



**ENERGY'S
SPAWN**

ABOUT 14 BILLION YEARS AGO ↗



AAAAAZ

AAAAA[↑]Z

AAAAA \hat{Z}



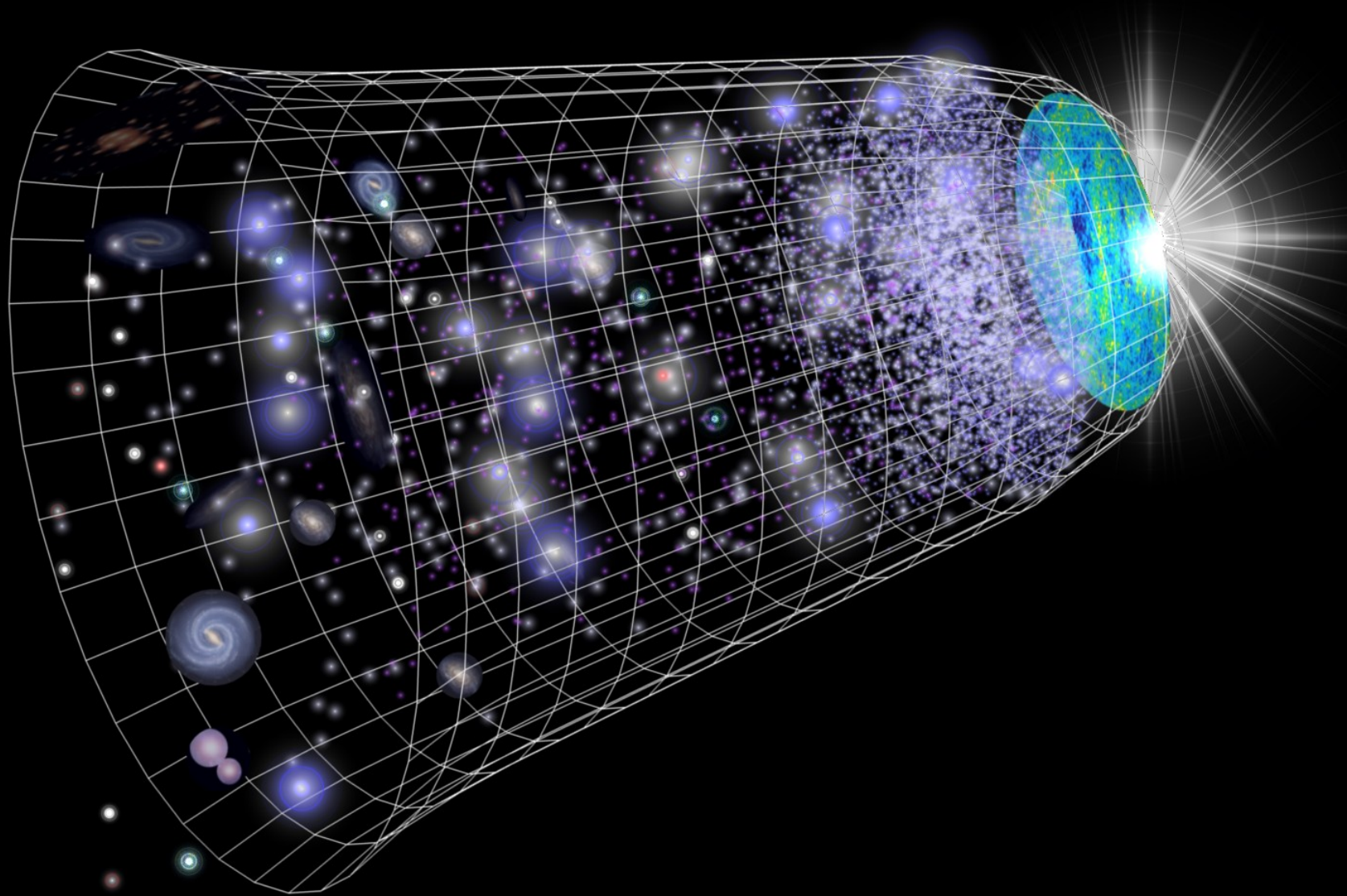
AAAAAZ



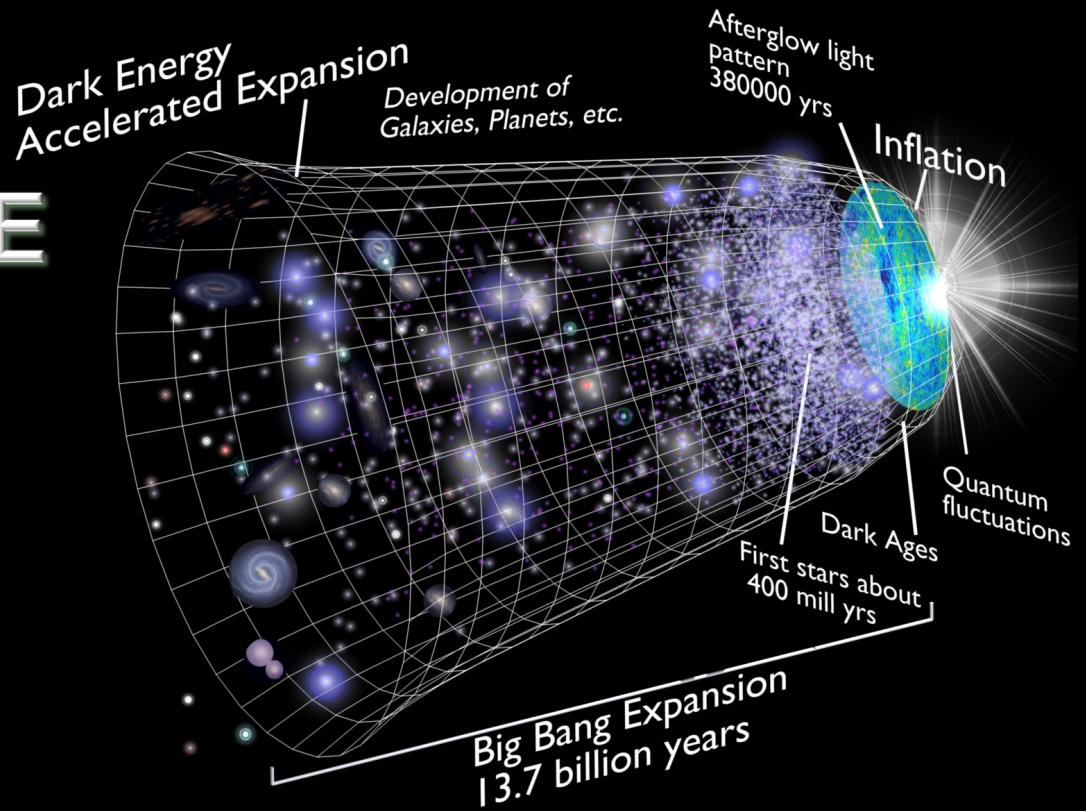
AAAAAẐ

AAAAAZ

AAAAACHOOO!



