

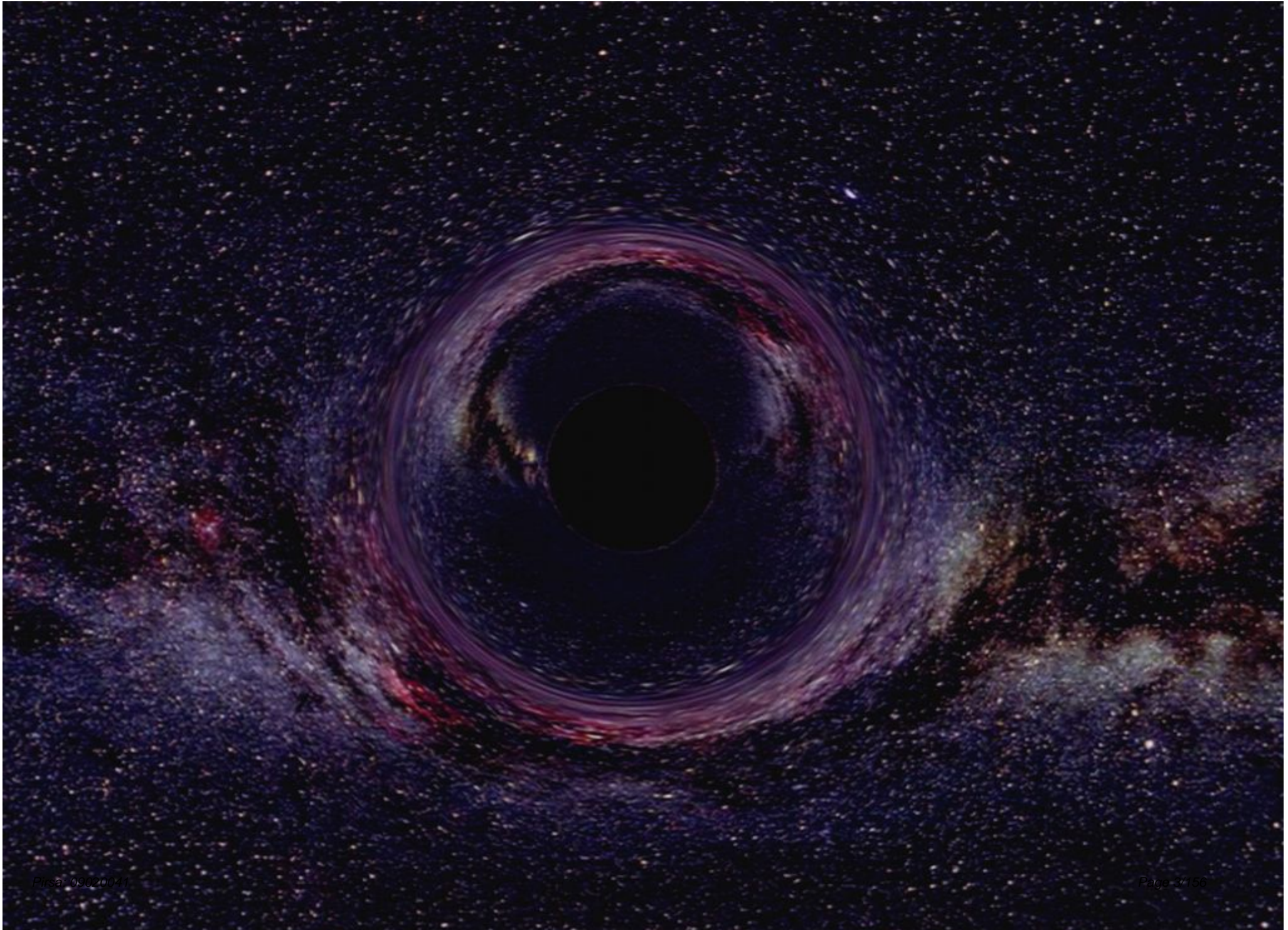
Title: Our Quirky Quantum World

Date: Feb 13, 2009 01:00 PM

URL: <http://pirsa.org/09020041>

Abstract: Our universe is unquestionably quantum in nature. What does this mean? Why does it matter? Whatâ€™s in it for me? Join us for a fun and fascinating session on â€œwhat you need to know about the quantum.â€• Find out why we canâ€™t live without it. Discover whatâ€™s so unbelievably quirky about it. And learn how it empowers amazing technologies, from present day (e.g. every electronic device on the planet) to future possibilities including quantum computing and global quantum communication. The half hour multimedia presentation will be followed by a half hour question and answer session with a leading scientist in the field. The future is quantum. Find out why.







Black Hole Science Café



Black Hole Science Café

Our Quirky Quantum World



Black Hole Science Café
Our Quirky Quantum World



Guest: Raymond Laflamme
Director, IQ

Black Hole Science Café
Our Quirky Quantum World



Guest: Raymond Laflamme
Director, IQC (UW)

Science Café

Our Quirky Quantum World



Guest: Raymond Laflamme
Director, IQC (UW)

Our Quirky Quantum World

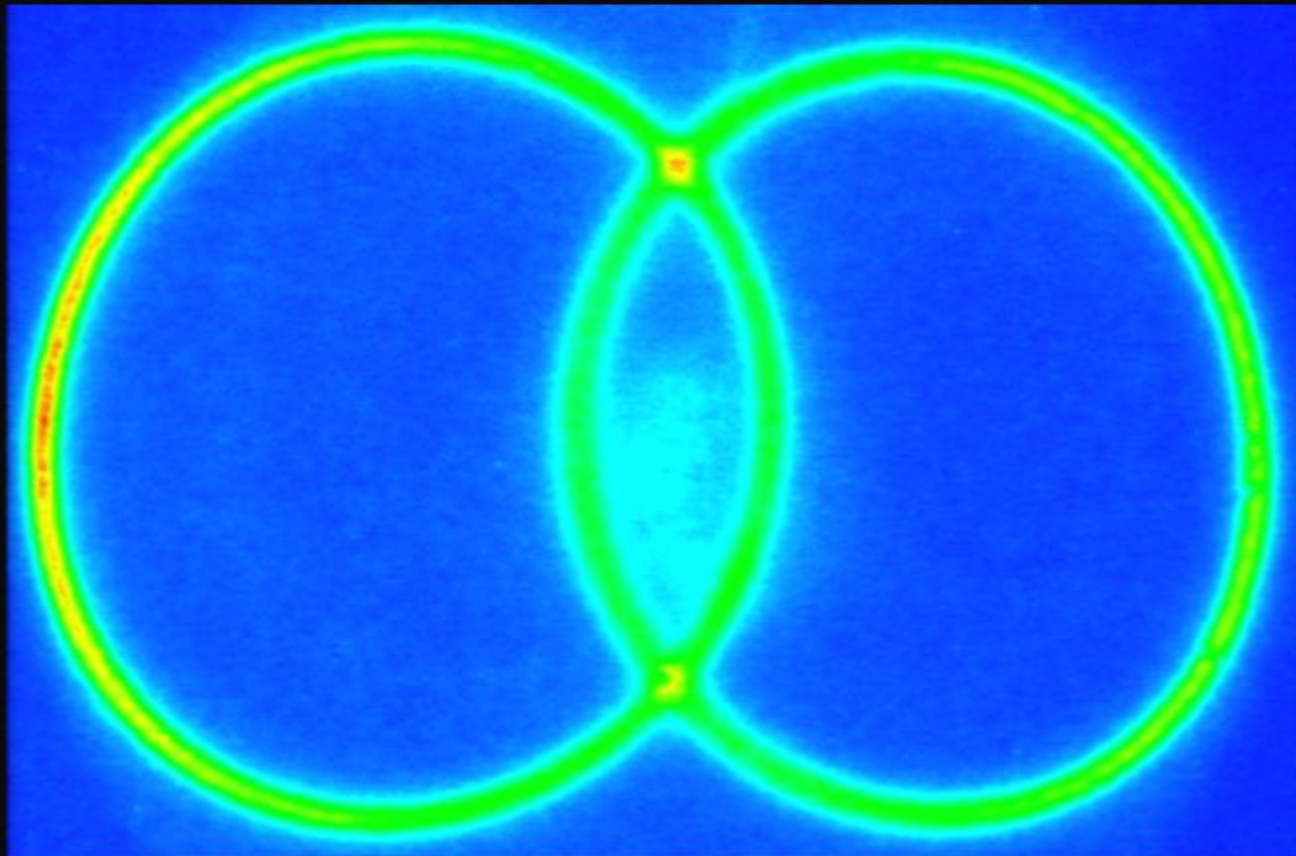
Guest: Raymond Laflamme
Director, IQC (UW)

Our Quirky Quantum World

Guest: Raymond Laflamme
Director, IQC (UW)

the world is quantum

the world is quantum

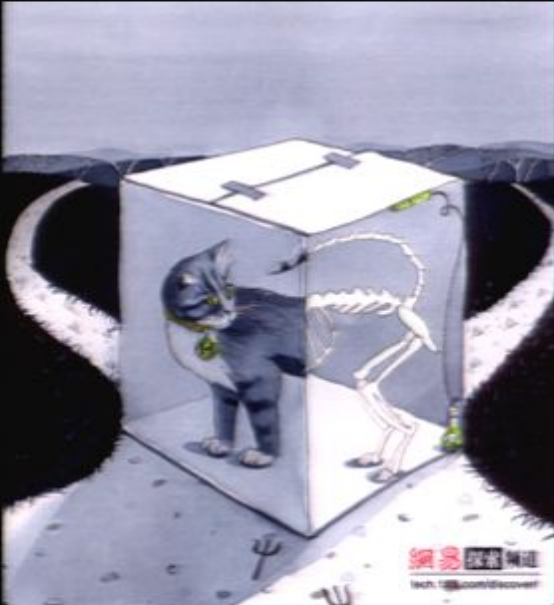


quantum is:

quantum is:
essential to our existence

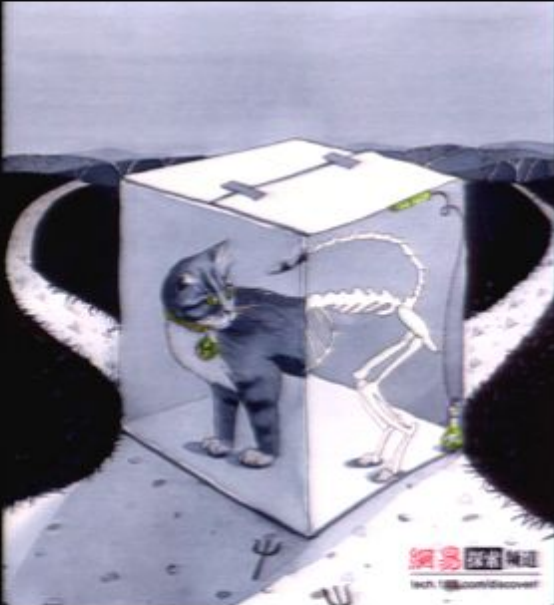


quantum is:
essential to our existence



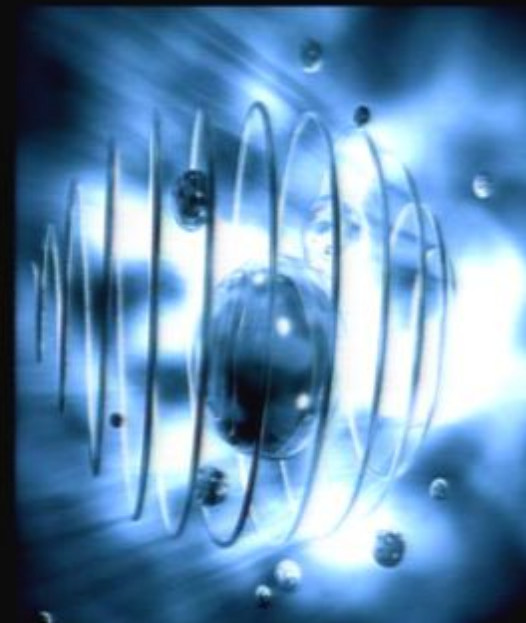
unbelievably quirky

quantum is:
essential to our existence



unbelievably quirky

empowering technology



the atom (c. 1911)



