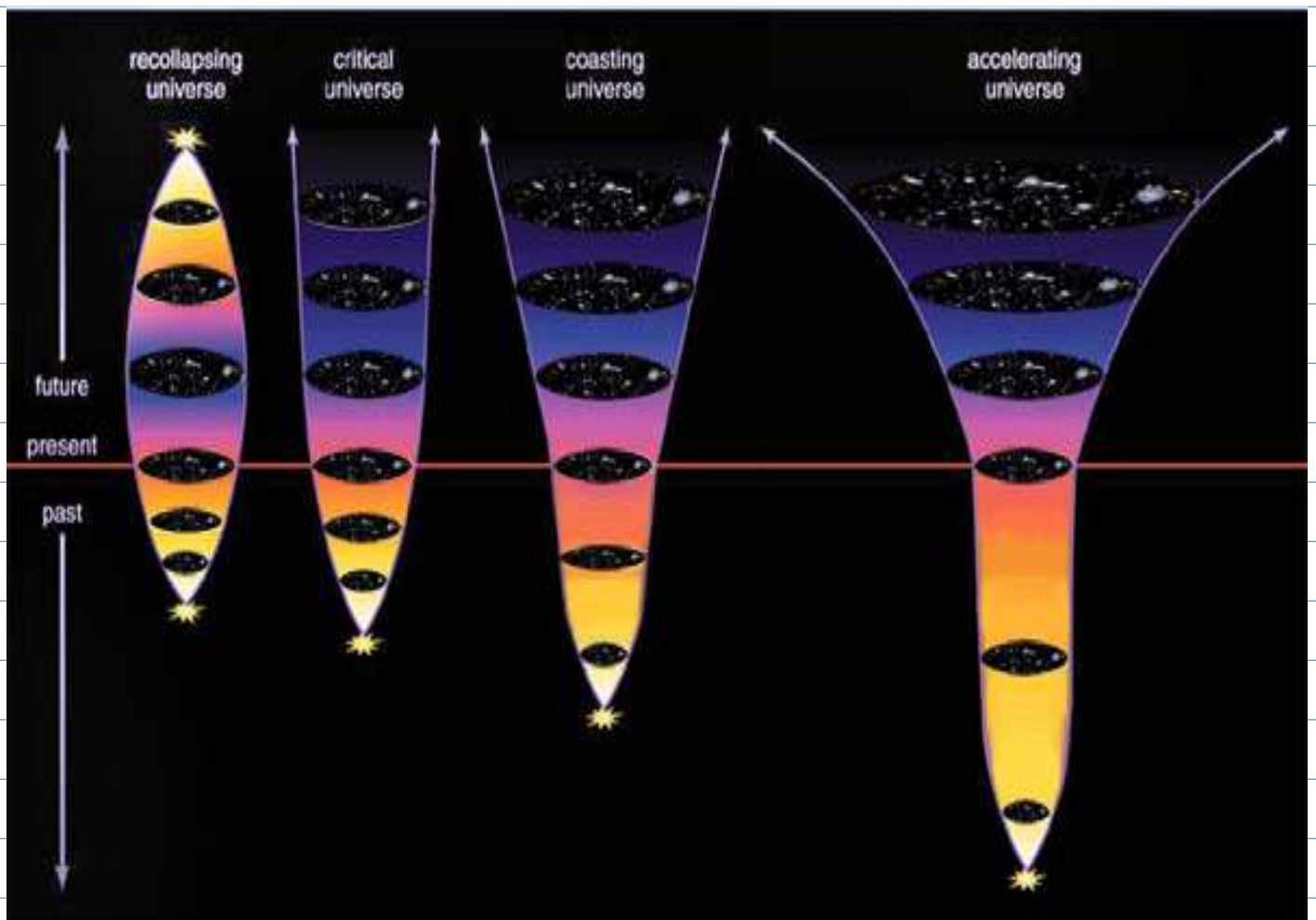


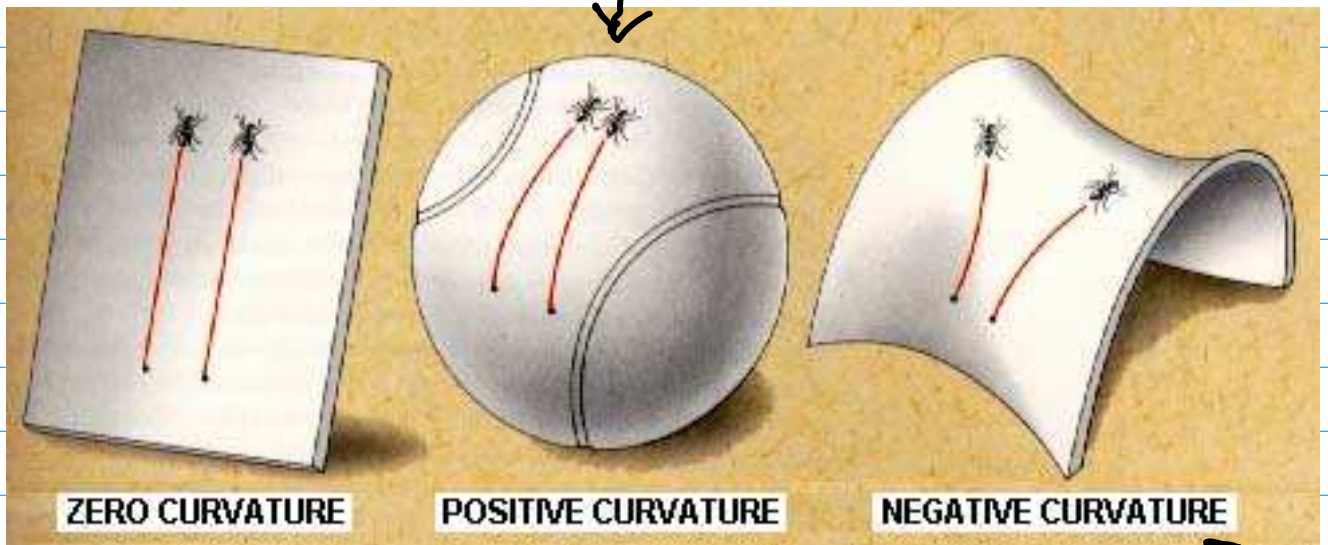
WHAT IS THE FATE OF THE UNIVERSE?

THE ANSWER DEPENDS ON THE DENSITY OF MATTER/ENERGY IN THE UNIVERSE CHARACTERIZED BY THE PARAMETER "OMEGA":

$$\Omega = \frac{n \leftarrow \text{DENSITY}}{n_c \leftarrow \text{CRITICAL DENSITY OF } 9.5 \times 10^{-30} \frac{\text{g}}{\text{cm}^3} \text{ (ABOUT 6 HYDROGEN ATOMS PER } \text{m}^3)}$$



$\Omega > 1$: RECOLLAPSING UNIVERSE -
- IT ENDS IN THE BIG CRUNCH ;
THE UNIVERSE HAS A POSITIVE
CURVATURE (LIKE THE SURFACE
OF A BALL)



