The Universe: where does it end?

Chris North

Cardiff University

The speed of light

c = 299,792,458 m/s

or 670,616,629 miles per hour

or 2 million million furlongs per fortnight

or ~300,000 km/s

That's fast, but how fast?

0.13 seconds

3 milliseconds

0.1 microseconds

1 nanosecond

Light travel time

Light travels…

…to the Sun in 8 minutes

…to the Moon in 1 second

…around the Earth 7 times in 1 hour

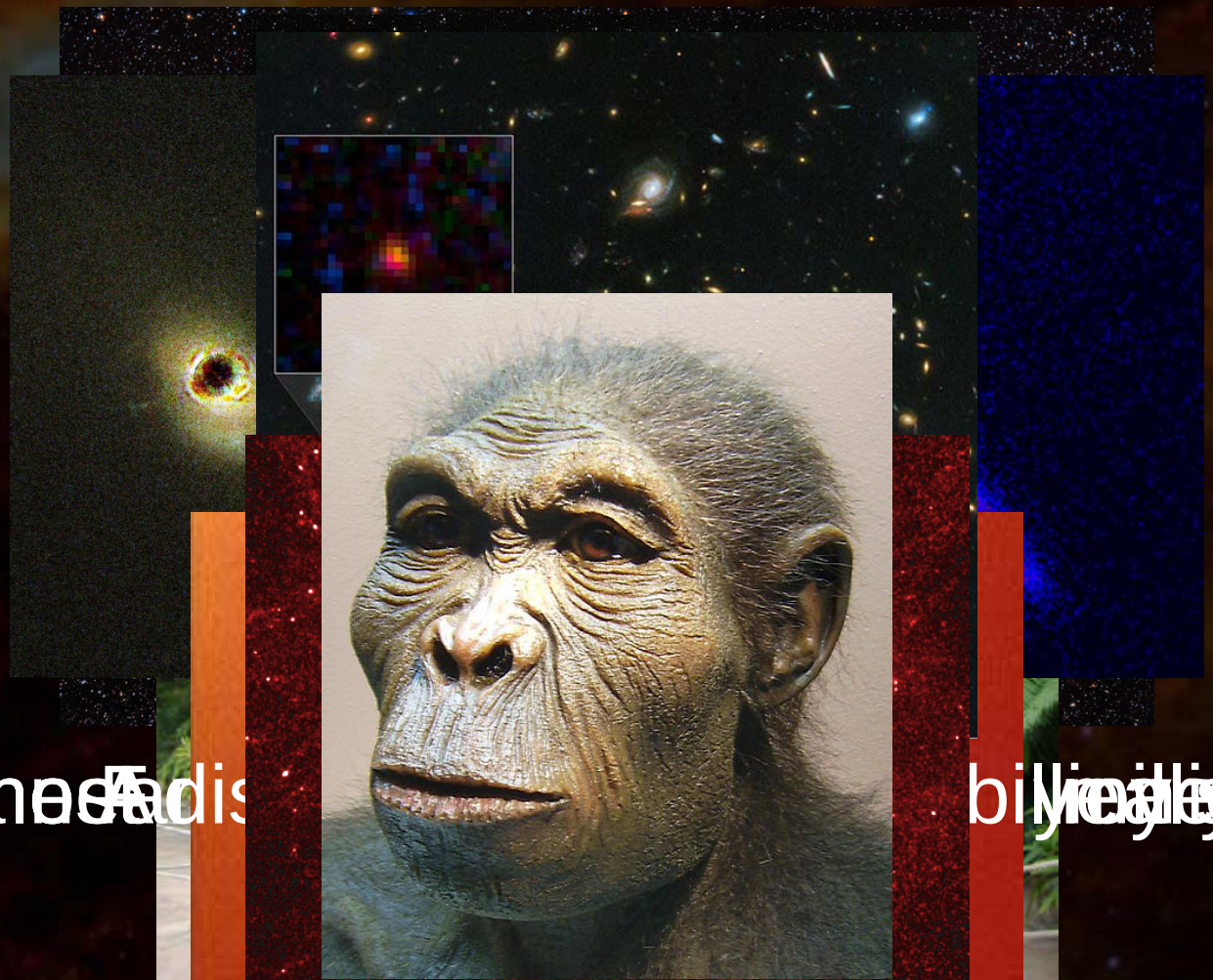
Light travel time

Light travels…

…to these students

Light travel time

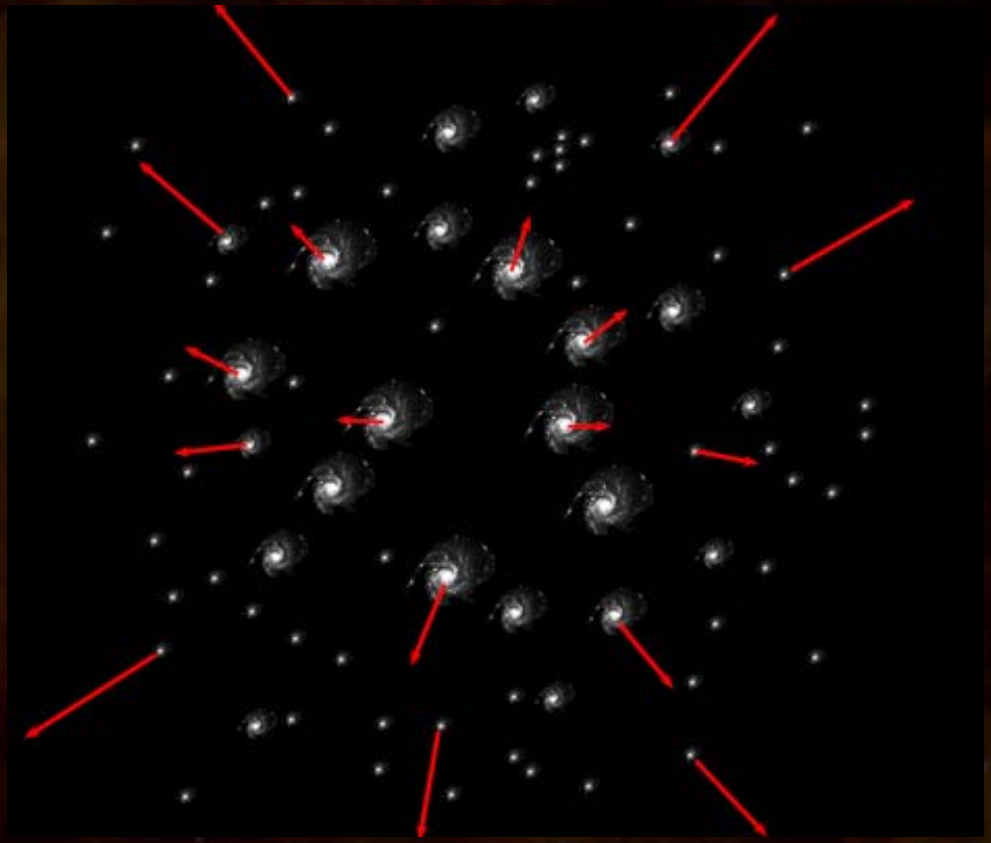
Light travels…



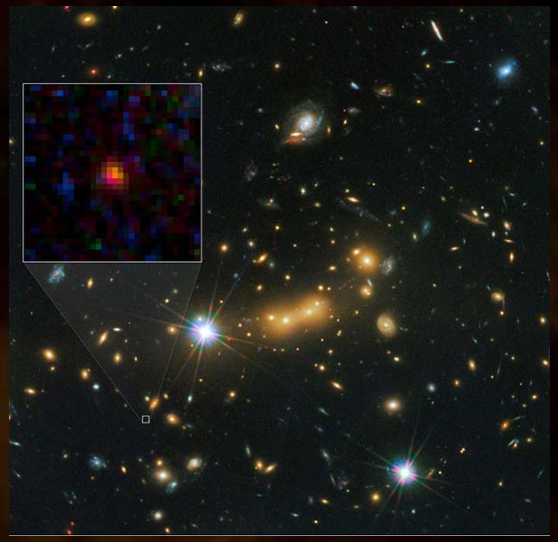
…to the edge of the observable universe

billions of years

Expanding Universe



Hubble's Law

Fornax Cluster	3C 273	Distant Galaxy
		
65 million years	2 billion years	13.4 billion years
1400 km/s	54,000 km/s	690,000 km/s
0.005 c	0.18 c	2.2 c
1.004 x	1.158 x	12 x

