



Asia's Largest

AI & Cloud

# Conference 2024

15 - 16, November 2024

Chennai Trade Center, Chennai





It's me

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IBM Certified Associate Developer -Quantum  
Computation using Qiskit v0.2 x

## About Me

15 years of experience at R&D and University level lecturing ■  
Founder / CEO - Anuthantra ✿ ■ IBM Quantum Educator ■  
IBM Qiskit Advocate Mentor ■ Senior IEEE Member ■  
Accredited AWS Educator ■ AWS Solution Architect



# From Code to Qubit: A Developer's Guide to Quantum Computing with IBM Qiskit

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**The story of Quantum Computing : an Illustrated Guide**

<https://www.thoughtworks.com/en-in/insights/blog/quantum-computing-illustrated-guide>

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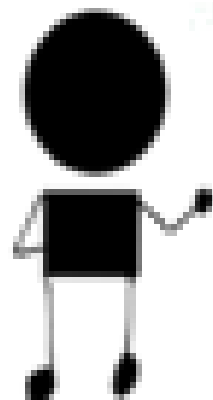


# DO WE NEED QUANTUM COMPUTERS

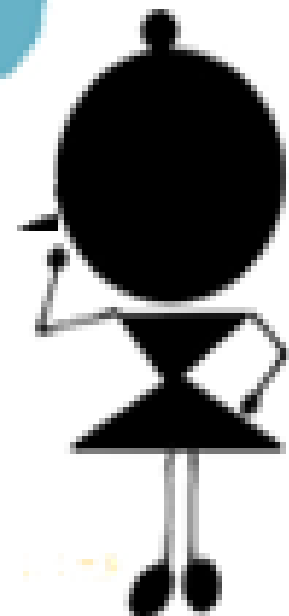
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NOT SO MUCH NEED AS IT MAY BE INEVITABLE  
ESPECIALLY IN LIGHT OF THESE QUESTIONS

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HOW LONG WILL  
MOORE'S LAW HOLD?



CAN WE SOLVE  
ALL PROBLEMS  
GIVEN ENOUGH  
COMPUTING POWER?

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ALSO, QUANTUM COMPUTERS ARE NOT INTENDED  
AS A REPLACEMENT TO THE ONES WE NOW USE

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# END OF MOORE'S LAW?

## THE "LAW"

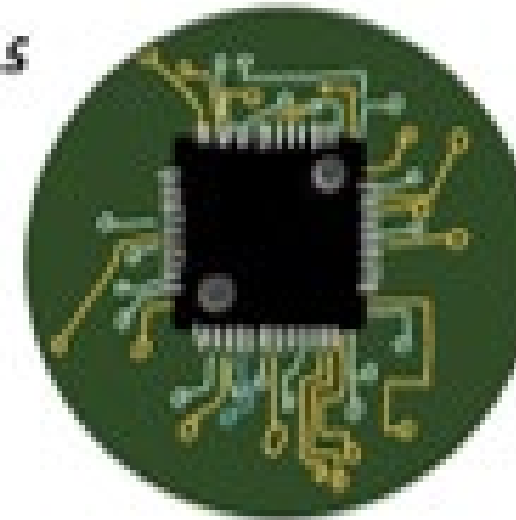


GORDON MOORE  
1965

WE CAN EXPECT THE  
SPEED OF COMPUTERS TO  
DOUBLE EVERY 2 YEARS  
OR SO

## THE PROCESSOR

PROCESSORS  
HAVE  
BECOME  
CHEAPER  
+  
SMALLER



ONE CHIP  
CONTAINS  
ABOUT A  
BILLION  
TRANSISTORS

## THE TRANSISTOR

TRANSISTOR IS THE SIMPLEST PROCESSOR



IT IS A SWITCH  
TO LET ELECTRONS  
FLOW - OR NOT

MUCH SMALLER THAN HUMAN HAIR

## THE END?

AS THE TRANSISTOR SIZE GETS SMALLER...



... QUANTUM EFFECTS\* WILL COME INTO PLAY

\*QUANTUM TUNNELING - WILL MAKE ELECTRONS "JUMP"  
AND FLOW EVEN WHEN THE SWITCH IS "OFF"

# SO, QUANTUM...



QUANTUS IS  
LATIN FOR  
'HOW GREAT'

QUANTUM IS  
THE SMALLEST  
'PIECE' OF ENERGY

QUANTUM MECHANICS  
DESCRIBES NATURE  
AT THE  
TINIEST OF SCALES

THE NOTION OF QUANTUM CAME AT A TIME WHEN  
THE PHENOMENA IN THE MACRO/CLASSICAL WORLD HAD  
BEEN WELL EXPLAINED BY MATHEMATICAL FORMULAE

