Most distant galaxy ever found sheds light on infant cosmos

Object allows astronomers a glimpse of Universe's era of 'reionization'.

Zeeya Merali

Observations of the most distant object yet discovered go a long way in supporting astronomers' models of the early Universe. But the far-flung galaxy, details of which are published in *Nature* today[1], also raises questions about the source of the first light in the cosmos.

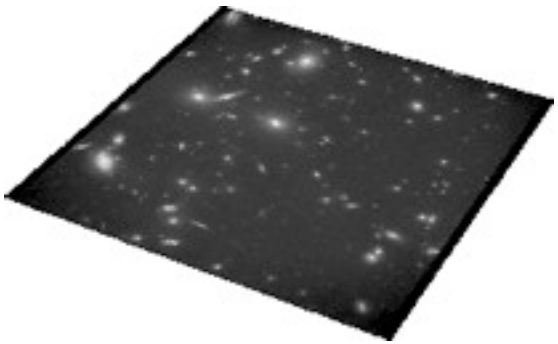
Light from a distant galaxy has provided a snapshot of the early universe.

ESO/L. Calçada

Light from the galaxy, named UDFy-38135539, left the object just 600 million years after the Big Bang, giving a snapshot of the cosmos in its infancy. This value smashes the previous record held by a galaxy by 150 million years[2]. The image shows the galaxy as it was when it was around 100 million years old and is just 1-10% of the mass of the Milky Way.