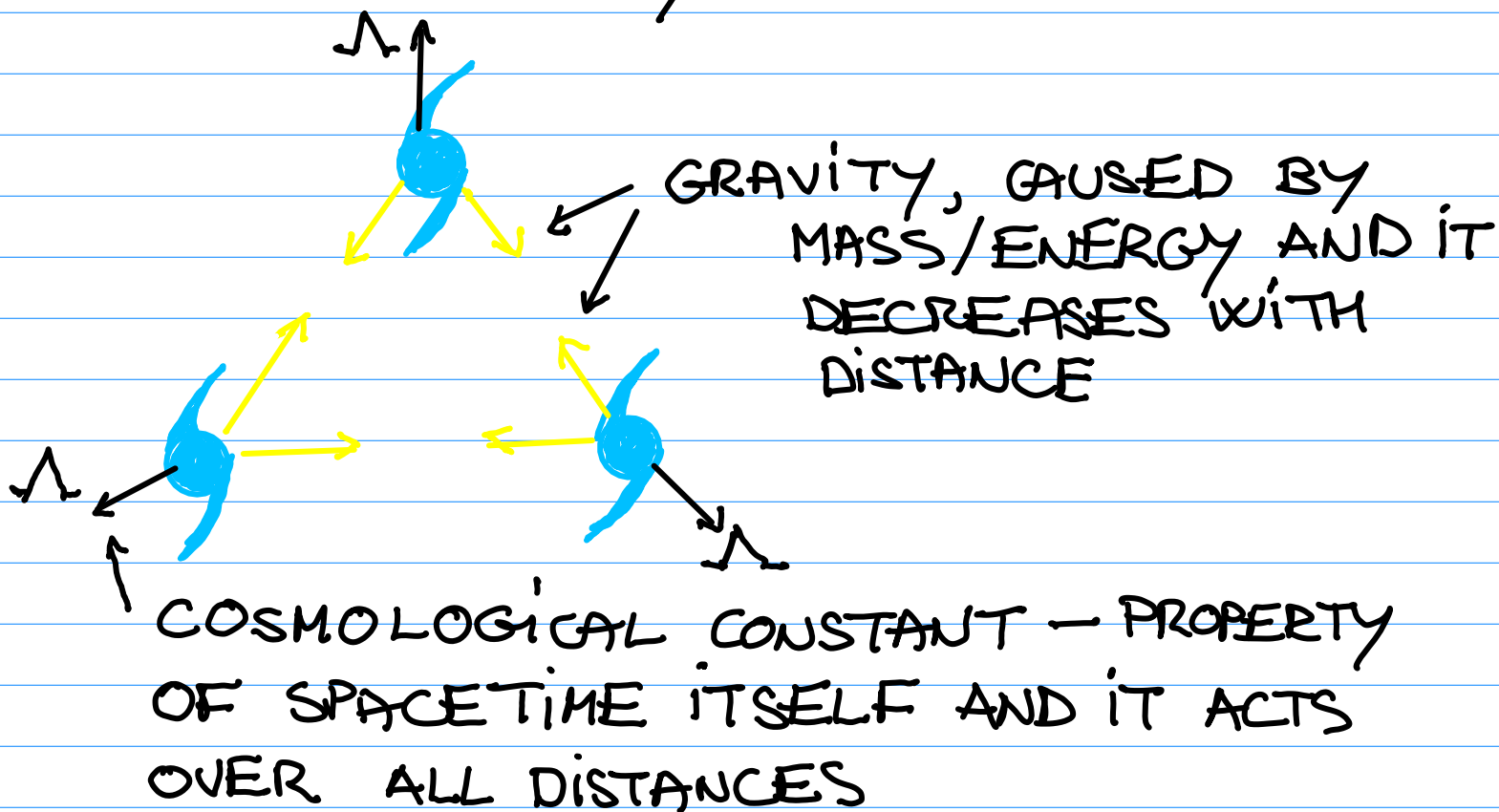
$\Omega < 1$: COASTING UNIVERSE - IT KEEPS
ON EXPANDING AT A CONSTANT
RATE ; THE CURVATURE IS NEGATIVE
(LIKE A SADDLE)

$\Omega = 1$: CRITICAL UNIVERSE - IT KEEPS
ON EXPANDING BUT THE
EXPANSION RATE WILL REDUCE
TO ZERO IN INFINITE FUTURE ;
THE CURVATURE IS ZERO (LIKE
A SHEET OF PAPER)

OBSERVATION (1998): 4-5 BILLION YEARS AGO THE EXPANSION RATE OF THE UNIVERSE STARTED TO INCREASE - THE EXPANSION OF THE UNIVERSE ACCELERATED.

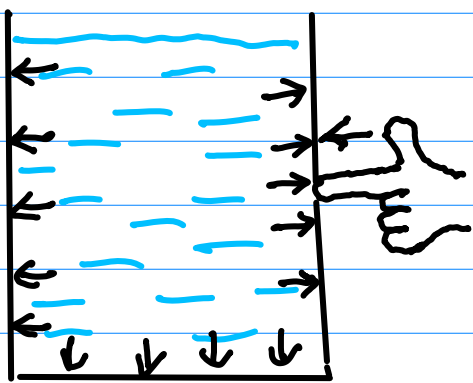
Why?

THE EINSTEIN'S "GREATEST BLUNDER" TO THE RESCUE: COSMOLOGICAL CONSTANT Λ , INTRODUCED TO PREVENT THE UNIVERSE FROM COLLAPSING UNDER ITS OWN GRAVITY.