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		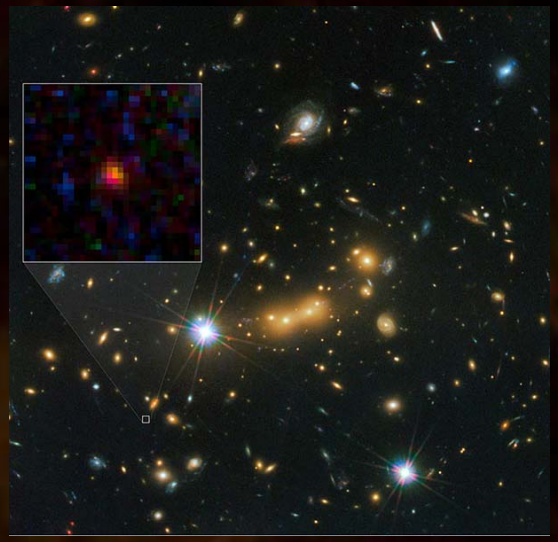
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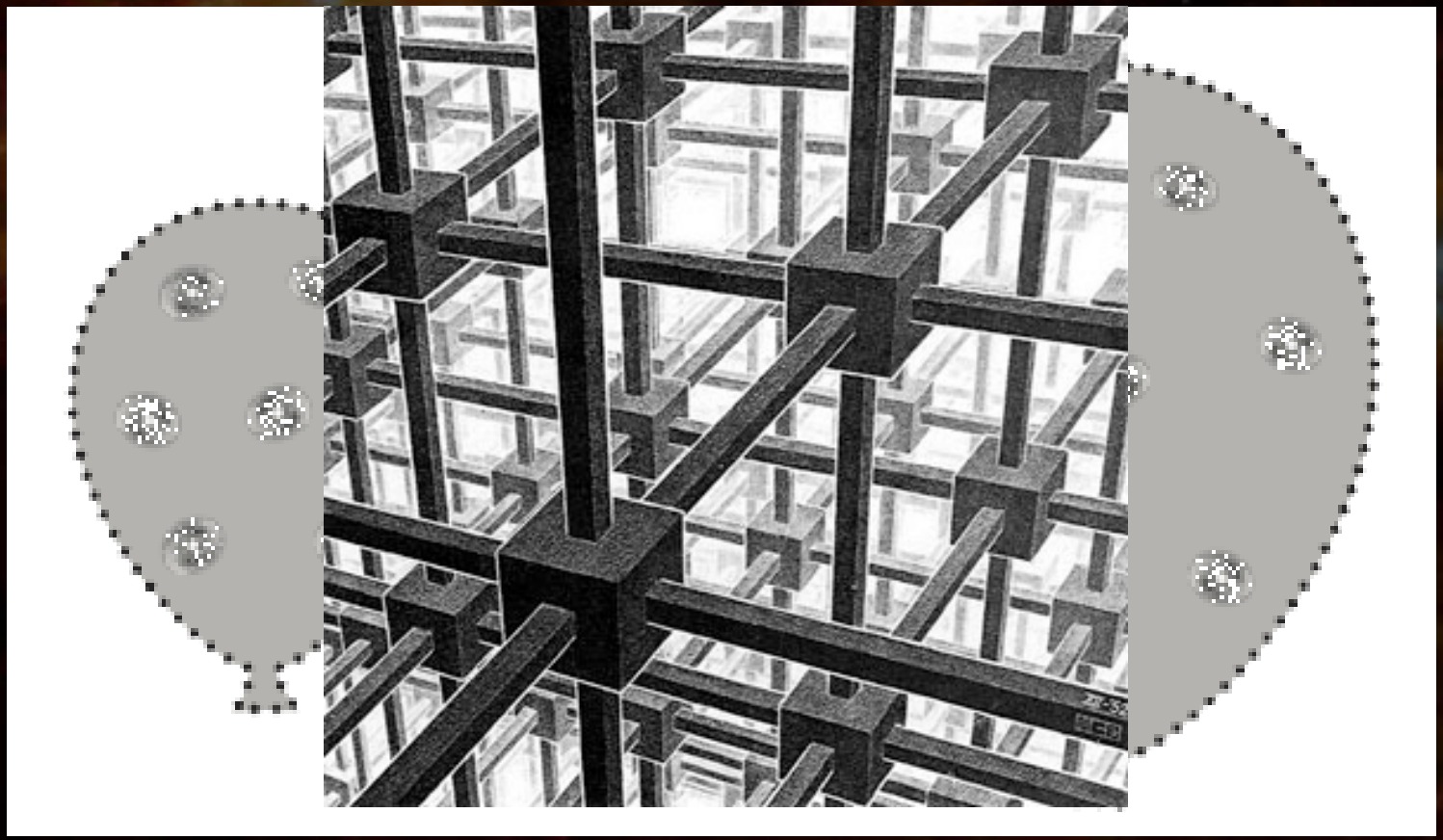
The Expanding Universe