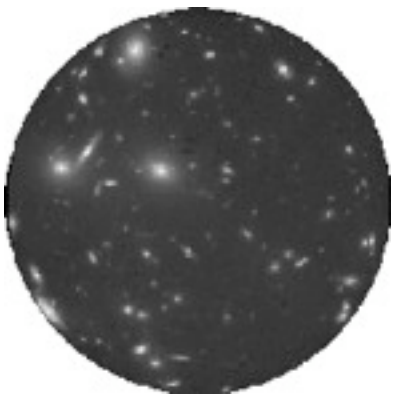
hyperbolic

$\rho_o < \rho_{crit}$



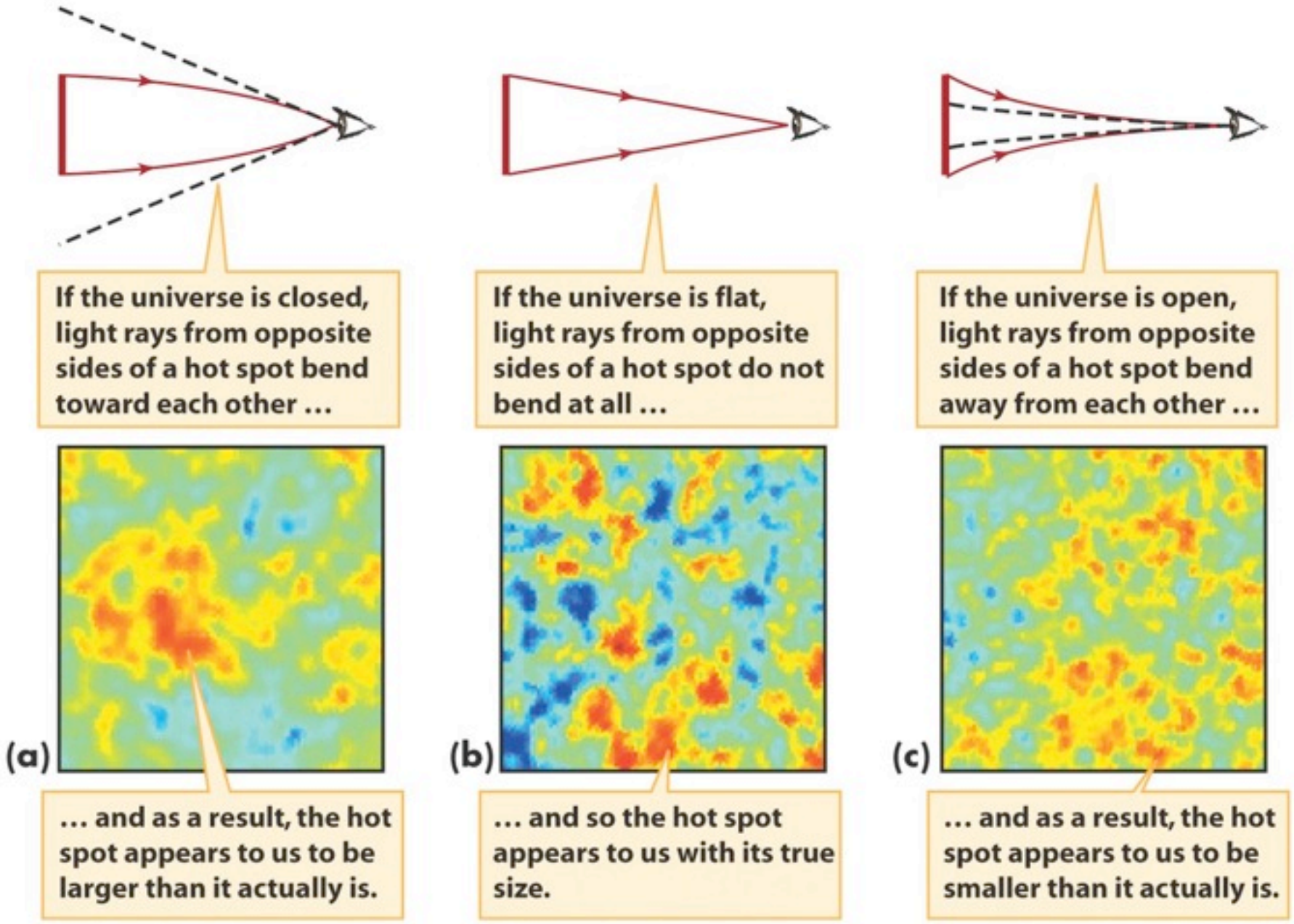
flat

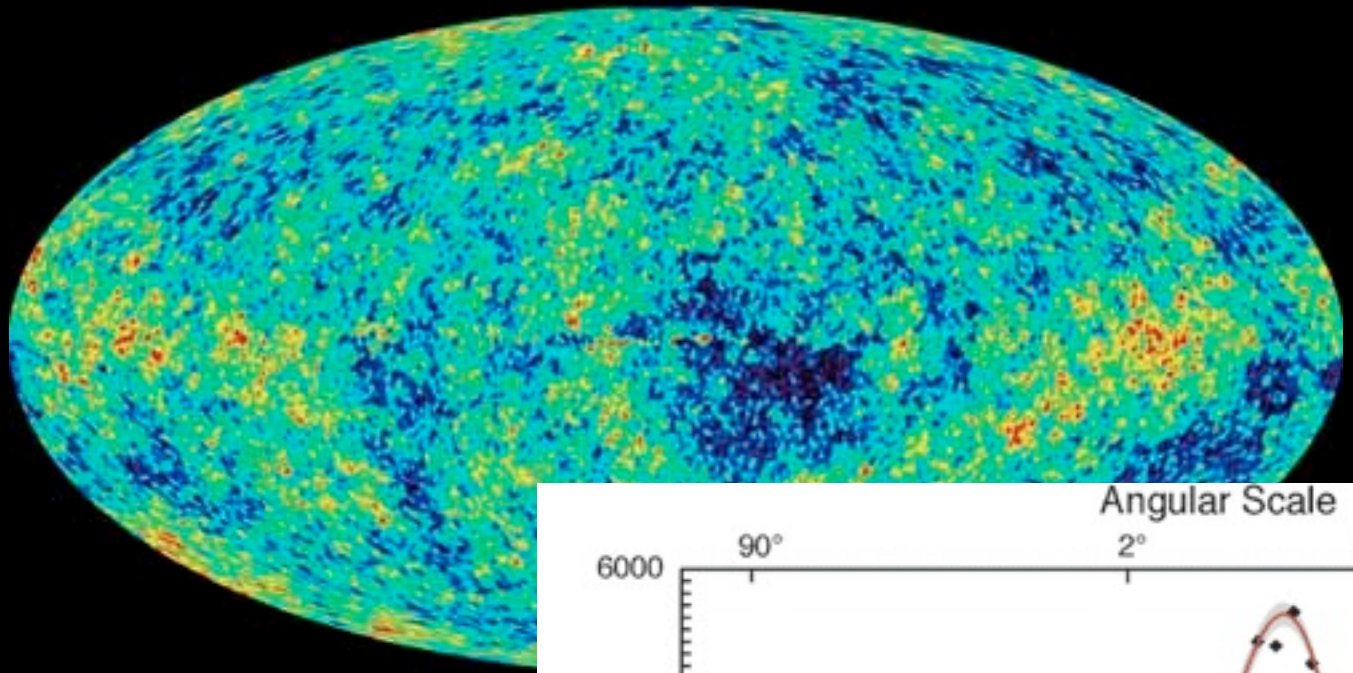
$\rho_o = \rho_{crit}$

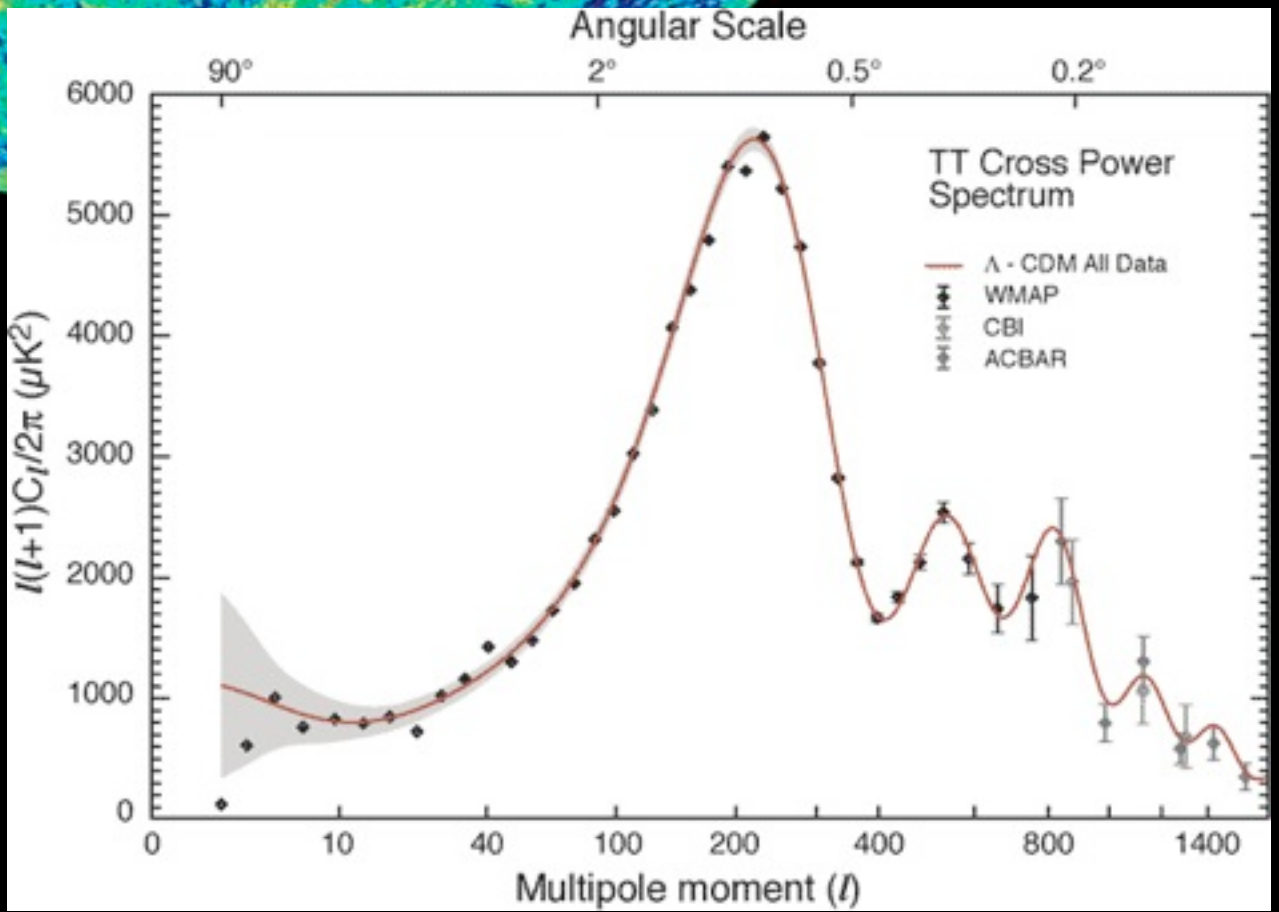


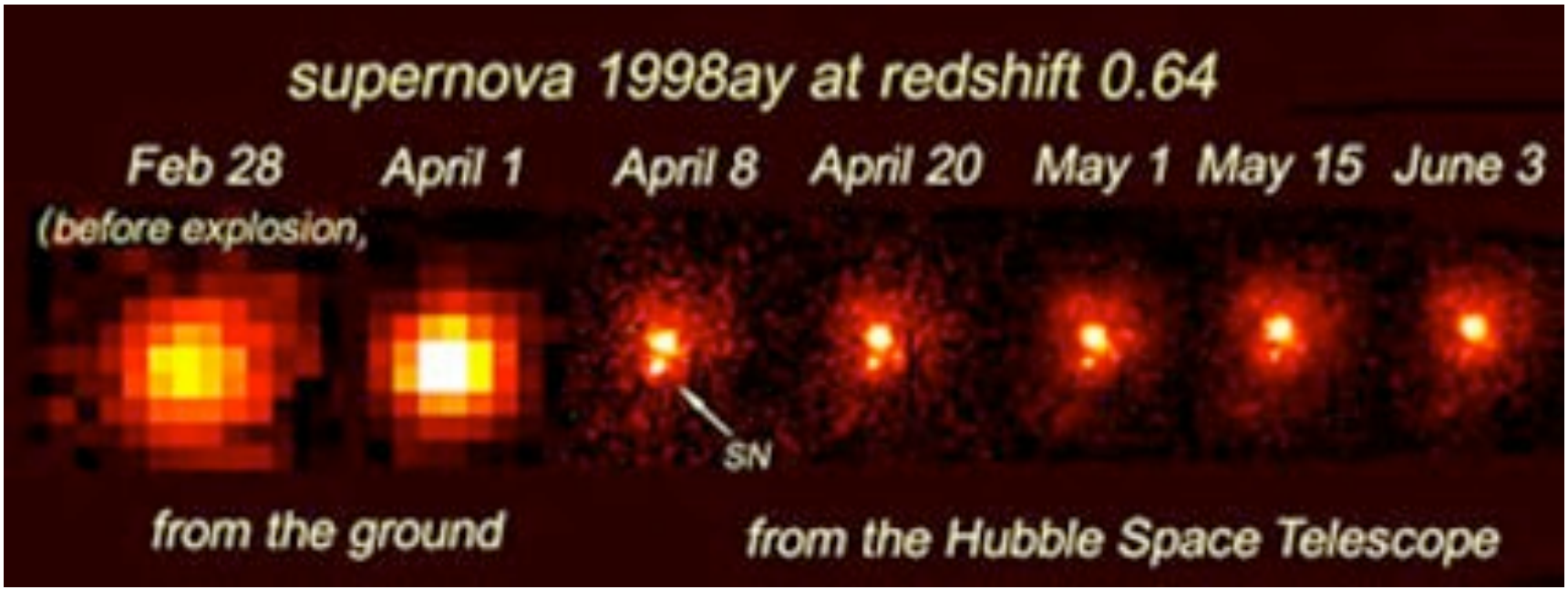
spherical

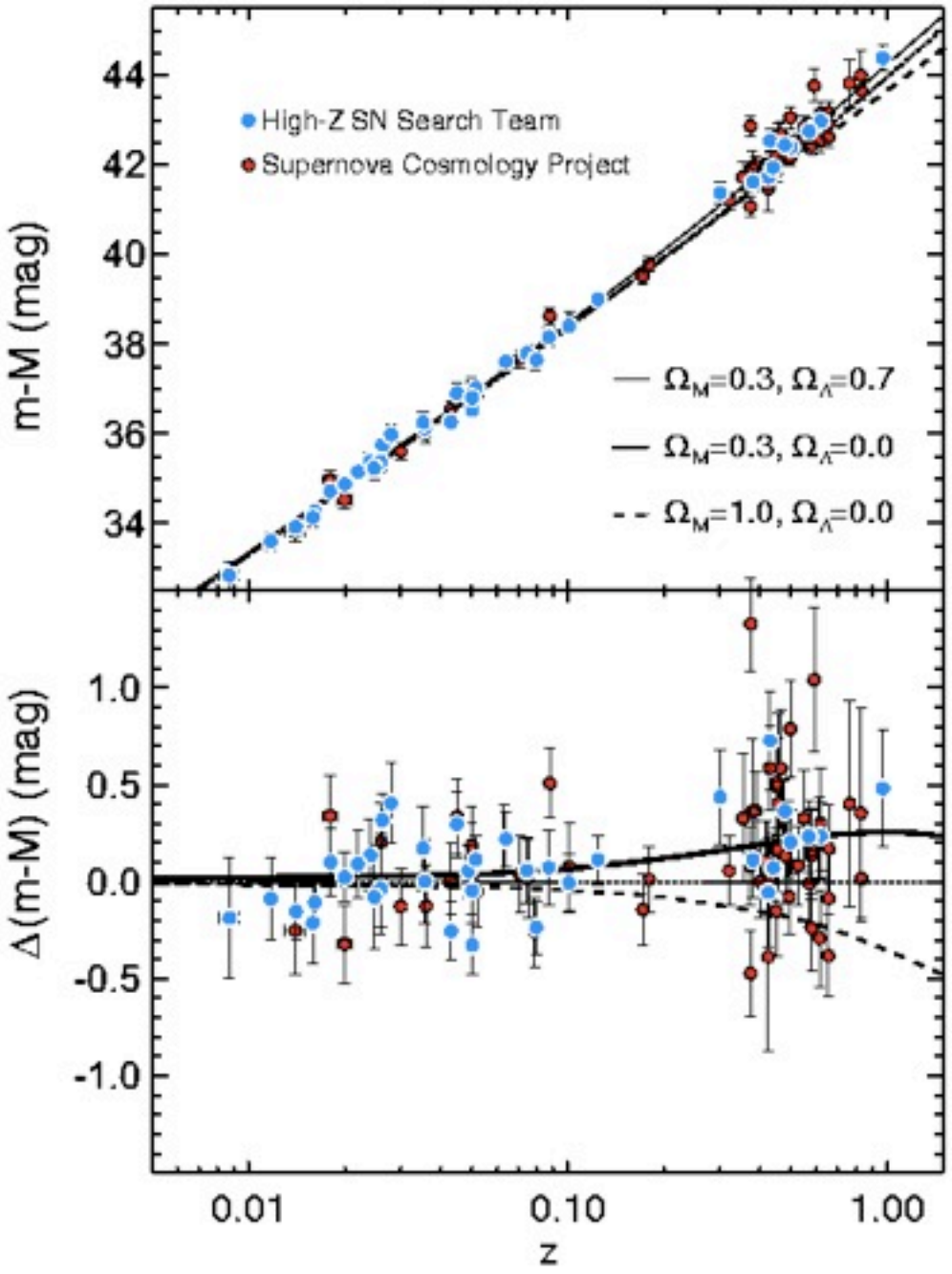
$\rho_o > \rho_{crit}$

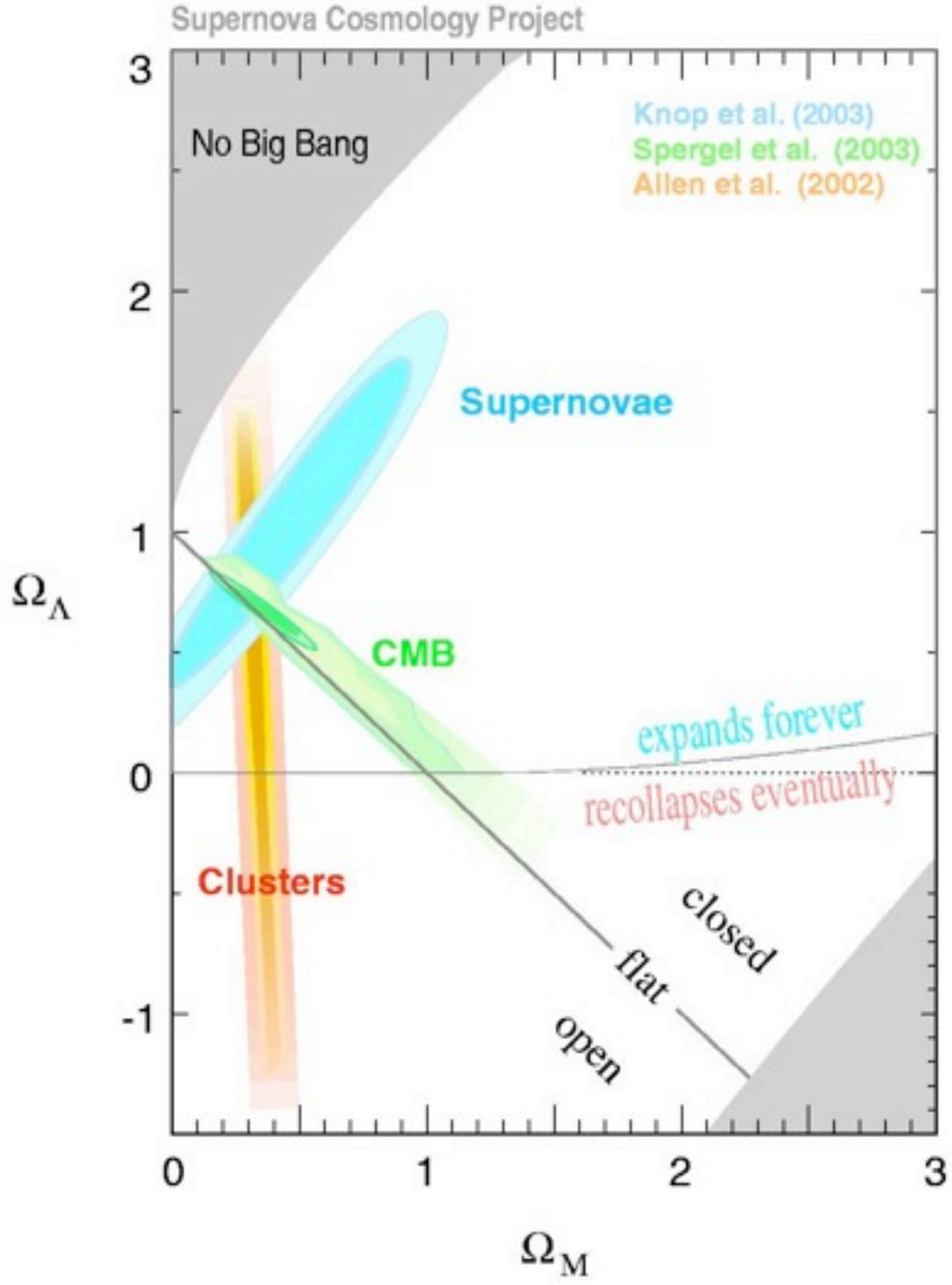

