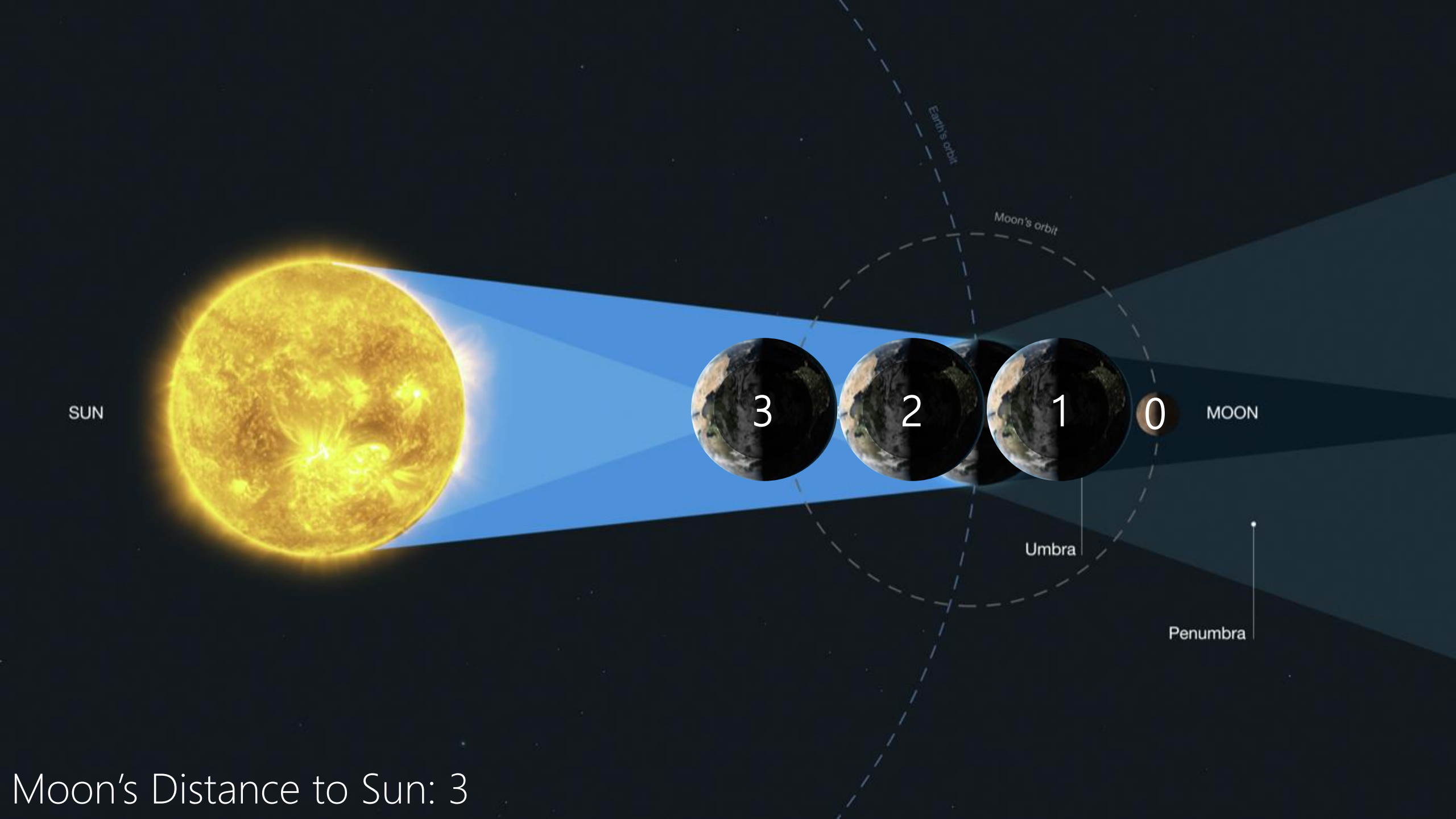
Moon’s Distance to Sun: 0



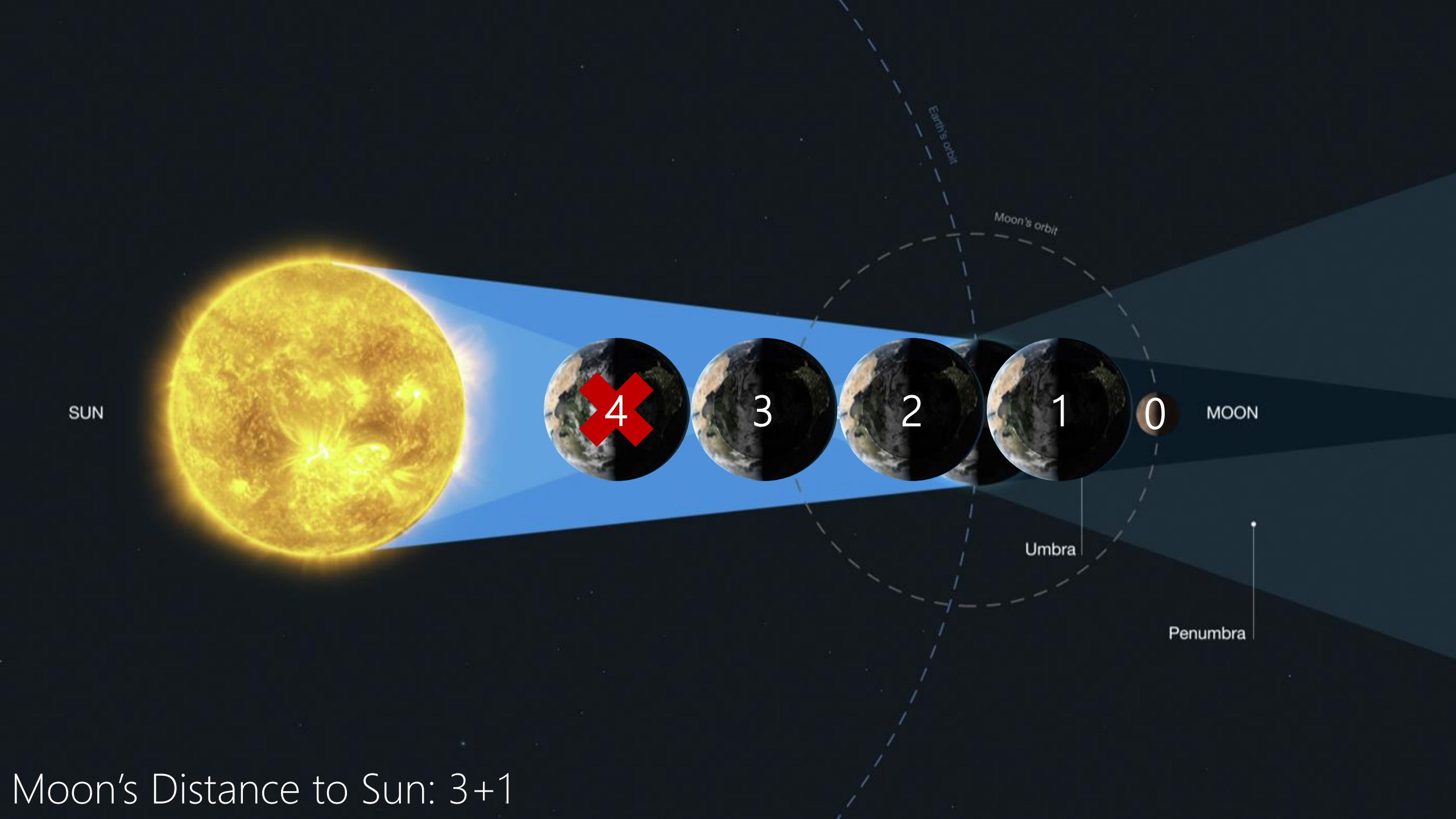
Moon’s Distance to Sun: 1



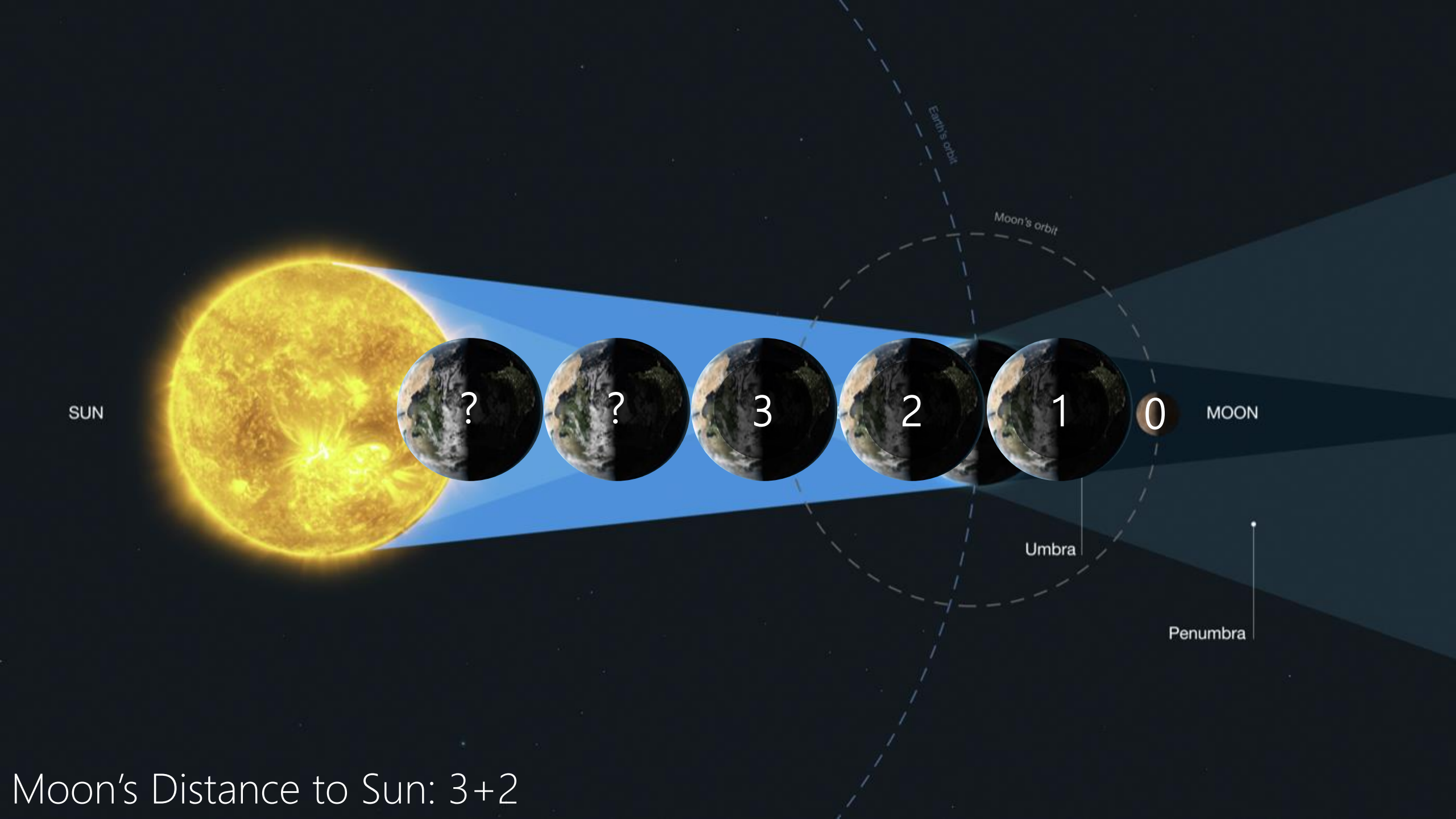
Moon’s Distance to Sun: 2



Moon’s Distance to Sun: 3

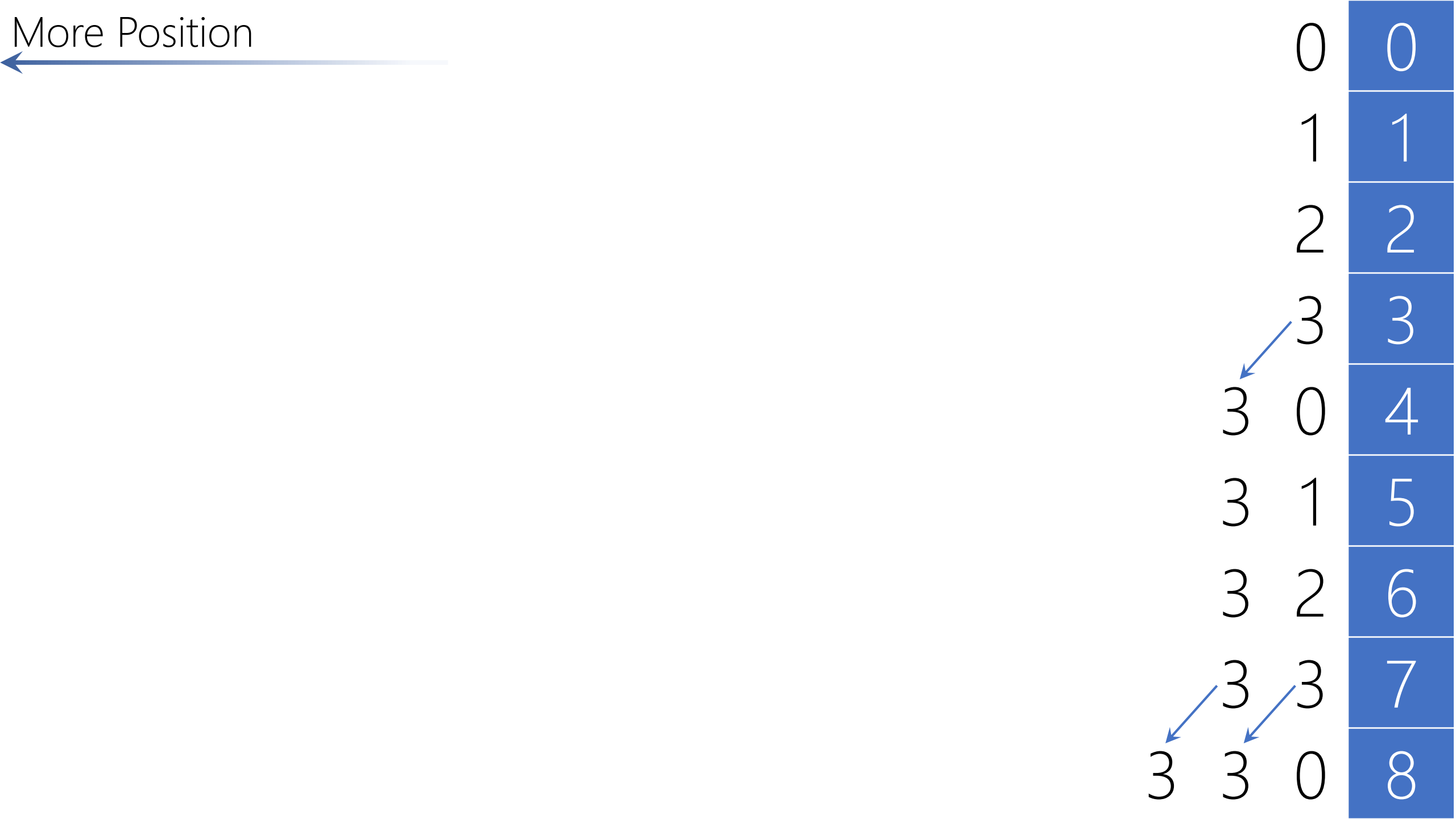


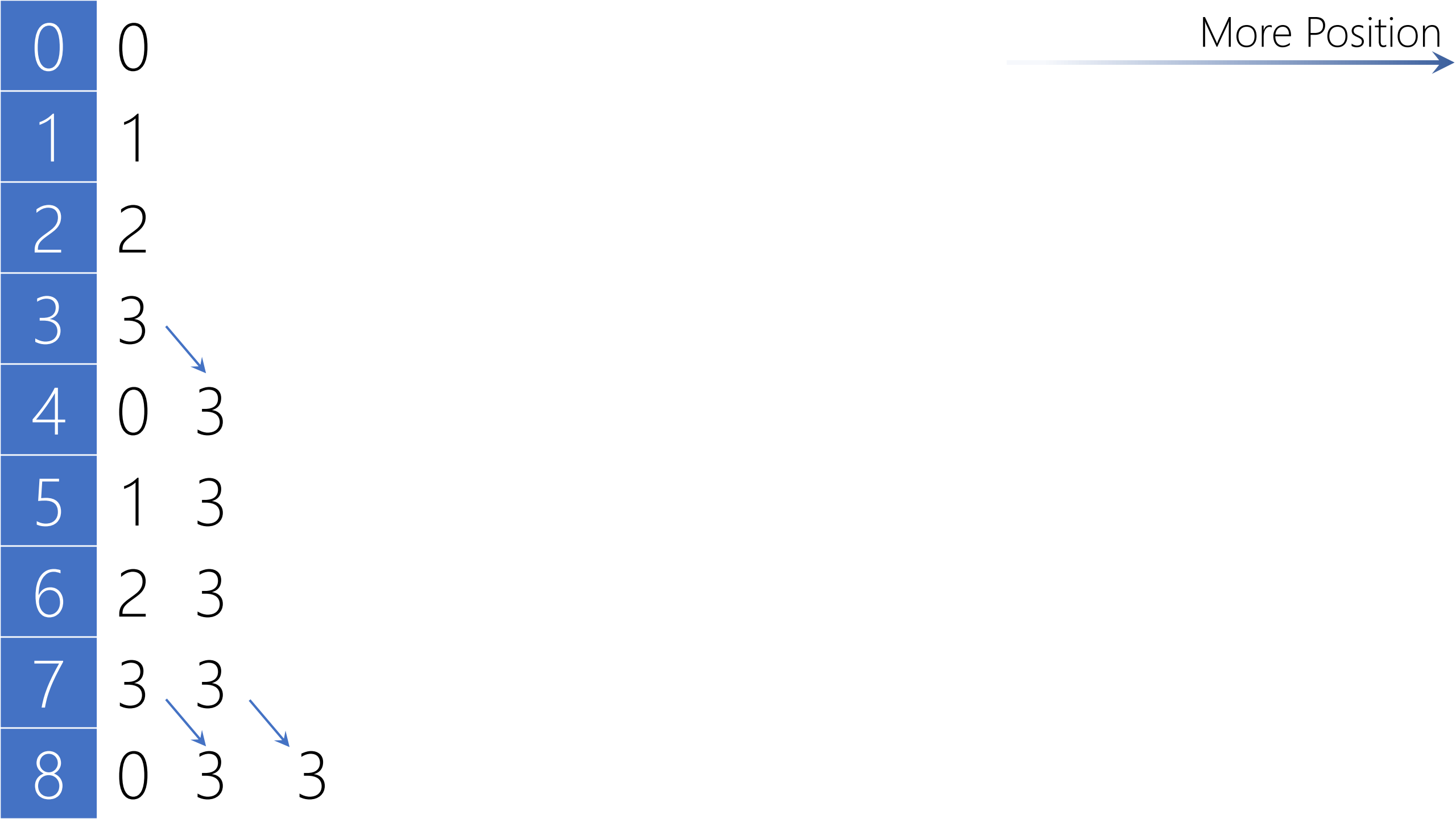
