

THE ENERGY CONTAINED IN ANY
OBJECT EQUALS ITS MASS
MULTIPLIED BY THE SPEED...



...OF LIGHT SQUARED.

EXACTLY!

DID YOU
UNDERSTAND
WHAT HE
SAID?

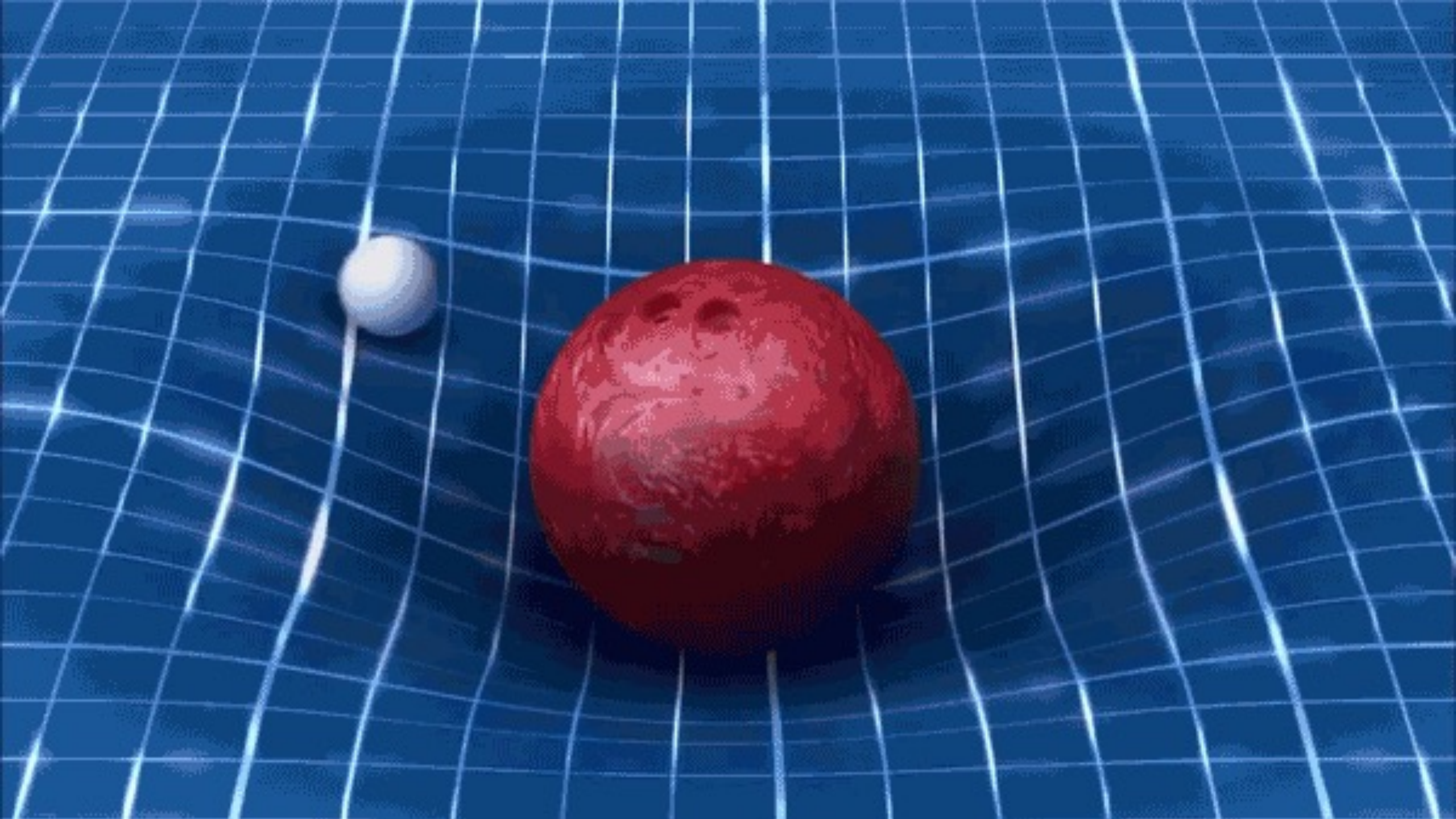
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SMILE AND
NOD.



Cartoonists

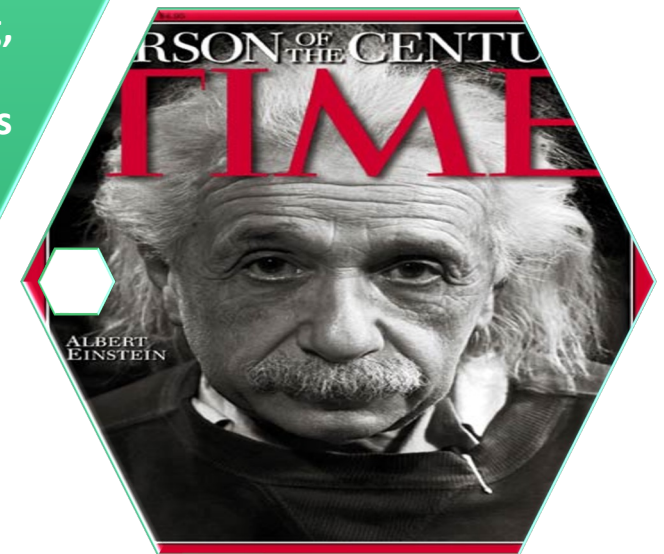




14 March 1879
Ulm (Germany)
18 April 1955
Princeton (New Jersey)

«He was the pre-eminent scientist in a century dominated by science. The touchstones of the era – the Bomb, the Big Bang, quantum physics and electronics – all bear his imprint» Dec 31, 1999