THE BIG SNEEZE

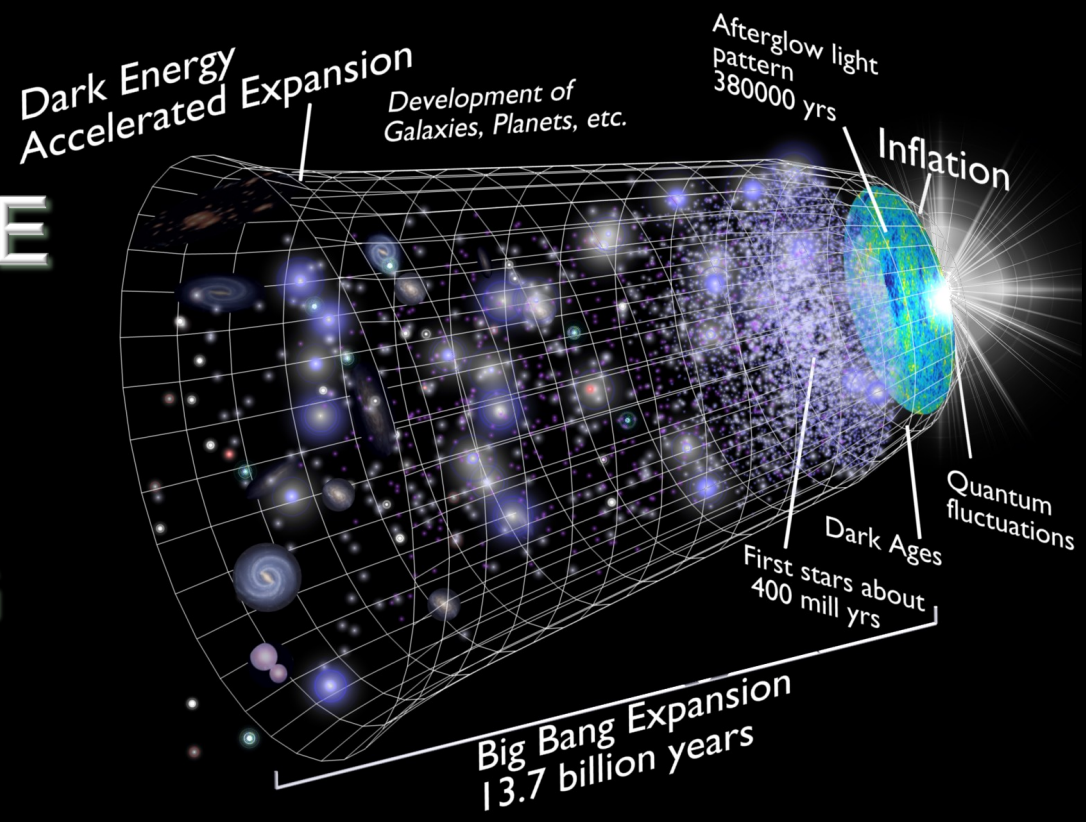


THE BIG SNEEZE

OR

THE BIG BANG

AS IT IS OFTEN CALLED

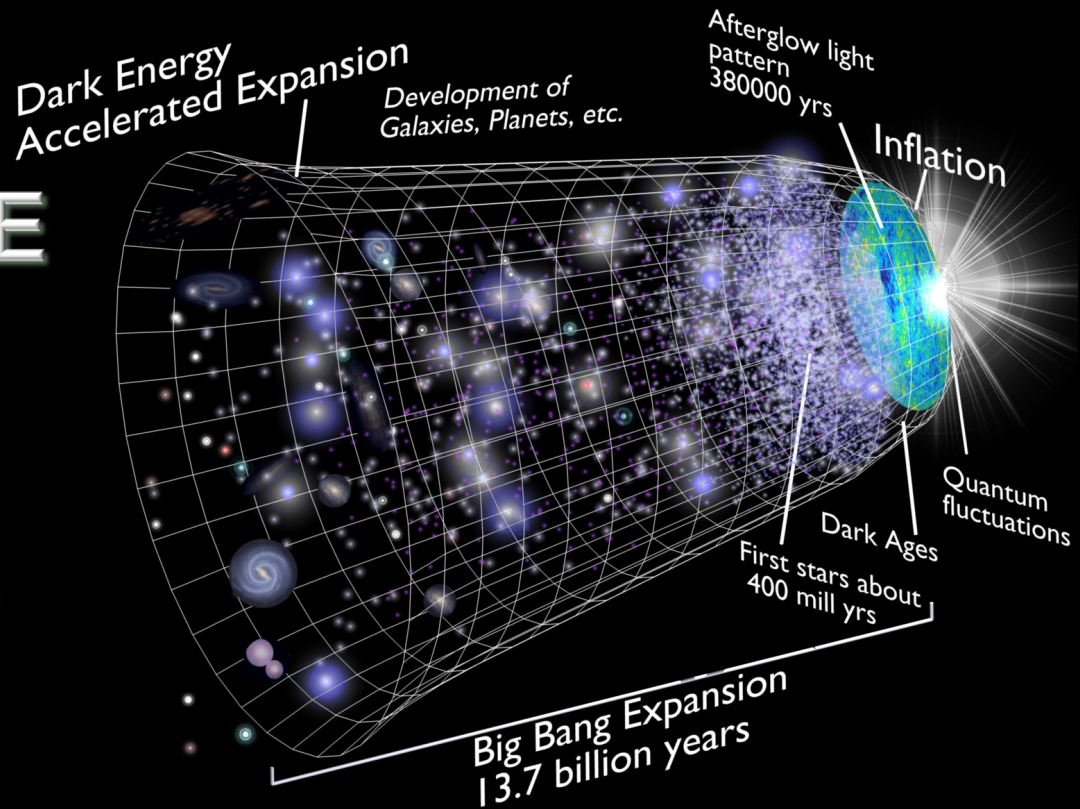


THE BIG SNEEZE

OR

THE BIG BANG

AS IT IS OFTEN CALLED



WITH THE CREATION OF ALL ENERGY, ALL MATTER, AND ALL OF THE KNOWN UNIVERSE, TOGETHER WITH SPACE AND TIME
ENERGY, LOTS OF IT, IS WHAT TURNED INTO
MATTER AND ANTIMATTER.

WE HAVE SEEN THAT:

ANTIMATTER + MATTER = ENERGY

*BUT CAN WE LOOK AT THIS
THE OTHER WAY AROUND?*

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*BUT CAN WE LOOK AT THIS
THE OTHER WAY AROUND?*

YƆЯƎIƆ = ЯƎTTAM + ЯƎTTAMITNA

or rather \hat{Z}

ENERGY = ANTIMATTER + MATTER

***AS WAS SHOWN IN THE BACKGROUND MATERIAL
VĀ CONSERVATION OF ENERGY-REVISITEDĀ,
MATTER AND ENERGY ARE INTERCHANGEABLE.
THEY ARE SIMPLY THE TWO MANIFESTATIONS OF MASS-ENERGY.***

AGAIN, LET'S LOOK AT THE CASE OF AN ELECTRON AND A POSITRON:

RECALL THAT:

AGAIN, LET'S LOOK AT THE CASE OF AN ELECTRON AND A POSITRON:

RECALL THAT:

MATTER



electron