Moon's Distance to Sun: 3+1



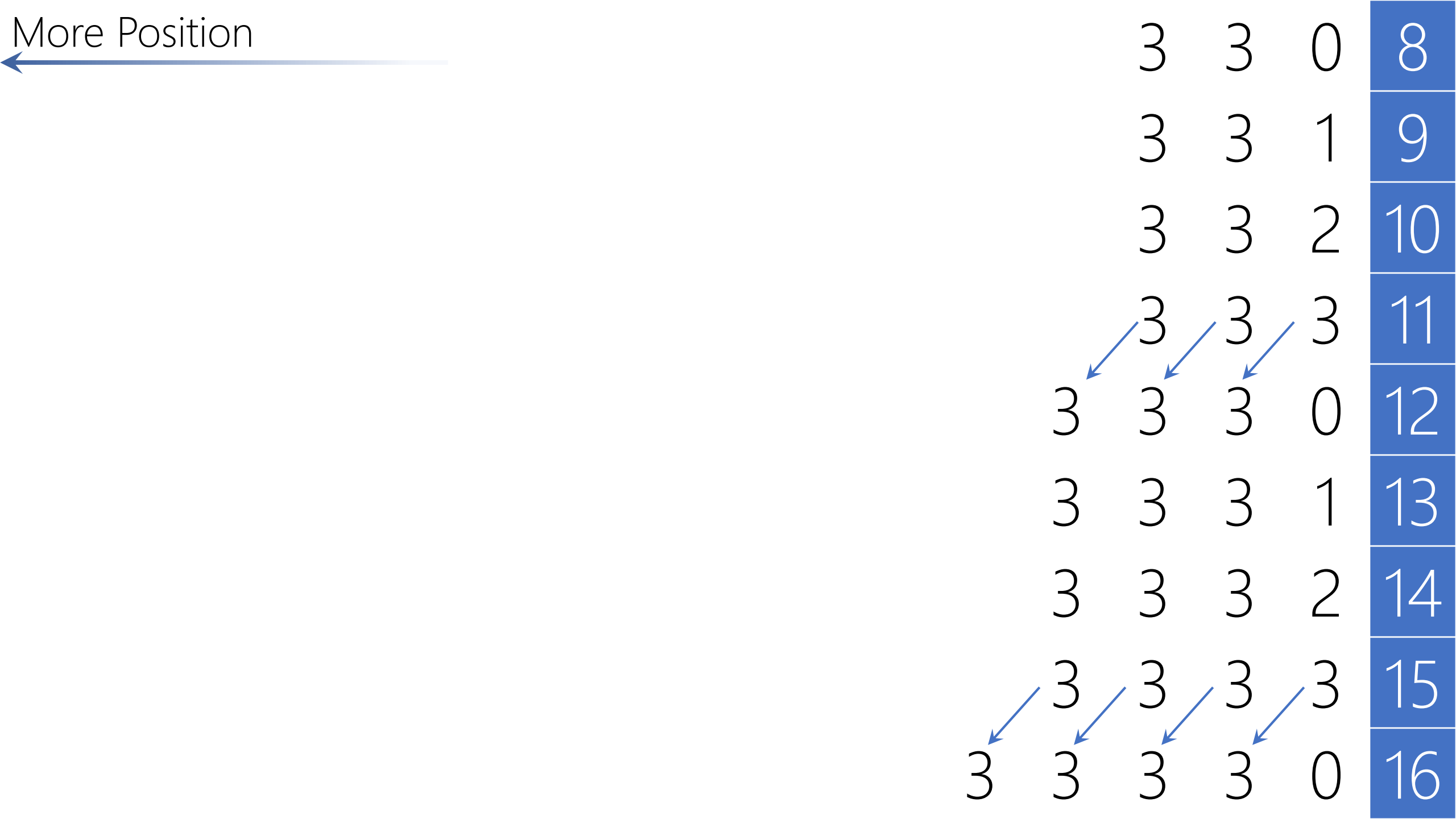
Moon's Distance to Sun: 3+2

More Position




More Position
0
1
2
3
4
5
6
7
8
0
1
2
3
0
3
1
3
2
3
3
3
0
3
3

More Position



More Position

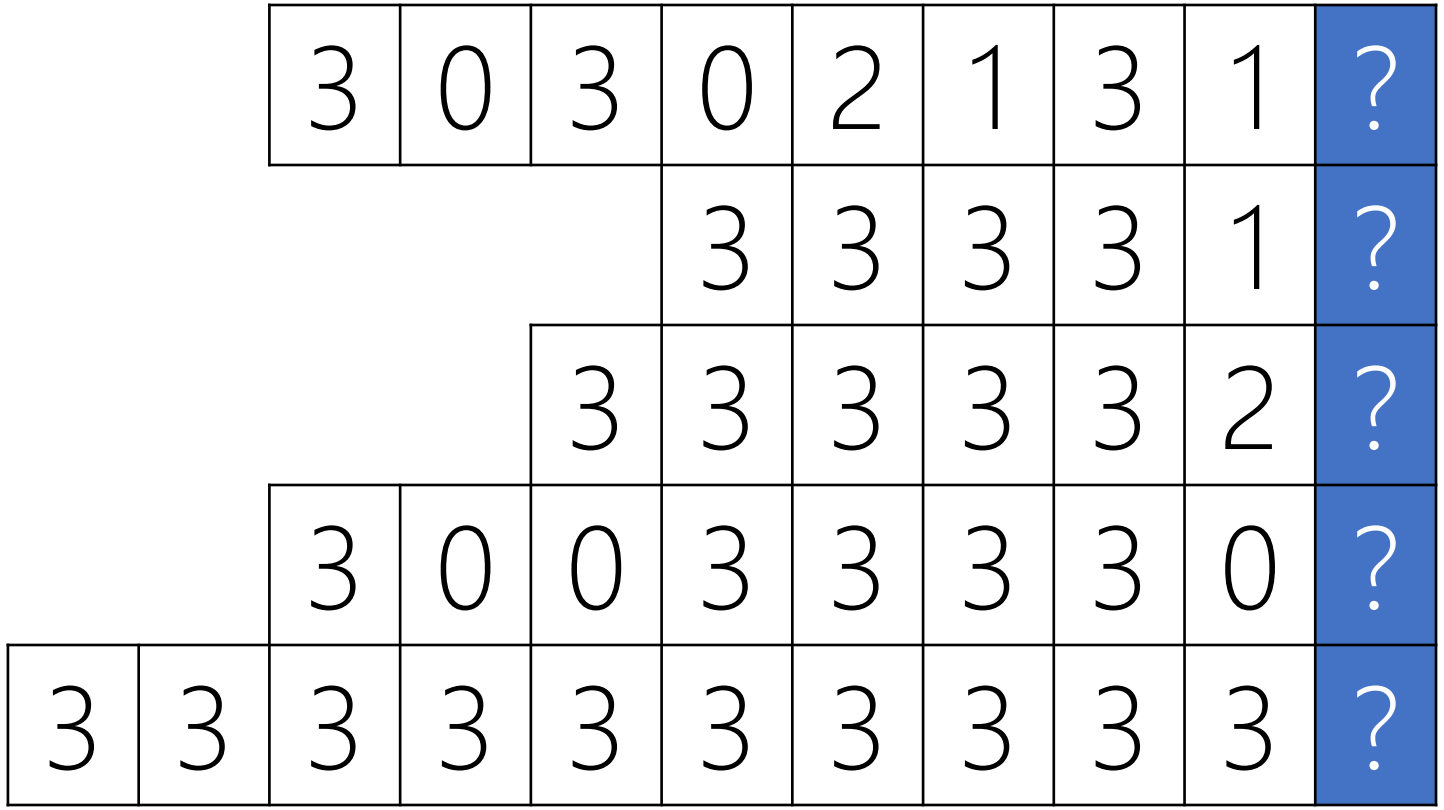
		0	(1-1)=0
		1	1+(1-1)=1
		2	2+(1-1)=2
		3	3+(1-1)=3
	3	0	3+0+(2-1)=4
	3	1	3+1+(2-1)=5