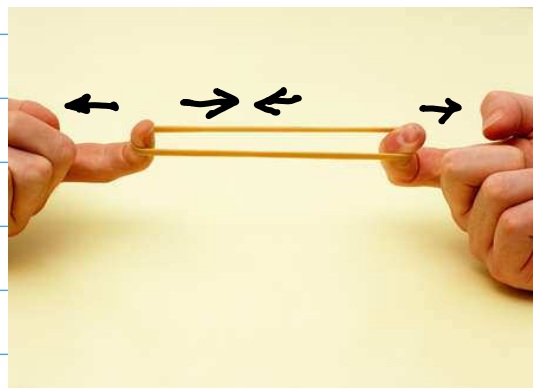


4-5 BILLION YEARS AGO, WHEN THE SEPARATION BETWEEN THE GALAXIES BECAME LARGE ENOUGH, Λ STARTED TO DOMINATE OVER GRAVITATIONAL ATTRACTION AND THE EXPANSION STARTED TO ACCELERATE.

WHAT IS THE PHYSICAL ORIGIN OF Λ ?
WE DON'T KNOW YET. WE CALL IT DARK ENERGY. IT HAS TO HAVE A POSITIVE ENERGY DENSITY BUT NEGATIVE PRESSURE (LIKE A STRETCHED RUBBER BAND)



POSITIVE PRESSURE



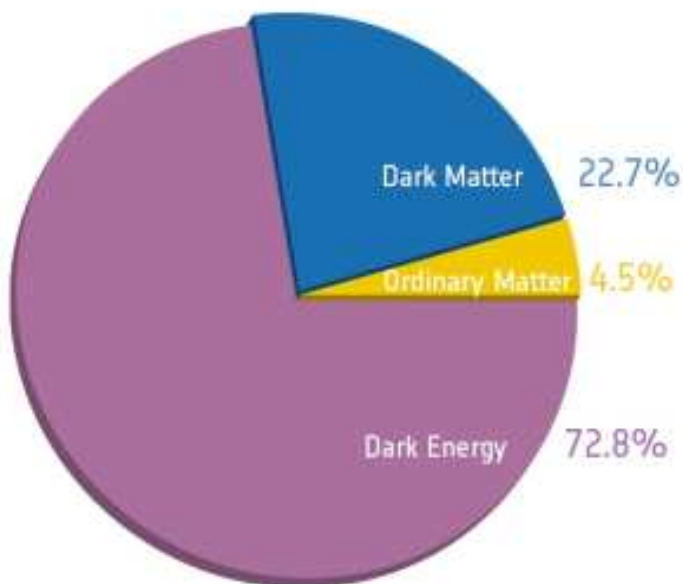
NEGATIVE PRESSURE

THE TOTAL Ω OF THE UNIVERSE IS

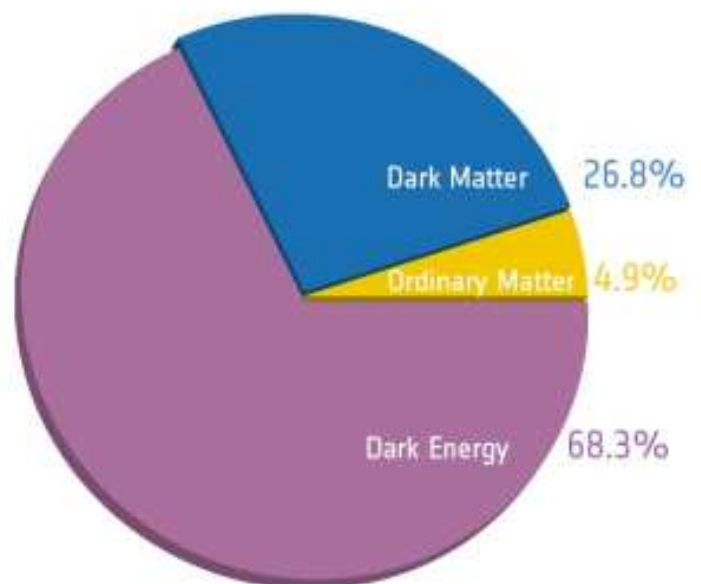
$$\Omega = \Omega_M + \Omega_\Lambda = 1$$

CONTRIBUTION
FROM ORDINARY
MATTER AND
DARK MATTER ≈ 0.3

CONTRIBUTION
FROM DARK ENERGY
 ≈ 0.7



Before Planck



After Planck

HENCE, THE UNIVERSE IS FLAT AND CURRENTLY EXPANDING AT AN ACCELERATED RATE.