AGAIN, LET'S LOOK AT THE CASE OF AN ELECTRON AND A POSITRON:

RECALL THAT:

MATTER + ANTIMATTER



+



electron

positron

AGAIN, LET'S LOOK AT THE CASE OF AN ELECTRON AND A POSITRON:

RECALL THAT:

MATTER + ANTIMATTER = ENERGY

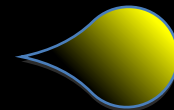
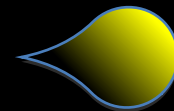


electron

+



positron

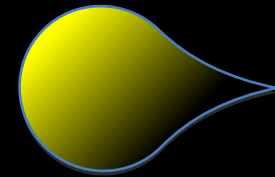


**two
photons**

WE NOW TAKE THIS EVENT IN A REVERSE ORDER ↗

WE NOW TAKE THIS EVENT IN A REVERSE ORDER \vec{z}

ENERGY

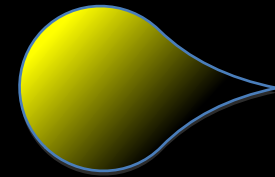


photon

WE NOW TAKE THIS EVENT IN A REVERSE ORDER \vec{z}

=

ENERGY



photon

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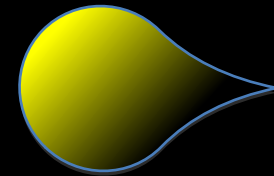
ANTIMATTER

=

ENERGY



positron



photon

WE NOW TAKE THIS EVENT IN A REVERSE ORDER \rightarrow

MATTER

+

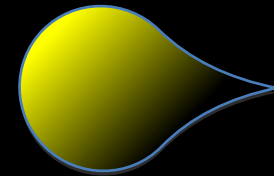
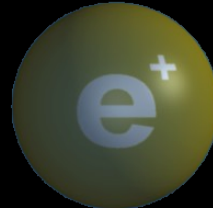
ANTIMATTER

=

ENERGY



+



electron

positron

photon

→ AND WRITE IT (MORE NORMALLY) FROM LEFT TO RIGHT:

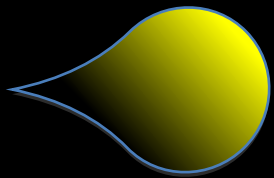
ENERGY

=

MATTER

+

ANTIMATTER

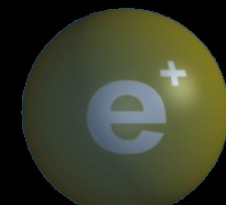


photon



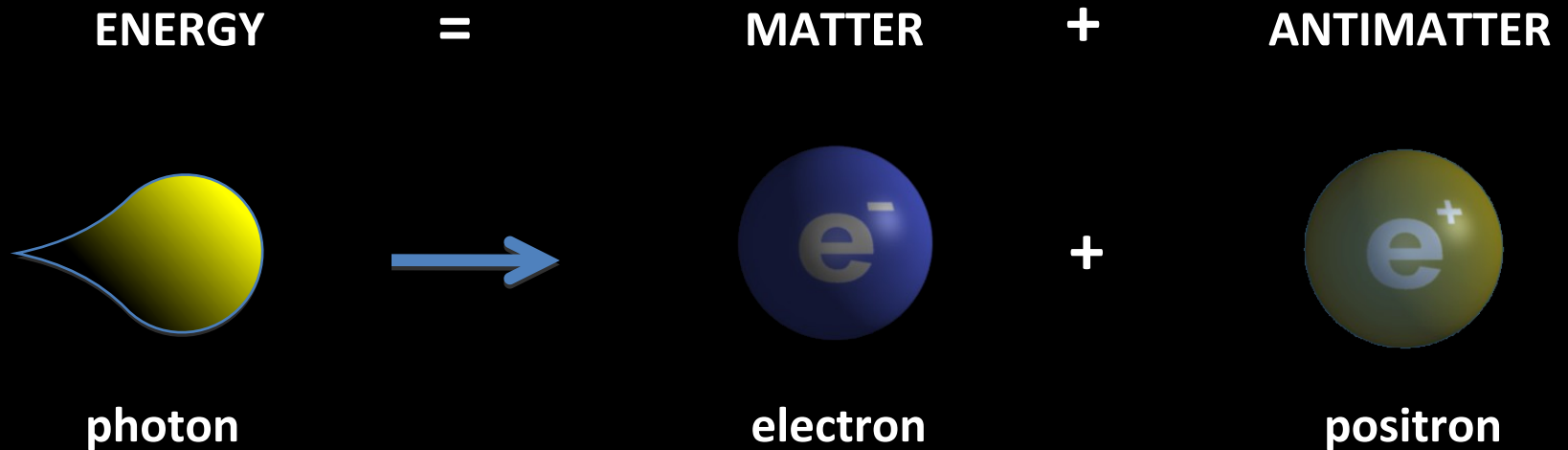
electron

+



positron

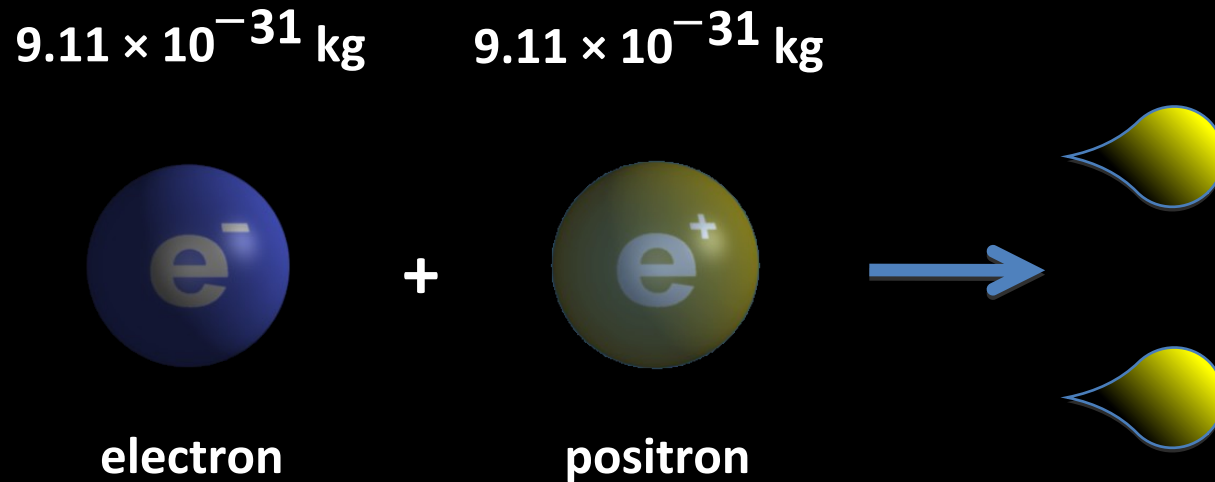
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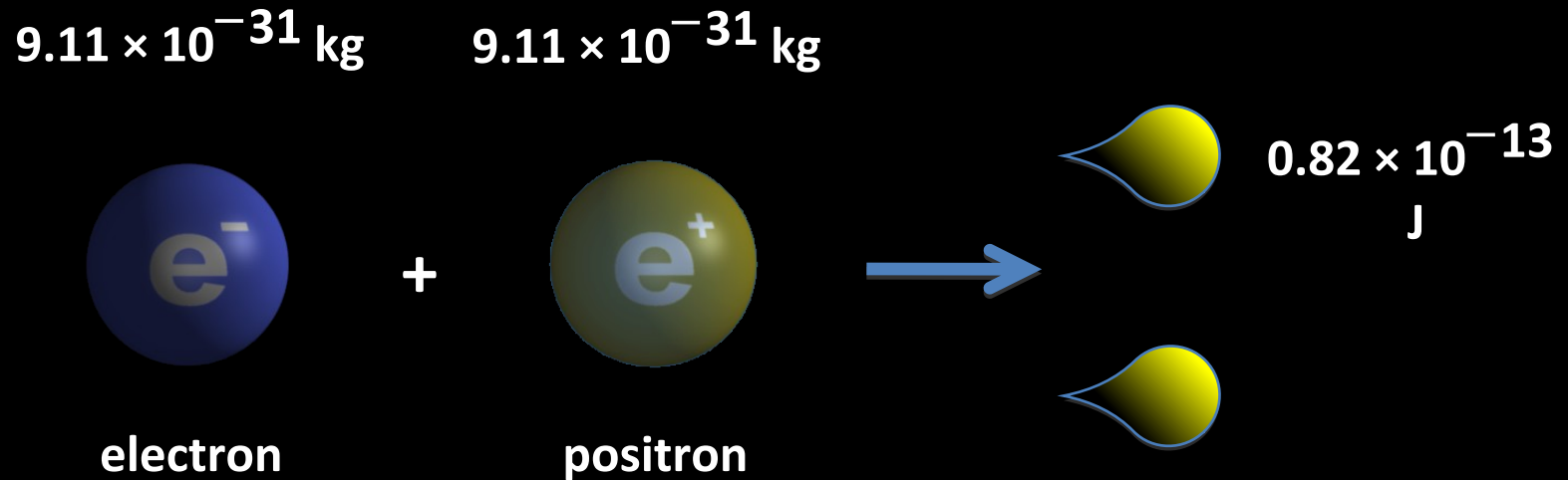
IT SHOULD BE NOTED THAT, UNDER NORMAL CIRCUMSTANCES THIS TRANSFORMATION DOES NOT OCCUR SPONTANEOUSLY, BUT REQUIRES THE PRESENCE OF A NUCLEUS FOR THE PHOTON TO INTERACT WITH. THIS IS DUE TO CONSERVATION OF MOMENTUM REQUIREMENTS. THIS IS ALSO WHY ONLY ONE PHOTON, NOT TWO, CAN TRANSFORM INTO THE MASSES OF THE ELECTRON AND POSITRON.