In 1921 he got the Nobel Prize in Physics «for his services to Theoretical Physics, and especially for his discovery of the law of the photoelectric effect»



1905: MIRACLE YEAR

Einstein published FOUR papers which contributed strongly to the foundation of modern physics and changed views on space, time, and matter. They were:

ABOUT PHOTOELECTRIC EFFECT

Annalen der Physik 17, 132-148

*On a Heuristic Viewpoint
Concerning the Production and
Transformation of Light*

ABOUT BROWNIAN MOTION

Annalen der Physik 17, 549–560

*On the Motion of Small Particles
Suspended in a Stationary Liquid,
as Required by the Molecular
Kinetic Theory of Heat*

ABOUT SPECIAL RELATIVITY

Annalen der Physik 17, 891–921

*On the Electrodynamics of
Moving Bodies*

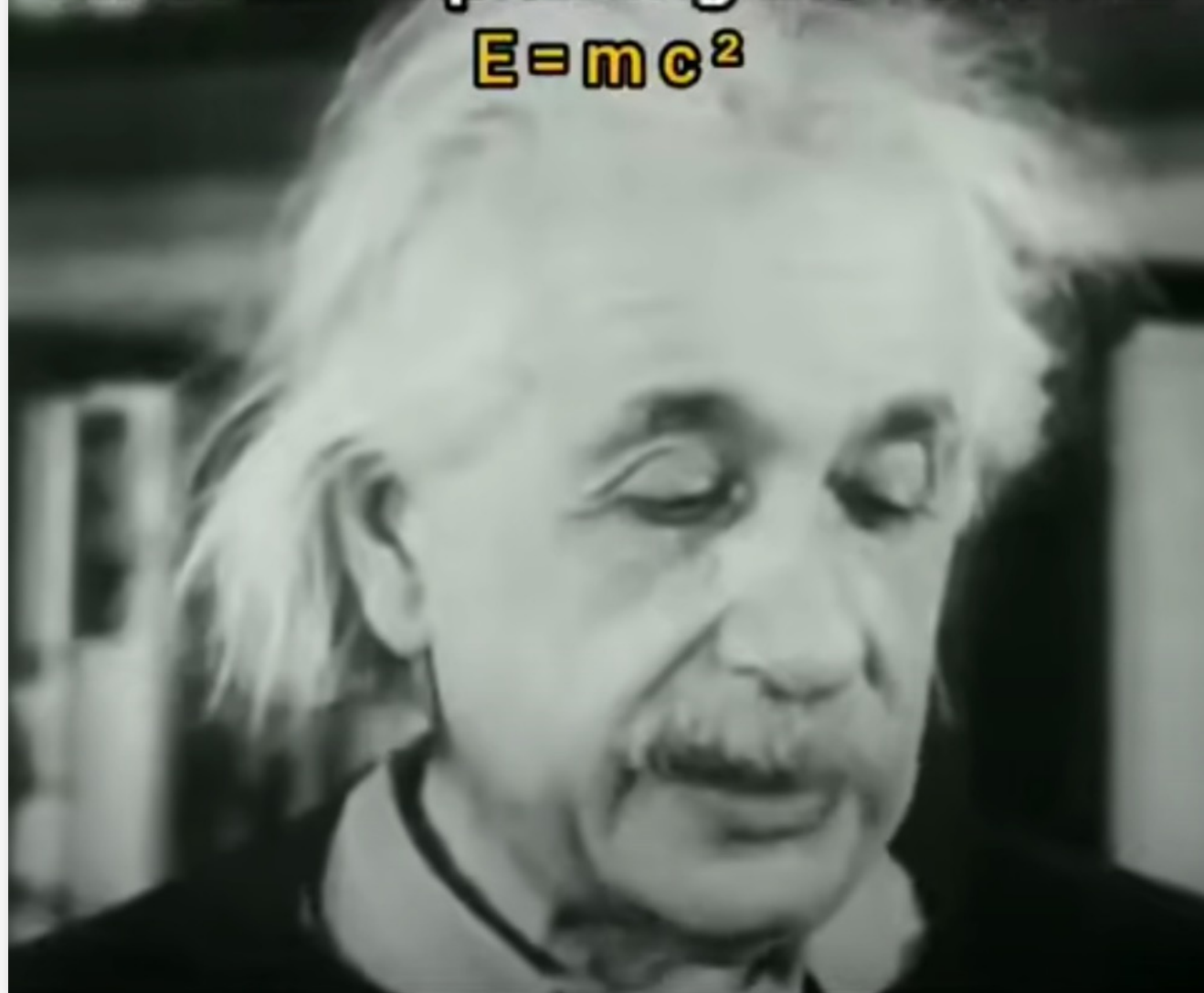
ABOUT MASS-ENERGY EQUIVALENCE

Annalen der Physik 18, 639–641

*Does the Inertia of a Body
Depend Upon Its Energy Content?*

Einstein Explaining his formula

$$E = mc^2$$



It followed from the special theory of relativity that mass and energy are both but different manifestations of the same thing, a somewhat unfamiliar conception for the average mind.

Furthermore the equation “E” is equal to “MC squared” in which energy is put equal to mass multiplied with the square of the velocity of light showed that a very small amount of mass may be converted into a very large amount of energy, and viceversa.

The mass and energy were in fact equivalent according to the formula mentioned before.