If the universe is closed, light rays from opposite sides of a hot spot bend toward each other …
If the universe is flat, light rays from opposite sides of a hot spot do not bend at all …
If the universe is open, light rays from opposite sides of a hot spot bend away from each other …
(a)
(b)
(c)
… and as a result, the hot spot appears to us to be larger than it actually is.
… and so the hot spot appears to us with its true size.
… and as a result, the hot spot appears to us to be smaller than it actually is.

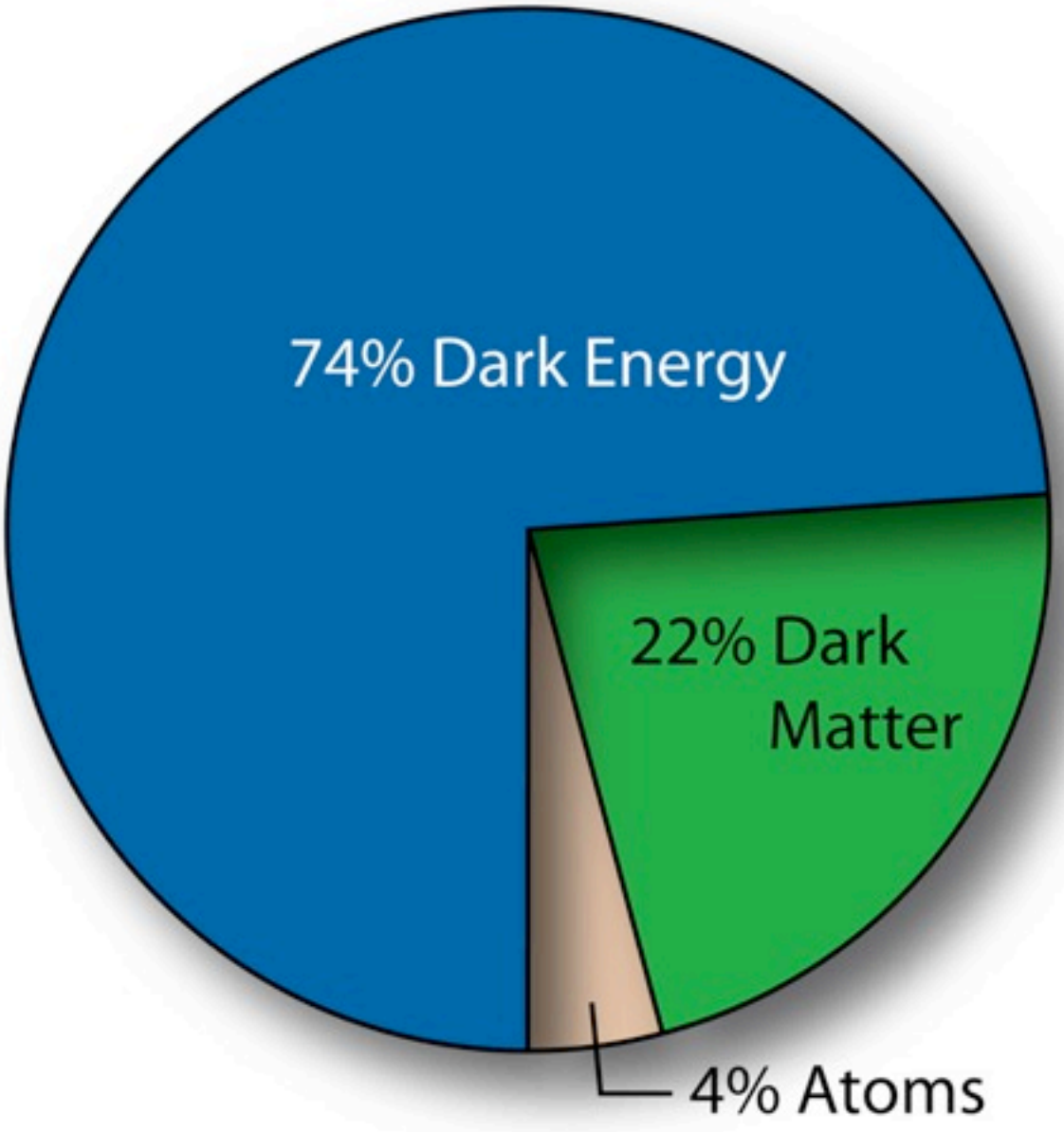



Angular Scale
90°
2°
0.5°
0.2°
6000
5000
4000
3000
2000
1000
0
$l(l+1)C_l/2\pi$ (μK^2)
TT Cross Power Spectrum
Λ - CDM All Data
WMAP
CBI
ACBAR
0
10
40
100
200
400
800
1400
Multipole moment (l)


supernova 1998ay at redshift 0.64
Feb 28
April 1
April 8
April 20
May 1
May 15
June 3
(before explosion,
SN
from the ground
from the Hubble Space Telescope


High-Z SN Search Team
Supernova Cosmology Project
Ω_M=0.3, Ω_Λ=0.7
Ω_M=0.3, Ω_Λ=0.0
Ω_M=1.0, Ω_Λ=0.0
m-M (mag)
Δ(m-M) (mag)
z
0.01
0.10
1.00
34
36
38
40
42
44
1.0
0.5
0.0
-0.5
-1.0