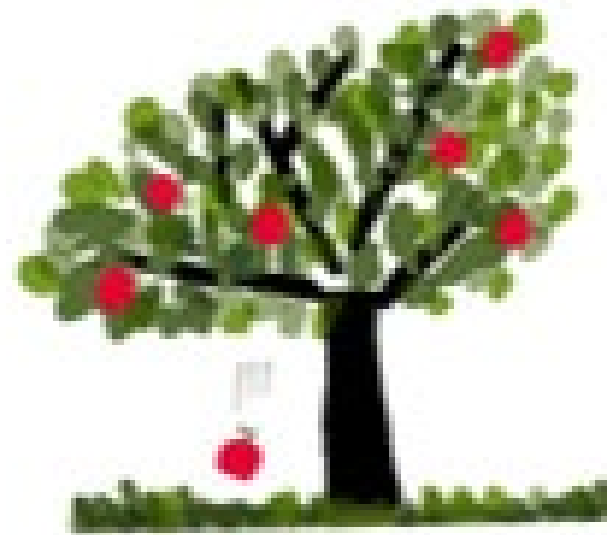


# THE CLASSICAL WORLD VIEW

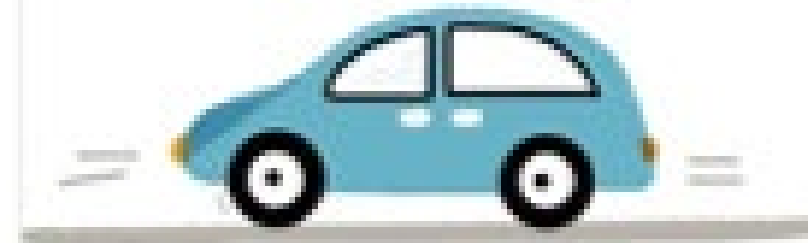


NEWTON  
LAID OUT A  
DETERMINISTIC  
PICTURE OF  
OUR WORLD

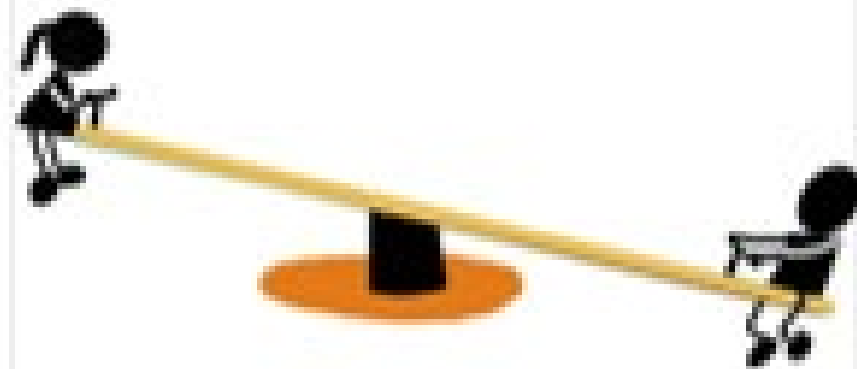
HIS MATHEMATICS  
DESCRIBED AND PREDICTED —