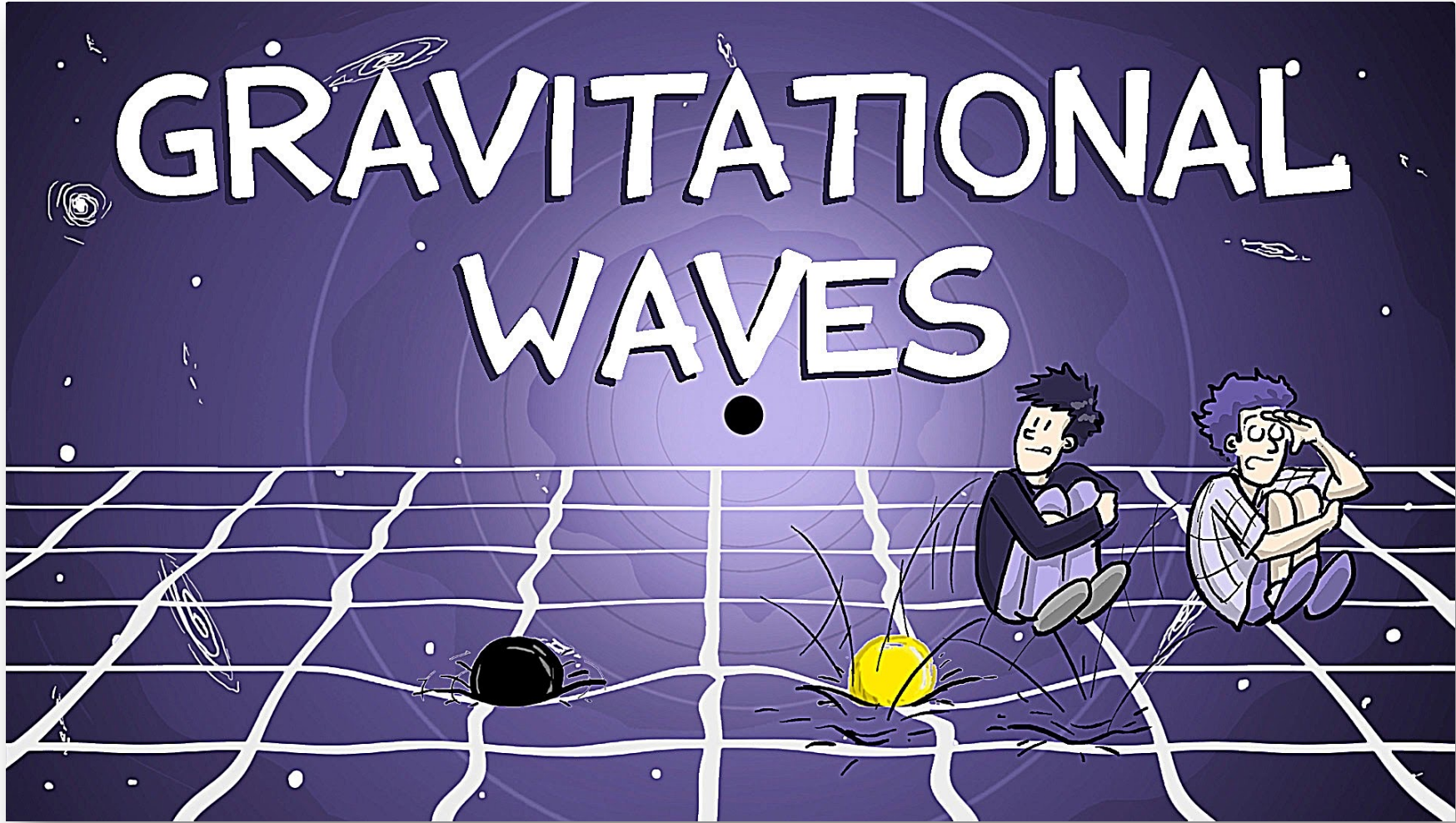
This was demonstrated by Cockroft and Walton in 1932 experimentally.