Supernova Cosmology Project
No Big Bang
Knop et al. (2003)
Spergel et al. (2003)
Allen et al. (2002)
Supernovae
CMB
Clusters
expands forever
recollapses eventually
closed
flat
open
3
2
1
0
-1
0
1
2
3
Ω_Λ
Ω_M


74% Dark Energy
22% Dark Matter
4% Atoms

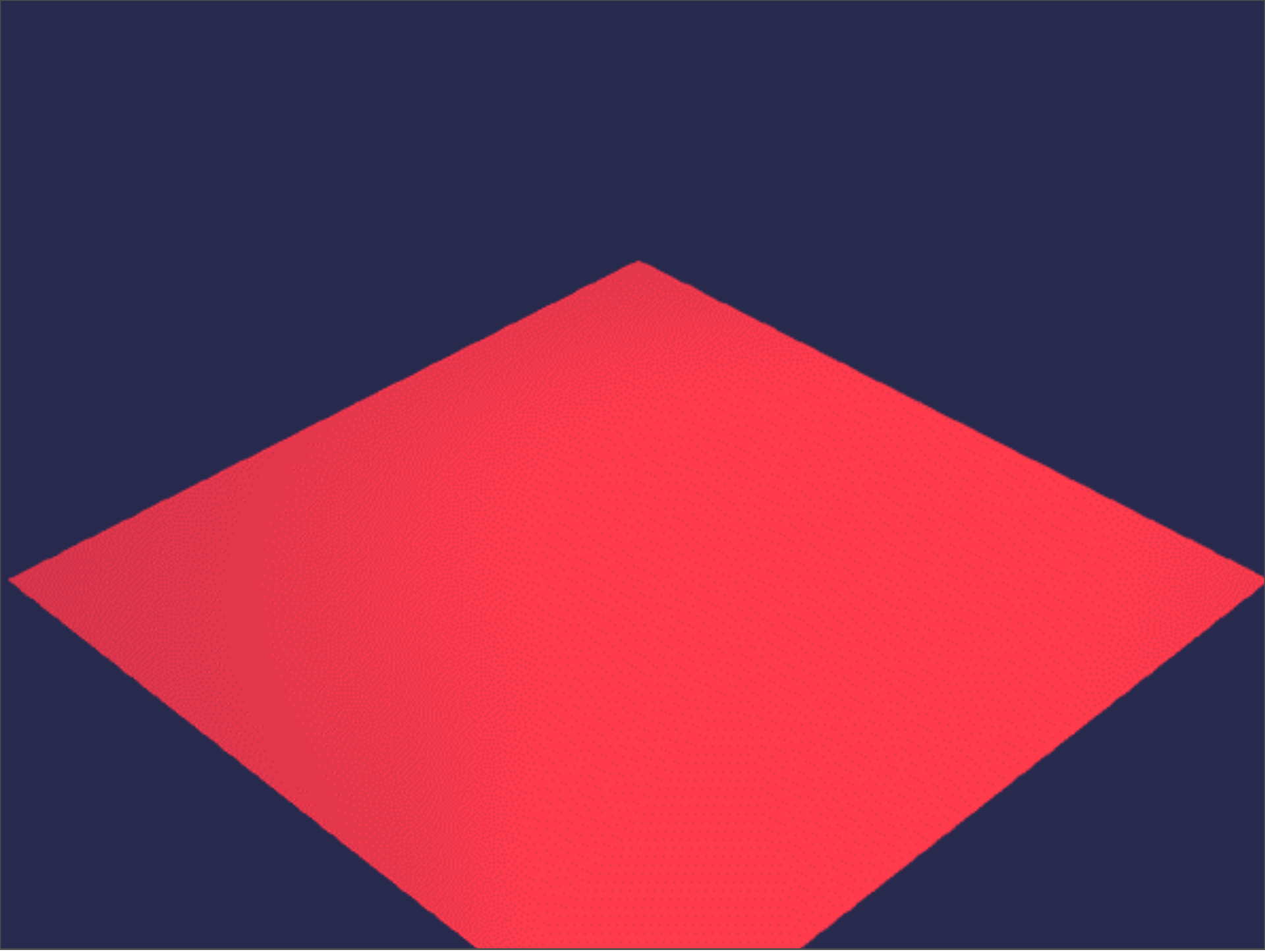
Alan Guth

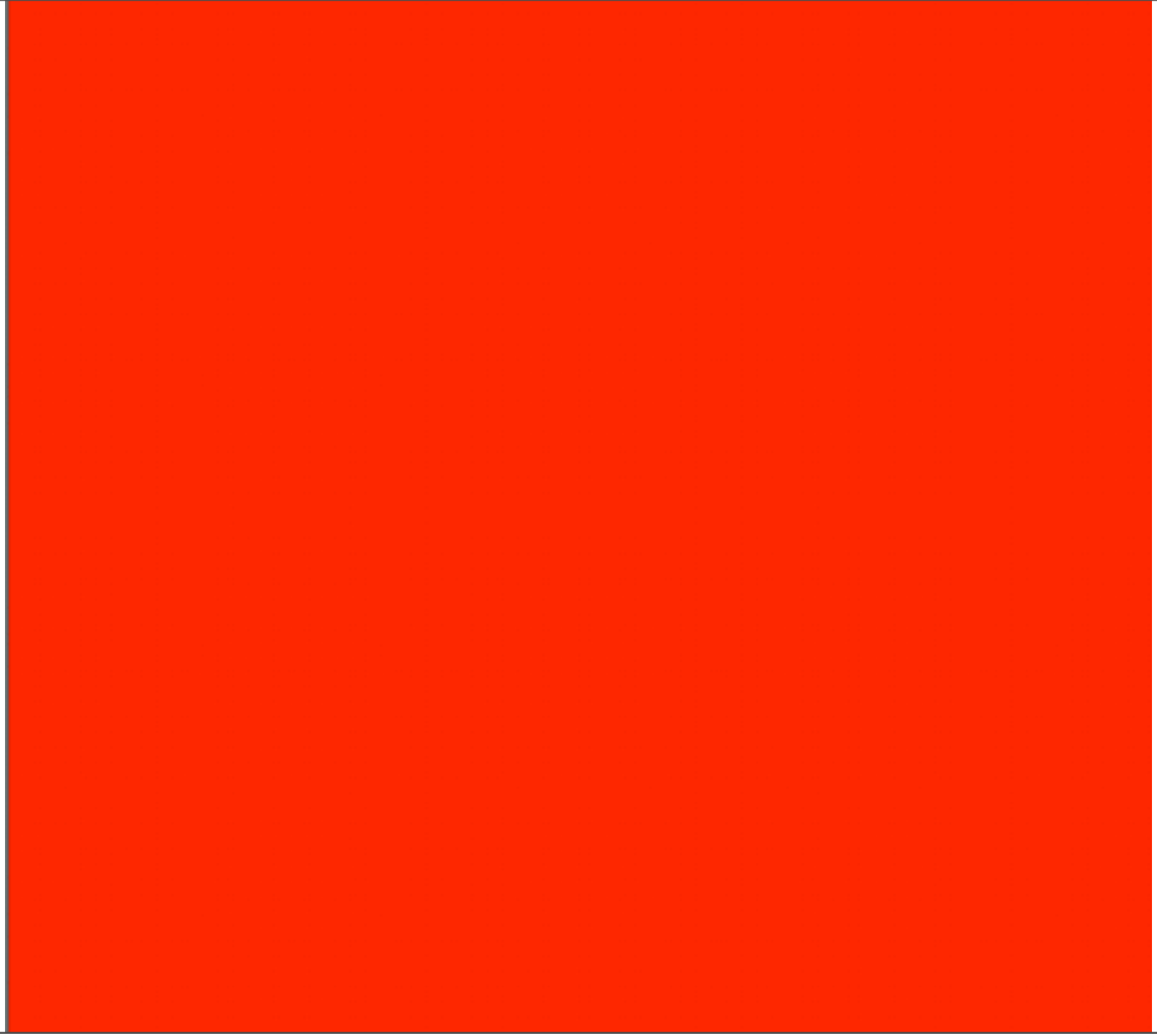