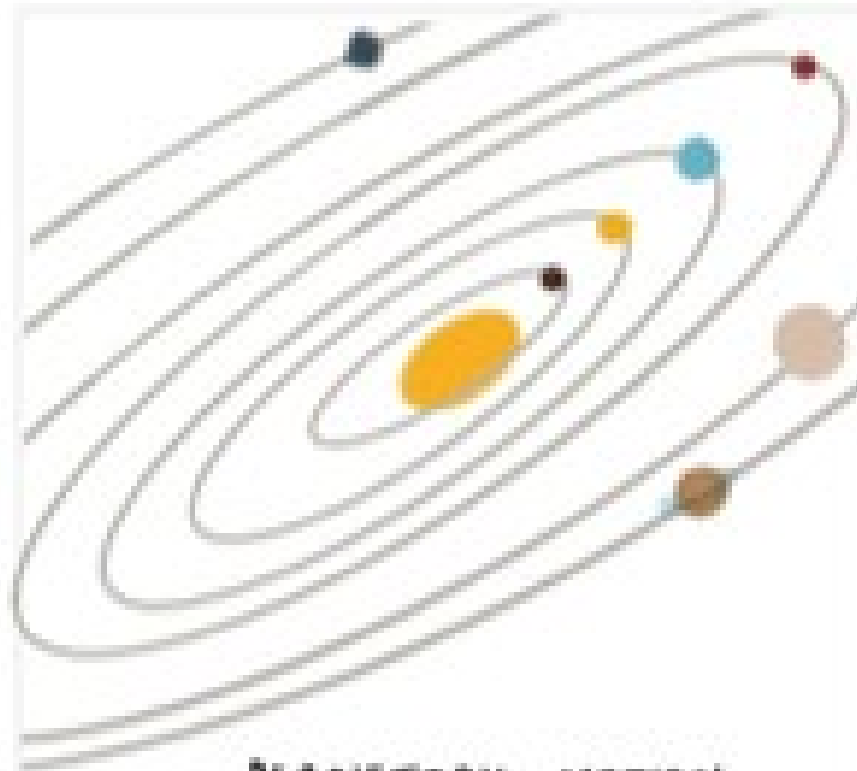
ACCELERATION  
INERTIA



VELOCITY  
MOMENTUM



ACTION  
REACTION



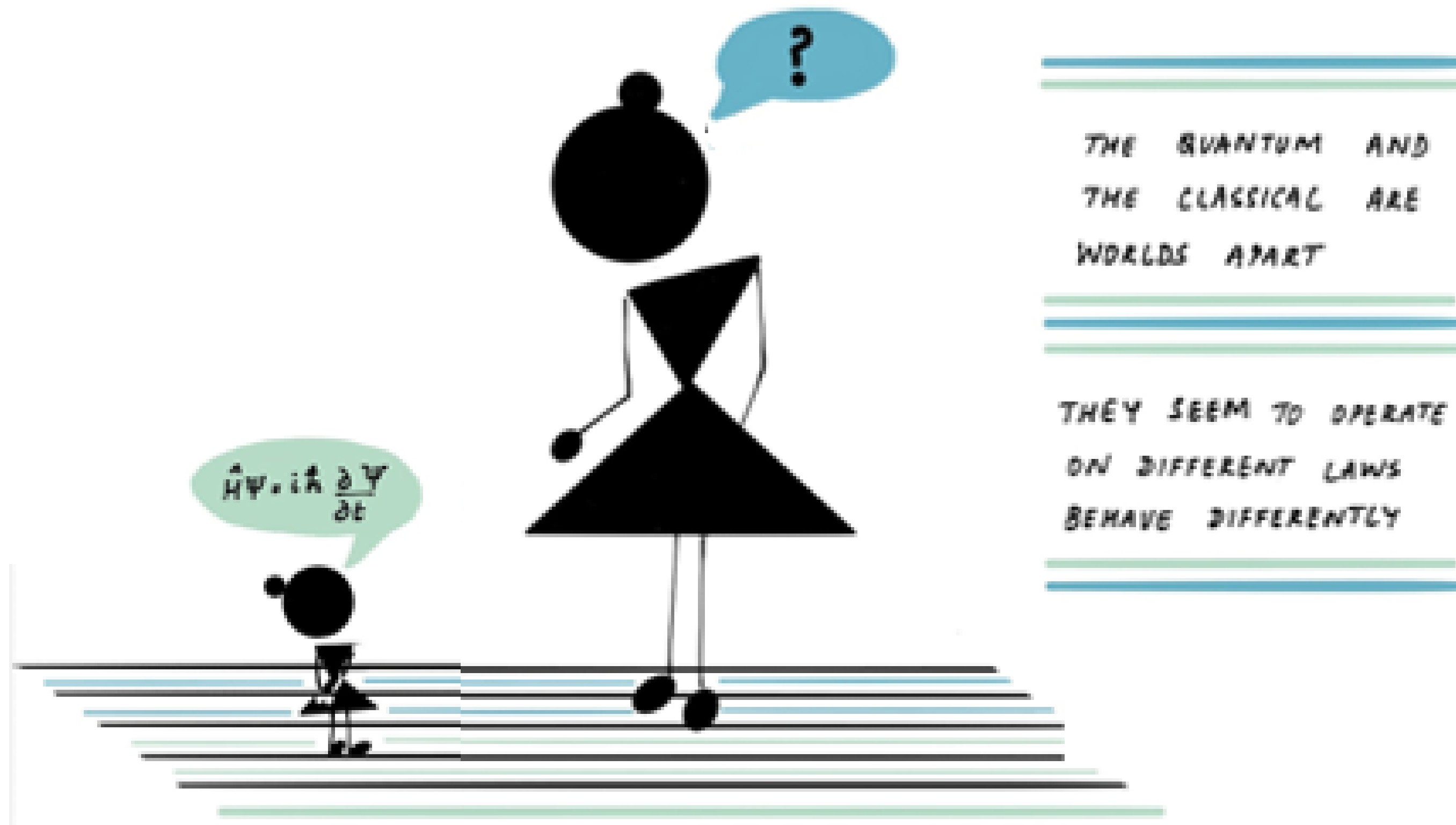
PLANETARY MOTION

THIS PREDICTABLE  
CLOCKWORK VIEW  
OF THE UNIVERSE  
WAS SOON ABOUT  
TO CHANGE





# QUANTUM VS CLASSICAL

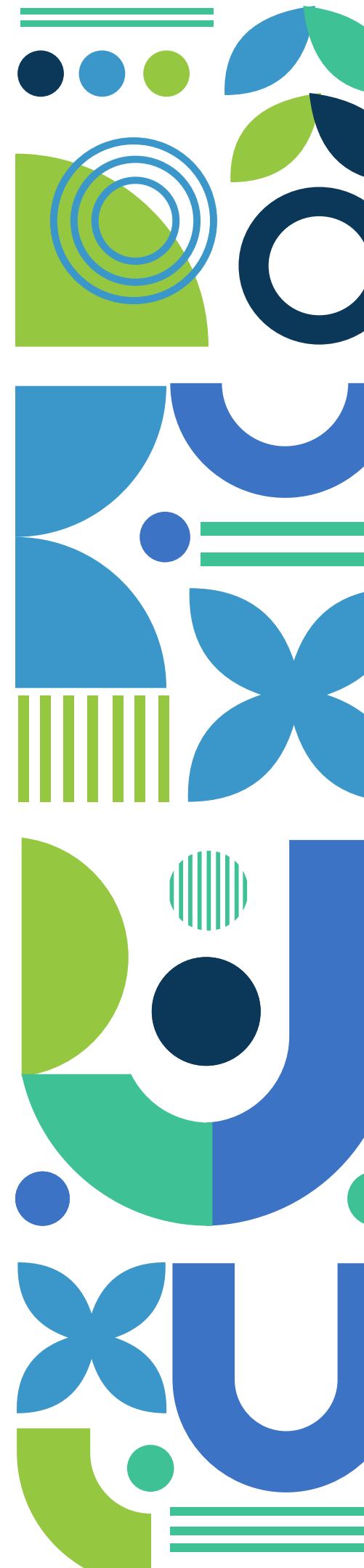


THE QUANTUM AND  
THE CLASSICAL ARE  
WORLDS APART

THEY SEEM TO OPERATE  
ON DIFFERENT LAWS  
BEHAVE DIFFERENTLY

HOW DO WE BEGIN TO UNDERSTAND OR COMPARE THE TWO?