The Expanding Universe

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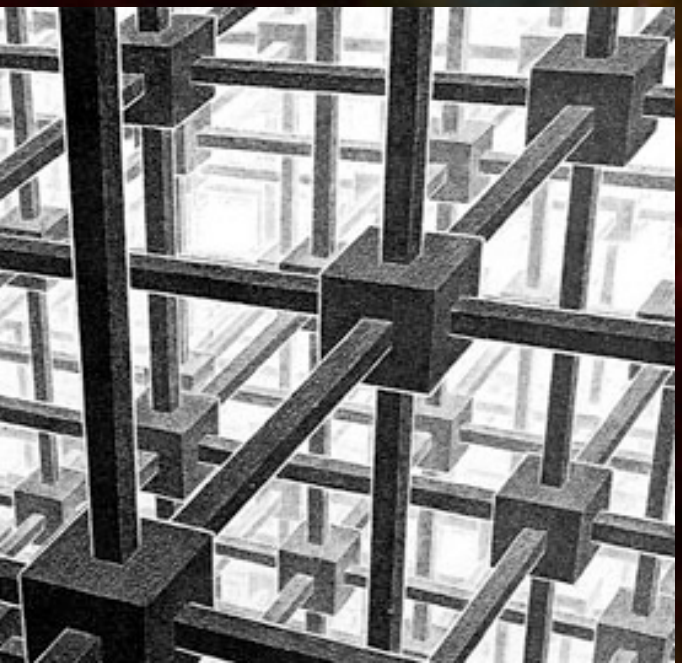
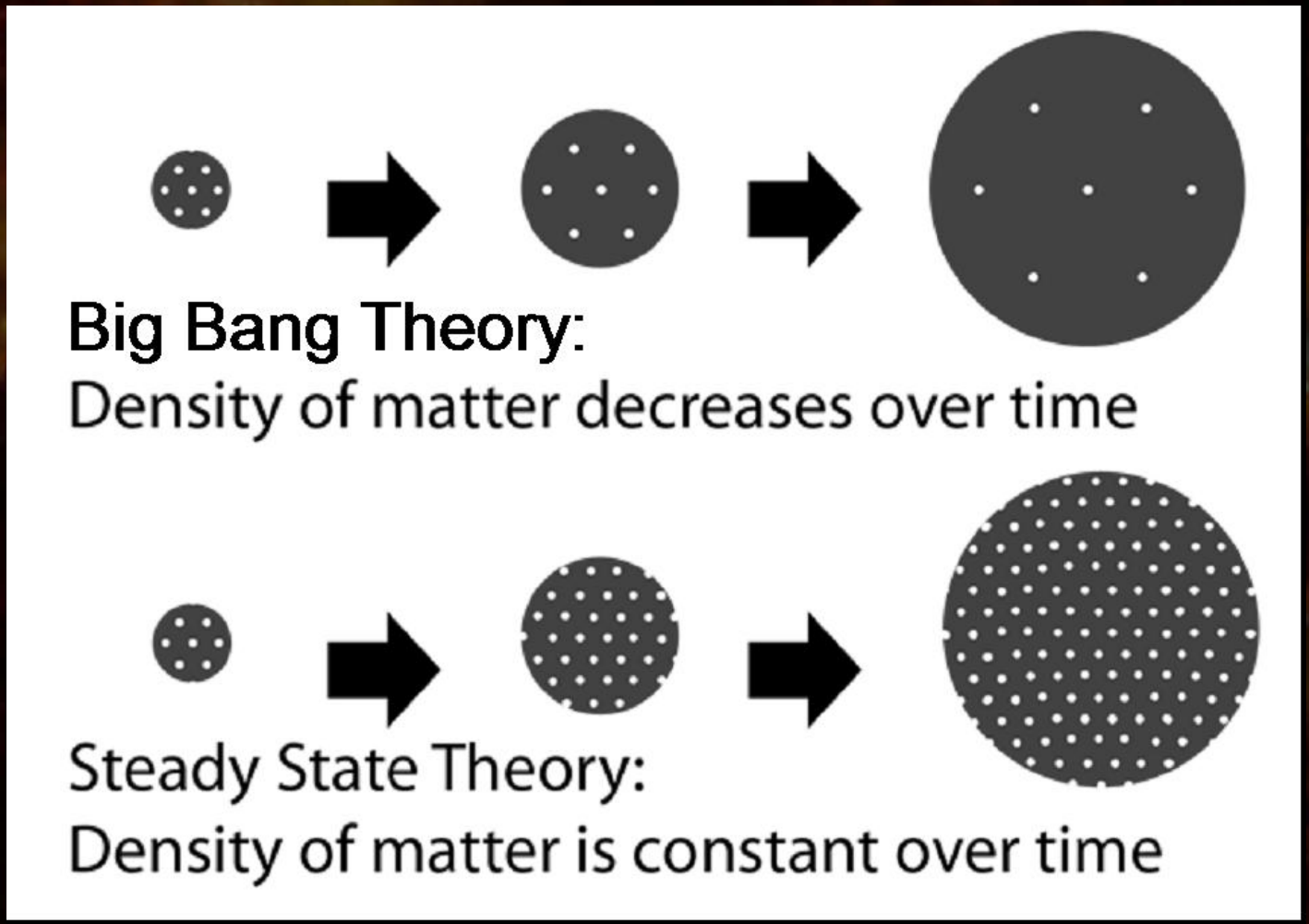