**ALSO RECALL THAT IN THE ANNIHILATION OF THE ELECTRON AND POSITRON,
THEIR MASSES ARE CONVERTED INTO
A TOTAL OF 1.64×10^{-13} JOULES OF ENERGY:**

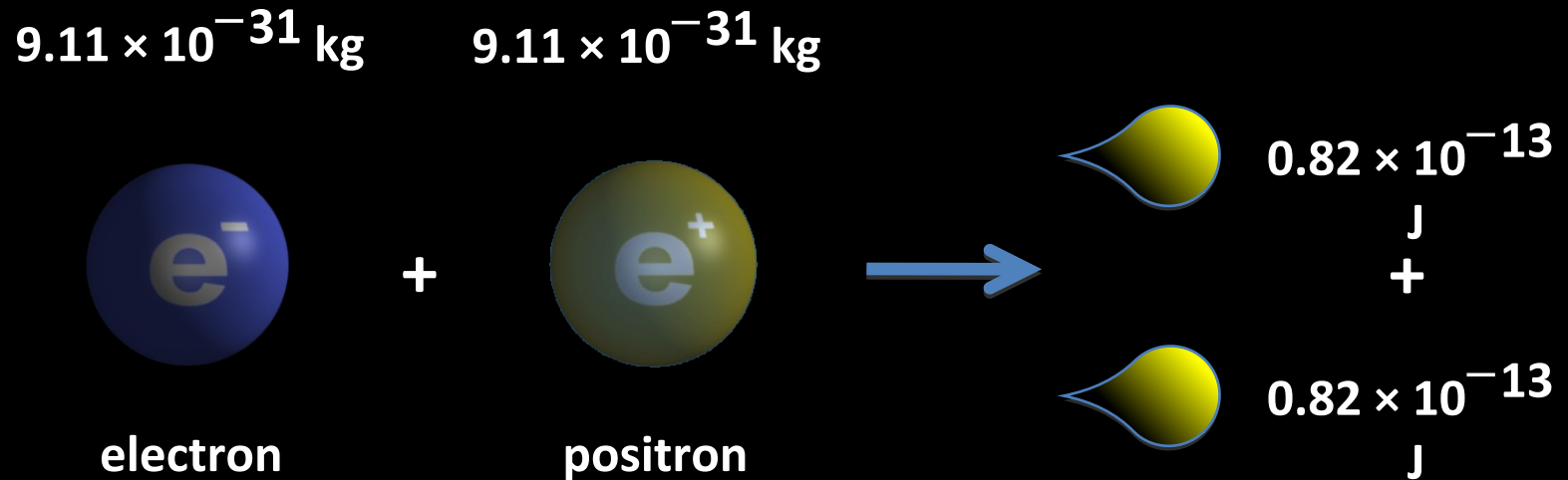
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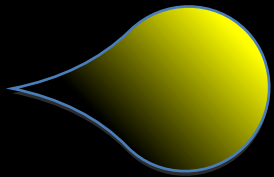
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$$\begin{array}{ccc} 9.11 \times 10^{-31} \text{ kg} & & 9.11 \times 10^{-31} \text{ kg} \\ \text{electron} & + & \text{positron} \\ \downarrow & & \downarrow \\ \text{e}^- & & \text{e}^+ \\ \downarrow & & \downarrow \\ \text{electron} & + & \text{positron} \\ \rightarrow & & \rightarrow \\ \text{photon} & & \text{photon} \\ 0.82 \times 10^{-13} \text{ J} & + & 0.82 \times 10^{-13} \text{ J} \\ \hline = 1.64 \times 10^{-13} \text{ J} \end{array}$$

THIS IMPLIES THAT A MINIMUM OF 1.64×10^{-13} JOULES OF ENERGY IS REQUIRED TO PRODUCE THE MASSES OF AN ELECTRON AND A POSITRON:

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ENERGY



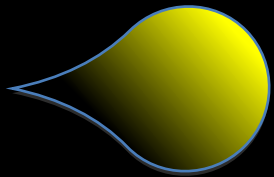
**1.64×10^{-13}
J**

THIS IMPLIES THAT A MINIMUM OF 1.64×10^{-13} JOULES OF ENERGY IS REQUIRED TO PRODUCE THE MASSES OF AN ELECTRON AND A POSITRON:

ENERGY

=

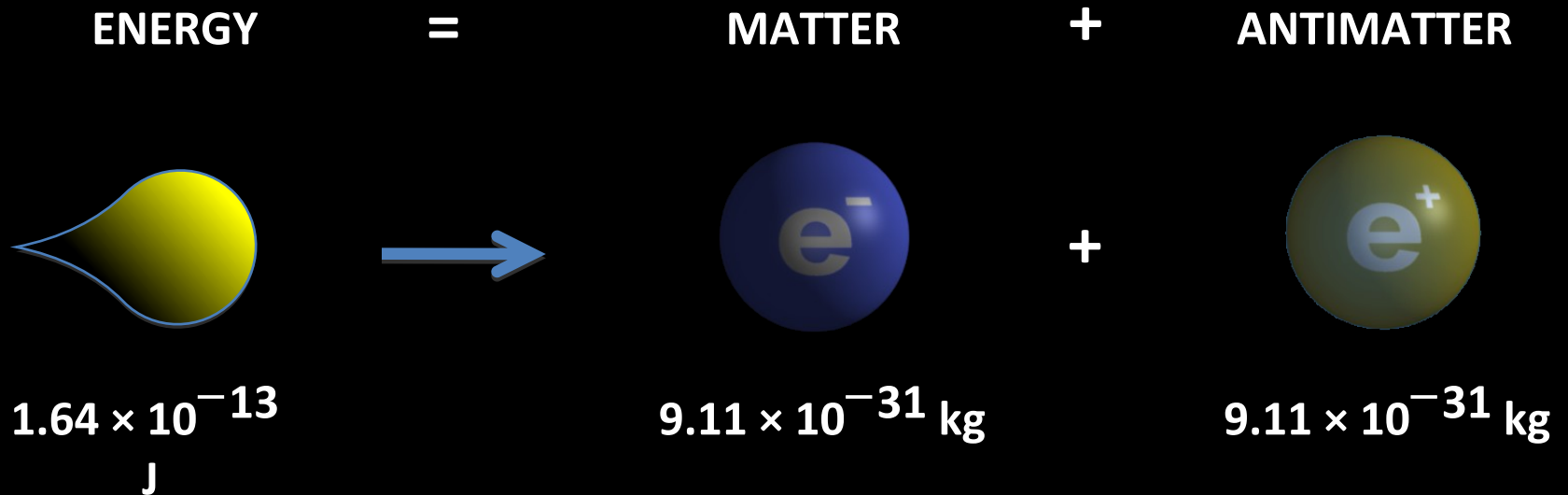
MATTER



1.64×10^{-13}
J

9.11×10^{-31} kg

THIS IMPLIES THAT A MINIMUM OF 1.64×10^{-13} JOULES OF ENERGY IS REQUIRED TO PRODUCE THE MASSES OF AN ELECTRON AND A POSITRON:



*THE STUDENTS SHOULD REALIZE THAT,
IN ORDER TO CALCULATE THE AMOUNT OF MASS
THAT CAN BE PRODUCED FROM ENERGY,
WE HAVE AGAIN USED*

$$E = mc^2$$

BUT THIS TIME, REARRANGED AS:

$$m = \frac{E}{c^2}$$

FOR EXAMPLE,
WITH 3.01×10^{-10} JOULES OF ENERGY,
WE COULD MAKE A TOTAL MASS OF:

$$m = \frac{3.01 \times 10^{-10}}{(3.00 \times 10^8)^2} = 3.34 \times 10^{-27} \text{ kg}$$

NOTICE THAT 3.01×10^{-10} J IS THE MINIMUM ENERGY REQUIRED FOR
THE PRODUCTION OF A PROTON AND AN ANTIPROTON,
SINCE EACH OF THESE HAS A MASS THAT IS ONE-HALF
THAT OF THE TOTAL MASS PRODUCED.



AT THIS POINT, YOU MIGHT BE WONDERING WHETHER:

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***1.64 × 10⁻¹³ JOULES OF ENERGY COULD FORM
2 ELECTRONS OR 2 POSITRONS?***

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OR, WHETHER

***3.01 × 10⁻¹⁰ JOULES OF ENERGY COULD FORM
2 PROTONS OR 2 ANTIPROTONS?***

AT THIS POINT, YOU MIGHT BE WONDERING WHETHER:

**1.64×10^{-13} JOULES OF ENERGY COULD FORM
2 ELECTRONS OR 2 POSITRONS?**

OR, WHETHER

**3.01×10^{-10} JOULES OF ENERGY COULD FORM
2 PROTONS OR 2 ANTIPROTONS?**

THE SIMPLE ANSWER IS...

NO.

NO.

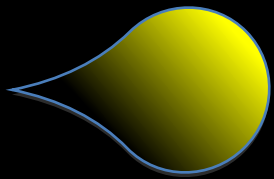
**NOT ONLY IS MASS-ENERGY CONSERVED
BUT CHARGE HAS TO BE CONSERVED, AS WELL.**

**A PHOTON, WHICH HAS ZERO CHARGE,
CANNOT PRODUCE
TWO NEGATIVELY CHARGED PARTICLES
NOR
TWO POSITIVELY CHARGED PARTICLES.**

BUT...

BUT...

CHARGE = 0



photon



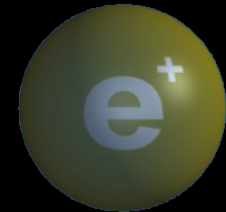
CHARGE = -1



electron

+

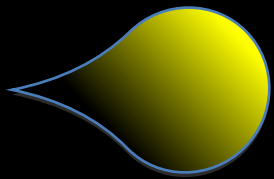
CHARGE = +1



positron

BUT...