A GOOD PLACE TO START IS TO LOOK AT PARTICLES & WAVES



# A SIMPLE EXPERIMENT

TO REMIND US

WHAT  
PARTICLES DO

WHAT  
WAVES DO

FILL A BUCKET WITH SAND

FIND A PLATE WITH 2 HOLES

POUR THE SAND ON THE PLATE

SEE IT MAKES 2 DISTINCT PILES



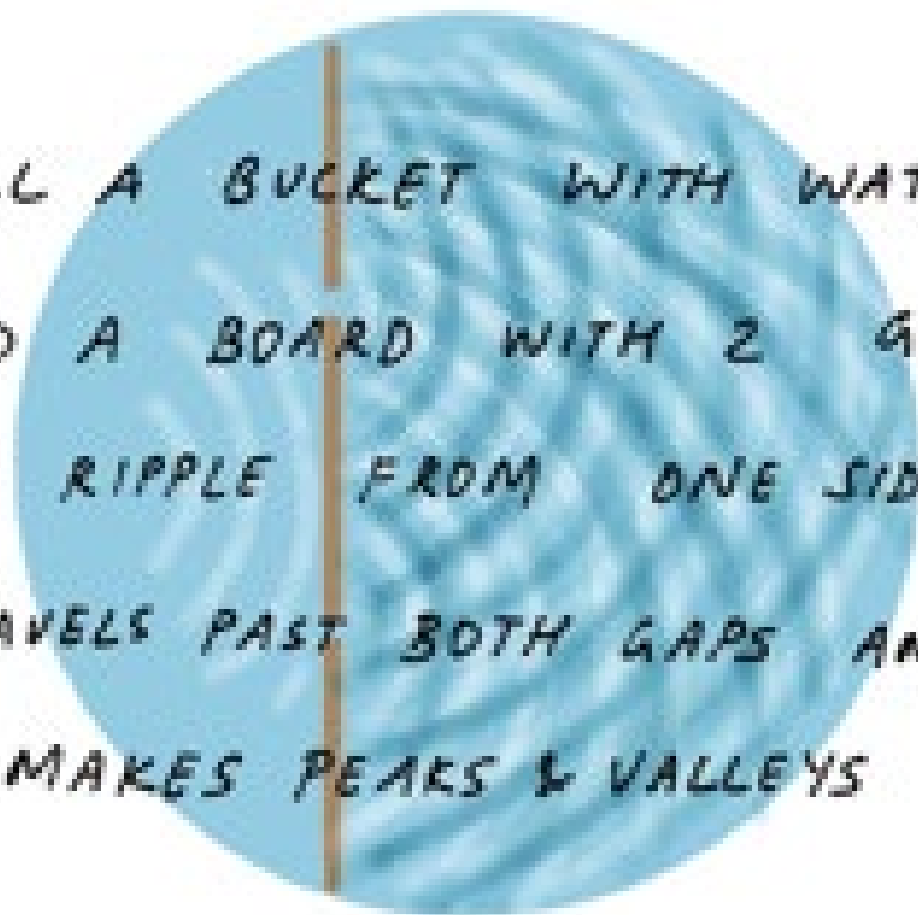
FILL A BUCKET WITH WATER

FIND A BOARD WITH 2 GAPS

A RIPPLE FROM ONE SIDE

TRAVELS PAST BOTH GAPS AND

MAKES PEAKS & VALLEYS



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WHY IS THIS RELEVANT?

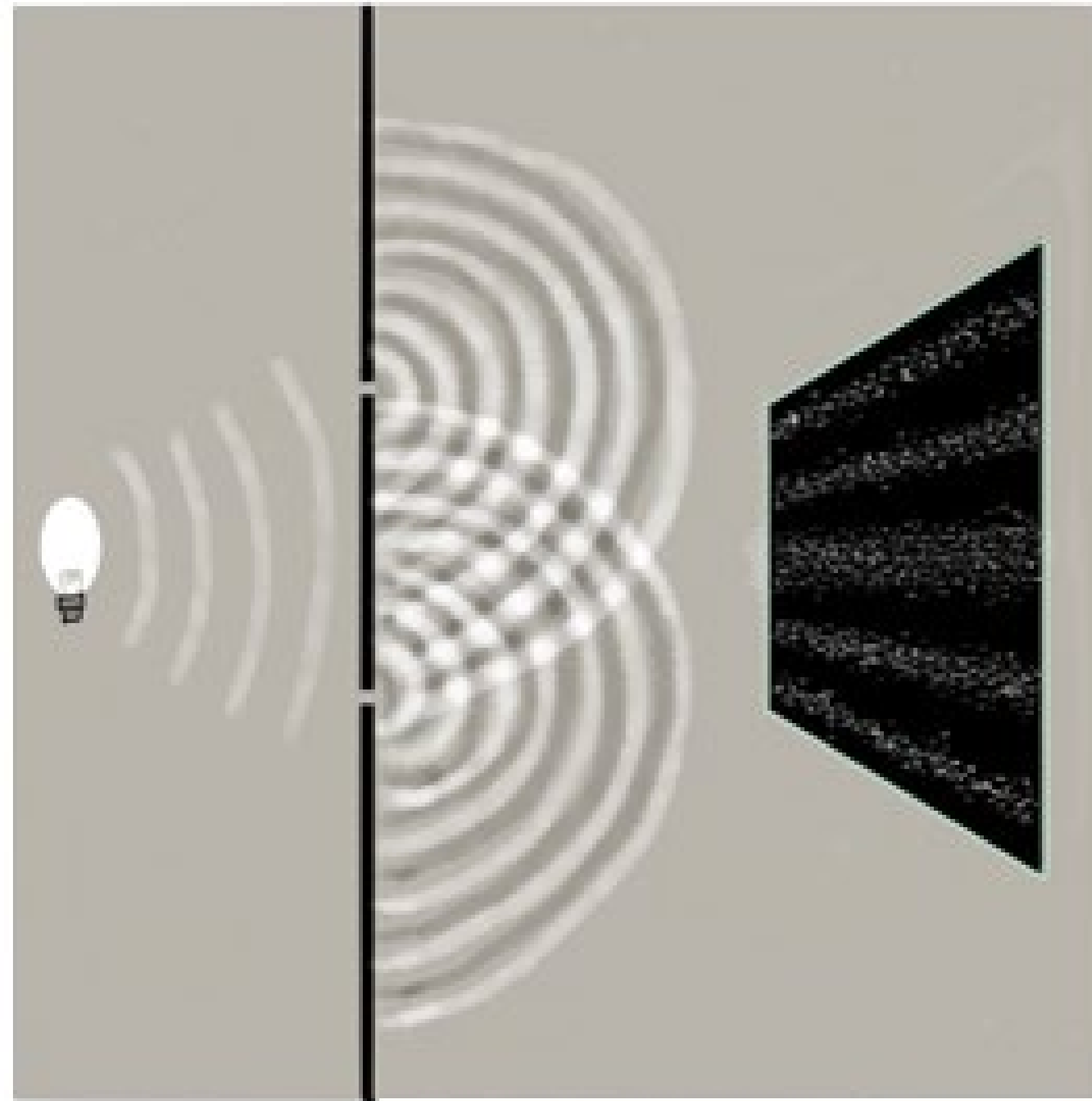
BECAUSE SIMILAR EXPERIMENTS  
IN THE QUANTUM WORLD GAVE  
VERY UNEXPECTED RESULTS.