The Expanding Universe

Steady State vs Big Bang



The nail in the coffin

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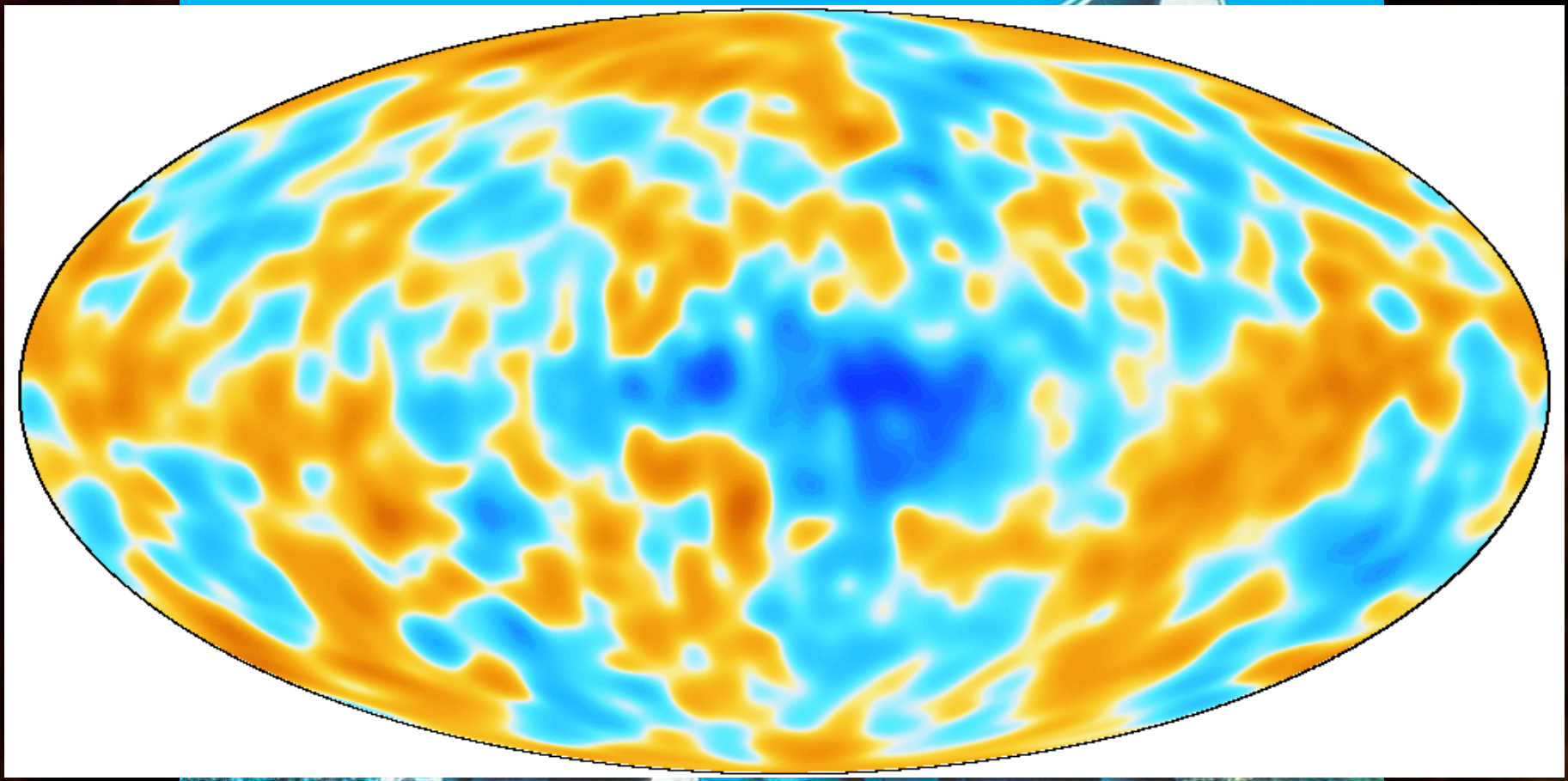
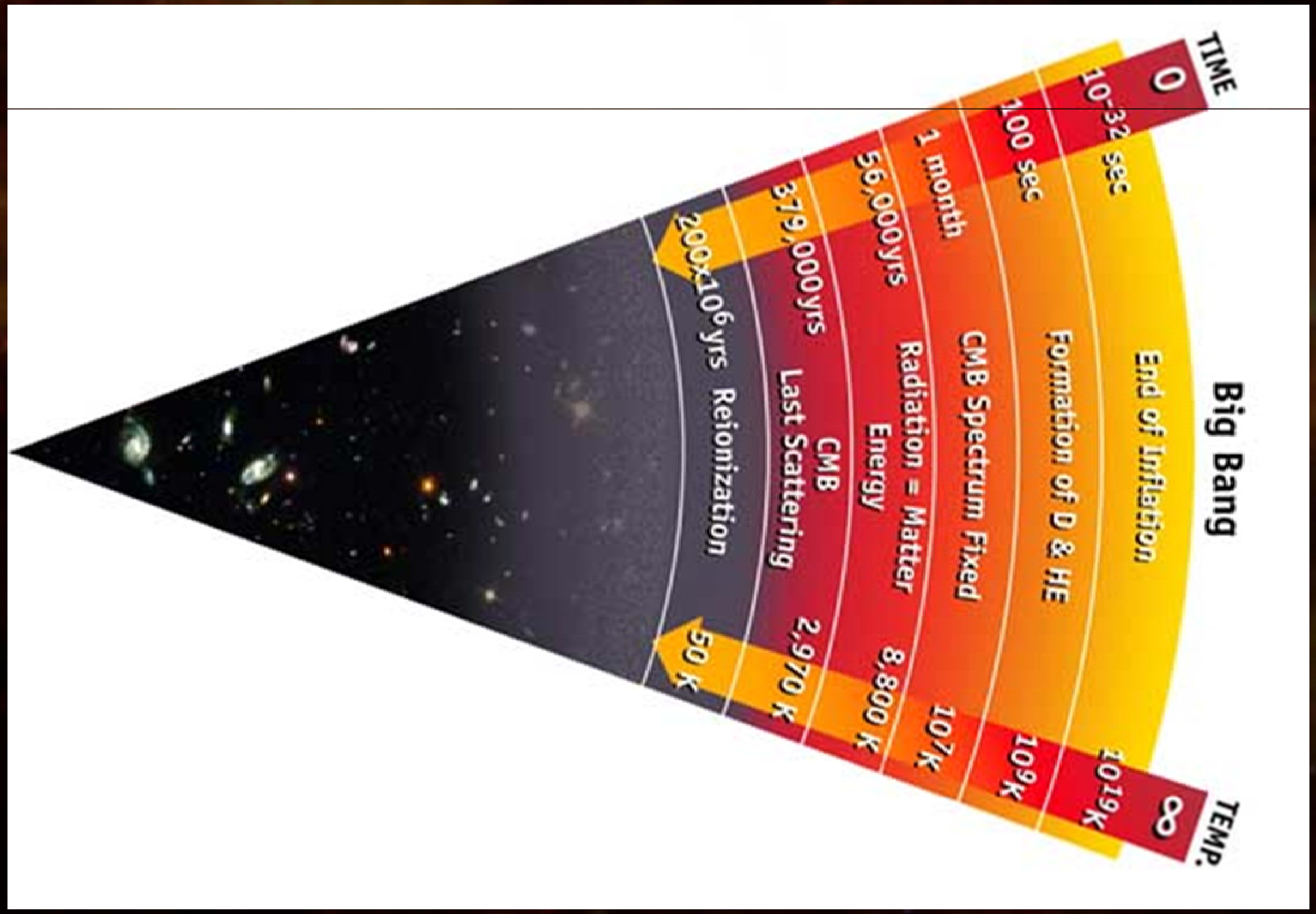
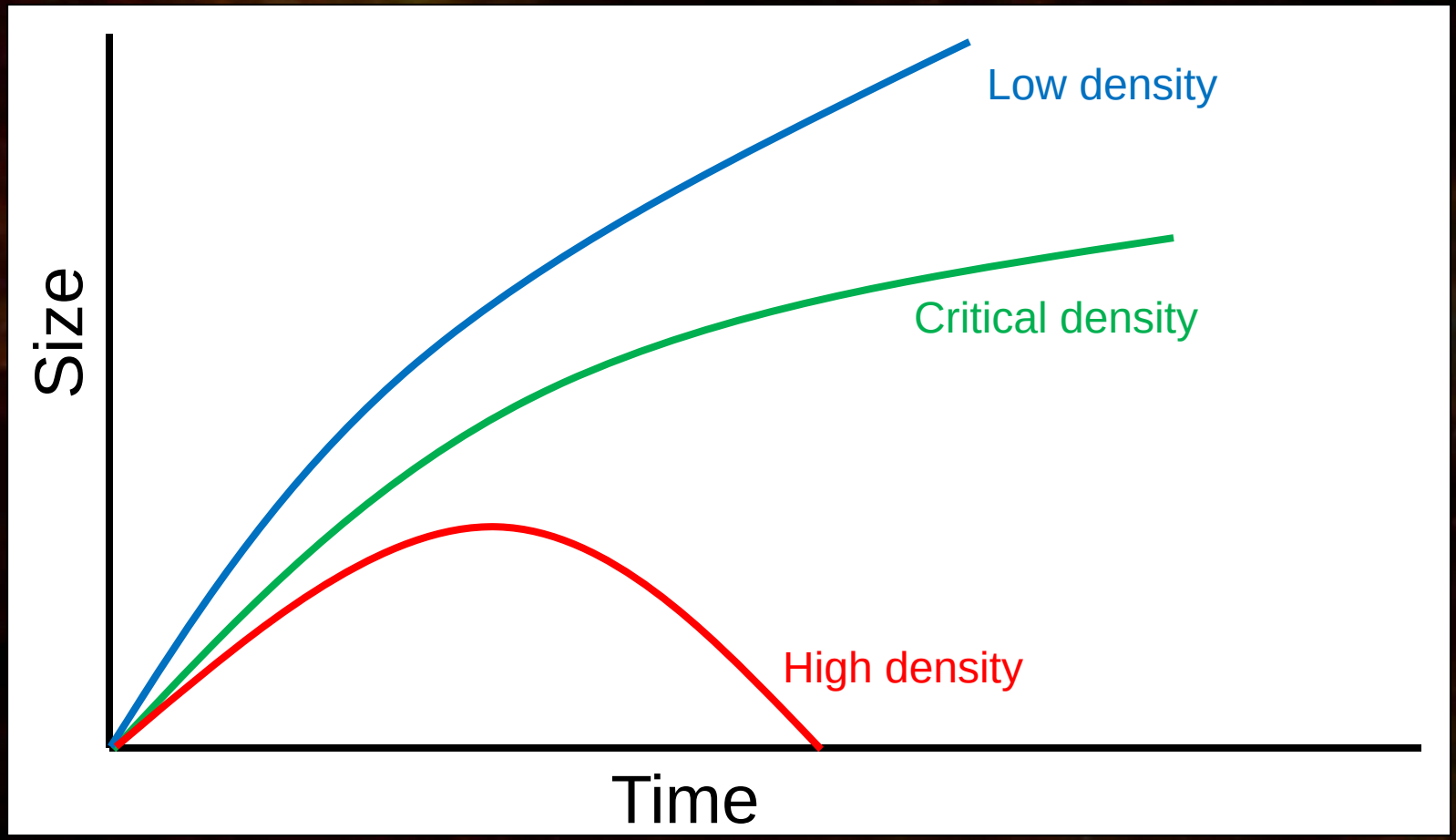