	3	2	3+2+(2-1)=6
	3	3	3+3+(2-1)=7
3	3	0	3+3+(3-1)=8

More Position

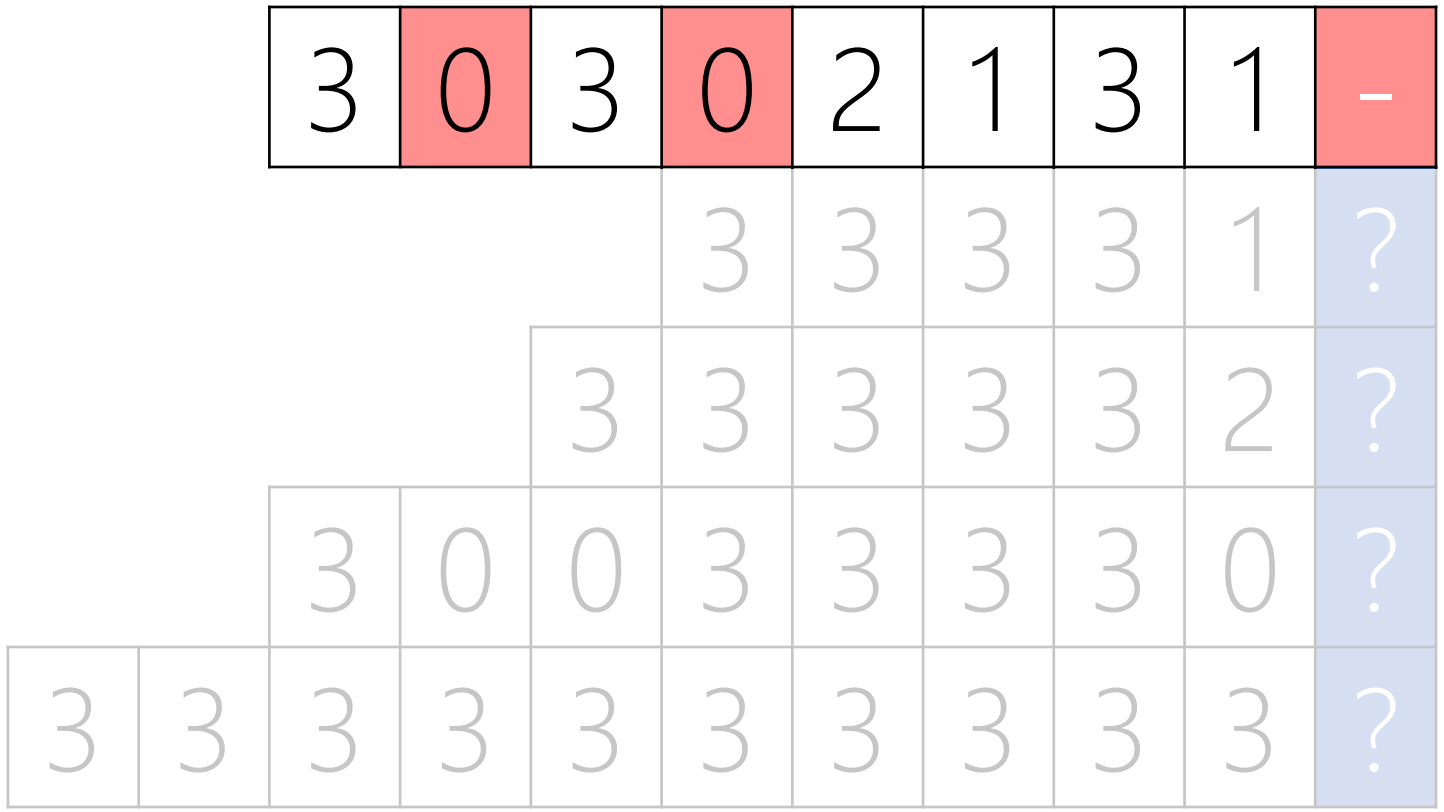
			3	3	0
			3	3	1
			3	3	2
			3	3	3
		3	3	3	0
		3	3	3	1
		3	3	3	2
		3	3	3	3
	3	3	3	3	0

3+3+0+(3-1)=8
3+3+1+(3-1)=9
3+3+2+(3-1)=10
3+3+3+(3-1)=11
3+3+3+0+(4-1)=12
3+3+3+1+(4-1)=13
3+3+3+2+(4-1)=14
3+3+3+3+(4-1)=15
3+3+3+3+(5-1)=16