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# BUT FIRST, THE EXPERIMENT: WITH LIGHT



EXPERIMENT BY THOMAS YOUNG 1800s

LIGHT (PHOTONS)

SHONE THROUGH

TWO NARROW SLITS

FORM ALTERNATE

DARK AND LIGHT BANDS

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AN INTERFERENCE PATTERN

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# PHOTON PEEKABOO

IT SEEMS,

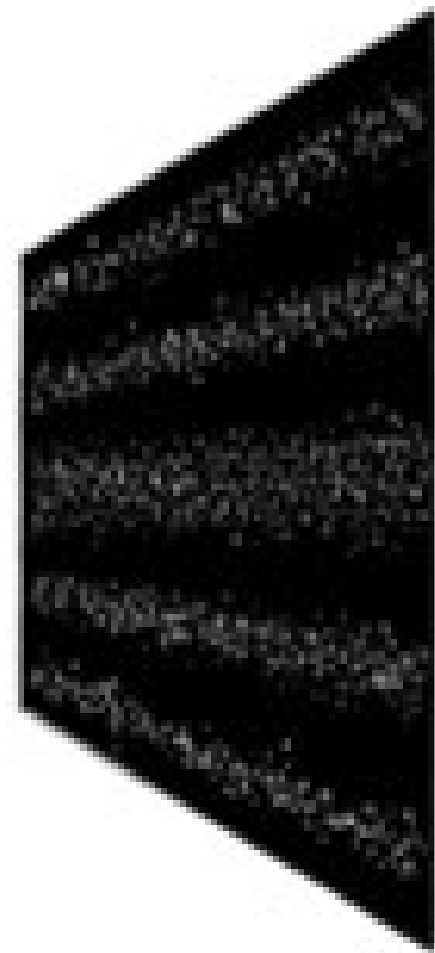
WHEN LEFT ALONE

PHOTONS PASS THROUGH

BOTH SLITS

LIKE A RIPPLE

THROUGH WATER.