The cosmic horizon



Fate of the Universe

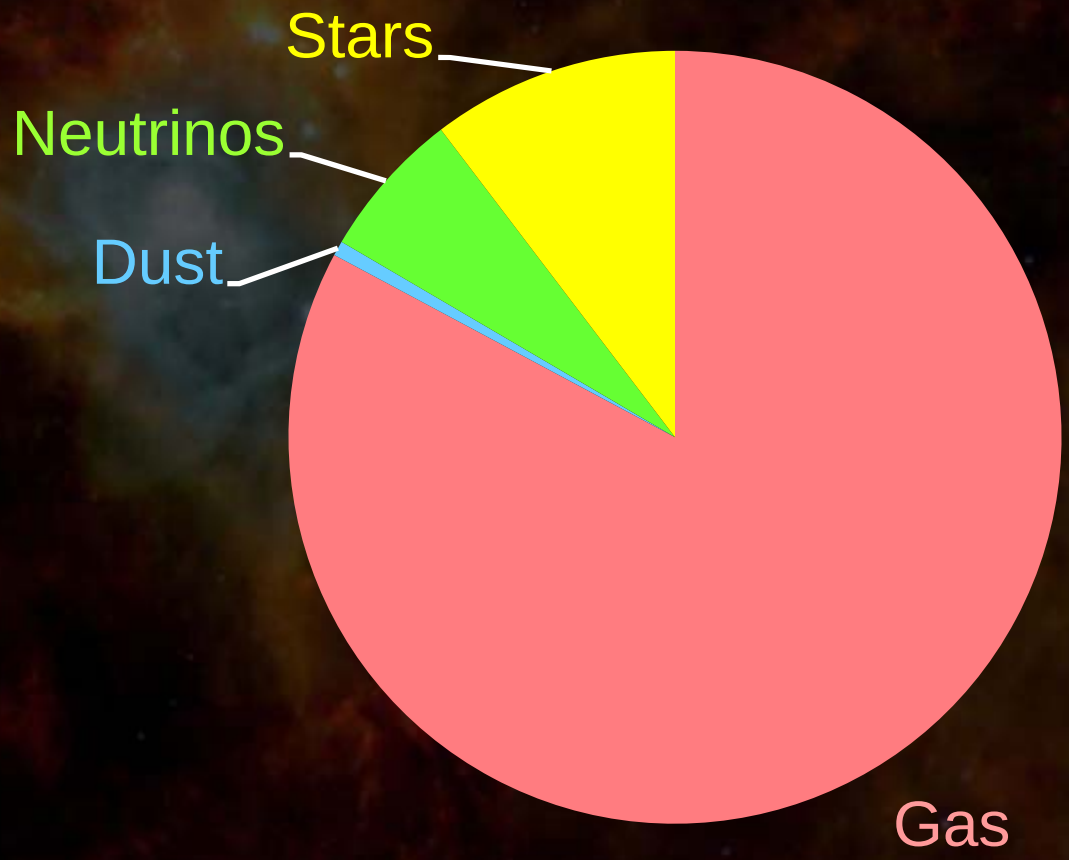


Critical Density: 6 hydrogen atoms per cubic metre

Universal composition (1800)

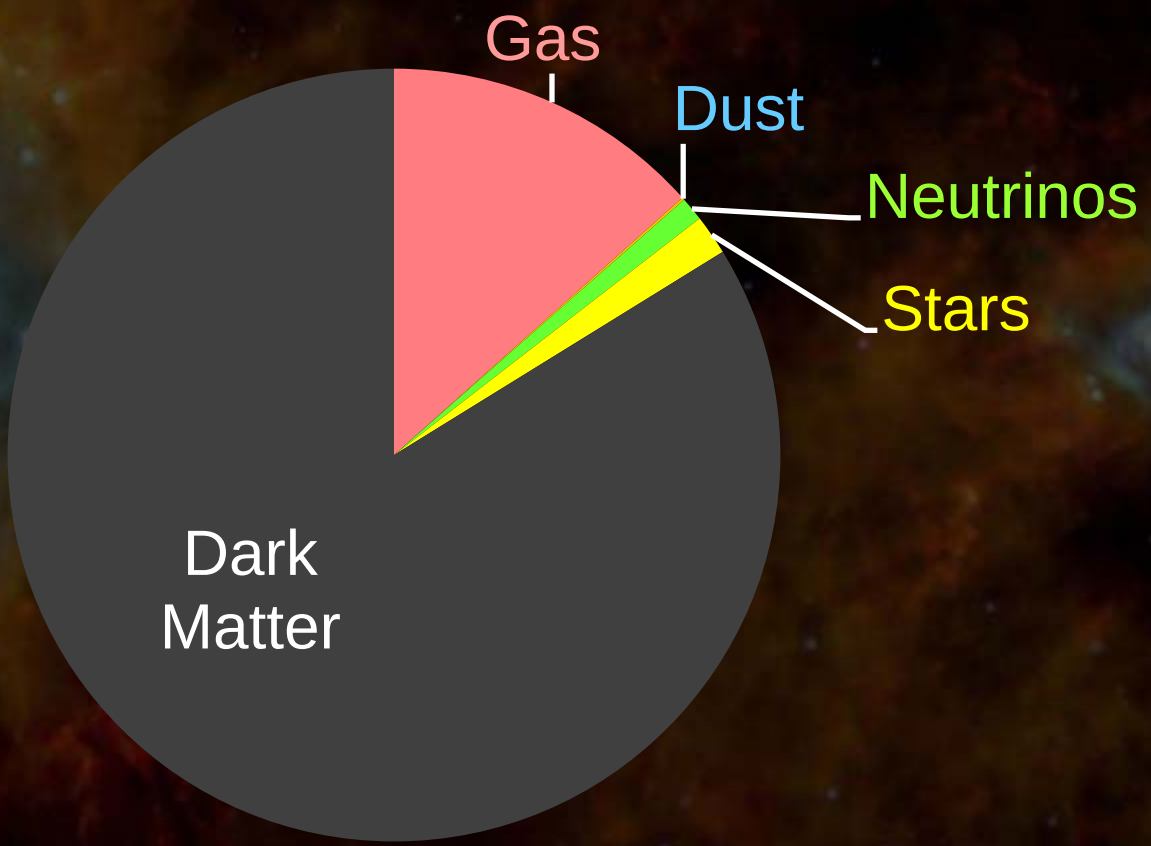
Density: 0.025 hydrogen atoms per cubic metre
(0.004 x critical density)

Universal composition (1950)



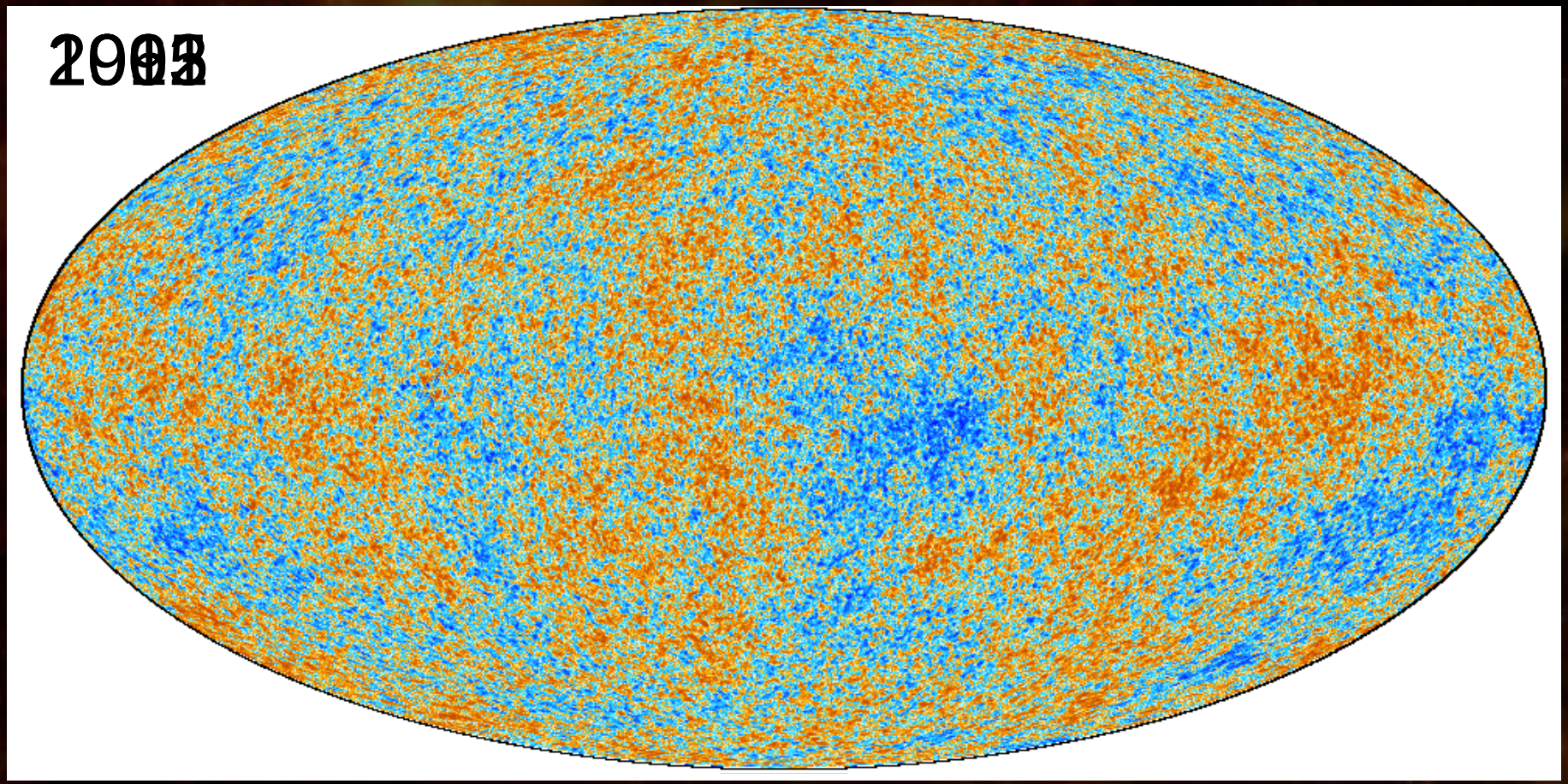
Density: 0.25 hydrogen atoms per cubic metre
(0.04 x critical density)