the problem:

electron can't stand still

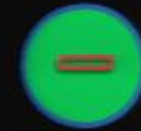


the problem:

electron can't stand still



the problem:



electron can't stand still



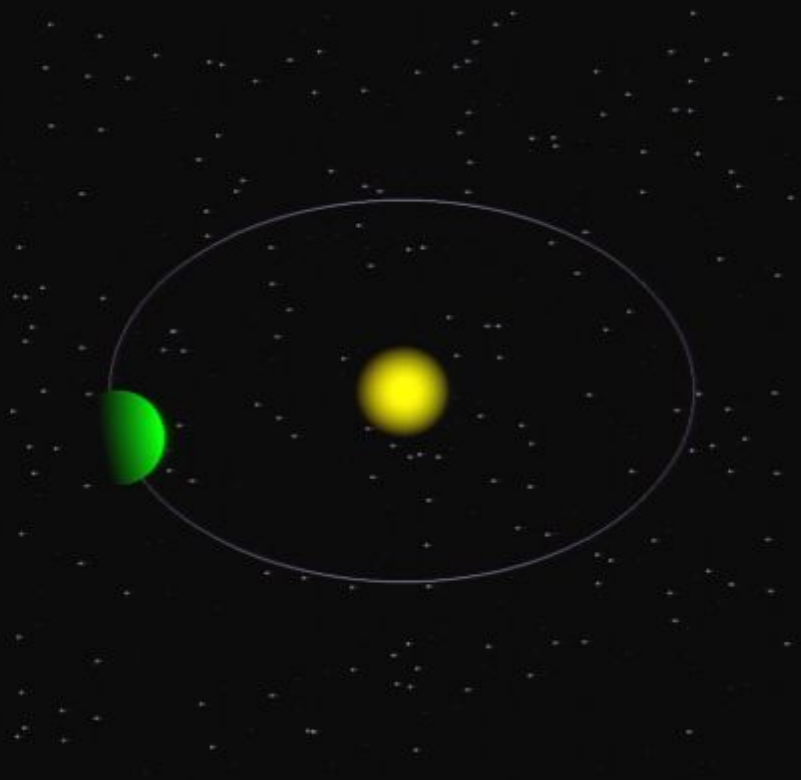
the problem:

electron can't stand still



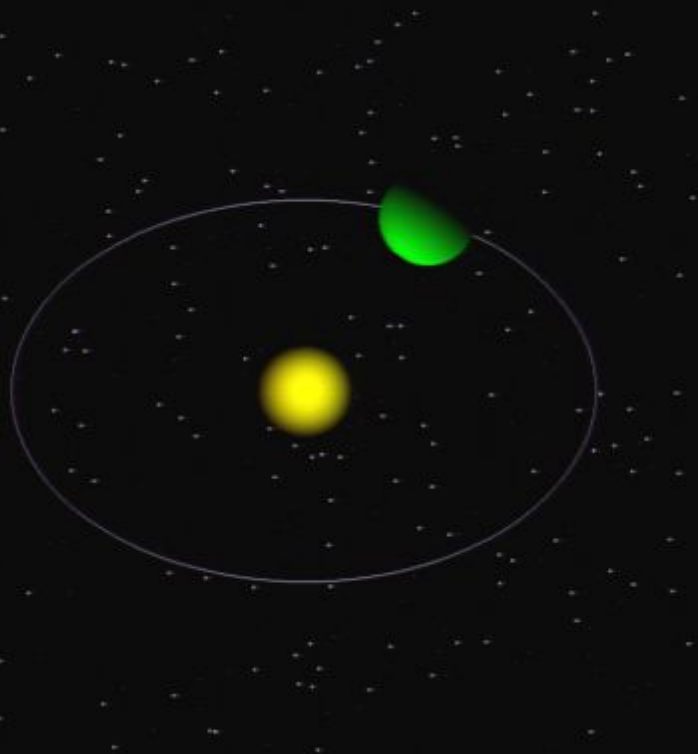
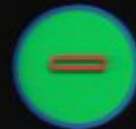
the problem:

electron can't stand still



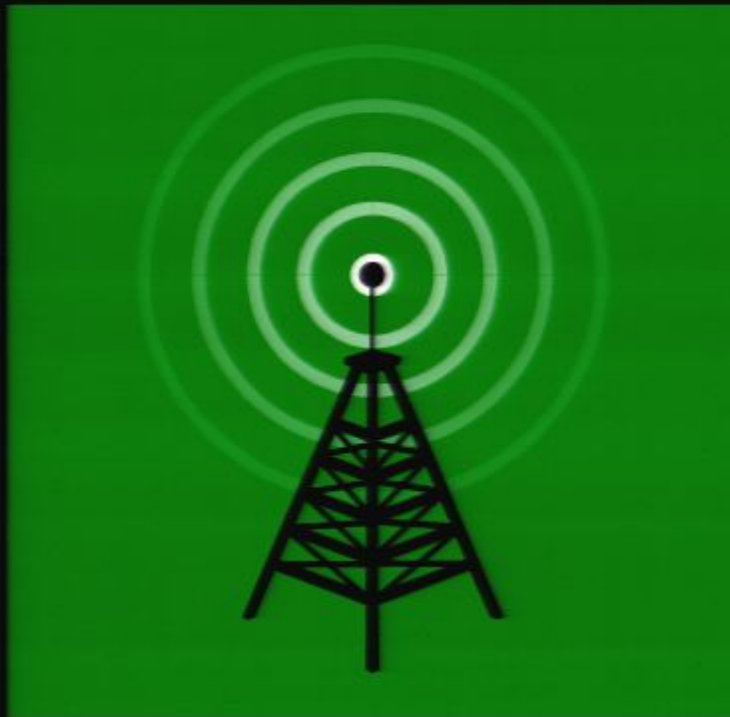
the problem:

electron can't stand still



the problem:

electron can't stand still



the problem:

electron can't stand still



the problem:

electron can't stand still



all matter in the universe should collapse
in a blinding flash of light



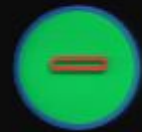
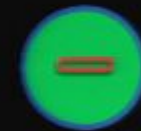
all matter in the universe should collapse
in a blinding flash of light



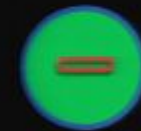
the problem:

electron can't stand still

electron can't move



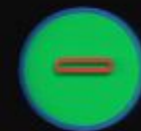
the problem:



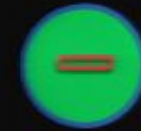
electron can't stand still



electron can't move



the problem:



electron can't stand still



electron can't move



so what's it doing?

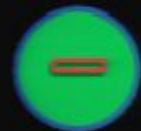
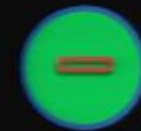
the problem:

electron can't stand still

impossible ➡

electron can't move

so what's it doing?



the problem:

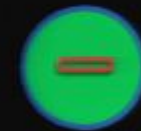
electron can't stand still

stupidly impossible

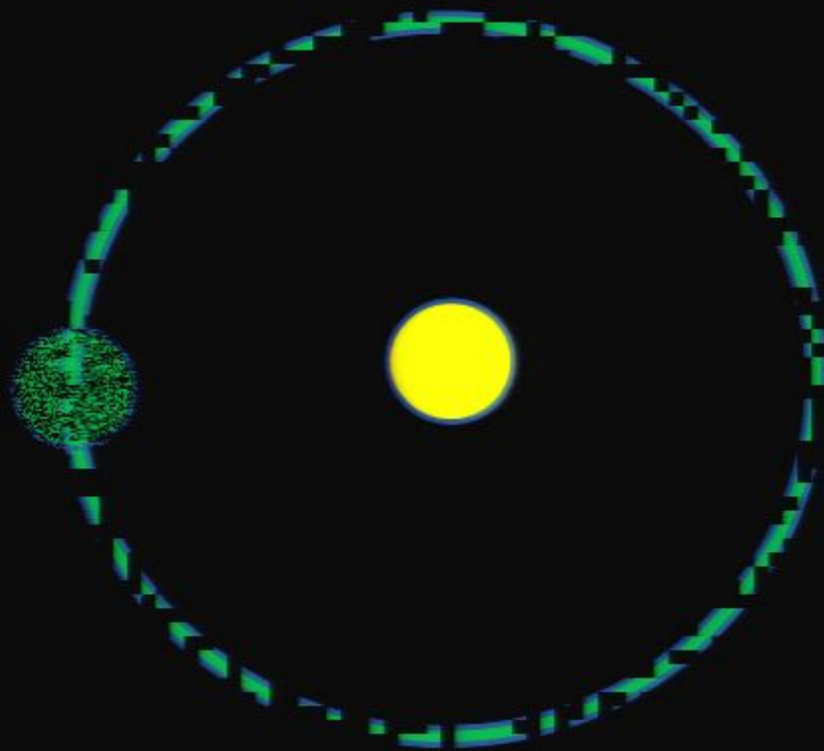
impossible

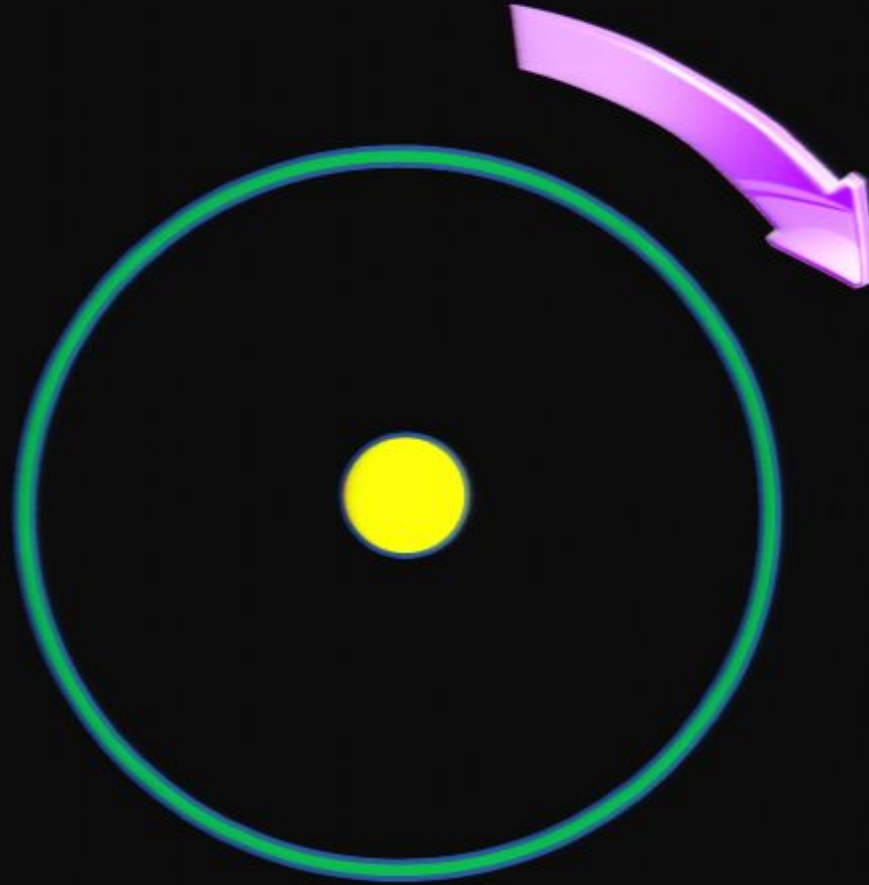
electron can't move

so what's it doing?