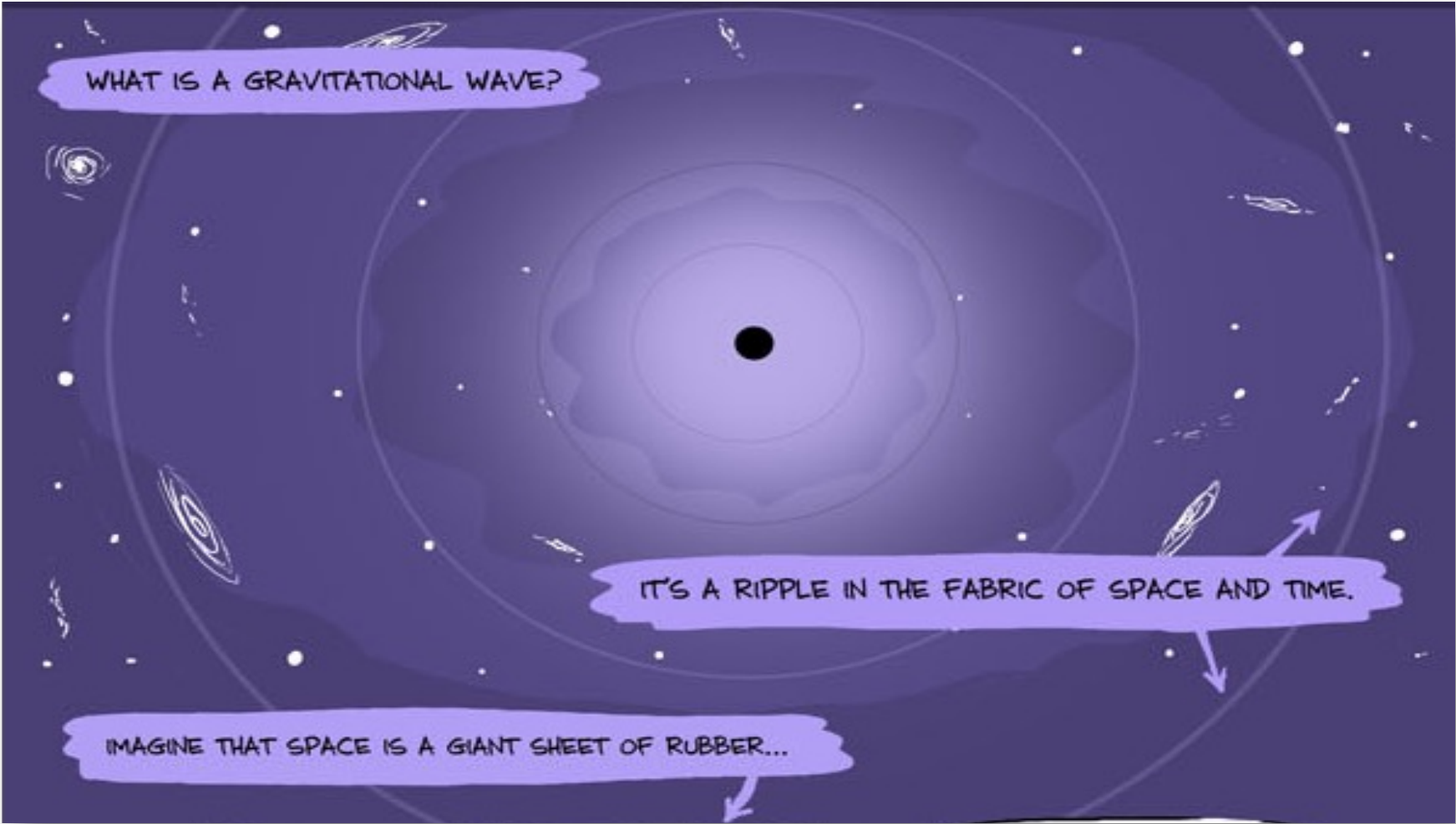




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GRAVITATIONAL WAVES

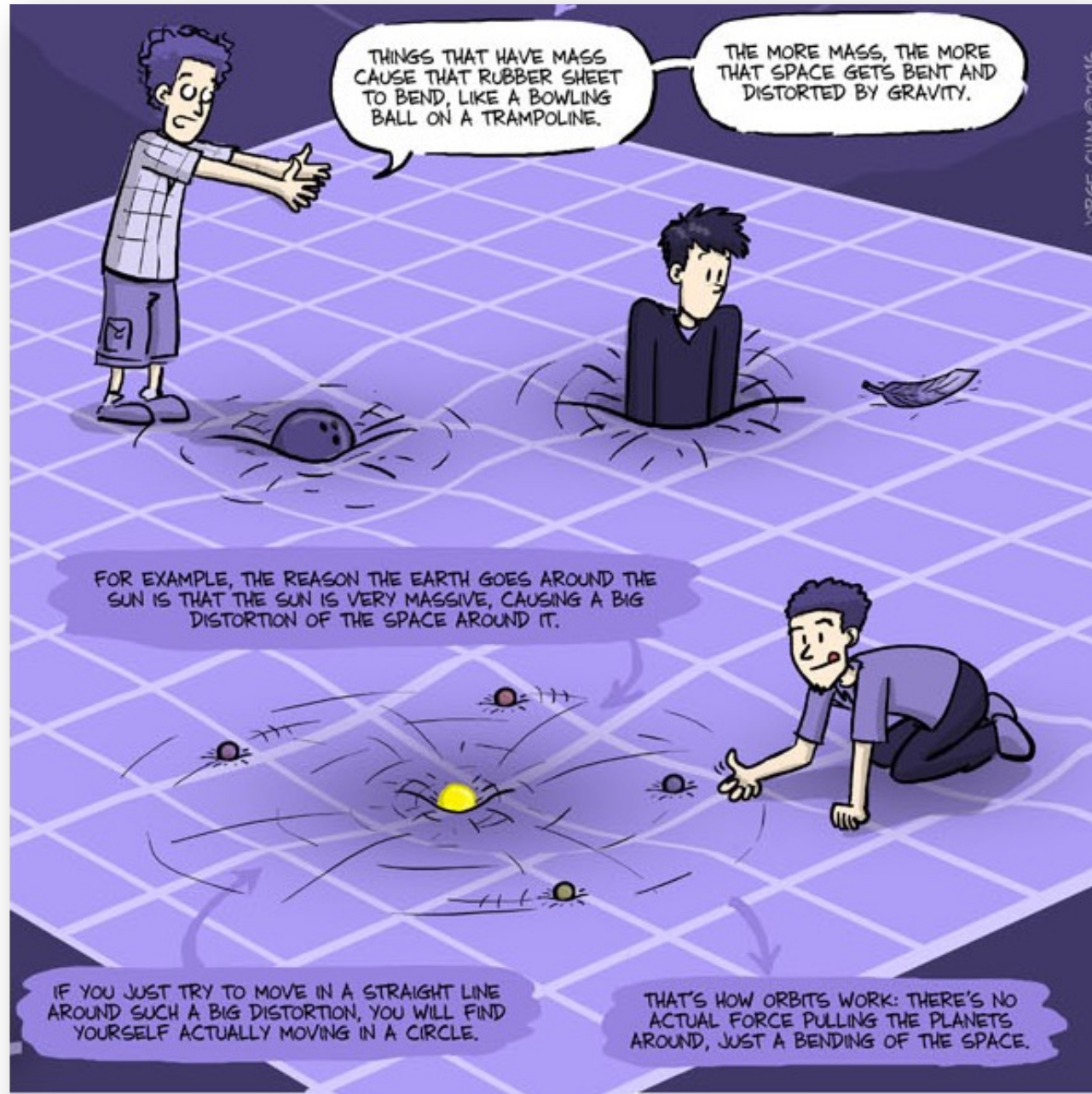




WHAT IS A GRAVITATIONAL WAVE?

IT'S A RIPPLE IN THE FABRIC OF SPACE AND TIME.

IMAGINE THAT SPACE IS A GIANT SHEET OF RUBBER...