Universal composition (1960)

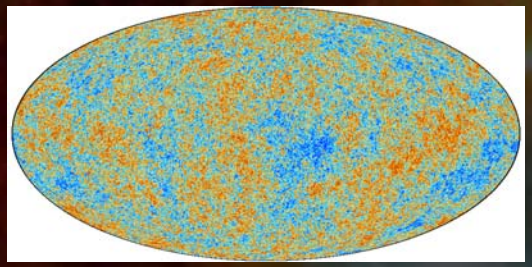


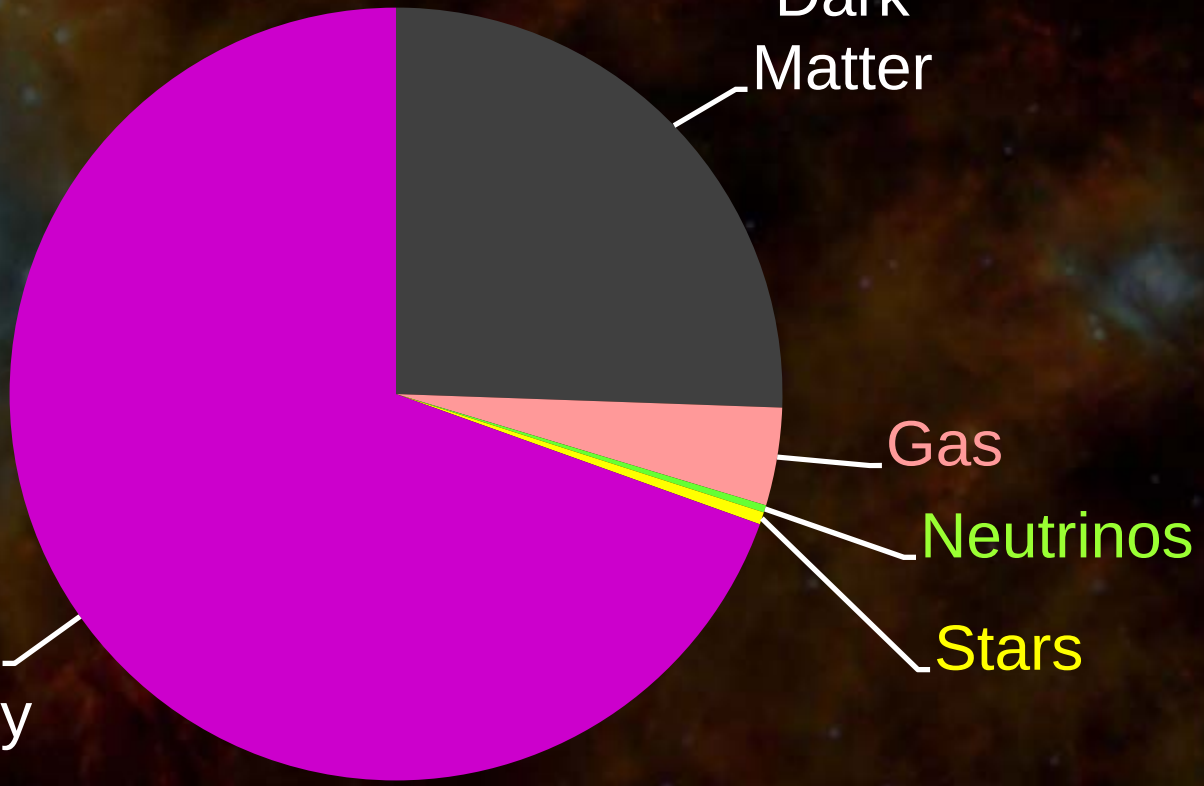
Density: 1.33 Hydrogen atoms per cubic metre
(0.2 x critical density)

Cosmic Microwave Background



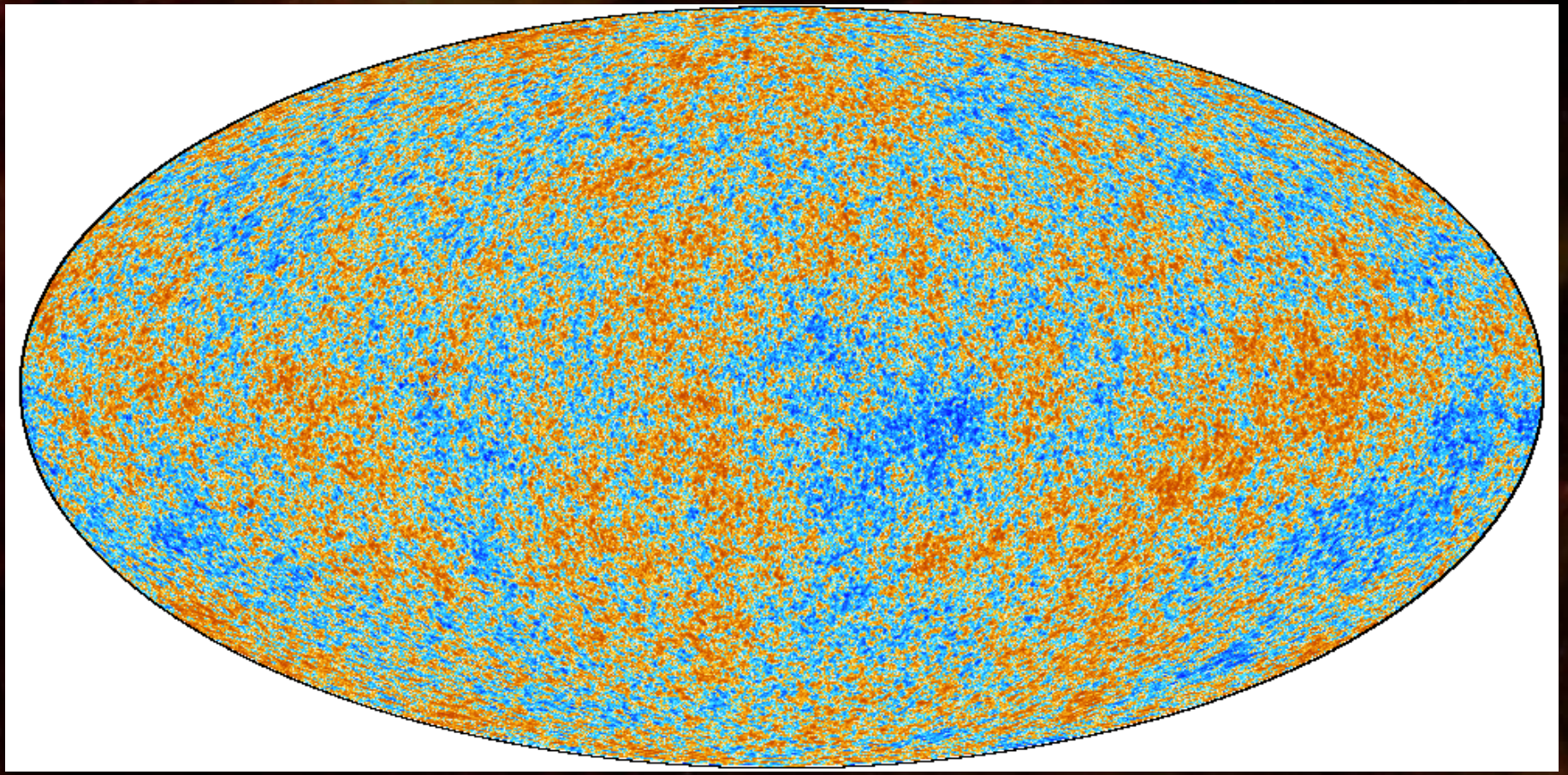
Universal composition (now)