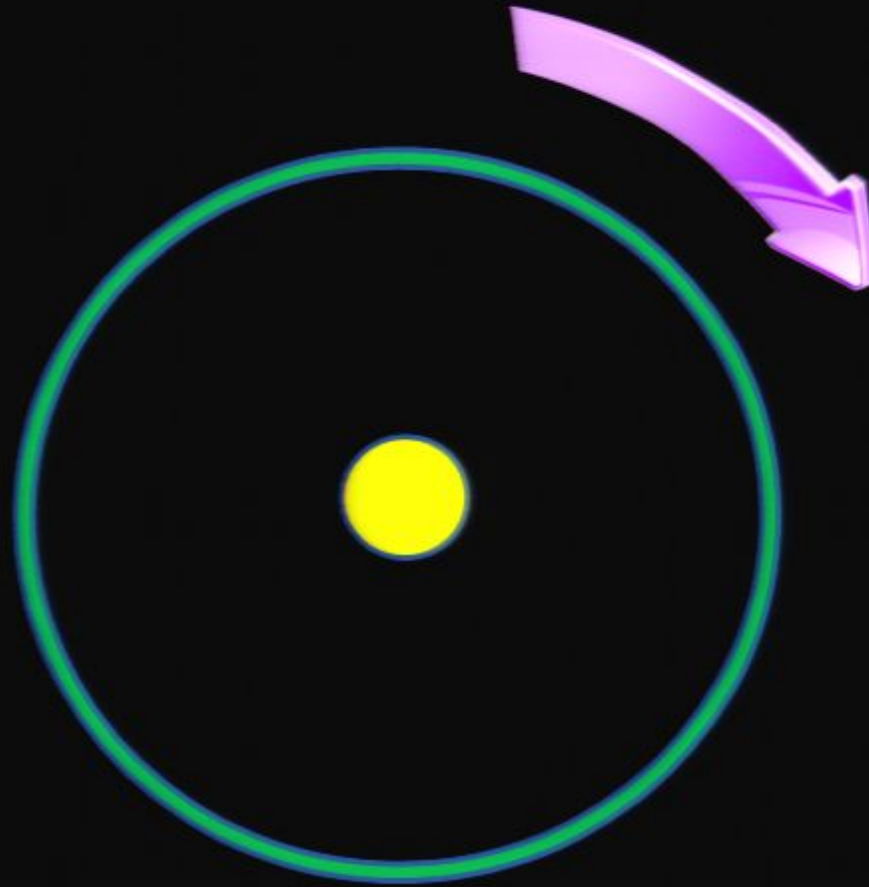








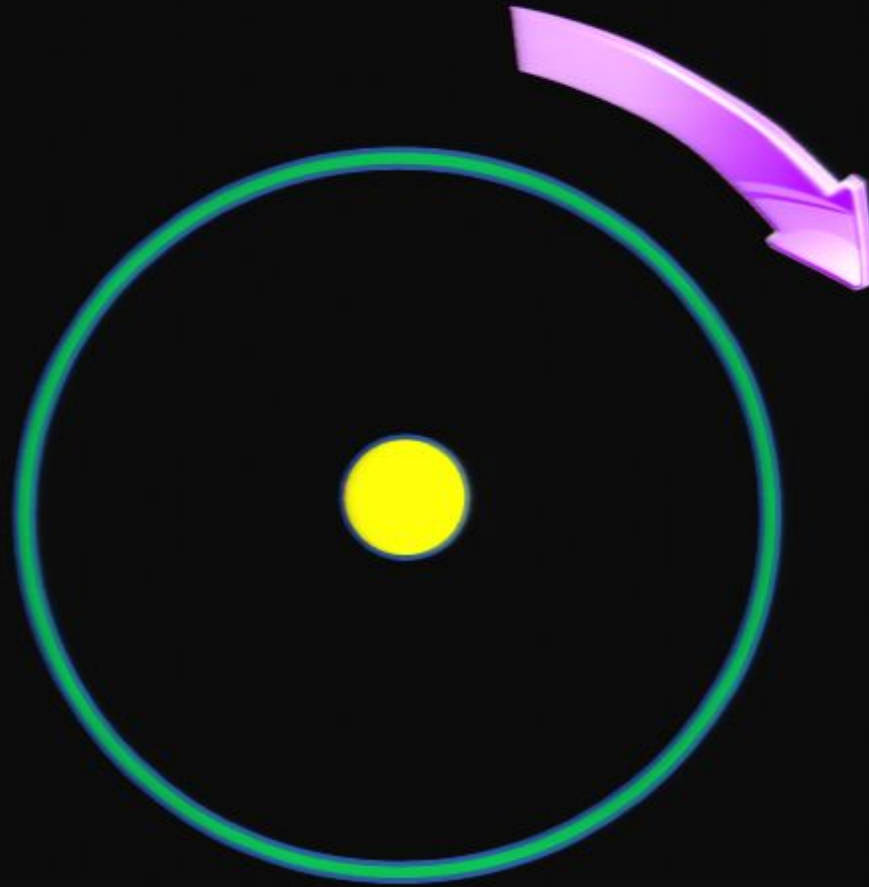
it's moving...but appears to be standing still



it's moving...but appears to be standing still



magnetic? YES



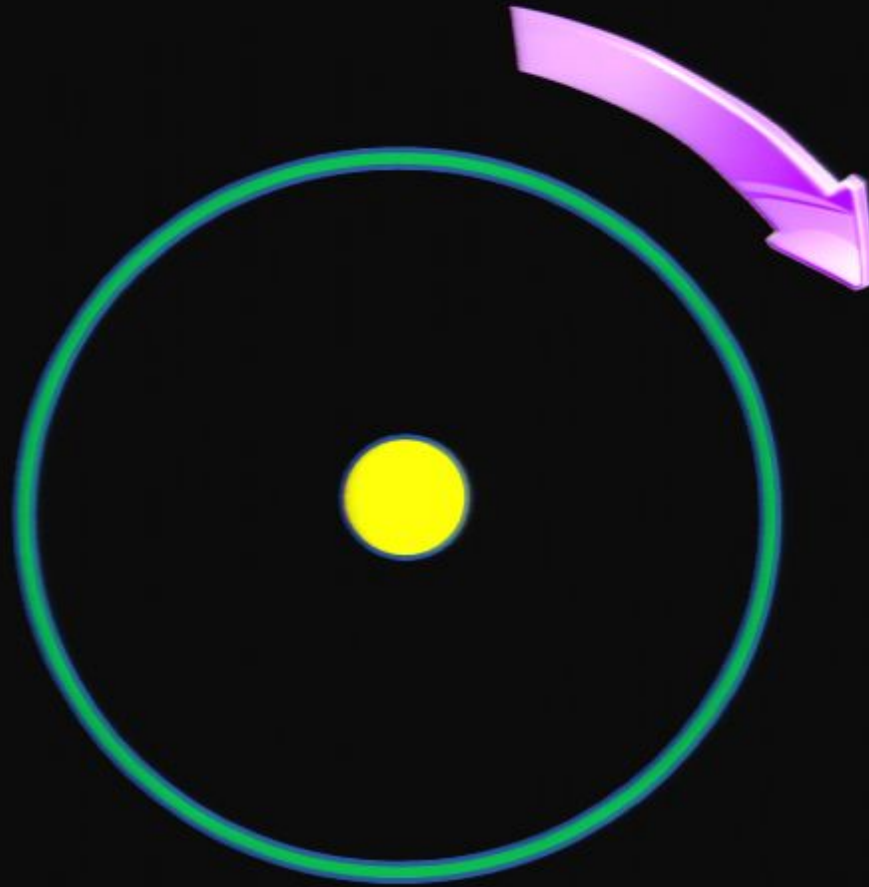
it's moving...but appears to be standing still