CHARGE = 0



photon



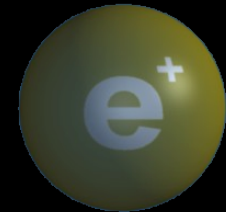
CHARGE = -1



electron

+

CHARGE = +1



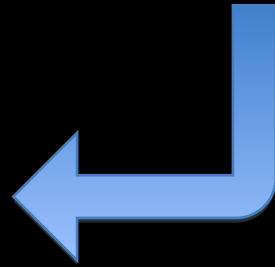
positron

***...IS OK, SINCE THE TOTAL CHARGE OF
THE ELECTRON PLUS THE POSITRON
IS ALSO ZERO (-1 + 1 = 0)***

***WHENEVER
ENERGY IS CONVERTED INTO
MASS, WE ALWAYS GET***

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**50%
Matter**



**WHENEVER
ENERGY IS CONVERTED INTO
MASS, WE ALWAYS GET**

**50%
Matter**



**50%
Anti-
matter**

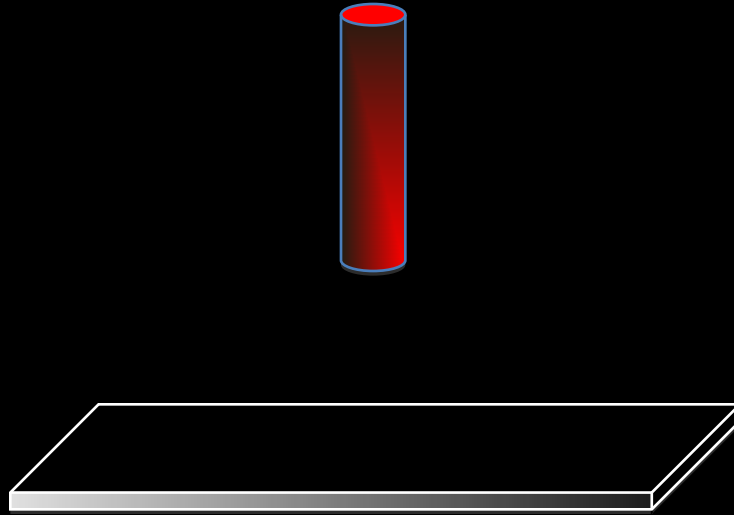
**WHENEVER
ENERGY IS CONVERTED INTO
MASS, WE ALWAYS GET**



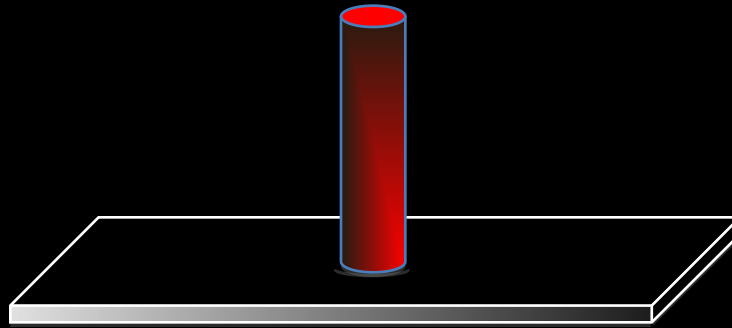
**THIS IS AN INESCAPABLE FACT, AND IT REVEALS AN UNDERLYING
SYMMETRY
BETWEEN MATTER AND ANTIMATTER.
YOU CAN'T GET ONE WITHOUT THE OTHER.**

YOU CAN THINK OF IT THIS WAY...

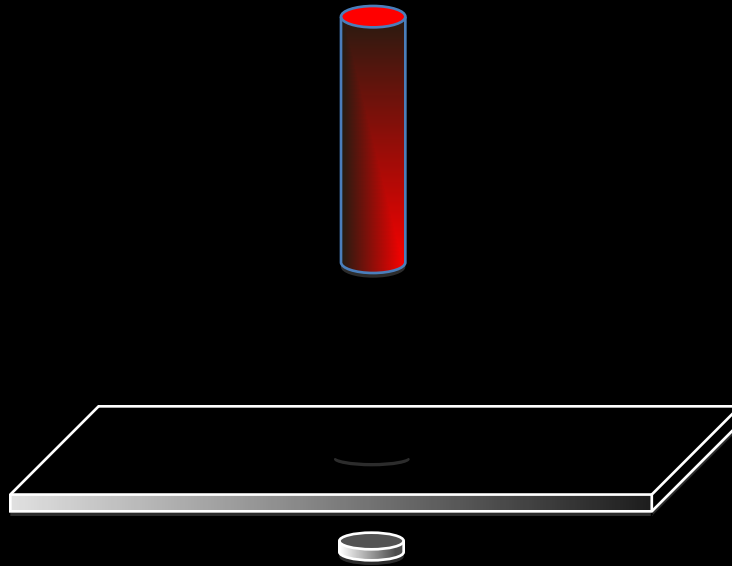
**YOU CAN THINK OF IT THIS WAY...
WHEN ENERGY IS USED TO PUNCH A SHEET OF METAL TO MAKE A
COIN...**



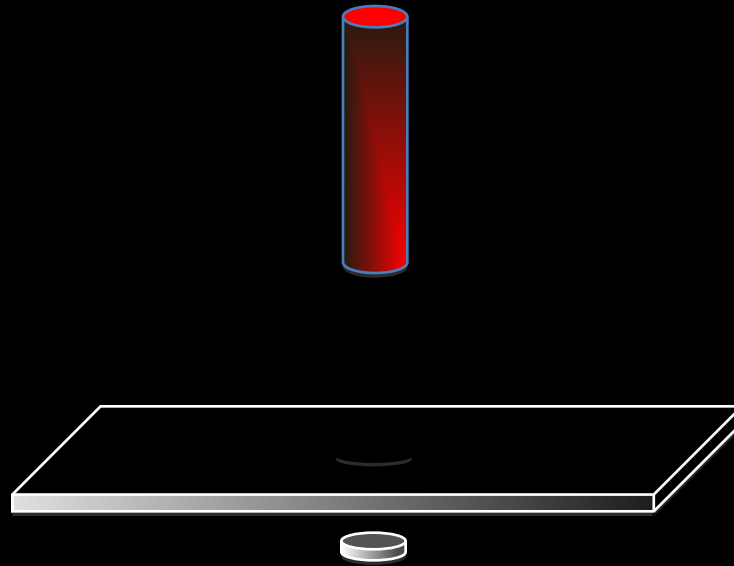
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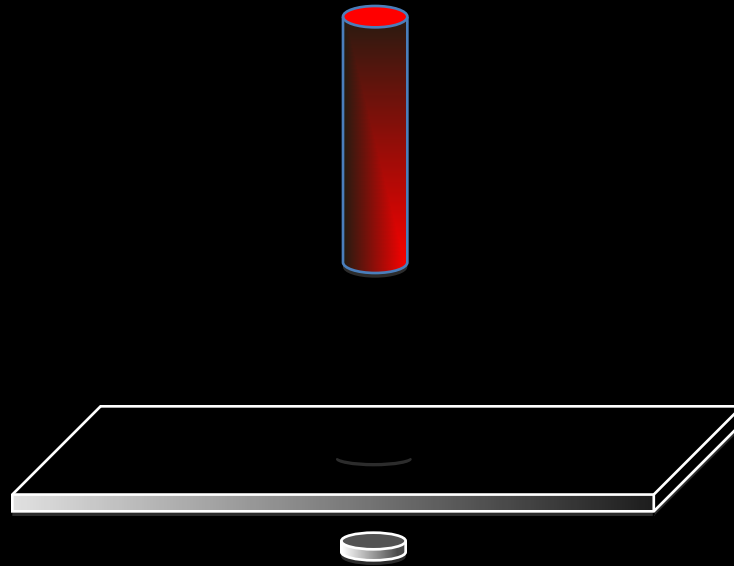


**YOU CAN THINK OF IT THIS WAY...
WHEN ENERGY IS USED TO PUNCH A SHEET OF METAL TO MAKE A
COIN...**



WE ALWAYS GET A COIN AND A HOLE.