THINGS THAT HAVE MASS CAUSE THAT RUBBER SHEET TO BEND, LIKE A BOWLING BALL ON A TRAMPOLINE.

THE MORE MASS, THE MORE THAT SPACE GETS BENT AND DISTORTED BY GRAVITY.

FOR EXAMPLE, THE REASON THE EARTH GOES AROUND THE SUN IS THAT THE SUN IS VERY MASSIVE, CAUSING A BIG DISTORTION OF THE SPACE AROUND IT.

IF YOU JUST TRY TO MOVE IN A STRAIGHT LINE AROUND SUCH A BIG DISTORTION, YOU WILL FIND YOURSELF ACTUALLY MOVING IN A CIRCLE.

THAT'S HOW ORBITS WORK: THERE'S NO ACTUAL FORCE PULLING THE PLANETS AROUND, JUST A BENDING OF THE SPACE.

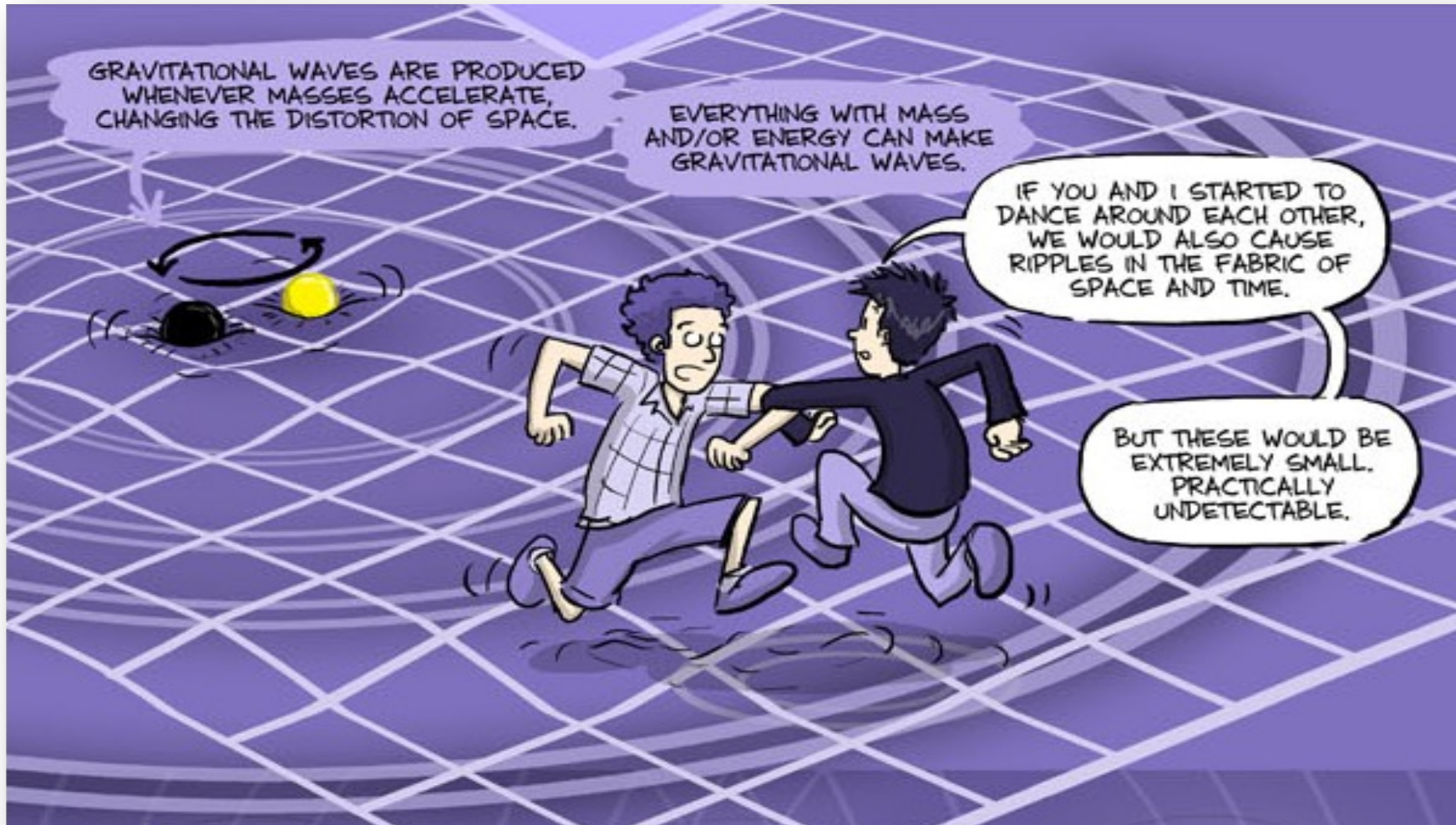
JORGE CHAM © 2016

GRAVITATIONAL WAVES ARE PRODUCED WHENEVER MASSES ACCELERATE, CHANGING THE DISTORTION OF SPACE.

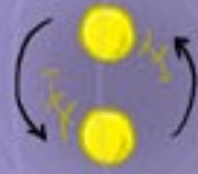
EVERYTHING WITH MASS AND/OR ENERGY CAN MAKE GRAVITATIONAL WAVES.

IF YOU AND I STARTED TO DANCE AROUND EACH OTHER, WE WOULD ALSO CAUSE RIPPLES IN THE FABRIC OF SPACE AND TIME.

BUT THESE WOULD BE EXTREMELY SMALL, PRACTICALLY UNDETECTABLE.



NOW GRAVITY IS VERY WEAK IN THE SCALE OF OTHER FORCES IN THE UNIVERSE...