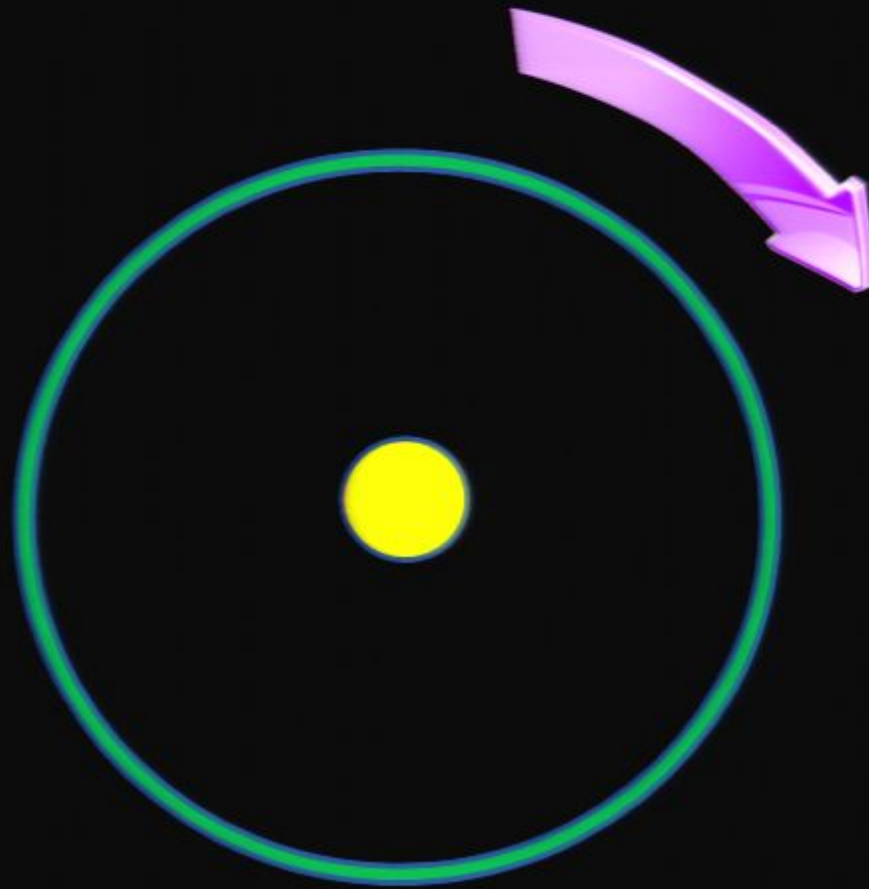
magnetic? YES

radiation? NO

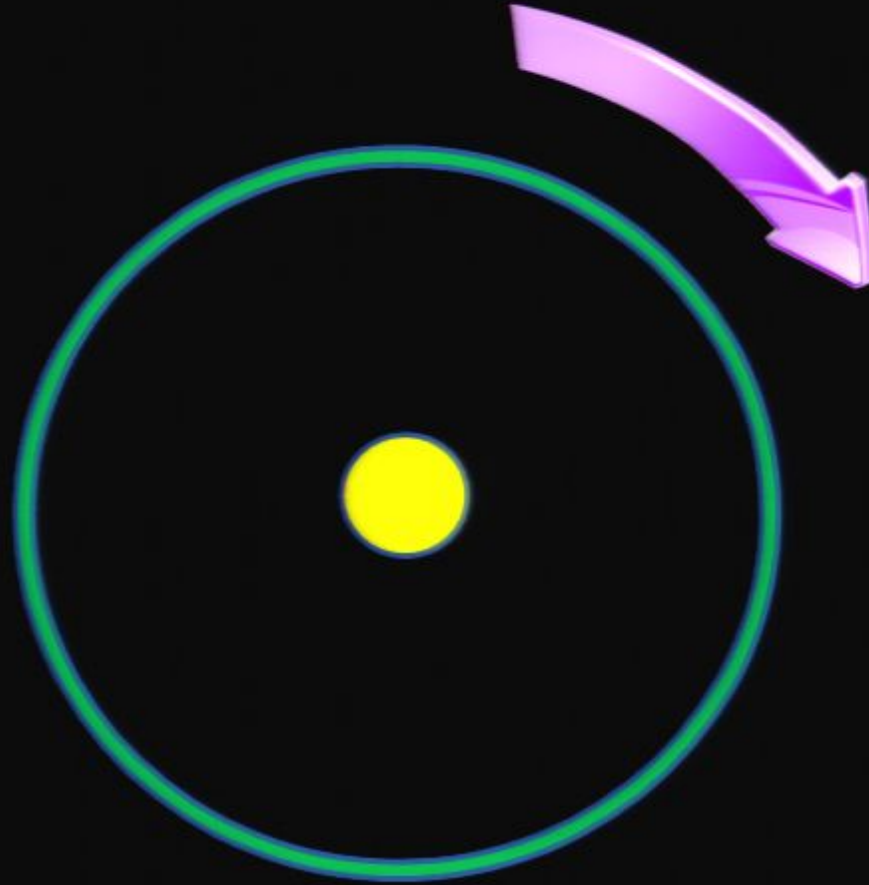




problem solved?

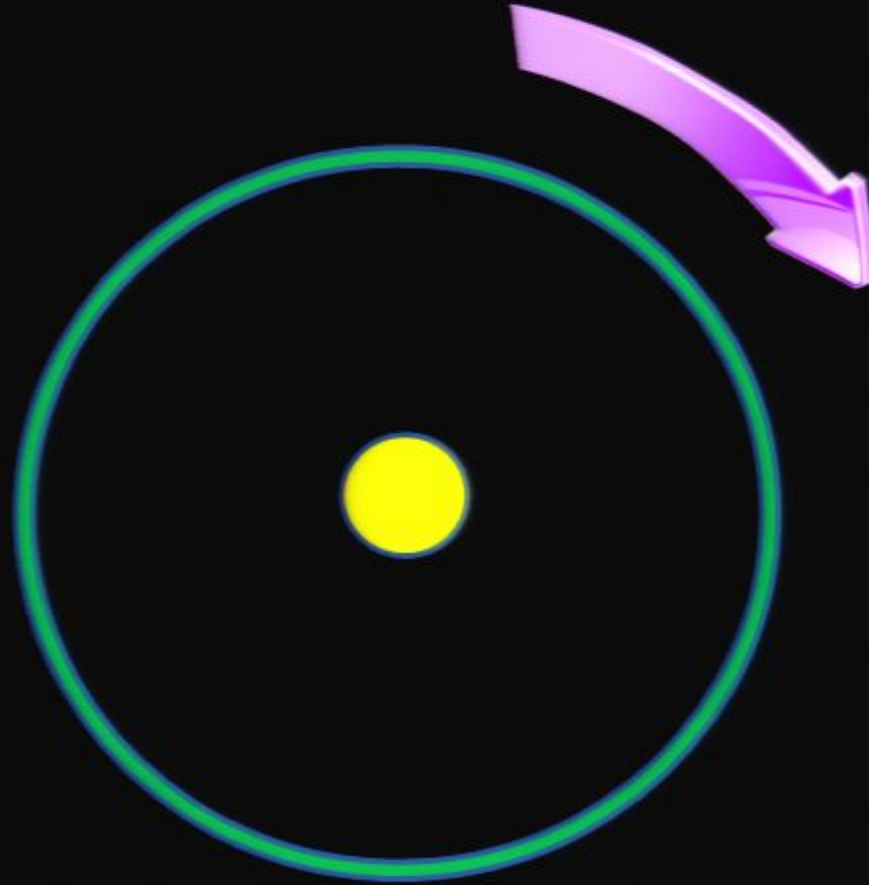


problem solved?

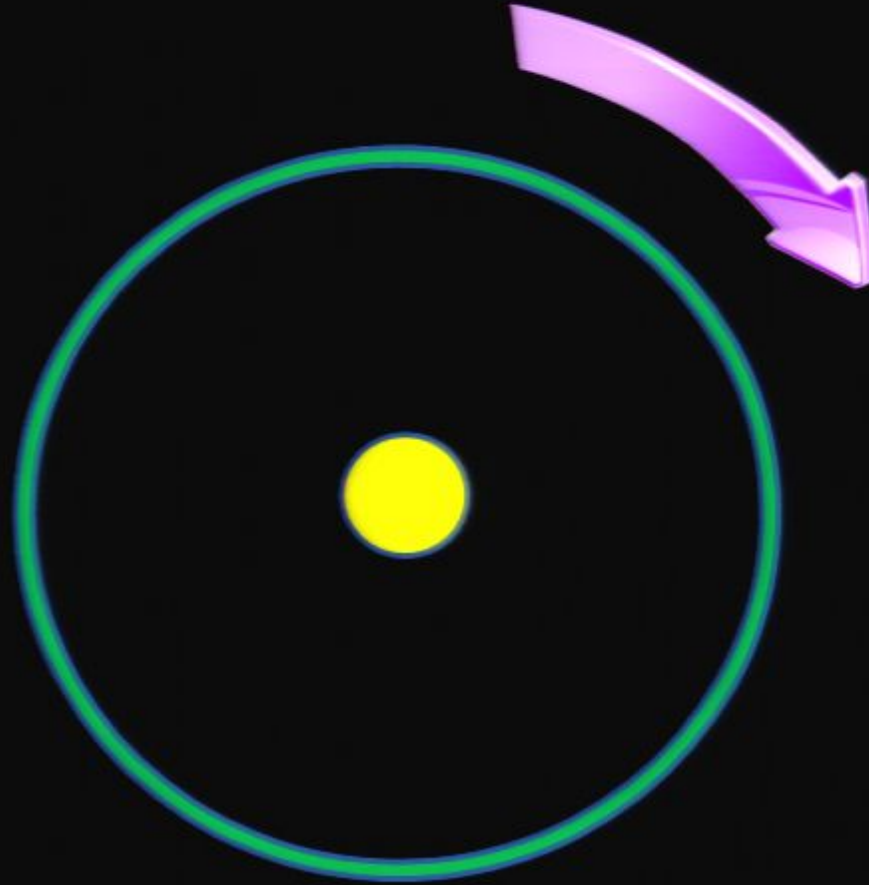


problem solved?

NO!



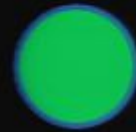
whenever we look for the electron:



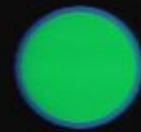
whenever we look for the electron:
we instantly find a whole electron
...at one place or another



whenever we look for the electron:
we instantly find a whole electron
...at one place or another



whenever we look for the electron:
we instantly find a whole electron
...at one place or another



whenever we look for the electron:
we instantly find a whole electron
...at one place or another

quirky quantum:



quirky quantum:



whenever we're not looking:

quirky quantum:



whenever we're not looking:

...it's nowhere definite

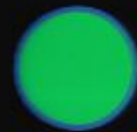
quirky quantum:



whenever we're not looking:

...it's nowhere definite ...potentially anywhere

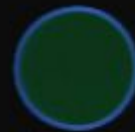
quirky quantum:



whenever we're not looking:

...it's nowhere definite ...potentially anywhere

quirky quantum:



whenever we're not looking:

...it's nowhere definite ...potentially anywhere

quirky quantum:



whenever we're not looking:

...it's nowhere definite ...potentially anywhere

quirky quantum:



whenever we're not looking:

...it's nowhere definite ...potentially anywhere

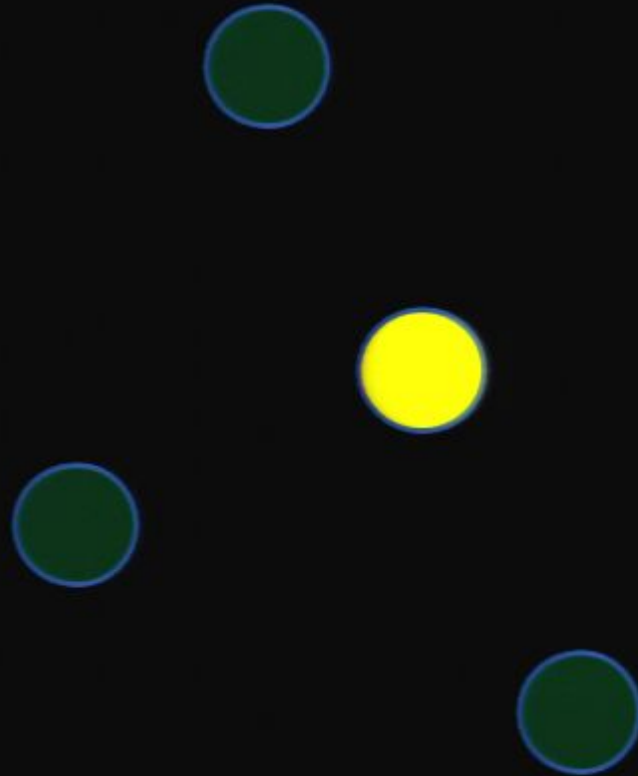
quirky quantum:



whenever we're not looking:

...it's nowhere definite ...potentially anywhere

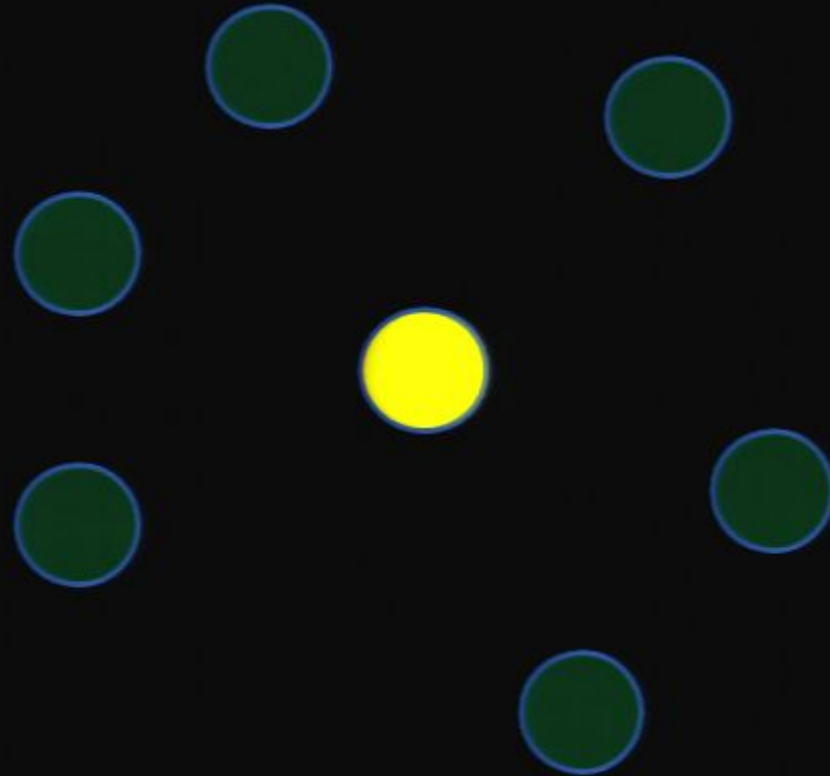
quirky quantum:



whenever we're not looking:

...it's nowhere definite ...potentially anywhere

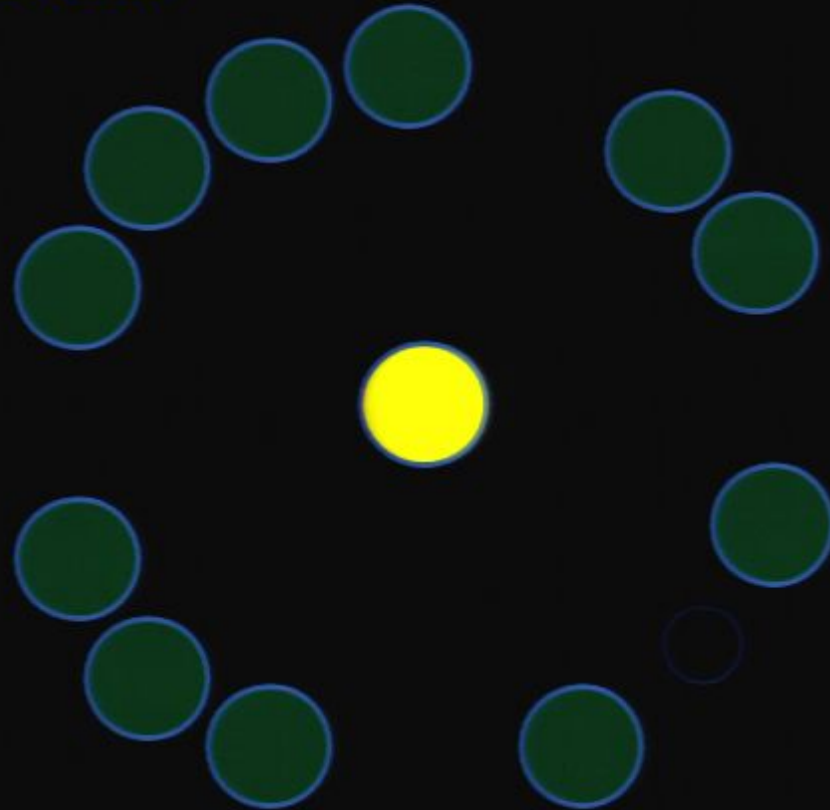
quirky quantum:



whenever we're not looking:

...it's nowhere definite ...potentially anywhere

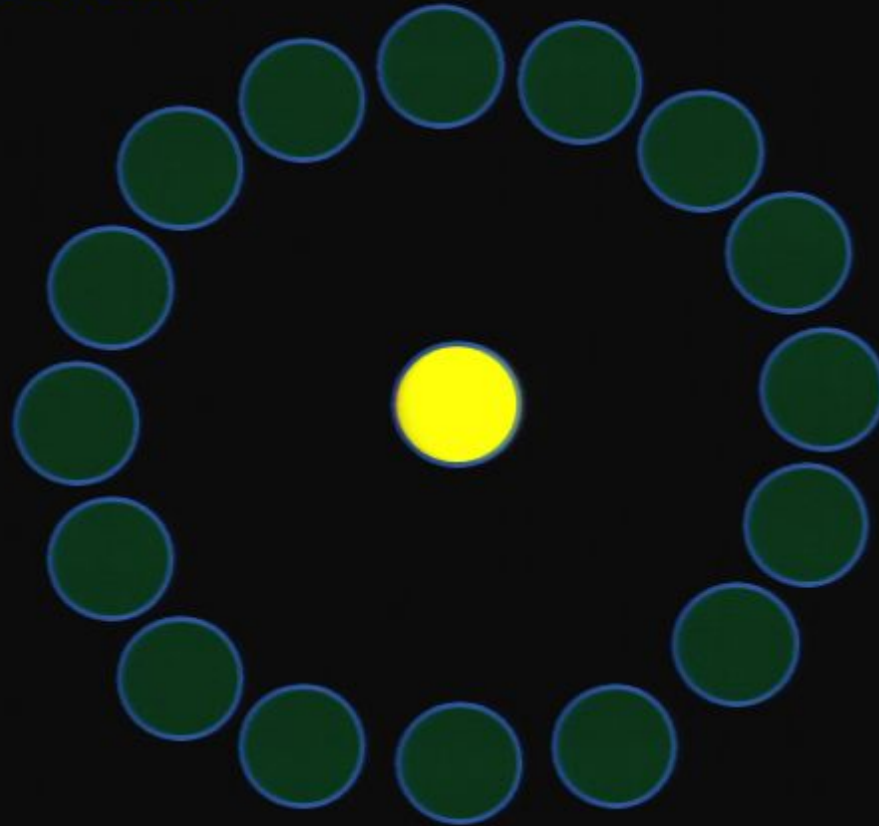
quirky quantum:



whenever we're not looking:

...it's nowhere definite ...potentially anywhere

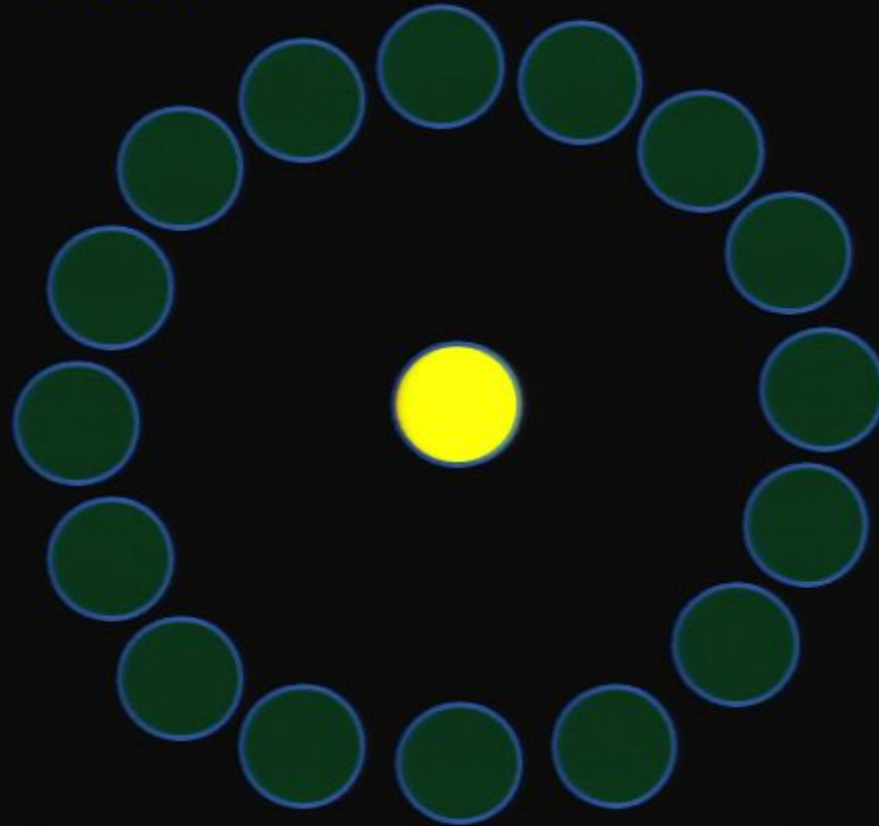
quirky quantum:



whenever we're not looking:

...it's nowhere definite ...potentially anywhere

quirky quantum:

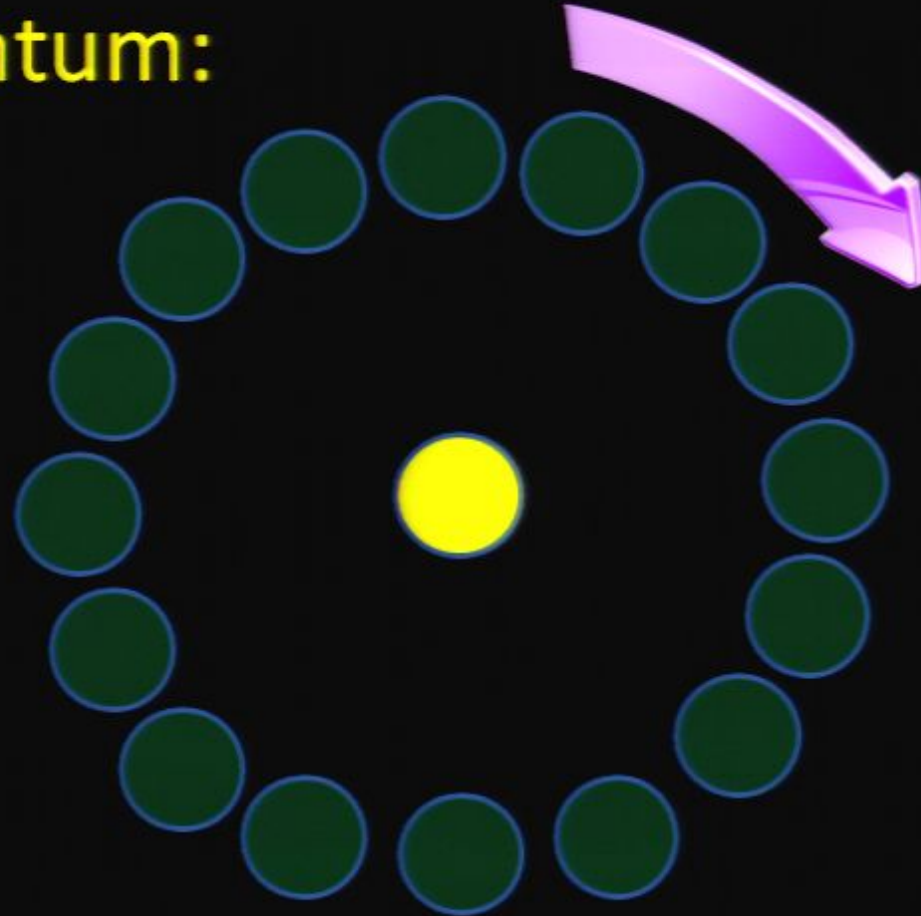


whenever we're not looking:

...it's nowhere definite ...potentially anywhere

...essentially everywhere at once!

quirky quantum:

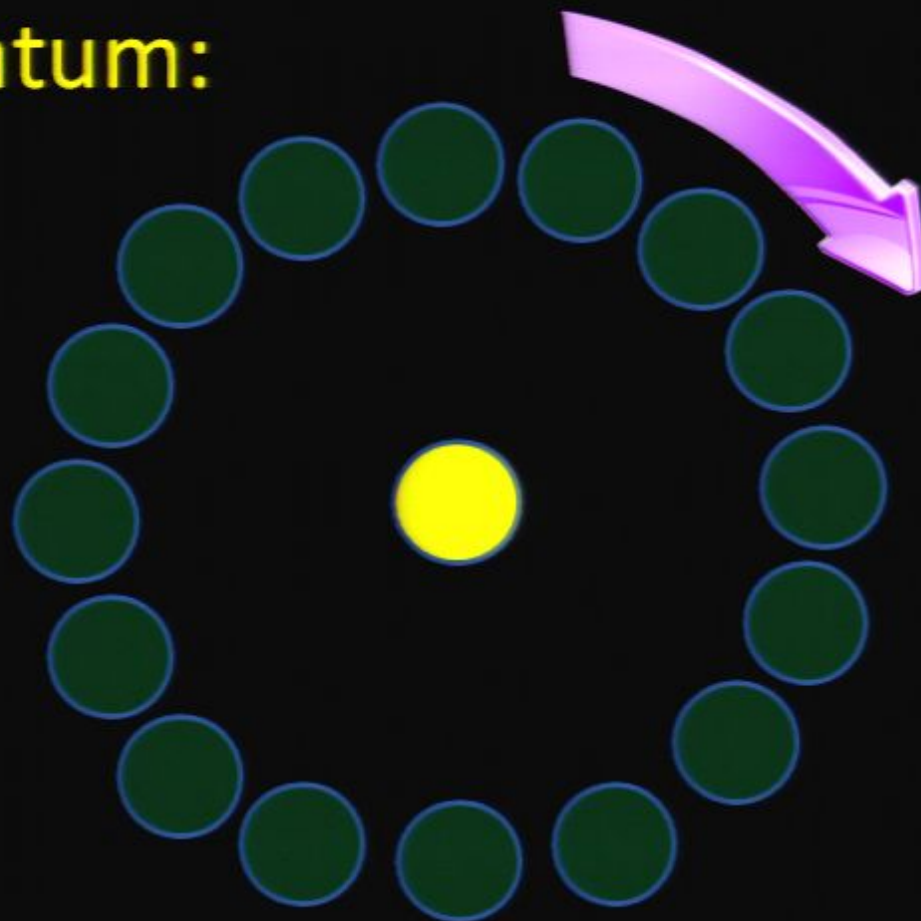


whenever we're not looking:

...it's nowhere definite ...potentially anywhere

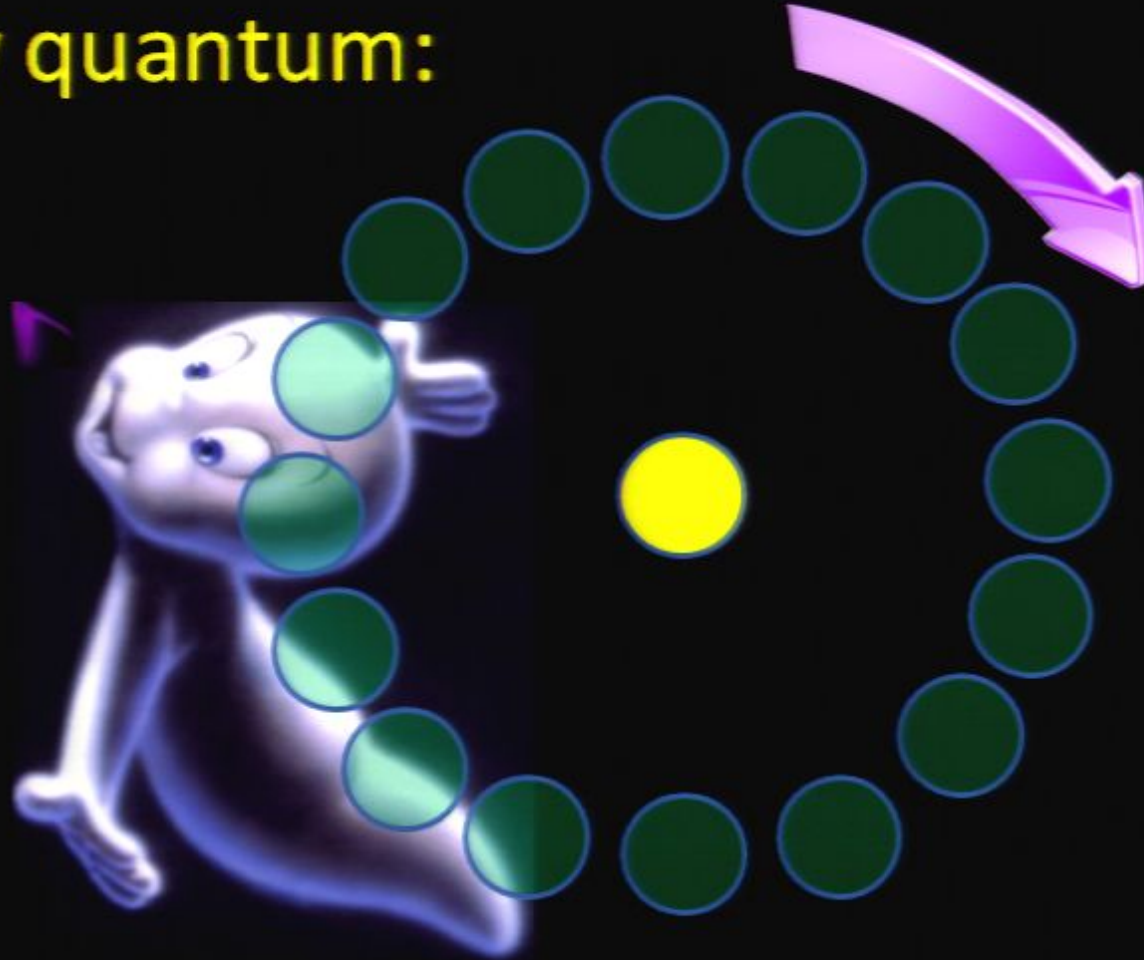
...essentially everywhere at once!

quirky quantum:



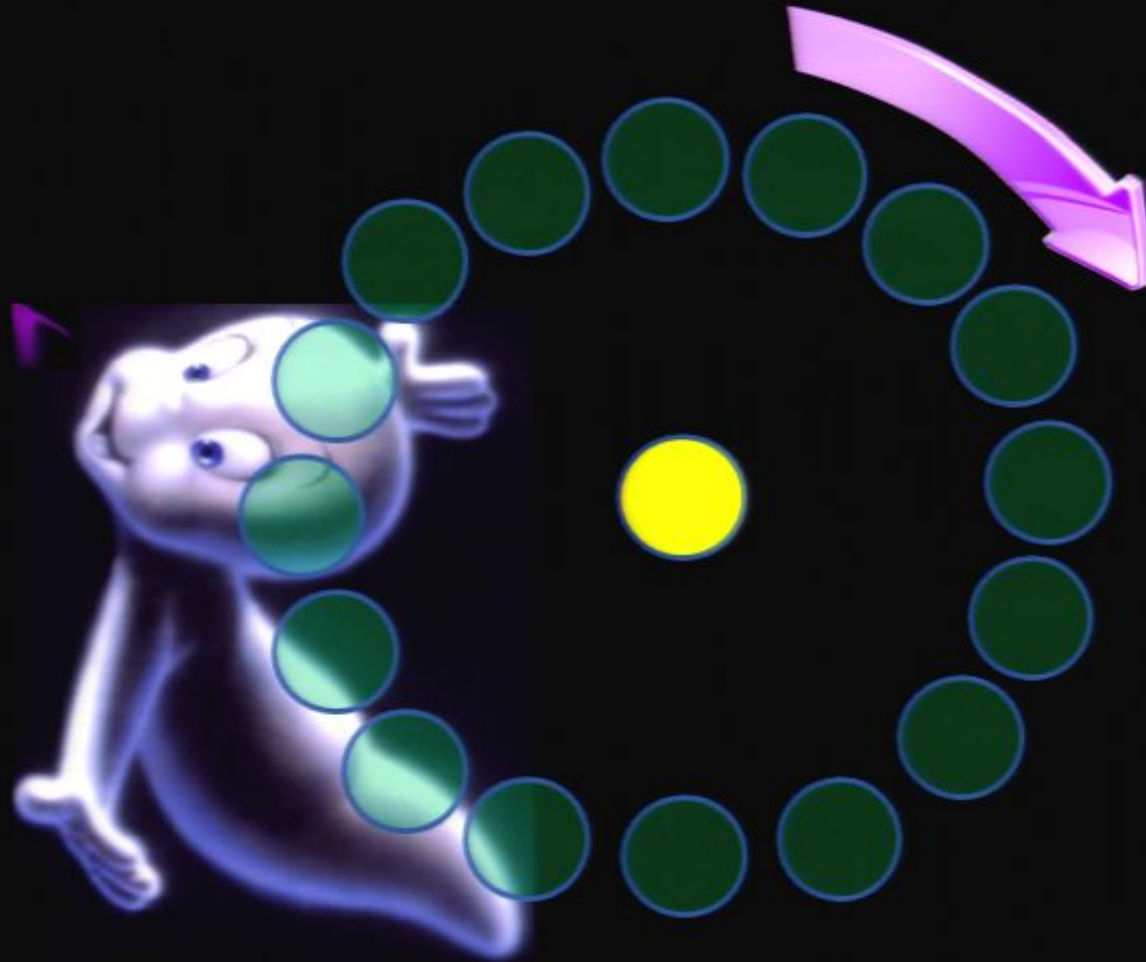
whenever we're not looking:

quirky quantum:

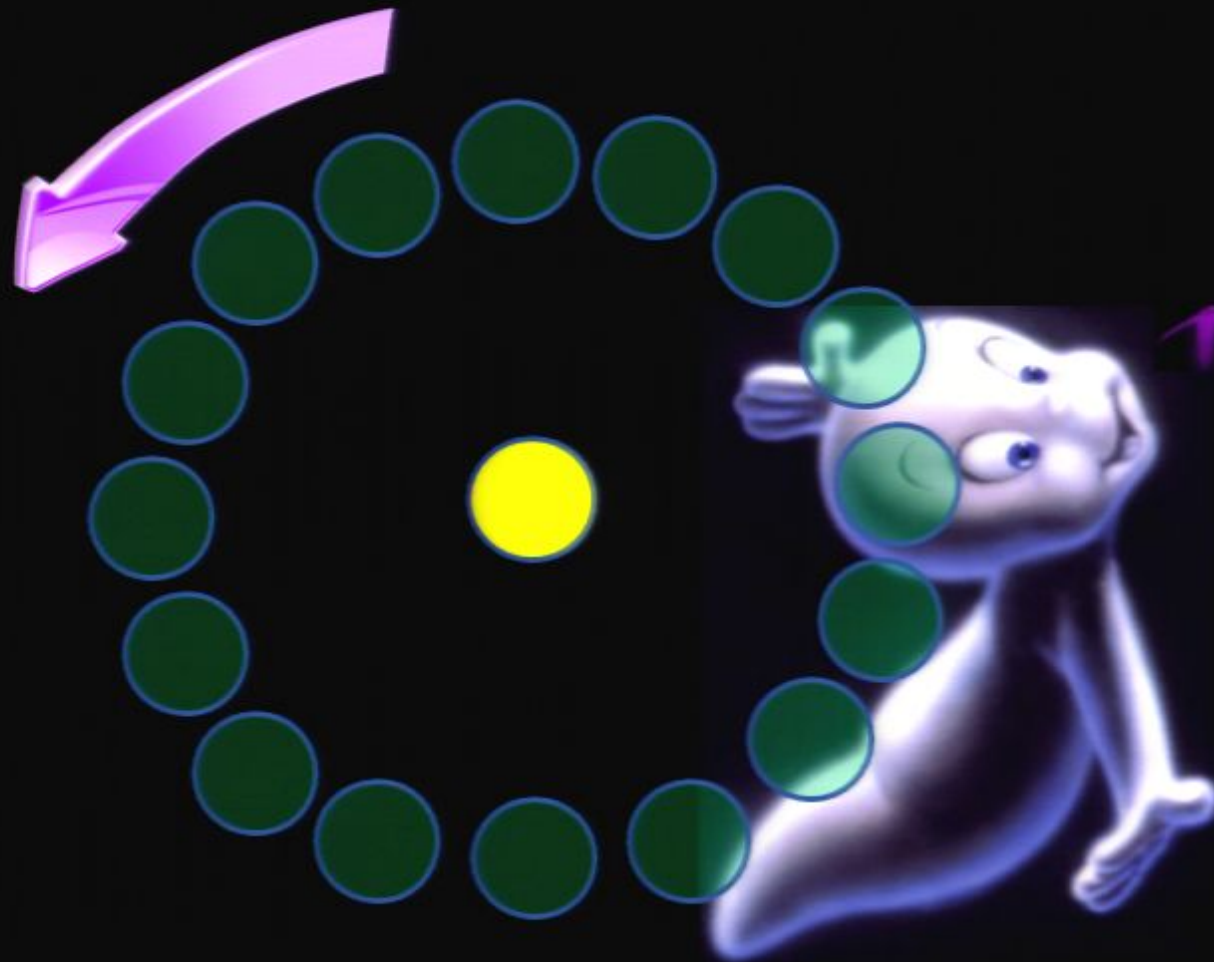


whenever we're not looking:

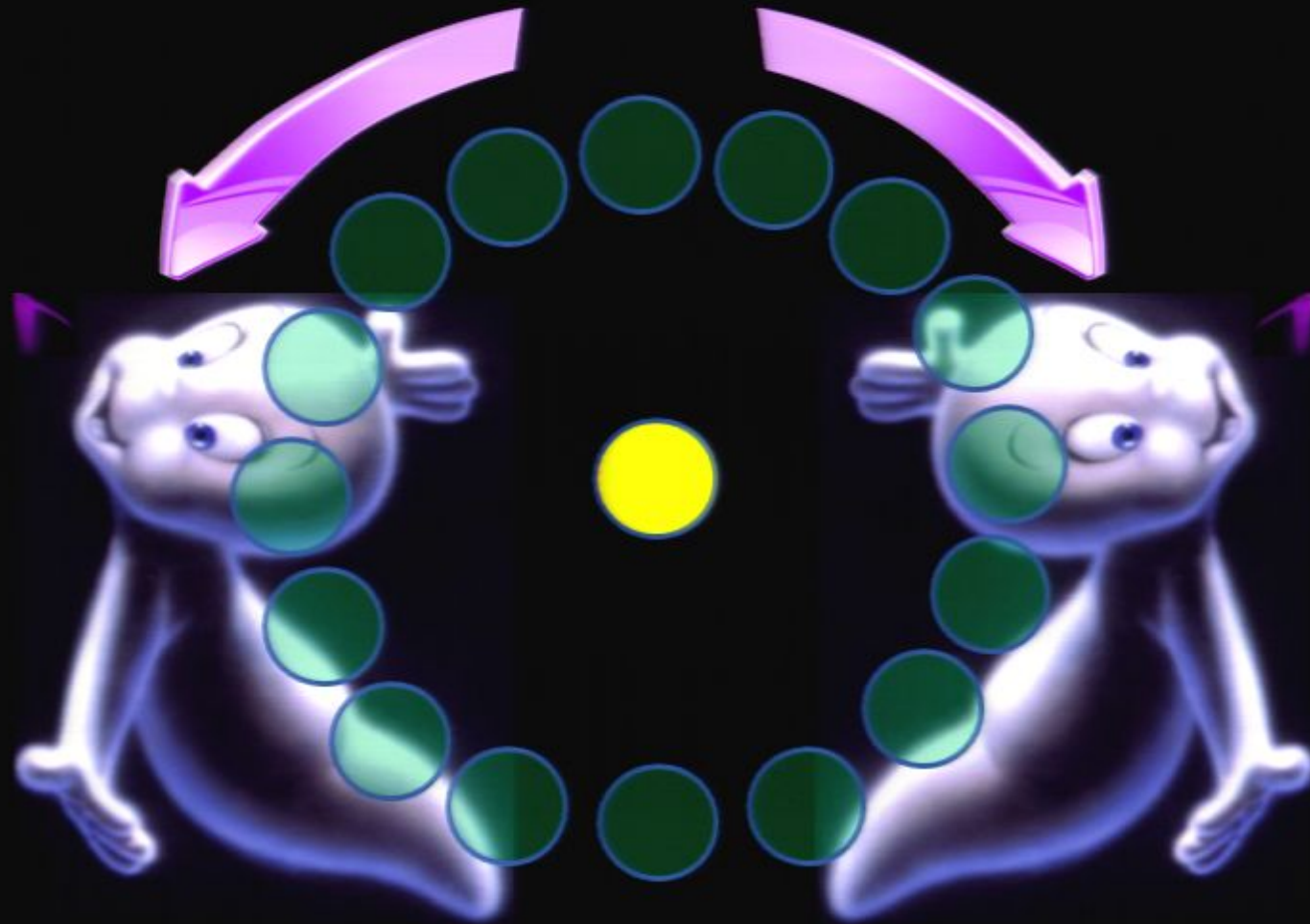
the electron behaves like a “ghost”