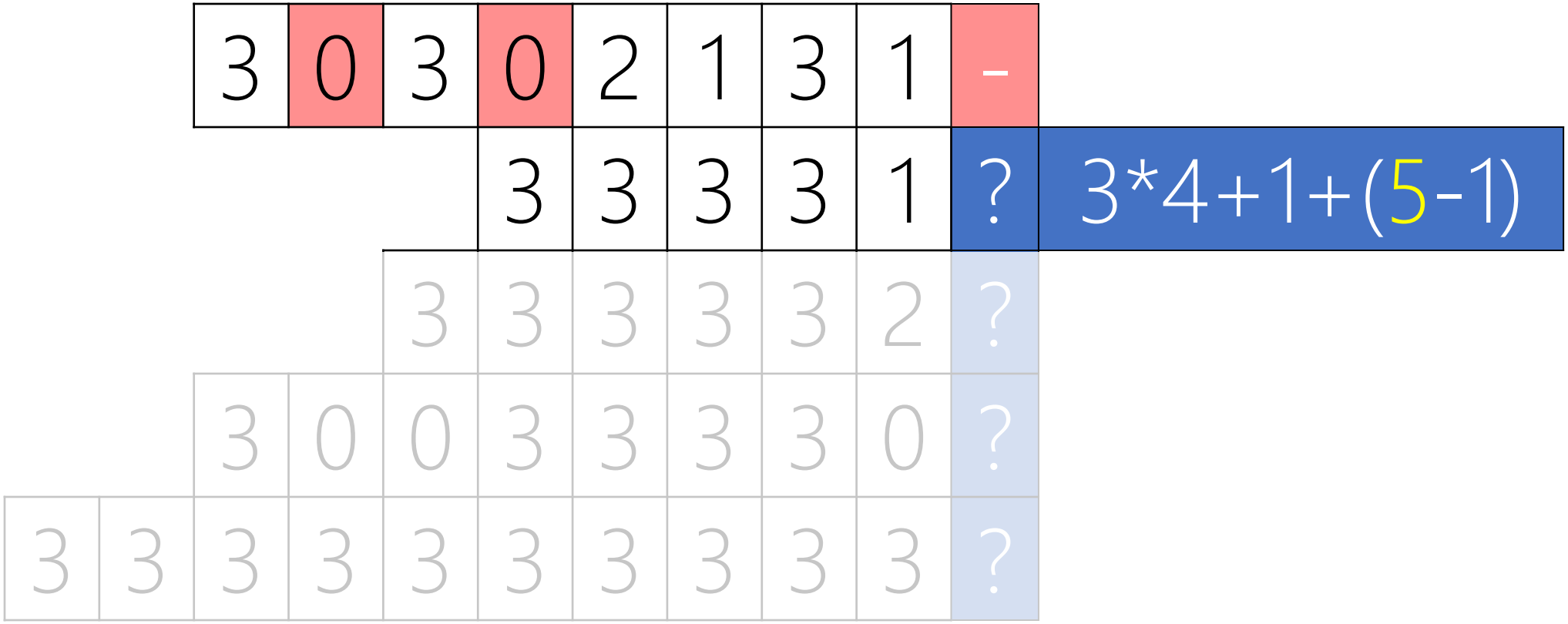
More Position



More Position

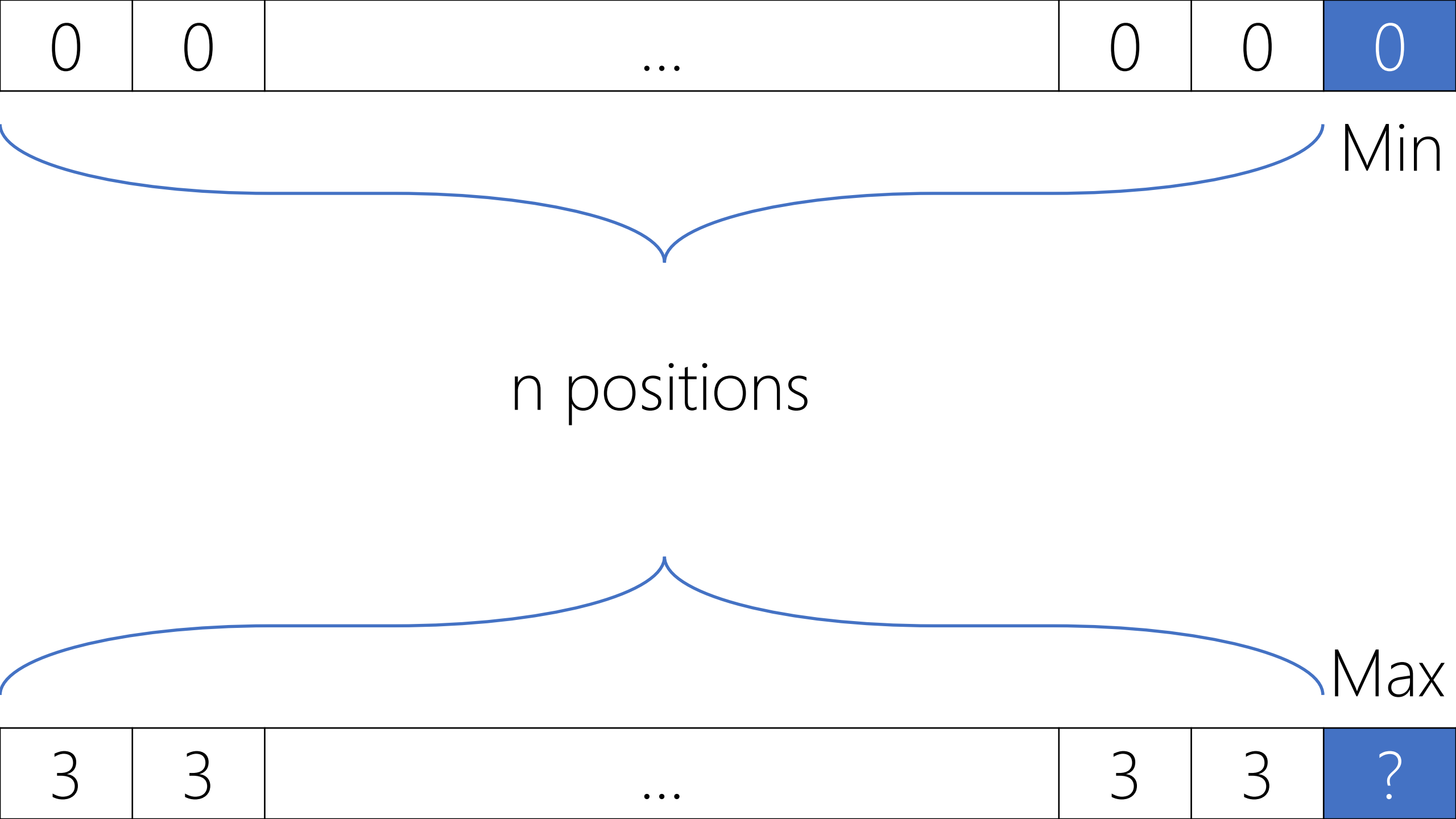


More Position

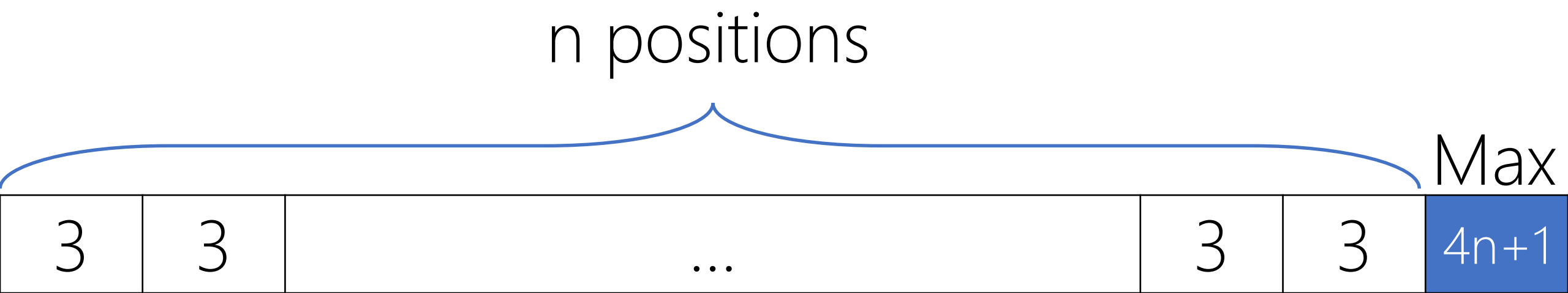


More Position

		3	0	3	0	2	1	3	1	-
					3	3	3	3	1	17
				3	3	3	3	3	2	22
		3	0	0	3	3	3	3	0	-
3	3	3	3	3	3	3	3	3	3	39


0
0
...
0
0
0
Min
n positions
Max
3
3
...
3
3
?

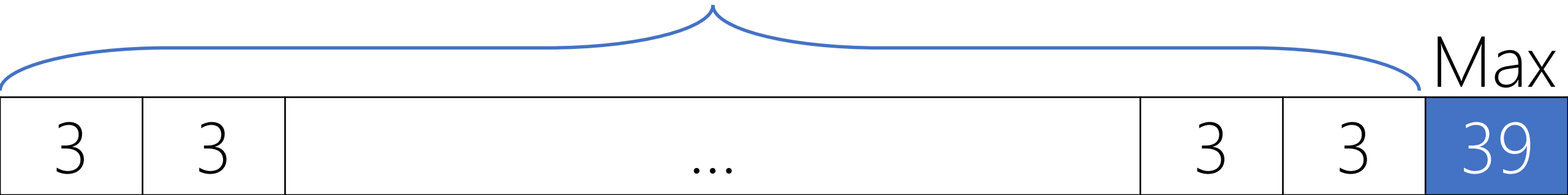
$$3+3+3+\cdots+3+(n-1) = 3\times n +(n-1)=4n-1$$



$$Max = 4n - 1$$

$$n=10 \Rightarrow (4 \times 10) - 1 = 39$$

10 positions

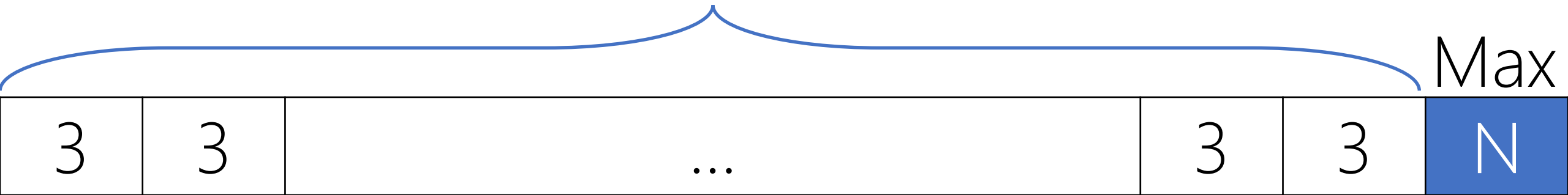


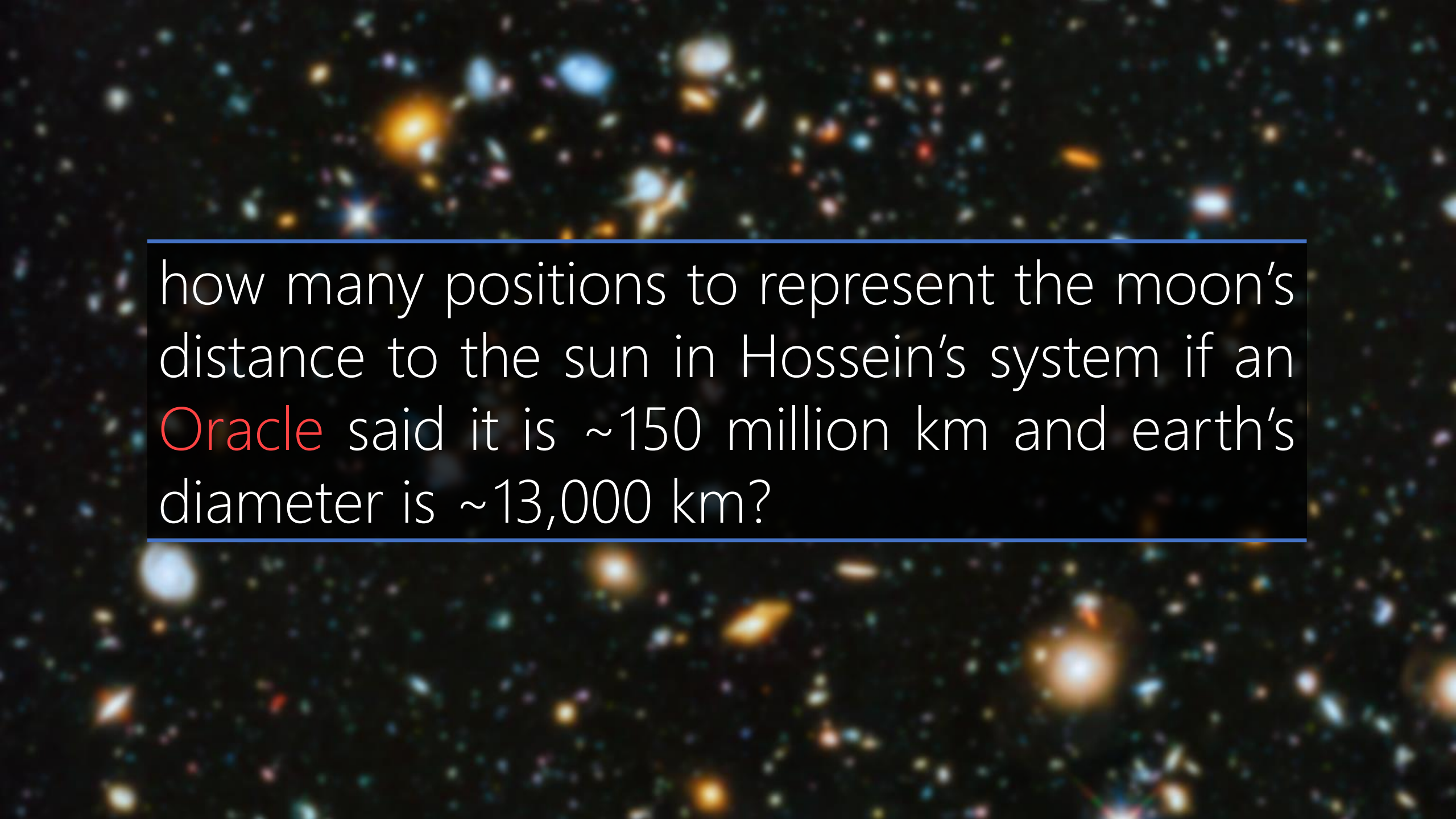
$$Max = N = 4n-1$$

$$N+1 = 4n$$

$$(N+1) \div 4 = n$$

? positions




how many positions to represent the moon's distance to the sun in Hossein's system if an Oracle said it is ~150 million km and earth's diameter is ~13,000 km?