PAIR OF NEUTRON STARS



PAIR OF BLACK HOLES

A NEUTRON STAR AND A BLACK HOLE



SO YOU NEED SOMETHING REALLY, REALLY MASSIVE MOVING VERY, VERY FAST, TO MAKE THE BIG RIPPLES THAT WE CAN DETECT.

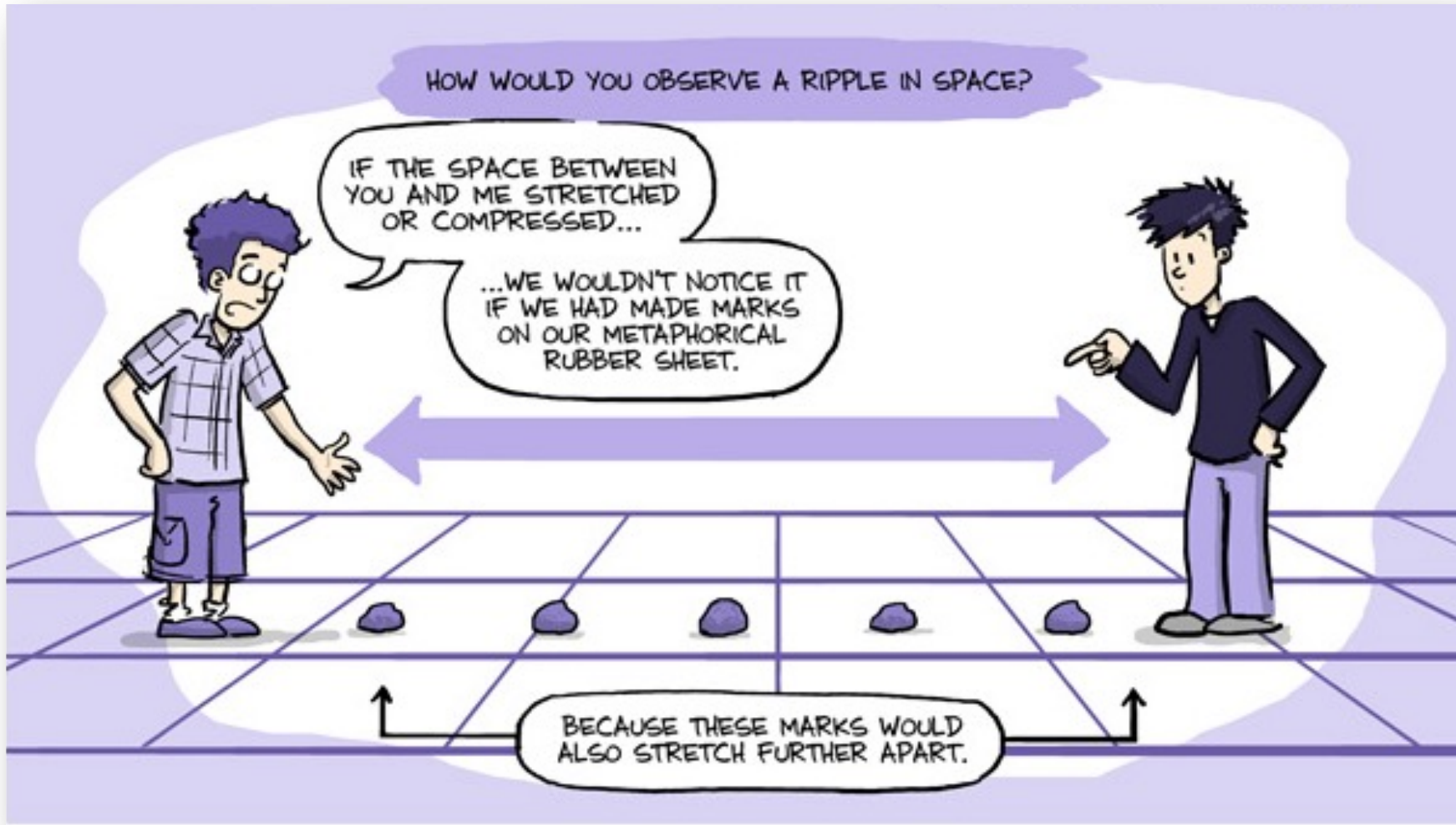


HOW WOULD YOU OBSERVE A RIPPLE IN SPACE?

IF THE SPACE BETWEEN YOU AND ME STRETCHED OR COMPRESSED...

...WE WOULDN'T NOTICE IT IF WE HAD MADE MARKS ON OUR METAPHORICAL RUBBER SHEET.

BECAUSE THESE MARKS WOULD ALSO STRETCH FURTHER APART.



BUT THERE'S ONE RULER THAT DOESN'T GET STRETCHED, ONE MADE USING THE SPEED OF LIGHT:

IF THE SPACE BETWEEN TWO POINTS GETS STRETCHED...

...THEN LIGHT WILL TAKE LONGER TO GO FROM ONE POINT TO THE OTHER.

AND IF THE SPACE GETS SQUEEZED...

...LIGHT TAKES LESS TIME TO CROSS THE TWO POINTS.

THIS IS WHERE THE LIGO (LASER INTERFEROMETER GRAVITATIONAL-WAVE OBSERVATORY) COMES IN.



IT HAS 4 KILOMETER LONG TUNNELS AND USES A LASER TO MEASURE THE CHANGES IN THE DISTANCE BETWEEN THE ENDS OF THE TUNNELS.

WHEN A GRAVITATIONAL WAVE COMES THROUGH, IT STRETCHES SPACE IN ONE DIRECTION, AND SQUEEZES SPACE IN THE OTHER DIRECTION.



4 km

BY MEASURING THE INTERFERENCE OF THE LASERS AS THEY BOUNCE BETWEEN THE DIFFERENT POINTS, PHYSICISTS CAN MEASURE VERY PRECISELY WHETHER THE SPACE IN BETWEEN HAS STRETCHED OR COMPRESSED.