Weak Anthropic Principle:

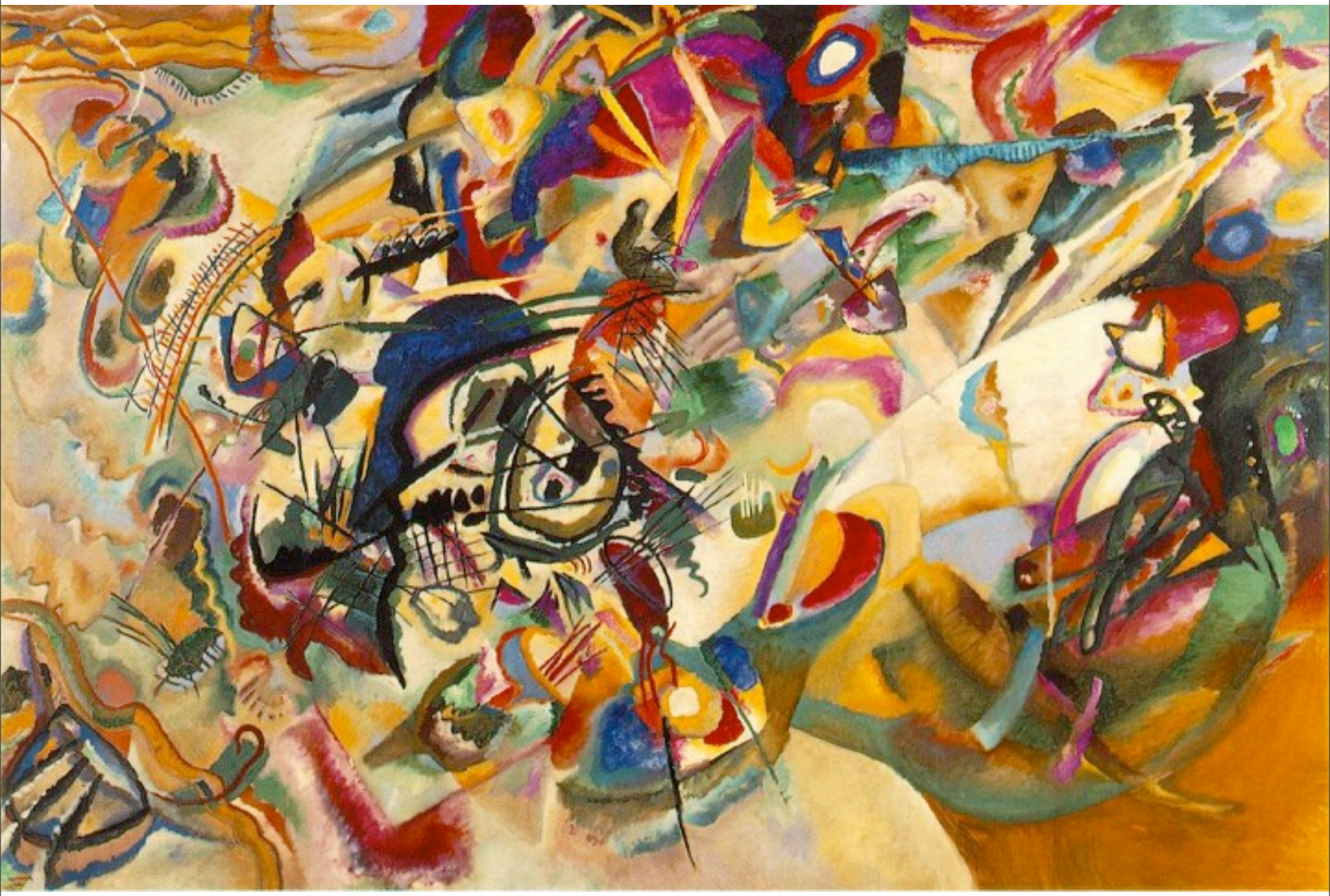
"The observed values of all physical and cosmological quantities are not equally probable but they take on values restricted by the requirement that there exist sites where carbon-based life can evolve and by the requirement that the Universe be old enough for it to have already done so."