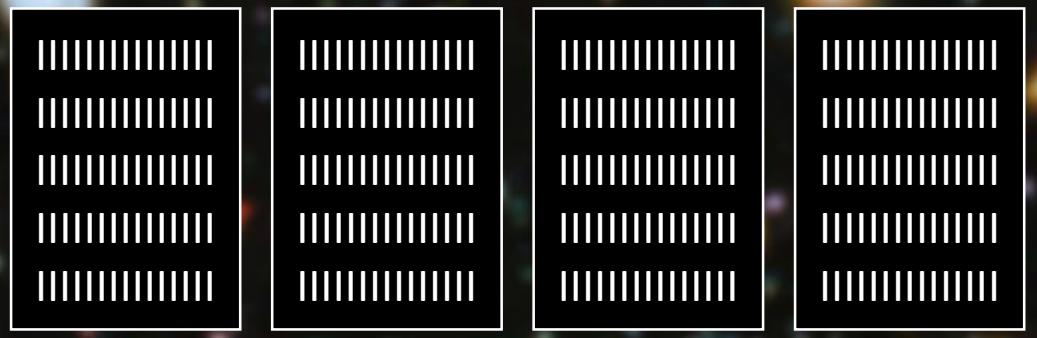
~150 million km ÷ ~13,000 km = ~12,000 Earth

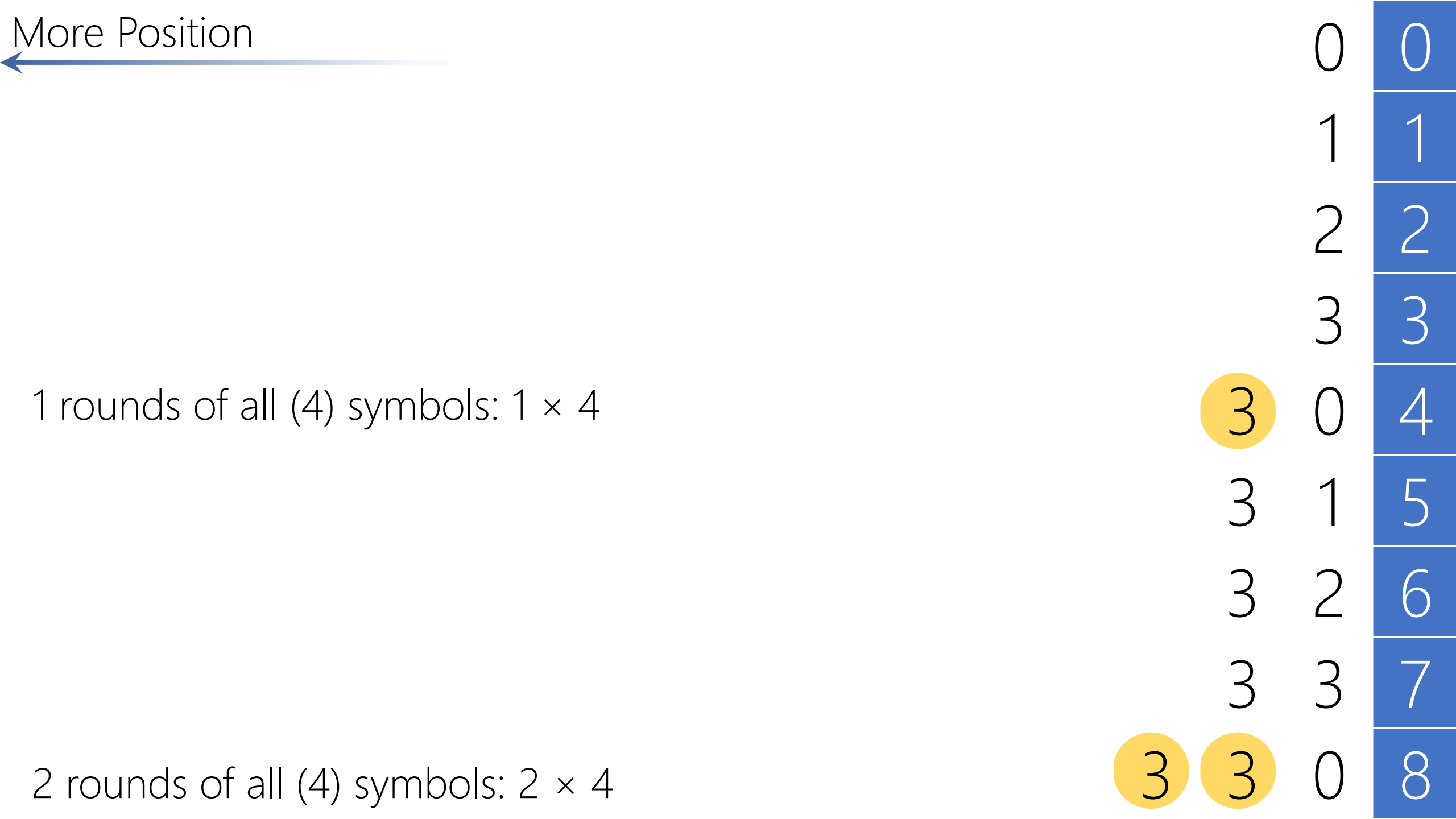
N = 12,000

n = (N+1)÷4 = (12,000+1)÷4 = ~3,000 positions

paper = ~3,000 positions

3,000 ÷ 3,000 = 1 pages



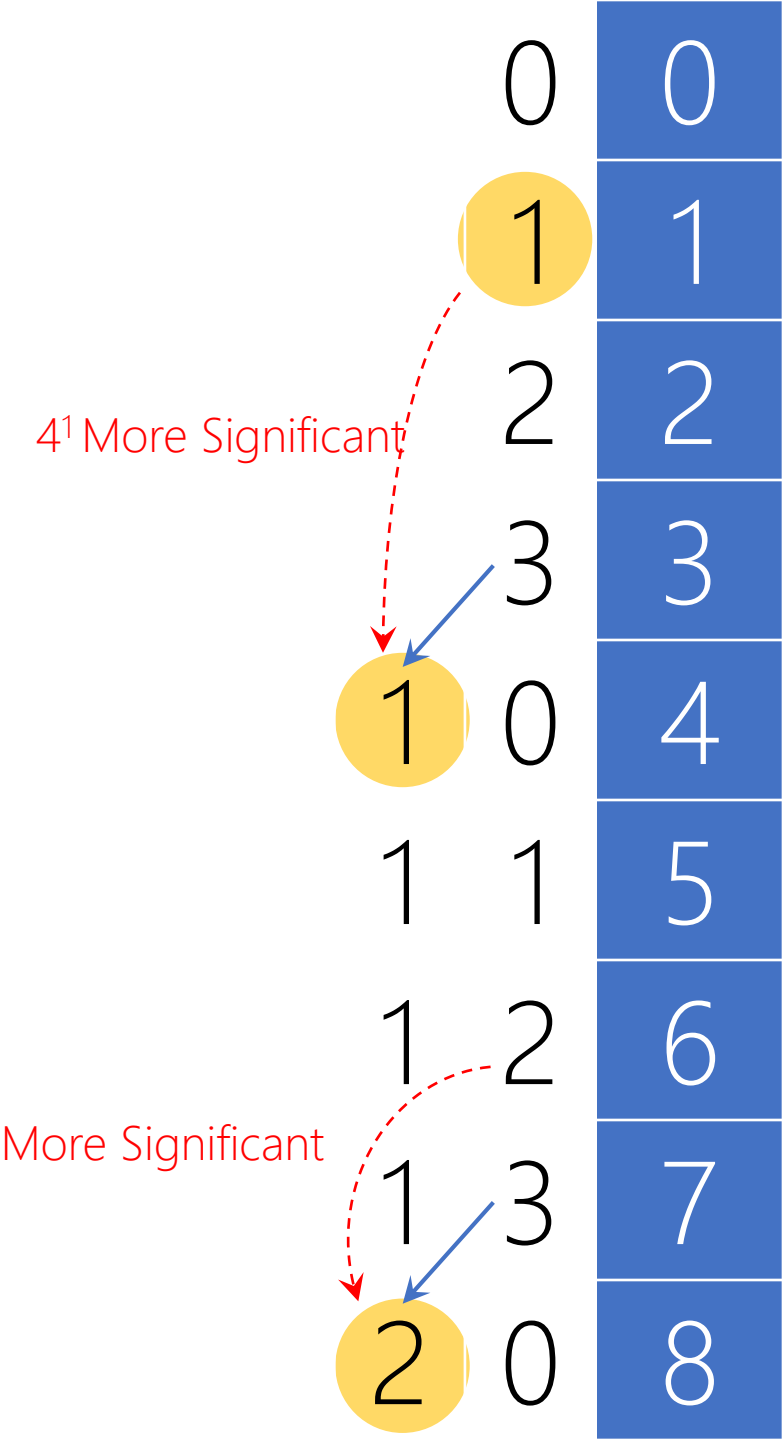

More Position
1 rounds of all (4) symbols: 1 × 4
2 rounds of all (4) symbols: 2 × 4
0 0
1 1
2 2
3 3
3 0 4
3 1 5
3 2 6
3 3 7
3 3 0 8

2 rounds of all (4) symbols: 2 × 4	3	3	0	8
	3	3	1	9
	3	3	2	10
	3	3	3	11
3 rounds of all (4) symbols: 3 × 4	3	3	3	0	12
	3	3	3	1	13
	3	3	3	2	14
	3	3	3	3	15
4 rounds of all (4) symbols: 4 × 4	3	3	3	3	0	16

More Significant Position

1 round of all (4) symbols = 1×4^1

2 rounds of all (4) symbols = 2×4^1



2 rounds of all (4) symbols = 2×4^1

4^1 More Significant

3 rounds of all (4) symbols = 3×4^1

2	0	8
2	1	9
2	2	10
2	3	11
3	0	12
3	1	13
3	2	14
3	3	15
?	?	16

2	0	8
2	1	9
2	2	10
2	3	11
3	0	12
3	1	13
3	2	14
3	3	15
1 0		16

1 rounds of all (4) symbols in the 2nd significant position
$= 4 \times 4^1 = 1 \times 4^2$