AND THE PRECISION
NEEDED IS INCREDIBLE.



TO DETECT A GRAVITATIONAL
WAVE, YOU NEED TO BE ABLE
TO TELL WHEN SOMETHING
CHANGES IN LENGTH BY A FEW
PARTS IN 10^{23} .

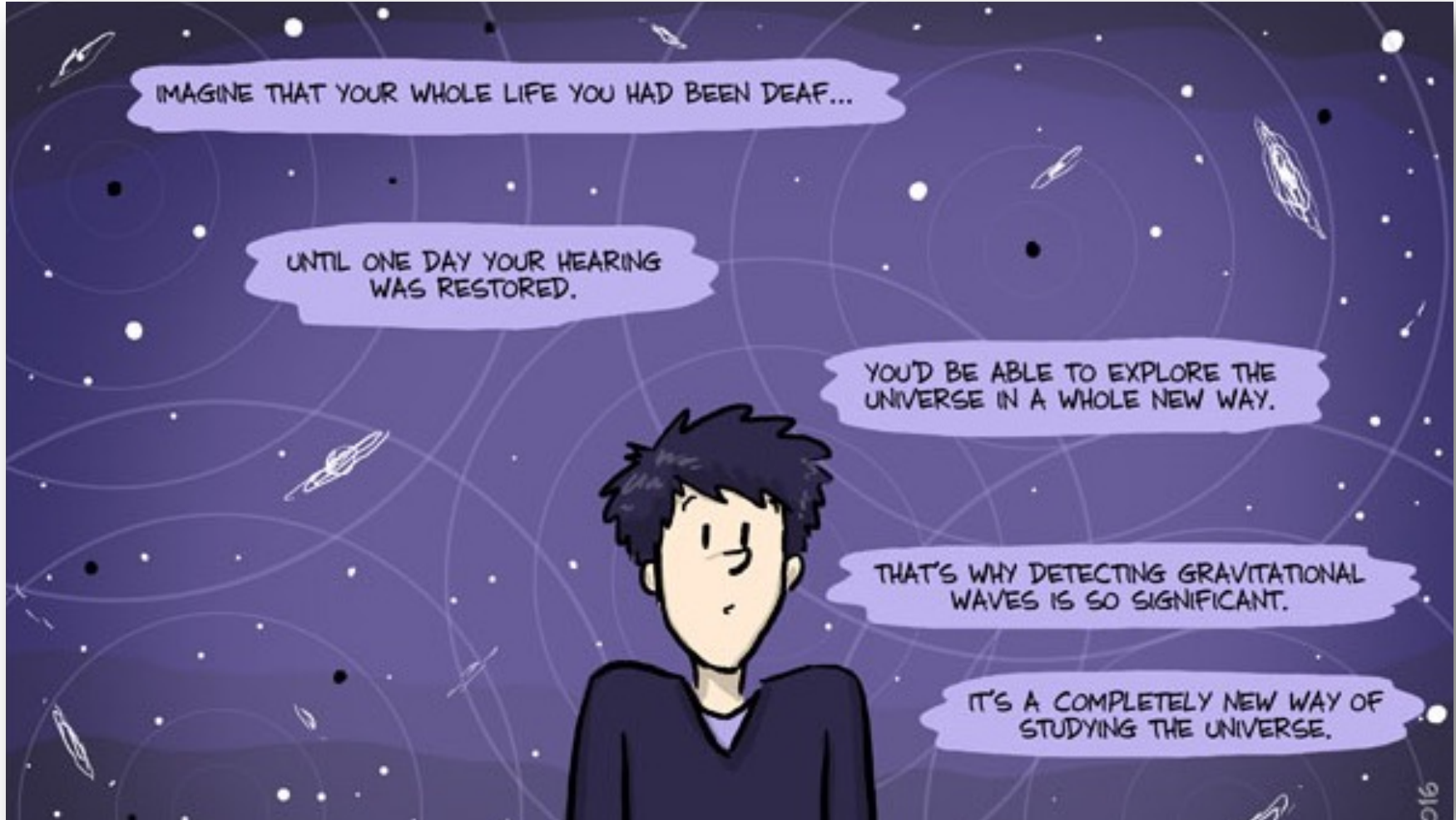


THAT'S LIKE BEING ABLE TO TELL THAT A STICK
1,000,000,000,000,000,000 METERS LONG HAS SHRUNK BY 5mm.

THE EFFECT OF A GW IS SO MINUSCULE AND EASILY CONFUSED WITH RANDOM NOISE, YOU NEED A SMART DATA ANALYSIS TECHNIQUE.

SCIENTISTS HOPE TO IDENTIFY THE PATTERNS OF GRAVITATIONAL WAVES BY COMPARING THE WIGGLES THEY MEASURE IN THE EXPERIMENT TO THE WIGGLES THEY EXPECT FROM GRAVITATIONAL WAVES.

IT'S LIKE TRYING TO IDENTIFY A SONG BEING HUMMED AT A NOISY PARTY. A VERY VERY NOISY PARTY.