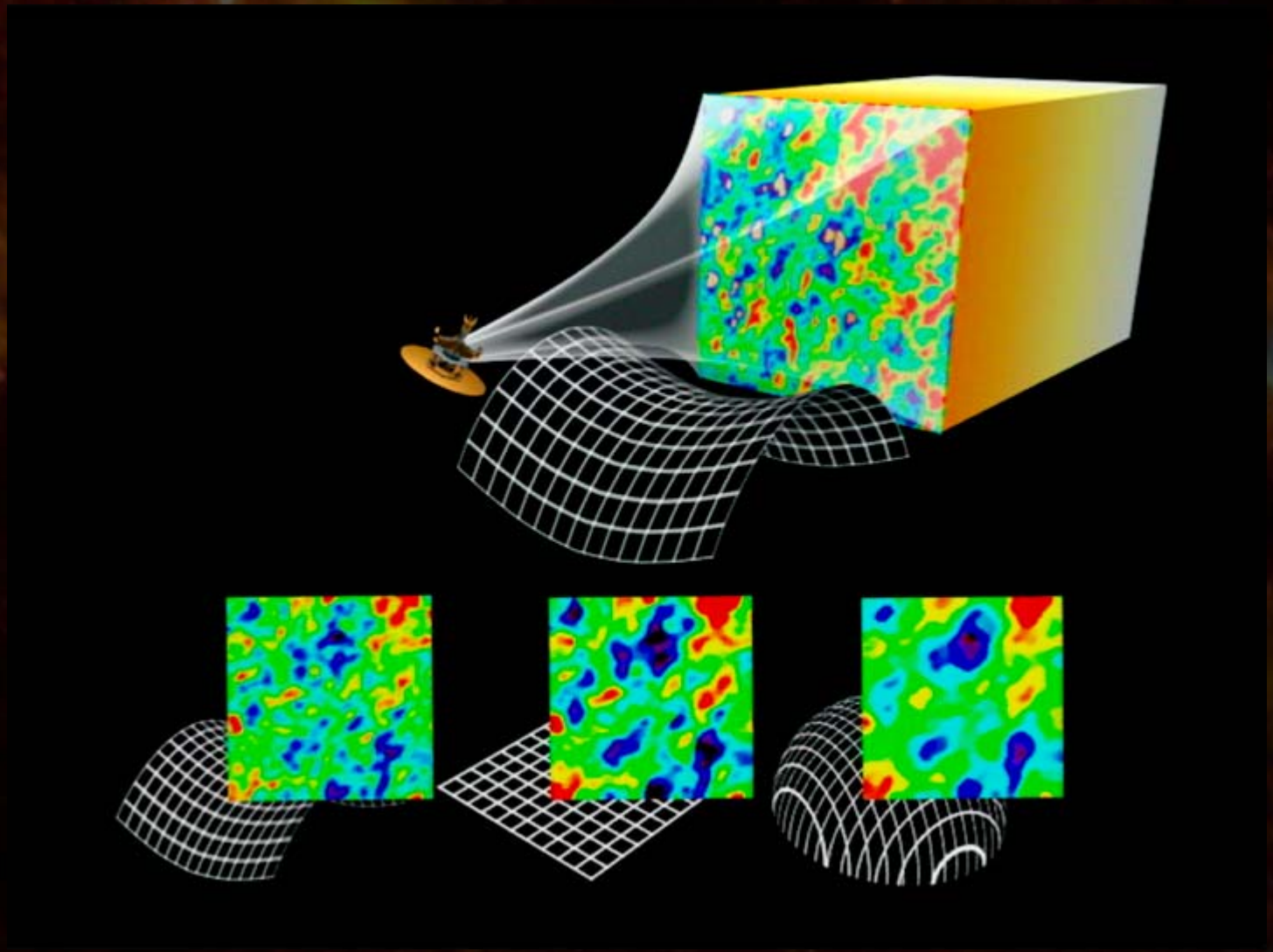


Density: 6 hydrogen atoms per cubic metre
(1.00 x critical density)