ADD A DETECTOR

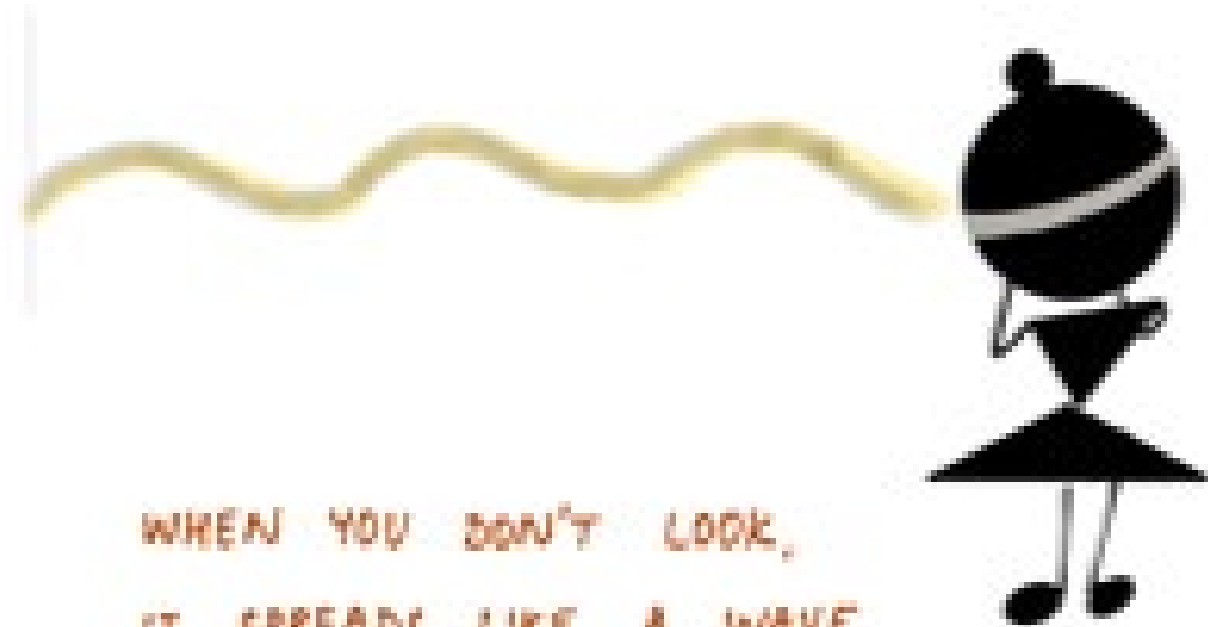
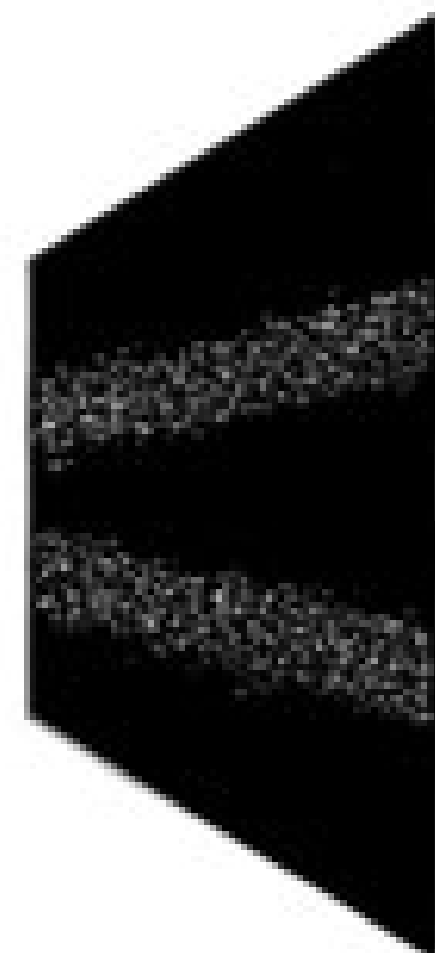
TO SEE WHICH SLIT

THE PHOTONS USED

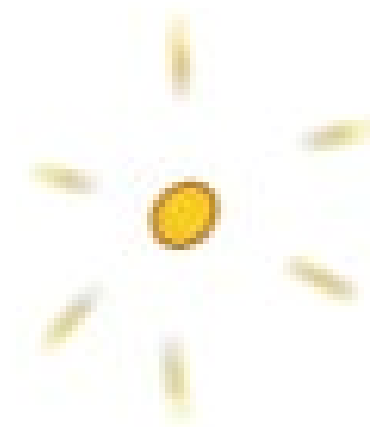
THEN,

LIKE POURING SAND

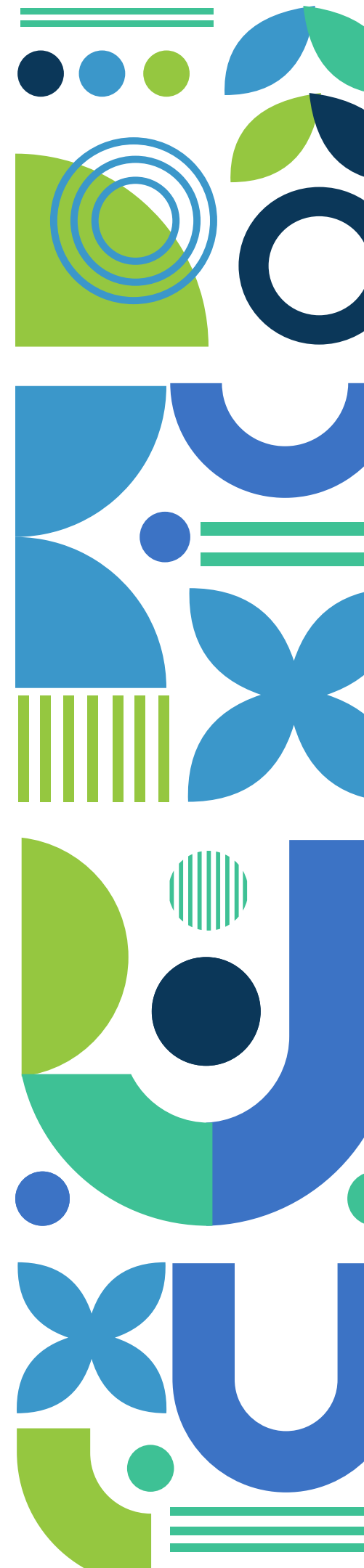
TWO BANDS FORM



WHEN YOU DON'T LOOK,  
IT SPREADS LIKE A WAVE



WHEN YOU LOOK  
IT 'COLLAPSES' TO A PARTICLE



## A vertical banner featuring a collage of colorful geometric shapes and patterns. The design includes various elements such as circles, squares, and abstract forms in shades of blue, green, and yellow. The shapes are arranged in a non-representational, abstract manner, creating a vibrant and modern visual composition.

- SUPERPOSITION
- ENTANGLEMENT

THEN POKE INTO  
THEIR NATURE MORE  
CLOSELY. WITH A  
MATHEMATICAL LENS.