**YOU CAN THINK OF IT THIS WAY...
WHEN ENERGY IS USED TO PUNCH A SHEET OF METAL TO MAKE A
COIN...**



WE ALWAYS GET A COIN AND A HOLE.

**THINK OF THE COIN AS A PARTICLE OF MATTER,
AND THE HOLE AS A PARTICLE OF ANTIMATTER.**

***NOW THAT YOU HAVE GONE THROUGH THE LESSONS
“OPERATION: ANNIHILATE”
AND
“ENERGY’S SPAWN”,
HERE IS SOMETHING TO THINK ABOUT...***

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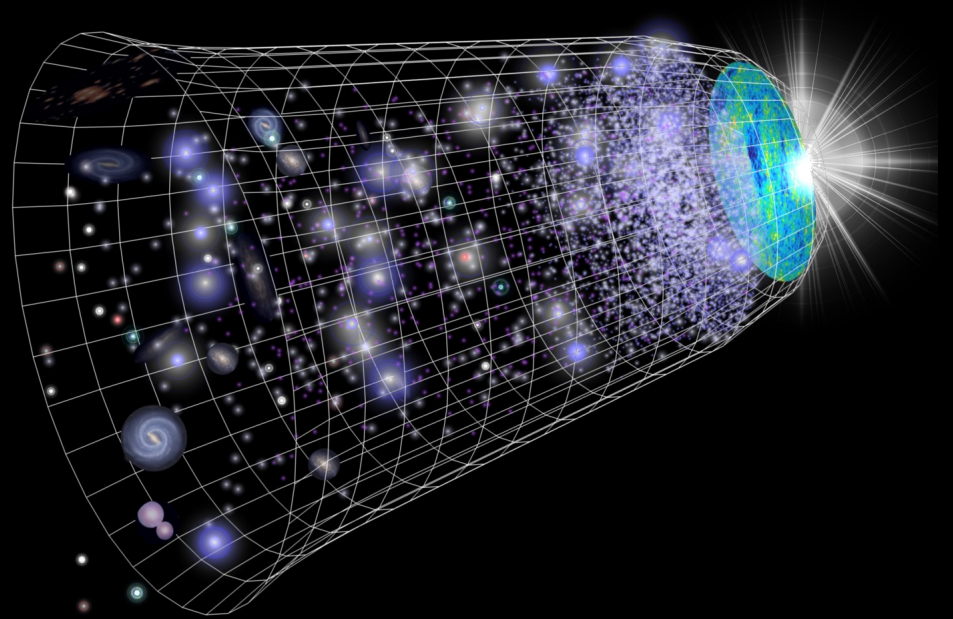
***IF ANTIMATTER + MATTER LEADS TO
TOTAL ANNIHILATION,***

***NOW THAT YOU HAVE GONE THROUGH THE LESSONS
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***IF ANTIMATTER + MATTER LEADS TO
TOTAL ANNIHILATION,
AND IF THE CONVERSION OF ENERGY TO MASS
ALWAYS YIELDS
 $\frac{1}{2}$ MATTER + $\frac{1}{2}$ ANTIMATTER...***

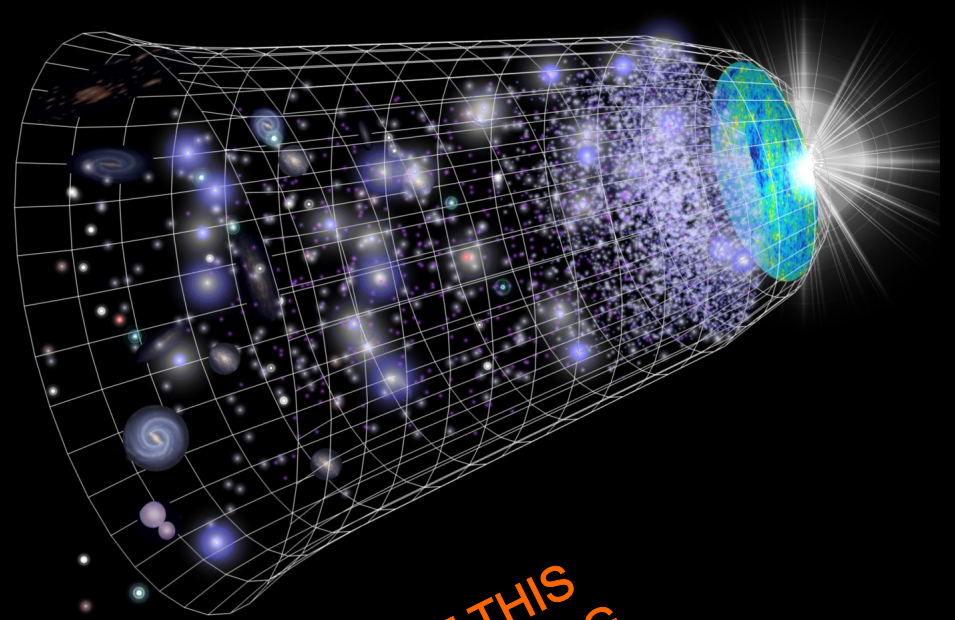
**...WHAT QUESTIONS
IMMEDIATELY ARISE
WHEN YOU THINK ABOUT OUR
UNIVERSE
AND ITS CREATION IN THE
BIG BANG (WHERE, AS WAS
PREVIOUSLY QUOTED),**

**”...ENERGY, LOTS OF IT, IS WHAT
TURNED INTO
MATTER AND ANTIMATTER.”**



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**THINK ABOUT THIS
BEFORE EMBARKING
ON LESSON PLAN # 7,
'THE MOTHER OF ALL
CONUNDRUMS ~**