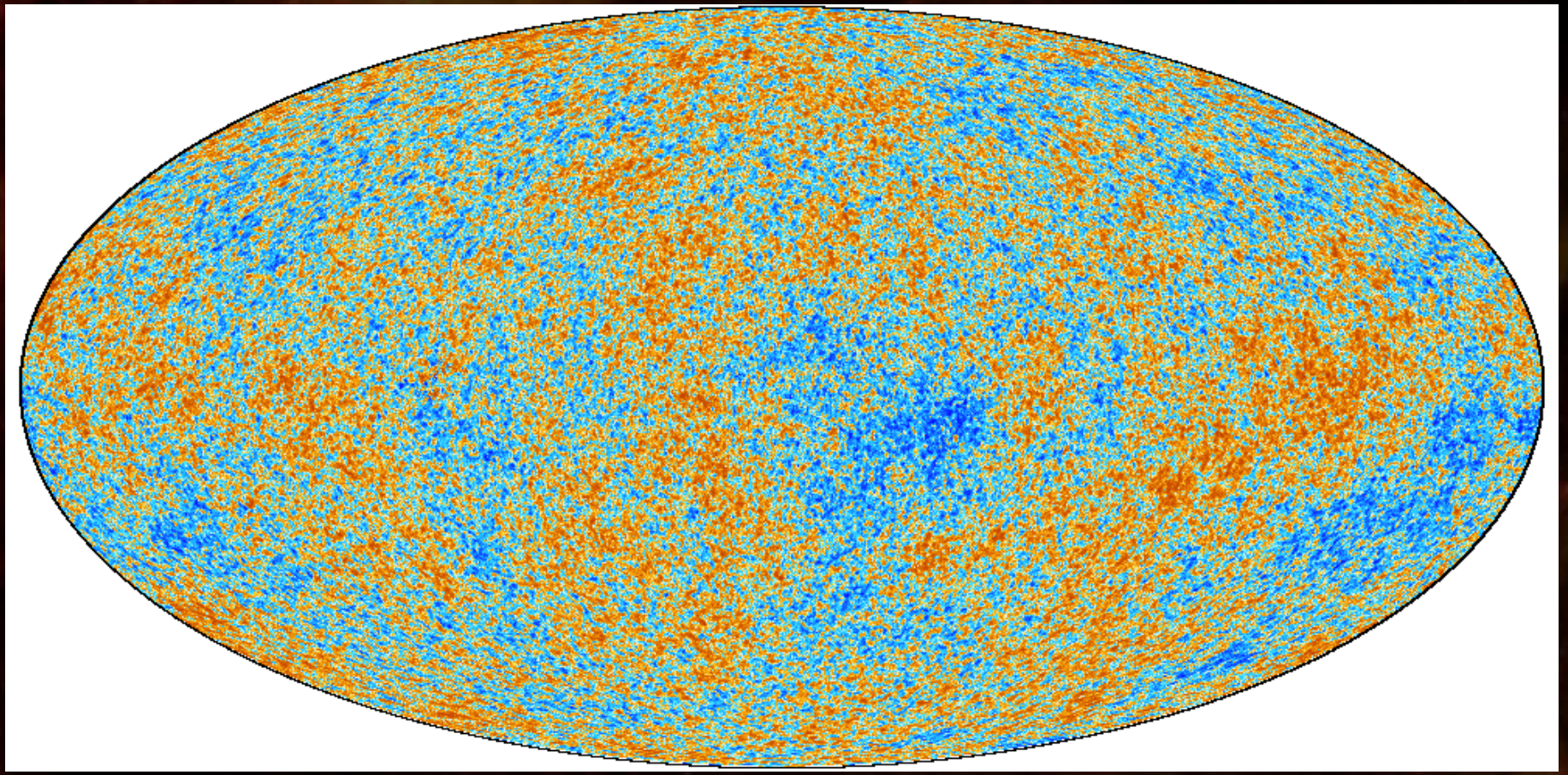
Geometry of Space



The Geometry of Space



The Horizon Problem



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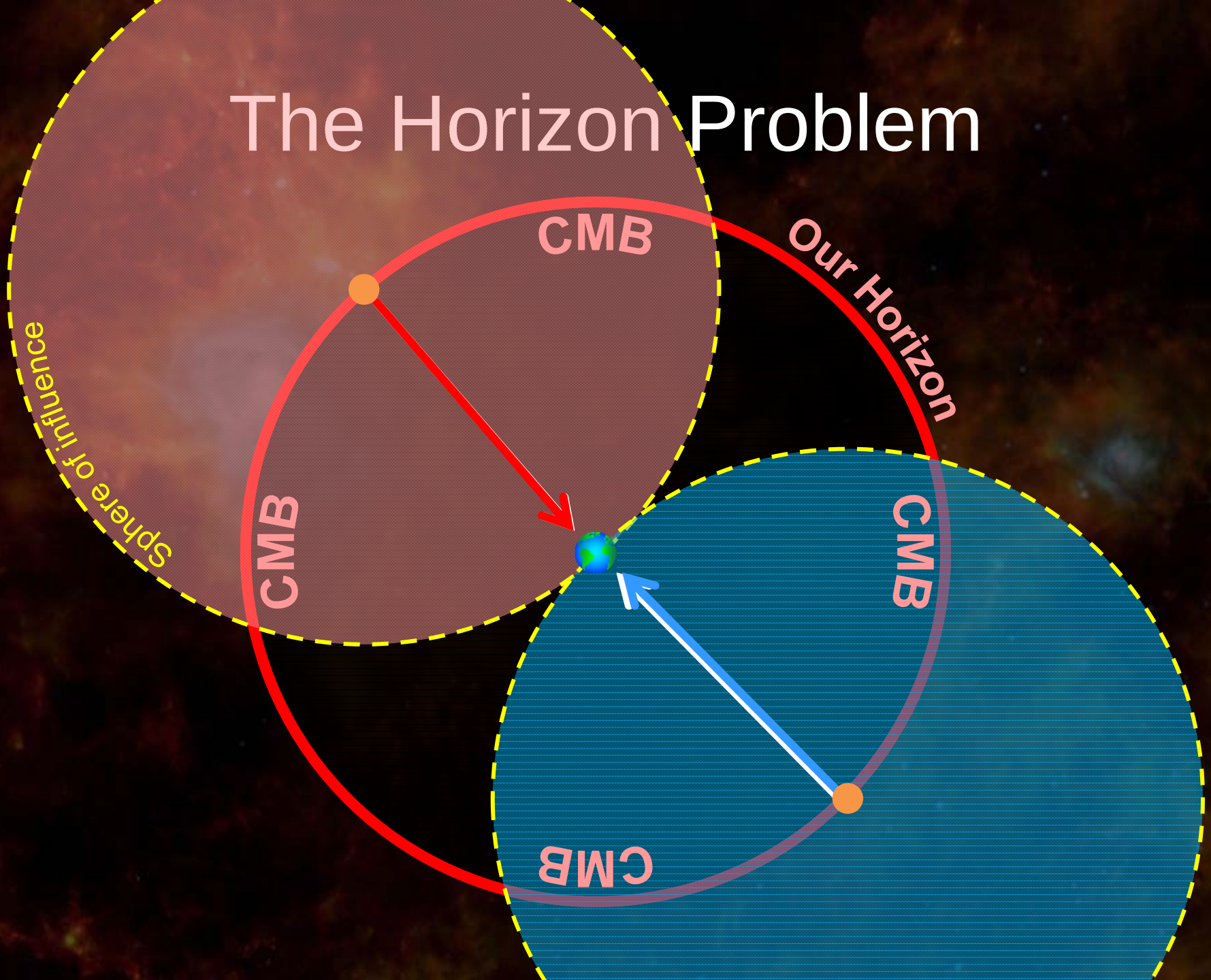
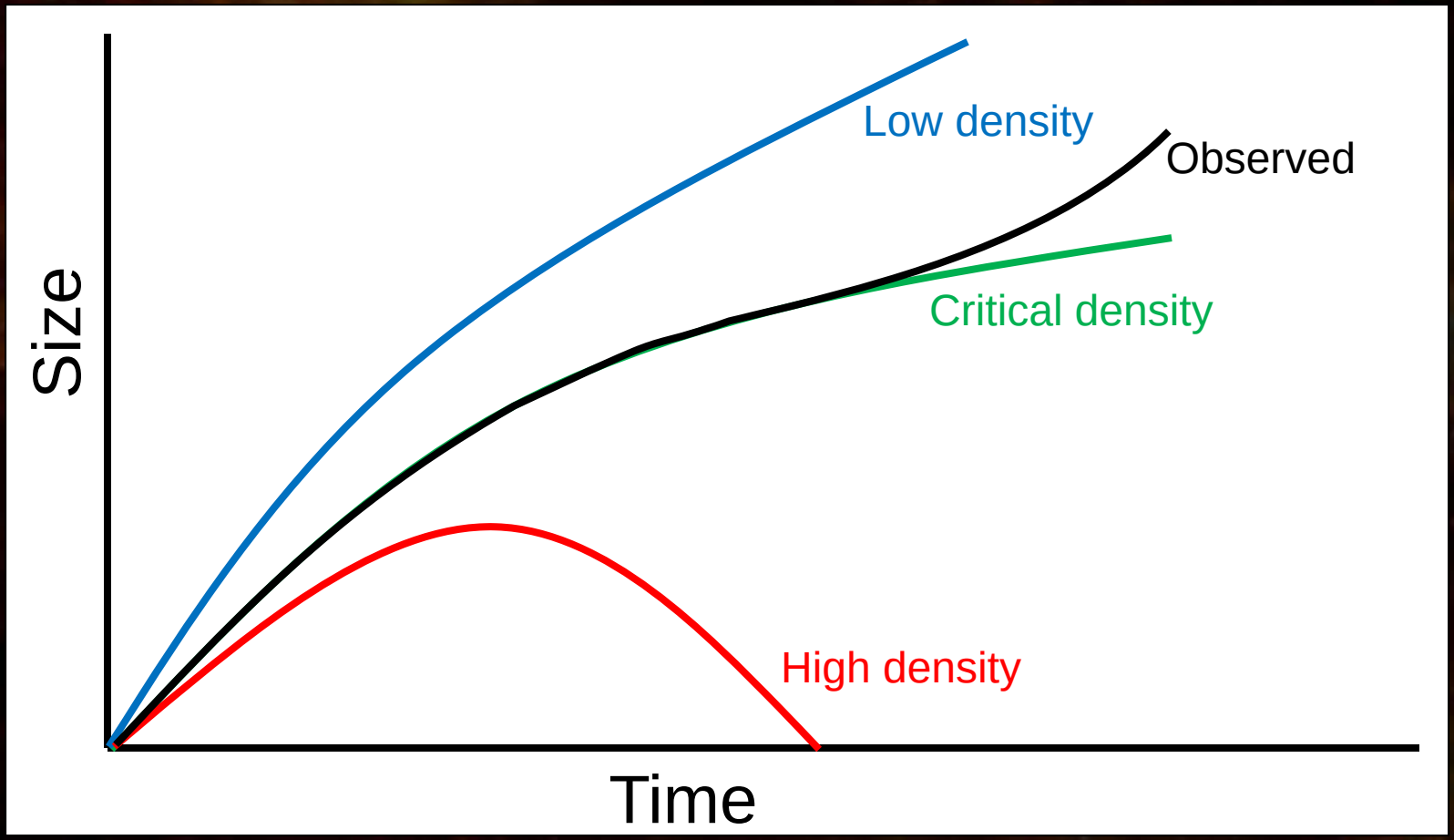


Inflation: the solution

Fate of the Universe



Remaining questions