# QUANTUM SUPERPOSITION



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THE QUANTUM PARTICLE  
(e.g. PHOTON, ELECTRON)  
SPREADS OUT LIKE A WAVE

---

---

IT "EXISTS" AS A  
WAVE OF PROBABILITY

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A STATE OF BEING IN  
MULTIPLE LOCATIONS AT ONCE  
EACH WITH A DIFFERENT PROBABILITY

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JUST AS WAVES IN WATER ADD UP  
TO FORM A RESULTANT WAVE...

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... QUANTUM STATES ADD UP TO FORM  
A SUPERPOSITION

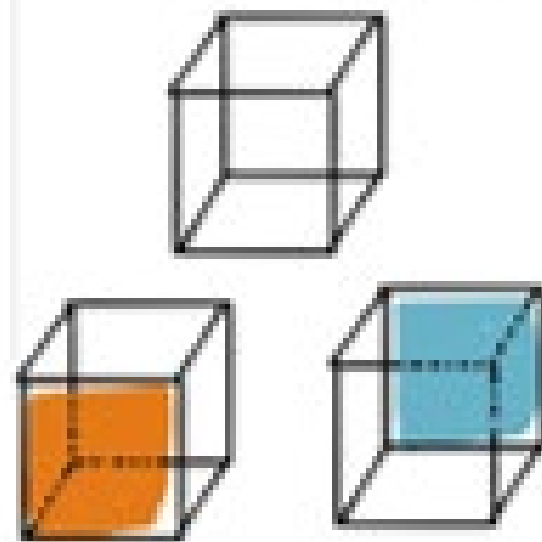
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# SUPERPOSITION: A MACRO PICTURE



HARD TO EXPRESS IN  
THE CLASSICAL WORLD

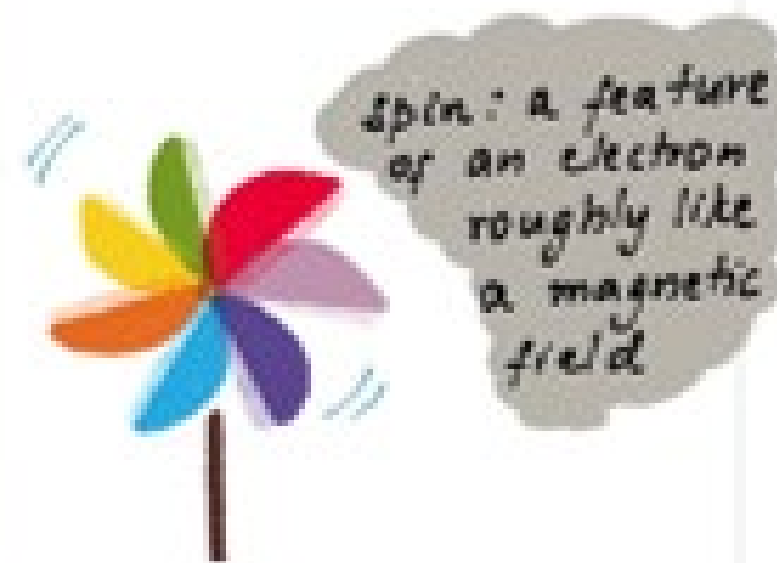


A COIN BEING FLIPPED  
IS HEADS  
IS TAILS  
A MIX OF BOTH  
WITH A 50-50 CHANCE

THE SCIENTIST'S CAT  
NEXT TO SOME POISON  
IS ALIVE  
IS DEAD

A CUBE YOU SEE  
WHAT FACE IS IN FRONT?  
THE BLUE?  
THE ORANGE?

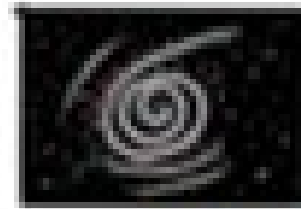
AN ELECTRON WITH SPIN  
THAT'S UP  
THAT'S DOWN  
UNTIL YOU CHECK!



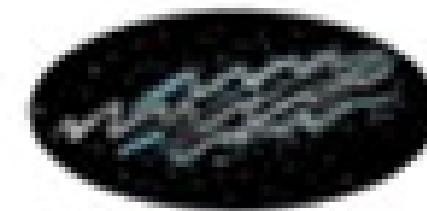
# ENTANGLEMENT: THE CORRELATION



UNDER THE RIGHT CONDITIONS  
TWO ELECTRONS  
OR PHOTONS  
CAN BE ENTANGLED



THIS MEANS:  
THE PROPERTIES OF THE TWO PARTICLES  
ARE "RELATED" EVEN IF THE  
PARTICLES ARE SEPARATED



MEASURING ONE  
INSTANTLY DECIDES THE  
STATE OF THE OTHER  
FASTER THAN THE SPEED OF LIGHT!

[ENTANGLED COINS WOULD  
BOTH MEASURE HEADS]