2	0	8
2	1	9
2	2	10
2	3	11
3	0	12
3	1	13
3	2	14
3	3	15
1	0	0	16

4^2 More Significant

1 rounds of all (4) symbols in the more significant position

$= 4 \times 4^1 = 1 \times 4^2$

QUATERNARY SYSTEM

/kwaa·**tur**·neh·ree/

aka. Base-4, Radix-4

$(0,1,2,3)_4$

Hindu-Arabic Numerals
Originated in India
7th Century AD

More Significant Position

#Symbols=4
Radix-4
Base-4

4^0	
0	$0\times4^0=0$
1	$1\times4^0=1$
2	$2\times4^0=2$
3	$3\times4^0=3$

More Significant Position

#Symbols=4
Radix-4
Base-4

4^1	4^0	
	0	$0\times4^0=0$
	1	$1\times4^0=1$
	2	$2\times4^0=2$
	3	$3\times4^0=3$
1	0	$1\times4^1+0\times4^0=4$
1	1	$1\times4^1+1\times4^0=5$
1	2	$1\times4^1+2\times4^0=6$
1	3	$1\times4^1+3\times4^0=7$
2	0	$2\times4^1+0\times4^0=8$

More Significant Position

#Symbols=4
Radix-4
Base-4

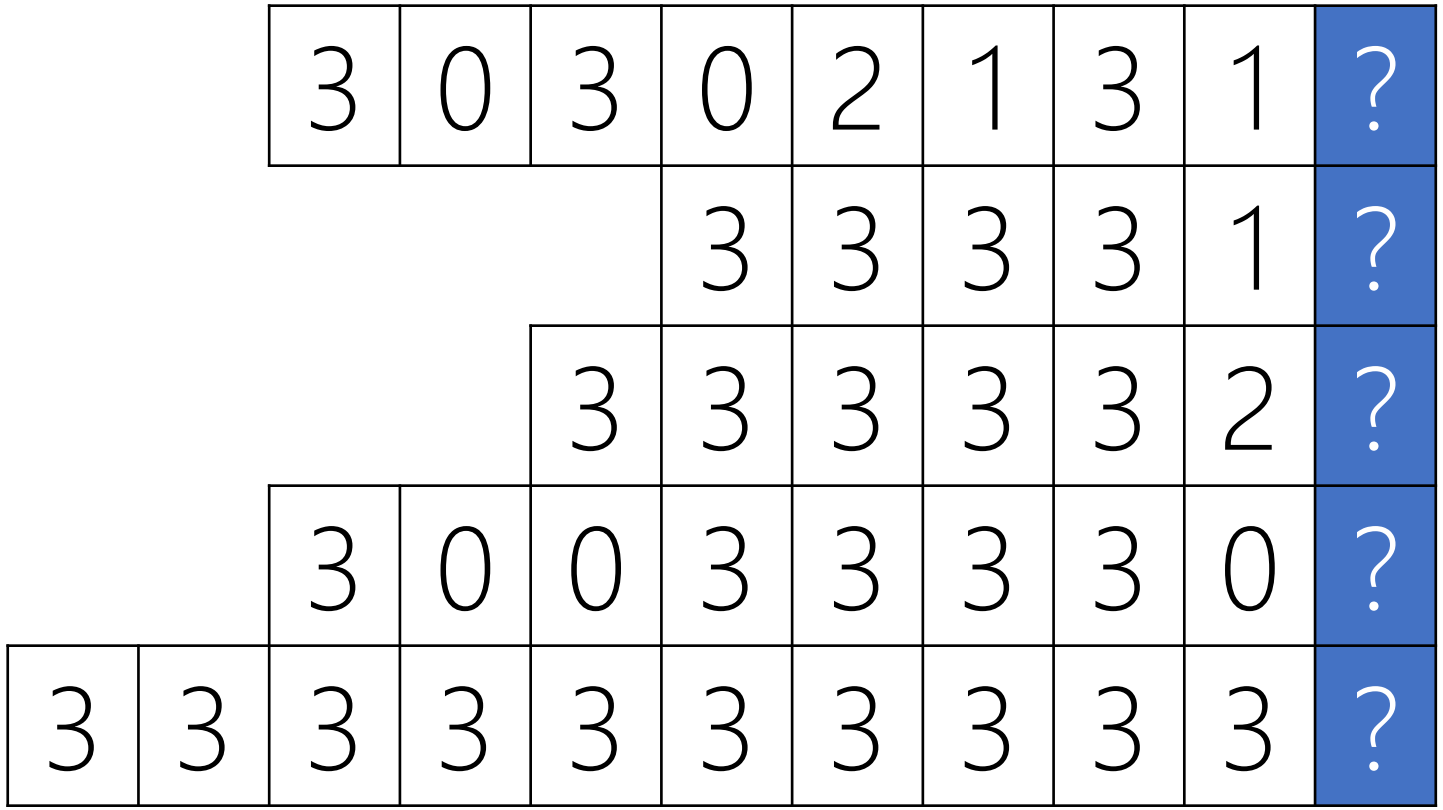
4^2	4^1	4^0	
	2	0	$2\times4^1+0\times4^0=8$
	2	1	$2\times4^1+1\times4^0=9$
	2	2	$2\times4^1+2\times4^0=10$
	2	3	$2\times4^1+3\times4^0=11$
	3	0	$3\times4^1+0\times4^0=12$
	3	1	$3\times4^1+1\times4^0=13$
	3	2	$3\times4^1+2\times4^0=14$
	3	3	$3\times4^1+3\times4^0=15$
1	0	0	$1\times4^2+0\times4^1+0\times4^0=16$

More Significant Position

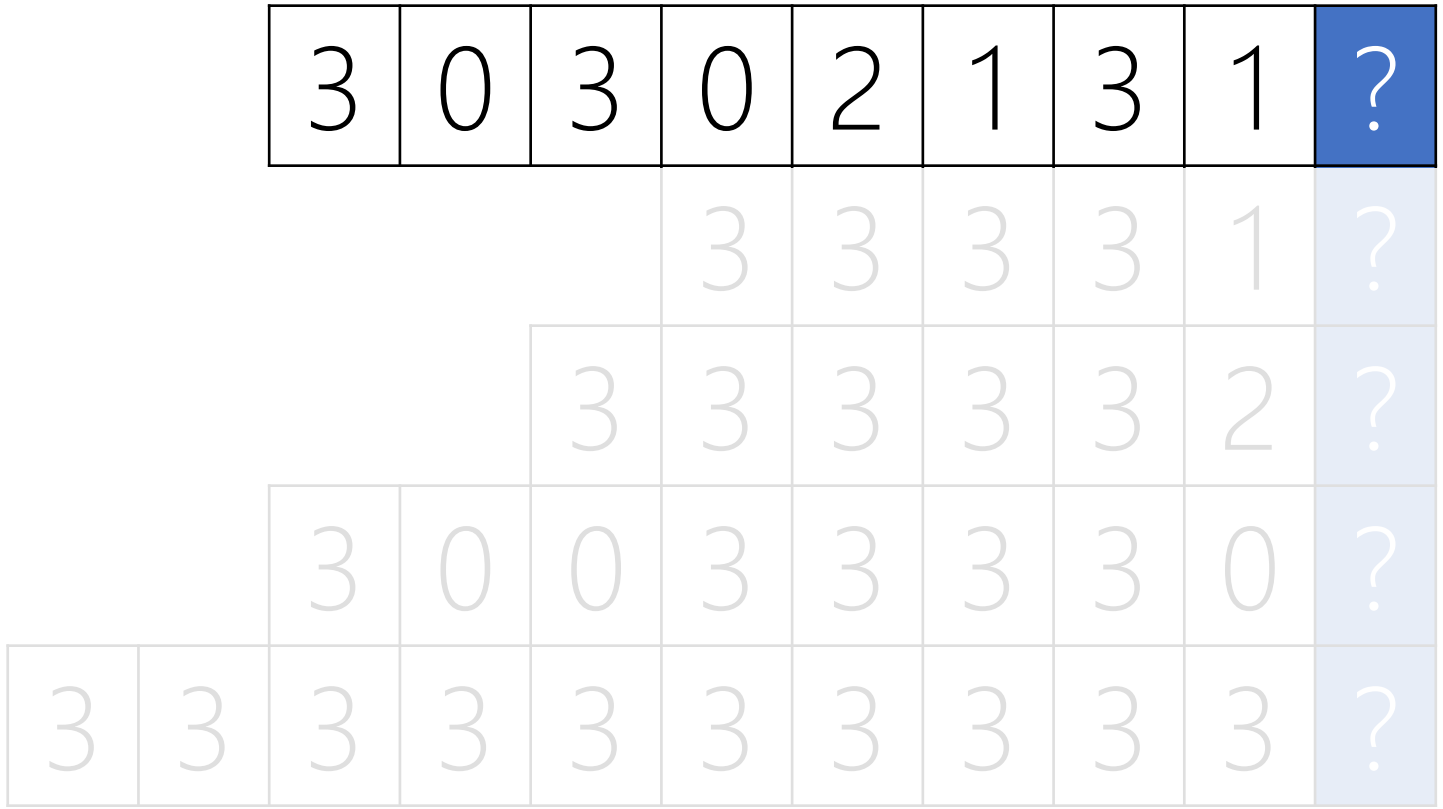
#Symbols=4
Radix-4
Base-4

4^3	4^2	4^1	4^0	
		2	0	$2\times4^1+0\times4^0=8$
		2	1	$2\times4^1+1\times4^0=9$
		2	2	$2\times4^1+2\times4^0=10$
		2	3	$2\times4^1+3\times4^0=11$
		3	0	$3\times4^1+0\times4^0=12$
		3	1	$3\times4^1+1\times4^0=13$
		3	2	$3\times4^1+2\times4^0=14$
		3	3	$3\times4^1+3\times4^0=15$
	1	0	0	$1\times4^2+0\times4^1+0\times4^0=16$