Strong Anthropic Principle:

"The universe must have those properties which allow life to develop within it at some stage in its history."





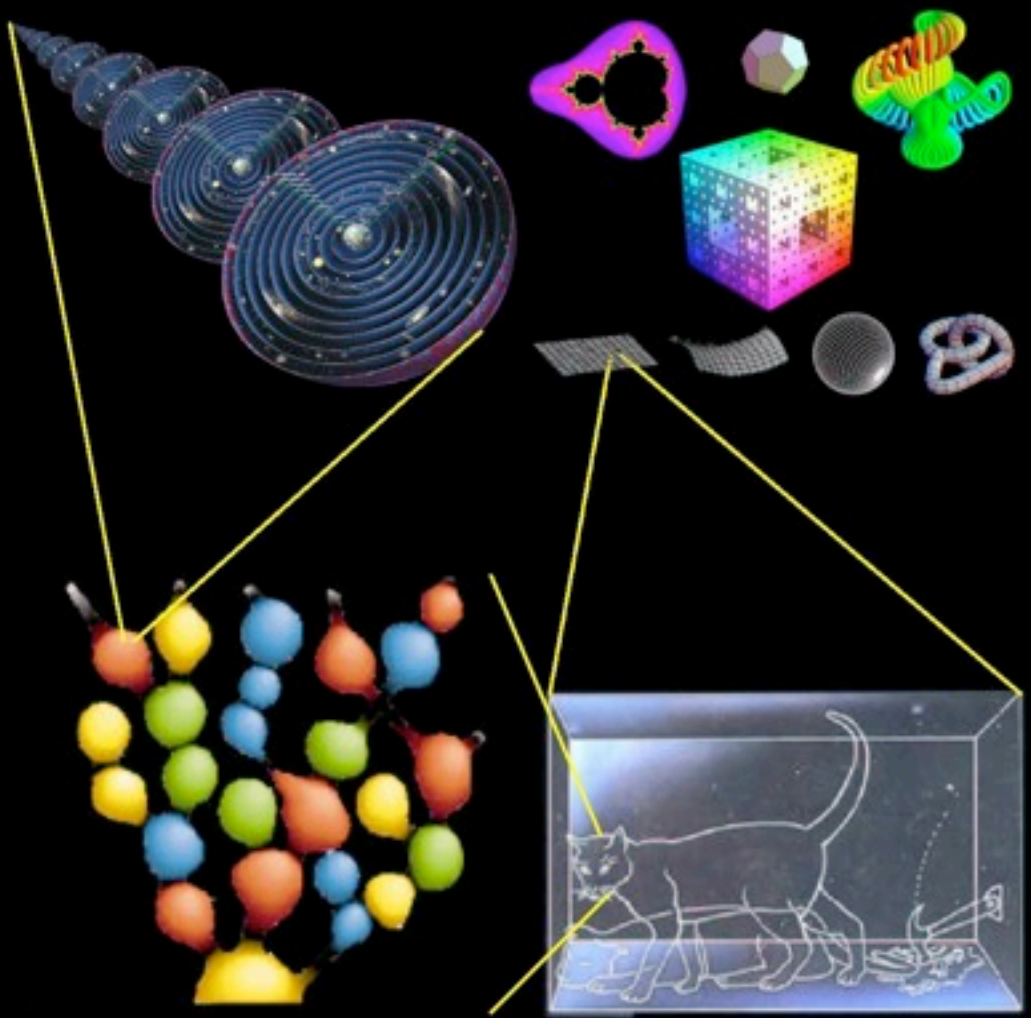


Level 1: Regions beyond our cosmic horizon

Features: Same laws of physics, different initial conditions
Assumptions: Infinite space, ergodic matter distribution
Evidence:
- Microwave background measurements point to flat, infinite space, large-scale smoothness
- Simplest model

Level 4: Other mathematical structures

Features: Different fundamental equations of physics
Assumption: Mathematical existence = physical existence
Evidence:
- Unreasonable effectiveness of math in physics
- Answers Wheeler/Hawking question: "why these equations, not others"



Level 2: Other post-inflation bubbles

Features: Same fundamental equations of physics, but perhaps different constants, particles and dimensionality
Assumption: Chaotic inflation occurred
Evidence:
- Inflation theory explains flat space, scale-invariant fluctuations, solves horizon problem and monopole problems and can naturally explain such bubbles
- Explains fine-tuned parameters

Level 3: The Many Worlds of Quantum Physics

Features: Same as level 2
Assumption: Physics unitary
Evidence:
- Experimental support for unitary physics
- AdS/CFT correspondence suggests that even quantum gravity is unitary
- Decoherence experimentally verified
- Mathematically simplest model

"Our aesthetic judgment therefore comes down to what we find more wasteful: many worlds or many words. Perhaps we will gradually get more used to the weird ways of our cosmos, and even find its strangeness to be part of its charm."

- Max Tegmark