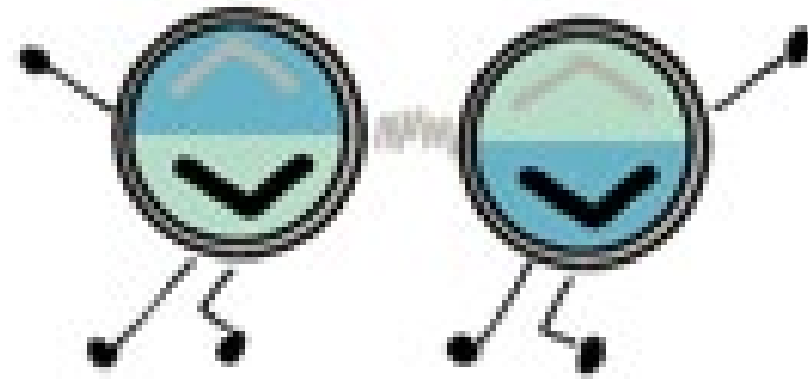




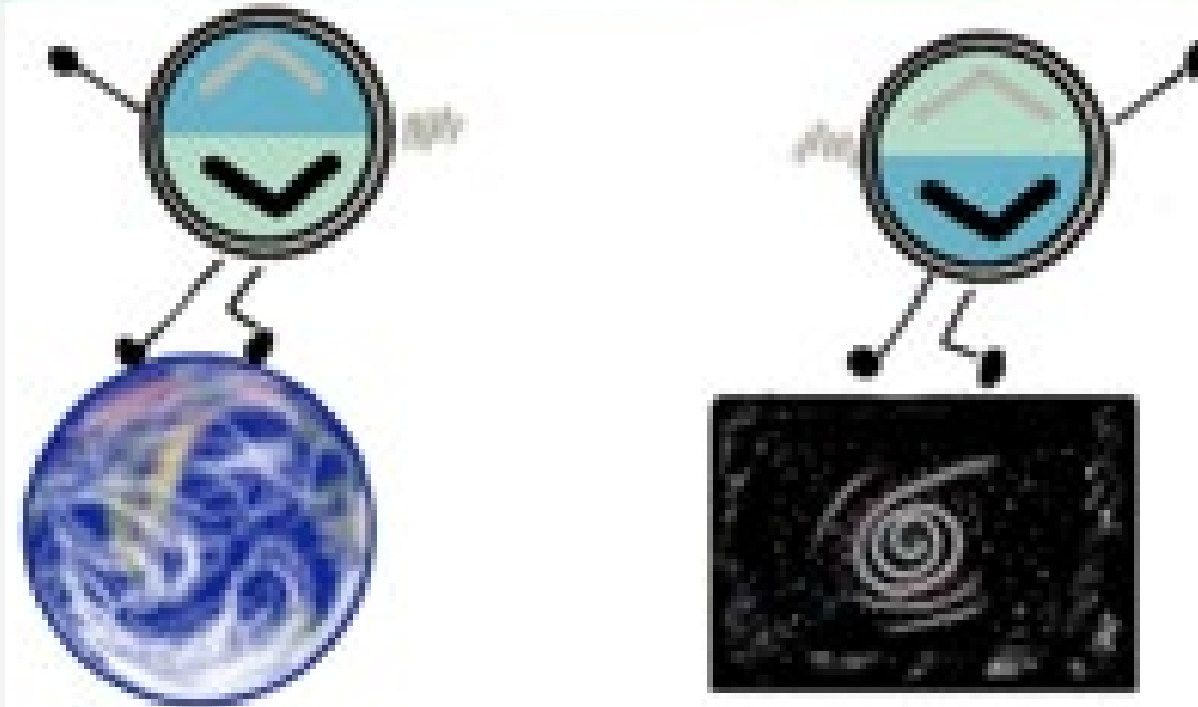
# ENTANGLED PARTICLES

INFLUENCE EACH OTHER'S STATE EVEN IF THEY ARE GALAXIES APART

ENTANGLED



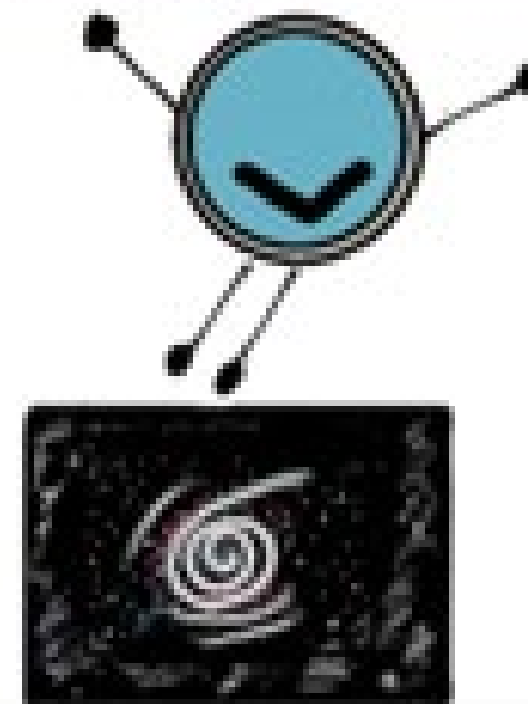
SEPARATE



MEASURE ONE

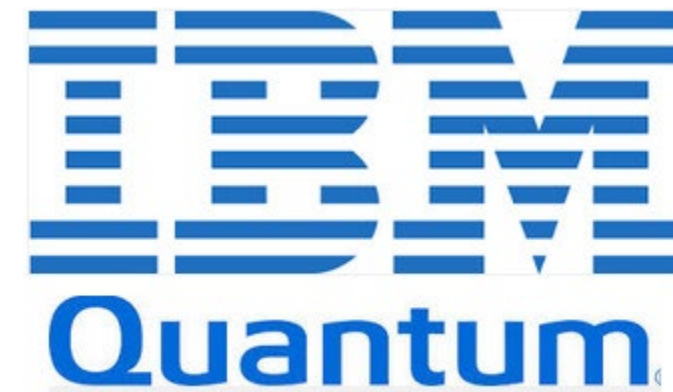


THE OTHER WILL MATCH



# IBM Qiskit Framework Demo

(Quantum Information Science Tool kit)



<https://www.ibm.com/quantum>



# THANK YOU!

**Jayakumar Vaithiyashankar**

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