More Significant Position



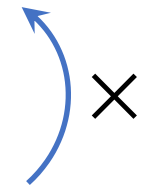
More Significant Position



More Significant Position

4^7	4^6	4^5	4^4	4^3	4^2	4^1	4^0	
3	0	3	0	2	1	3	1	

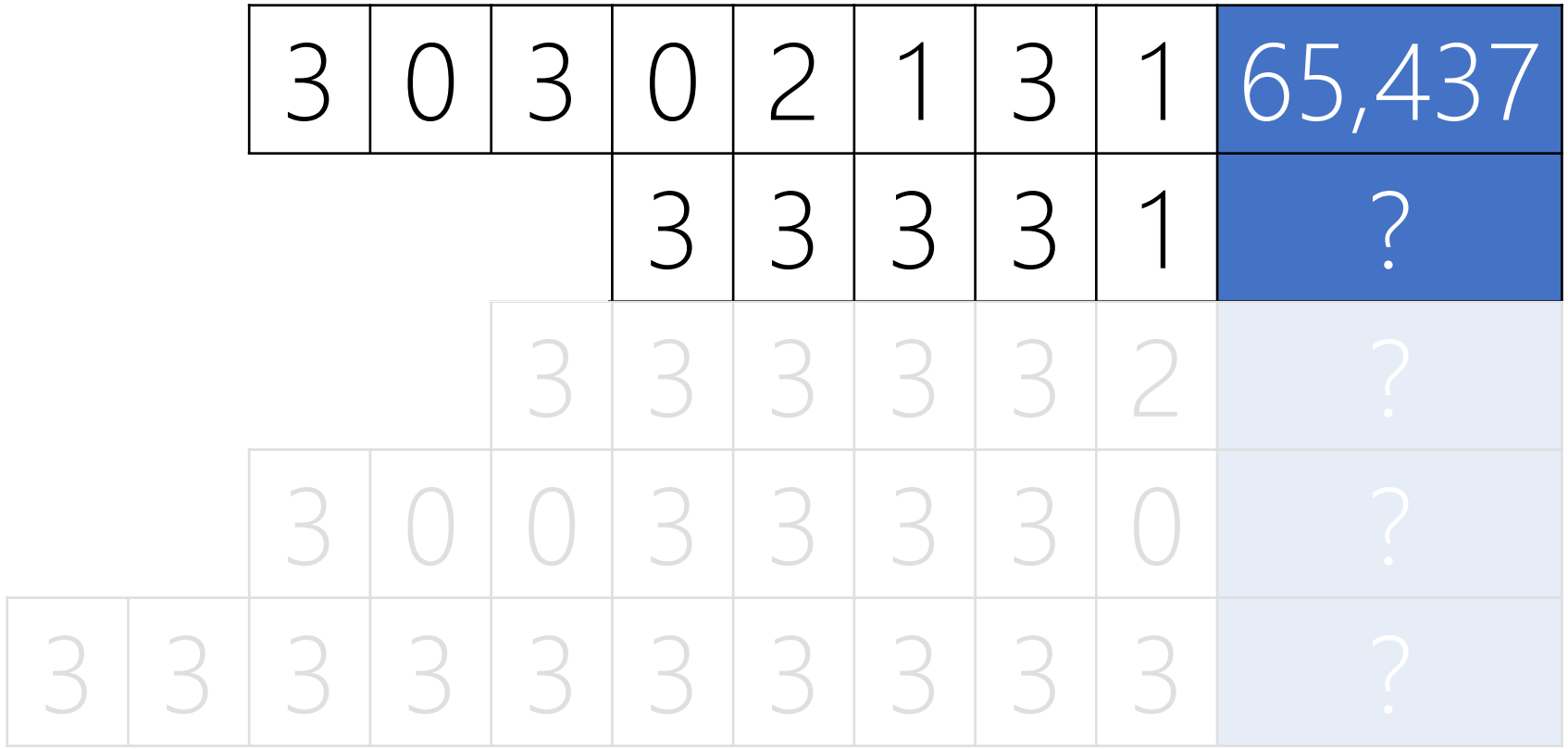
More Significant Position

4^7	4^6	4^5	4^4	4^3	4^2	4^1	4^0	
3	0	3	0	2	1	3	1	
3×4^7	0×4^6	3×4^5	0×4^4	2×4^3	1×4^2	3×4^1	1×4^0	

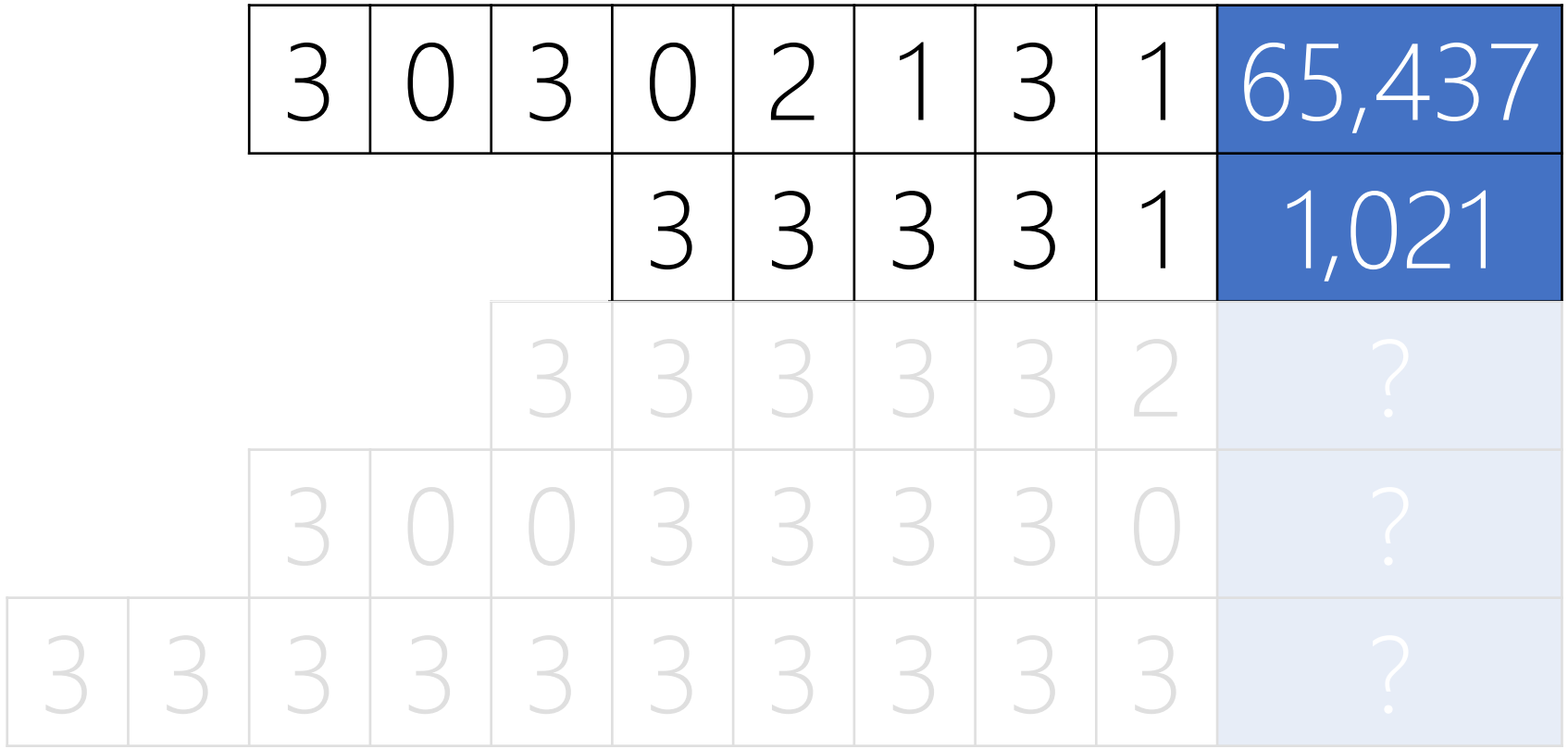
More Significant Position

4^7	4^6	4^5	4^4	4^3	4^2	4^1	4^0	
3	0	3	0	2	1	3	1	×
3×4^7	0×4^6	3×4^5	0×4^4	2×4^3	1×4^2	3×4^1	1×4^0	$\sum$
								65,437

More Significant Position



More Significant Position

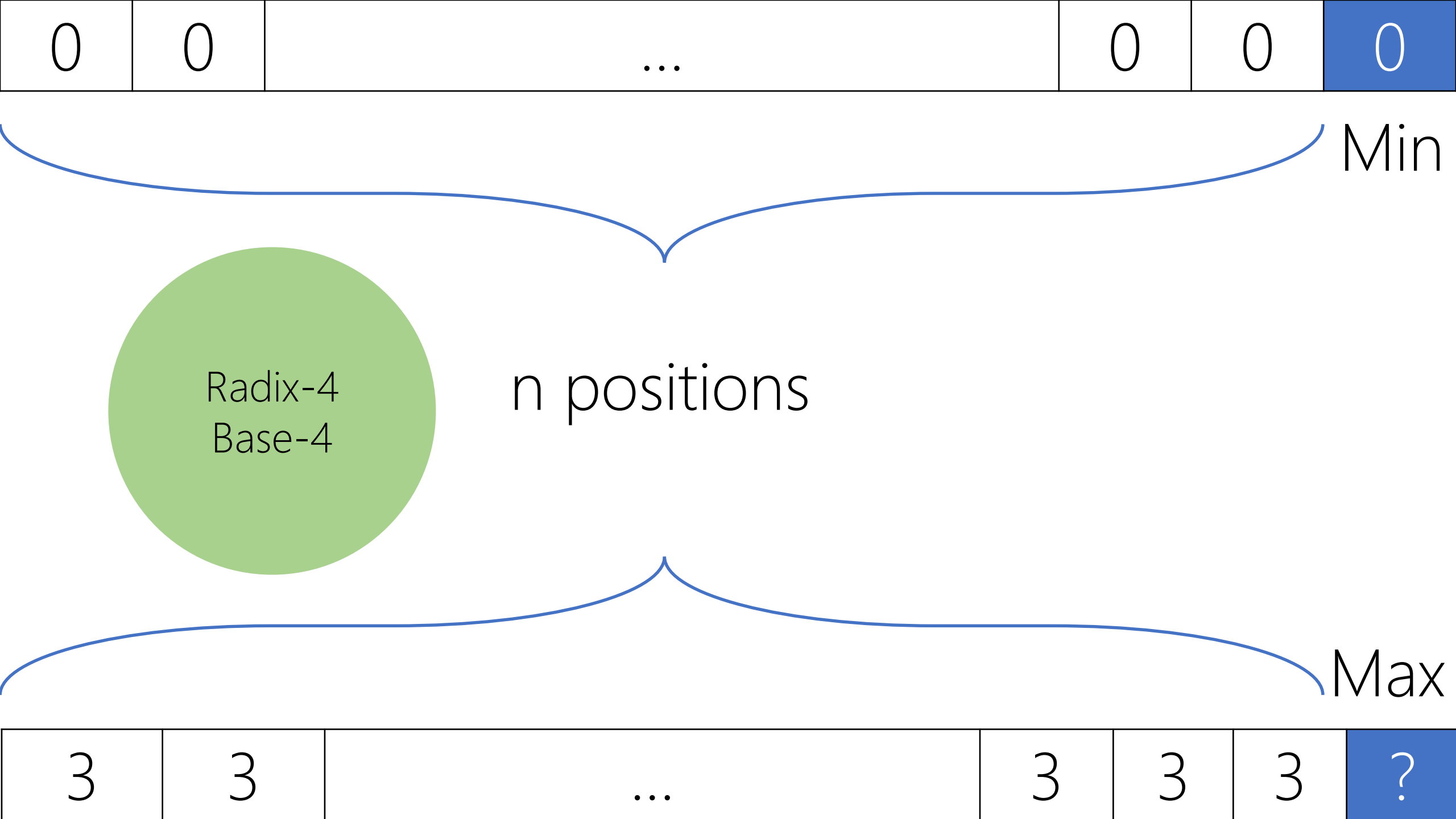


More Significant Position

		3	0	3	0	2	1	3	1	65,437
					3	3	3	3	1	1,021
				3	3	3	3	3	2	4,094
		3	0	0	3	3	3	3	0	50,172
3	3	3	3	3	3	3	3	3	3	1,048,575

More Significant Position

									Base-4	Hossein's Number System
		3	0	3	0	2	1	3	1	65,437	-
					3	3	3	3	1	1,021	17
				3	3	3	3	3	2	4,094	22
		3	0	0	3	3	3	3	0	50,172	-
3	3	3	3	3	3	3	3	3	3	1,048,575	39


0
0
...
0
0
0
Min
Radix-4
Base-4
n positions
Max
3
3
...
3
3
3
?