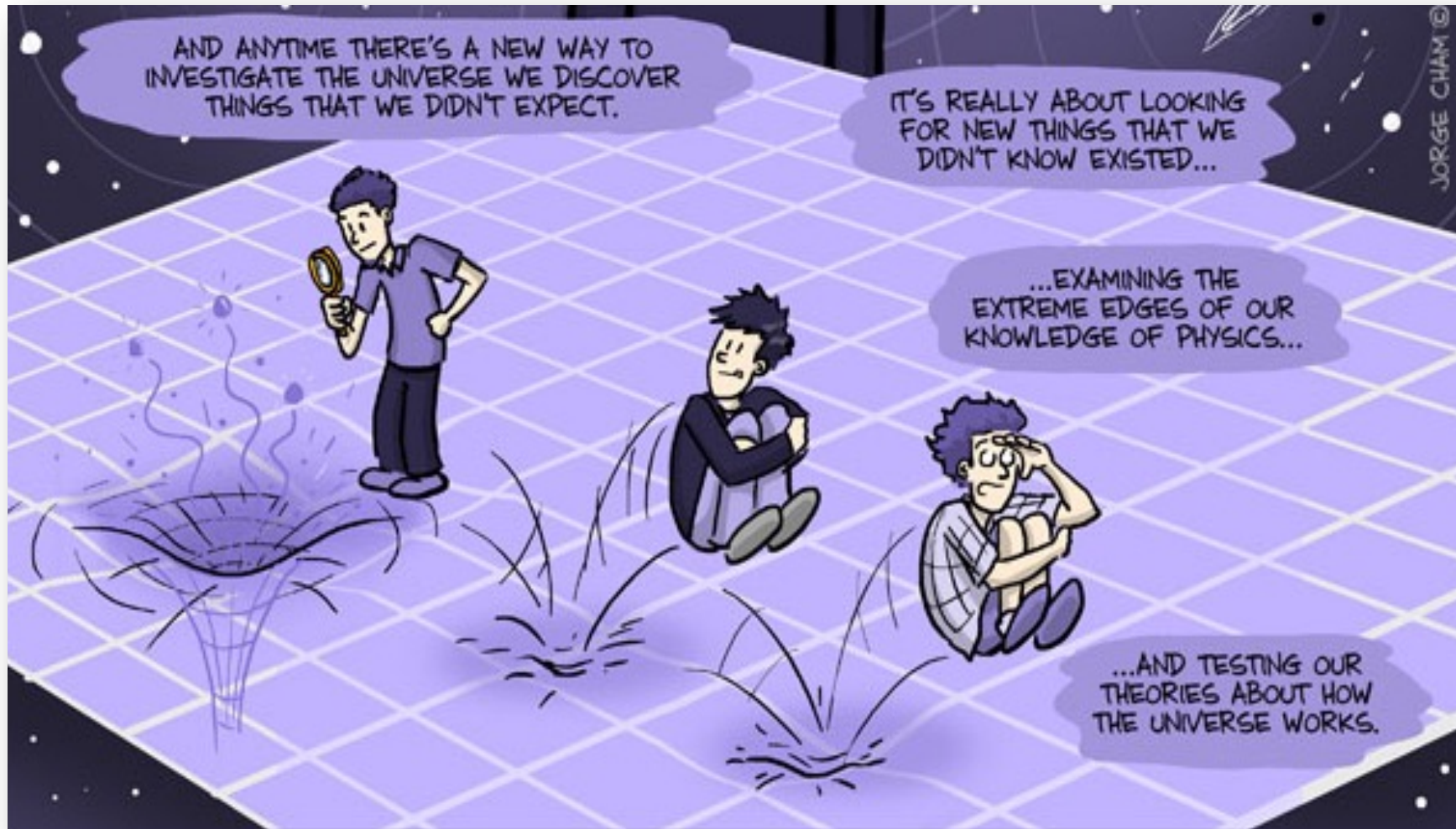
IMAGINE THAT YOUR WHOLE LIFE YOU HAD BEEN DEAF...

UNTIL ONE DAY YOUR HEARING
WAS RESTORED.

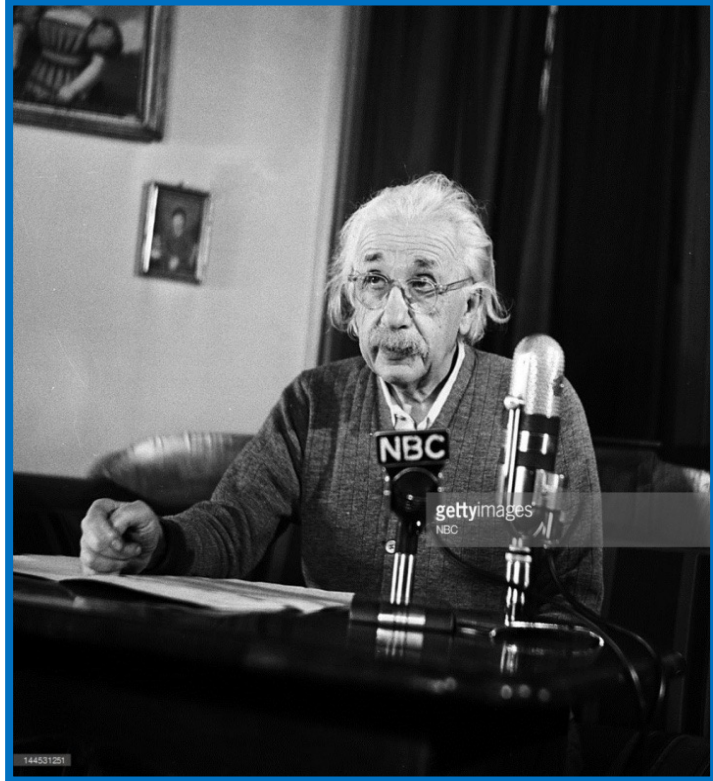
YOU'D BE ABLE TO EXPLORE THE
UNIVERSE IN A WHOLE NEW WAY.

THAT'S WHY DETECTING GRAVITATIONAL
WAVES IS SO SIGNIFICANT.

IT'S A COMPLETELY NEW WAY OF
STUDYING THE UNIVERSE.



[SOURCE](#)



Address on Peace in the Atomic Era

**Speech during the aft. program
Mrs. Roosevelt Meets the Public
on NBC television network,
Feb. 12, 1950**