$$N = 3 \times 4^{n-1} + 3 \times 4^{n-2} + \cdots + 3 \times 4^2 + 3 \times 4^1 + 3 \times 4^0$$

$$N = 3 \times (4^{n-1} + 4^{n-2} + \cdots + 4^2 + 4^1 + 4^0)$$

$$N = 3 \times \left(\frac{4^n - 1}{4 - 1}\right)$$

$$N = 4^n - 1$$

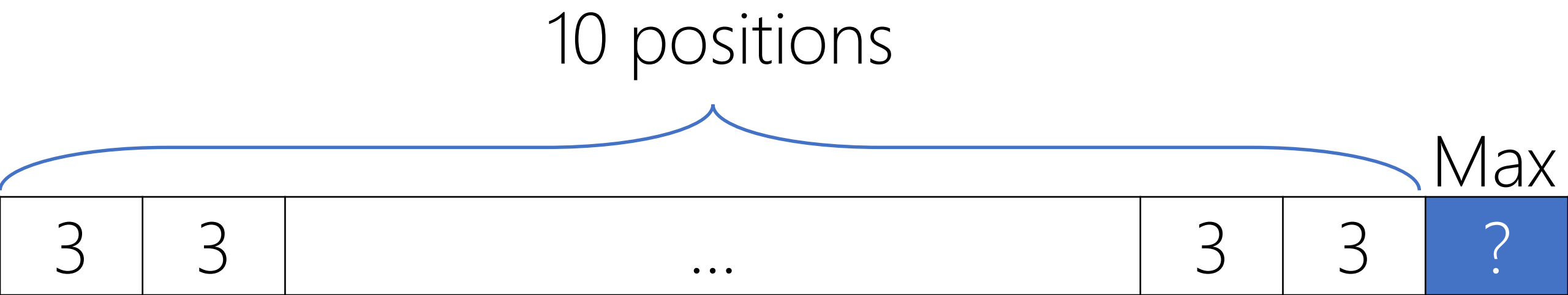
$4n - 1$
Hossein's System

n positions

Max

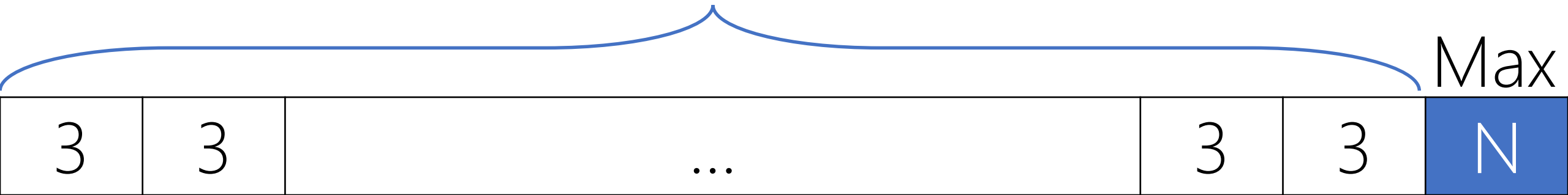
4^{n-1}	4^{n-2}		4^2	4^1	4^0	
3	3	…	3	3	3	N

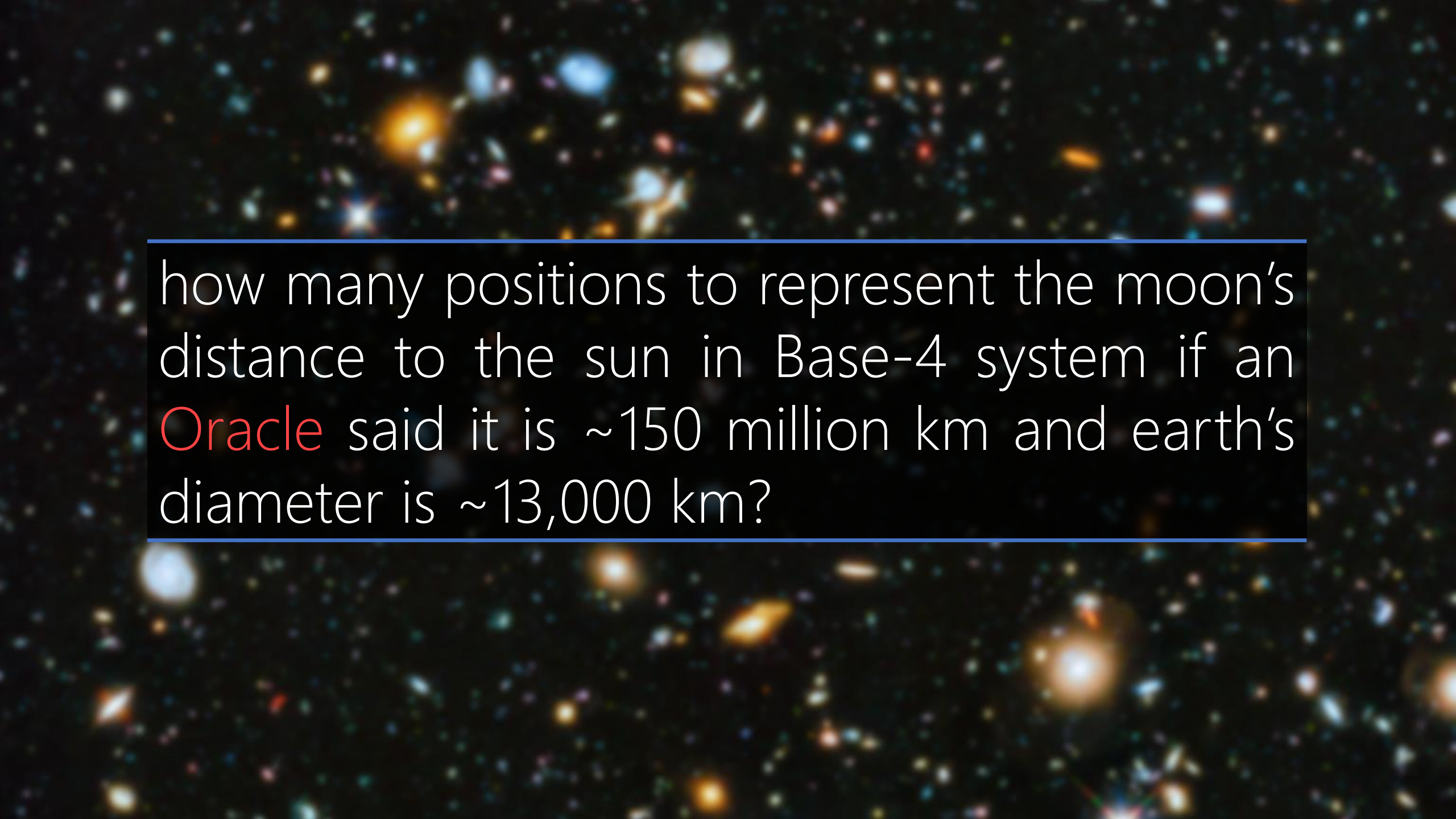
$$n = 10 \Rightarrow\ 410 - 1 = 1{,}048{,}575$$



$$4^n - 1 = N$$
$$4^n = N + 1$$
$$n = \log_4(N + 1)$$

? positions



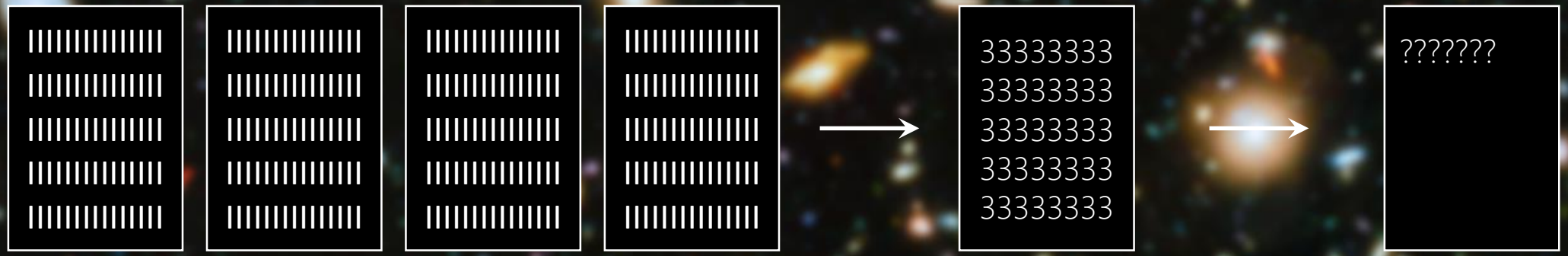

how many positions to represent the moon's distance to the sun in Base-4 system if an Oracle said it is ~150 million km and earth's diameter is ~13,000 km?

~150 million km ÷ ~13,000 km = ~12,000 Earth

N = 12,000

$n = \text{Log}_4 (12{,}000+1) = \text{Log}_{10}\ 12{,}001 \div \text{Log}_{10}\ 4 = 4 \div 0.6 = 6.79$

~ 7 positions

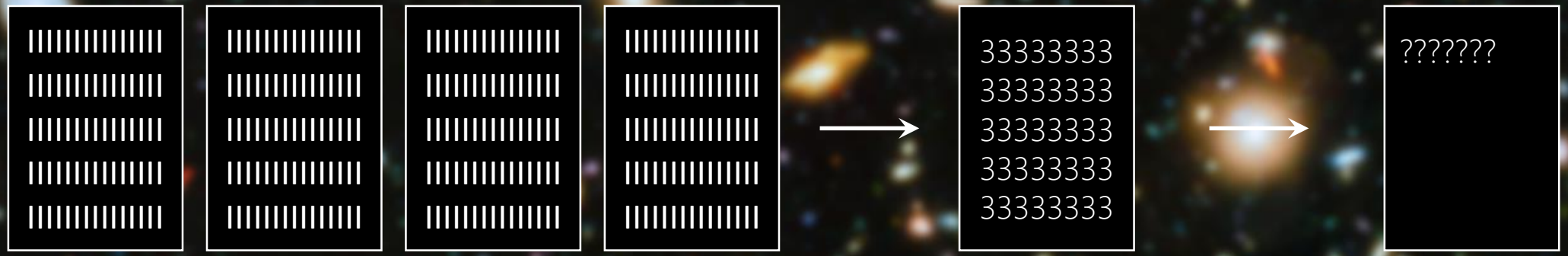


~150 million km ÷ ~13,000 km = ~12,000 Earth

N = 12,000

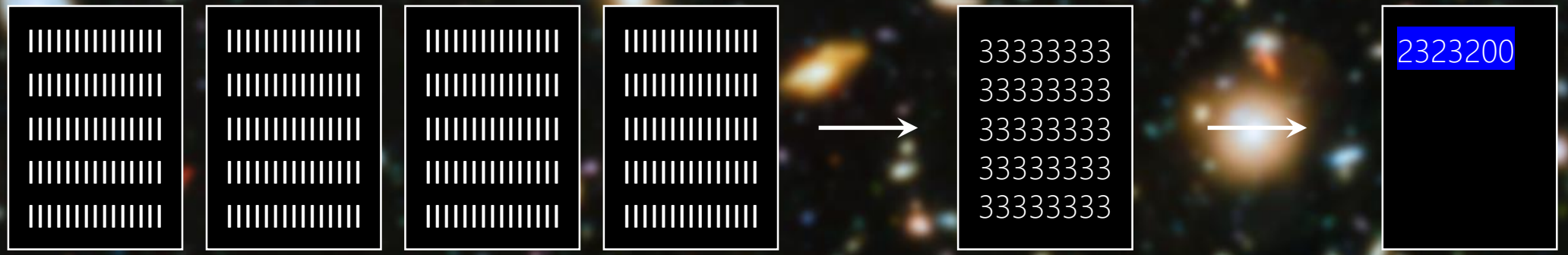
$n = \text{Log}_4 (12{,}000+1) = \text{Log}_{10}\ 12{,}001 \div \text{Log}_{10}\ 4 = 4 \div 0.6 = 6.79$

~ 7 positions



$$N = 12{,}000 \longrightarrow (2323200)_4$$

We'll see how to convert from decimal to base-4 or any other number systems later. Stay tuned!



QUESTION