ghost goes right



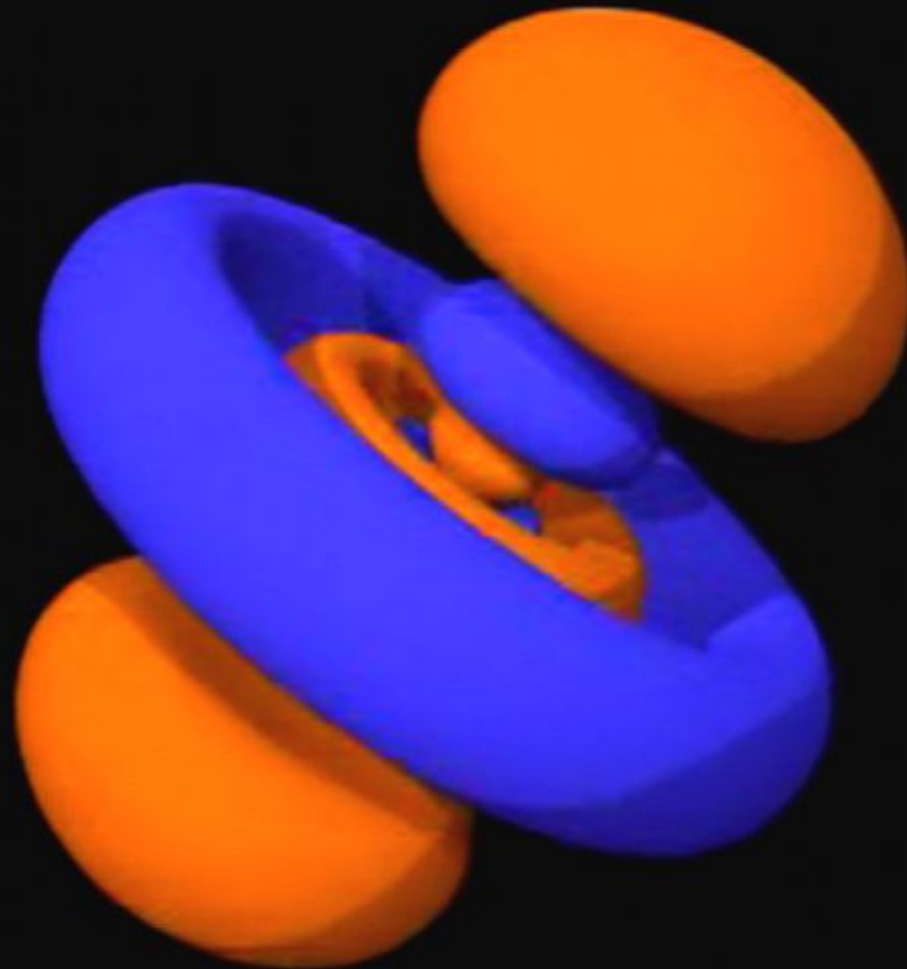
ghost goes left



super-ghost goes right **AND** left
...simultaneously

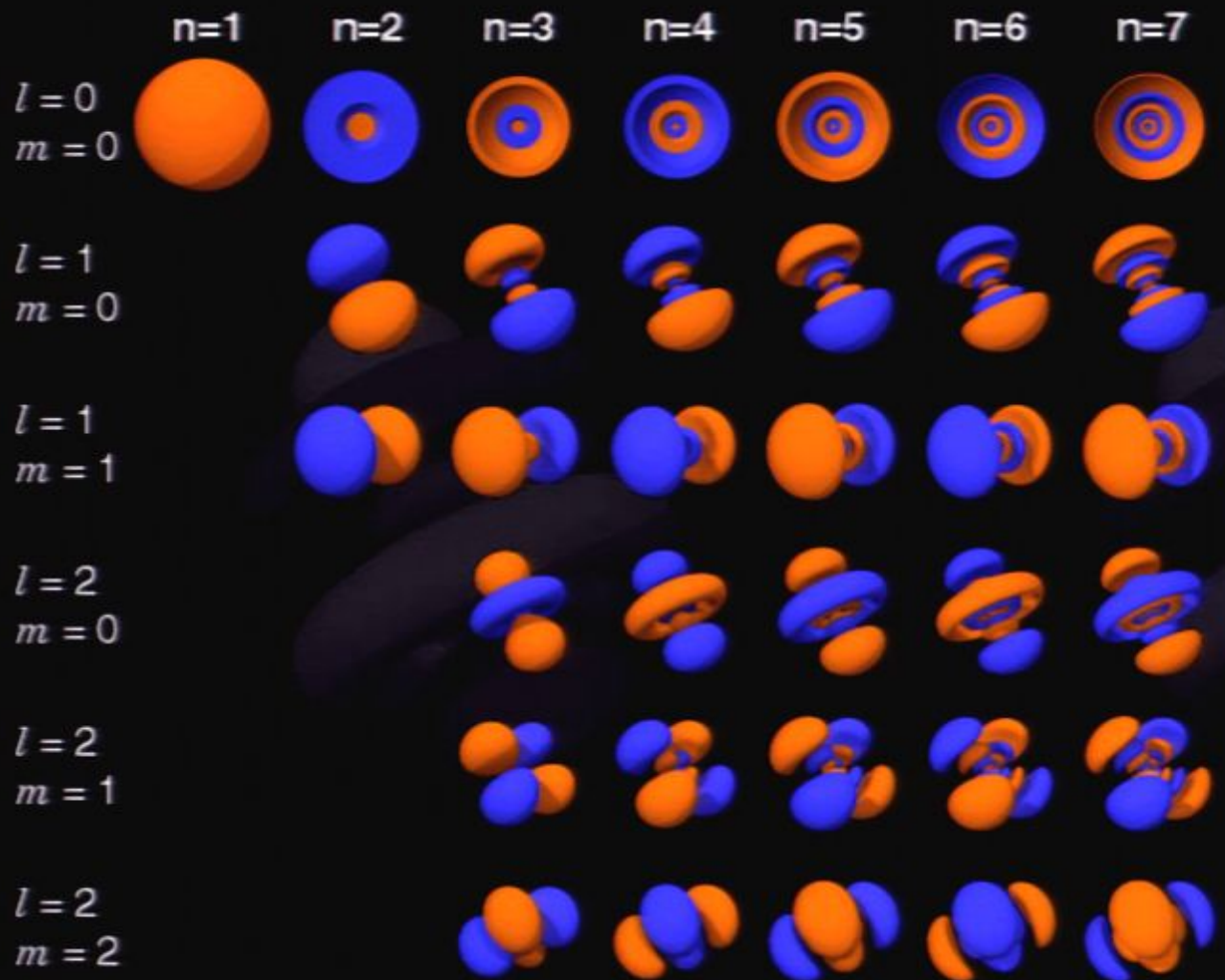


typical super-ghost state





more super-ghost fun



the upshot so far:



atoms (you and me) can't exist in a
“commonsense” world:

A OR B

they can exist
in a “quirky quantum” world:



A AND B

the upshot so far:



atoms (you and me) can't exist in a
“commonsense” world:

A OR B

they can exist
in a “quirky quantum” world:



A AND B

the upshot so far:



atoms (you and me) can't exist in a
“commonsense” world:

A OR B

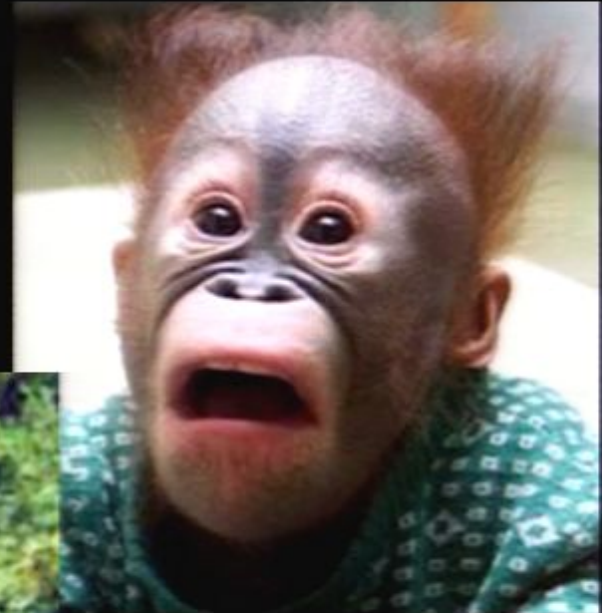
they can exist
in a “quirky quantum” world:



A AND B

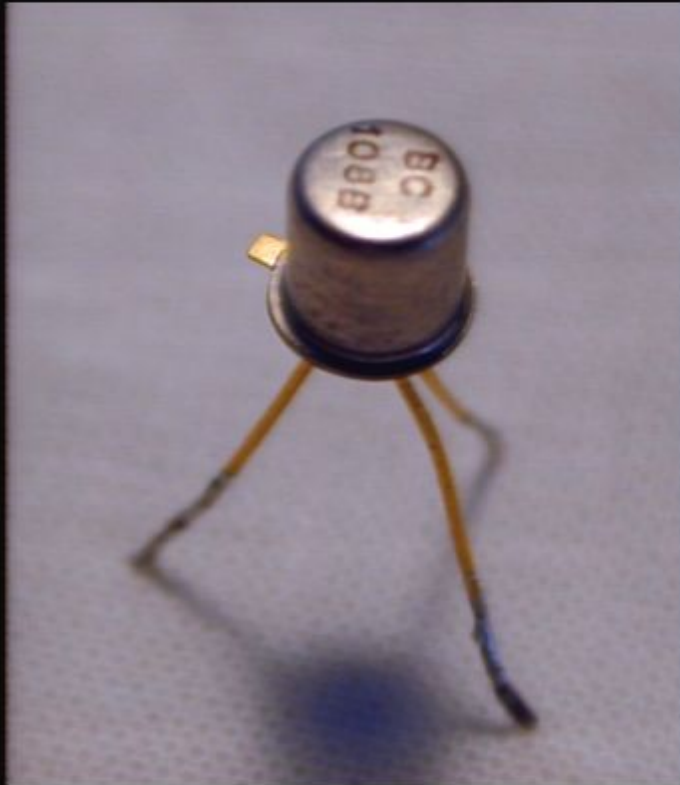






putting the ghost to work:

putting the ghost to work:



putting the ghost to work:



putting the ghost to work:



putting the ghost to work:



putting the ghost to work:

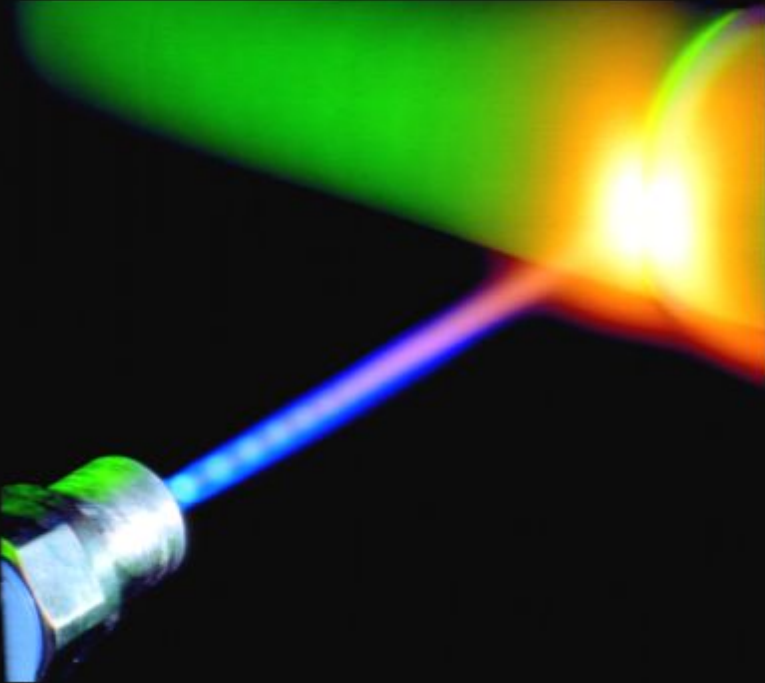


putting the ghost to work:

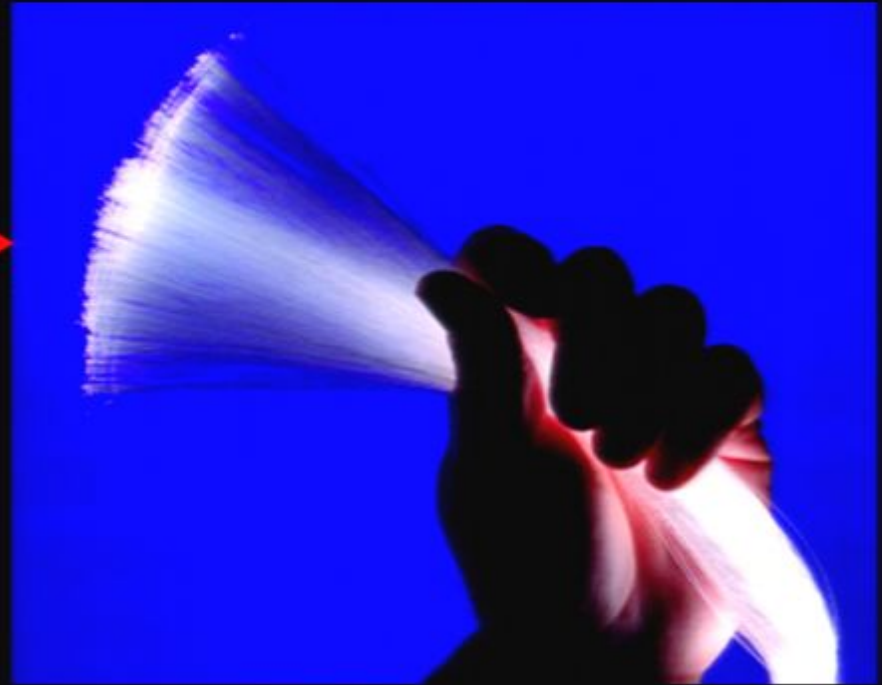


...every electronic device
on the planet.

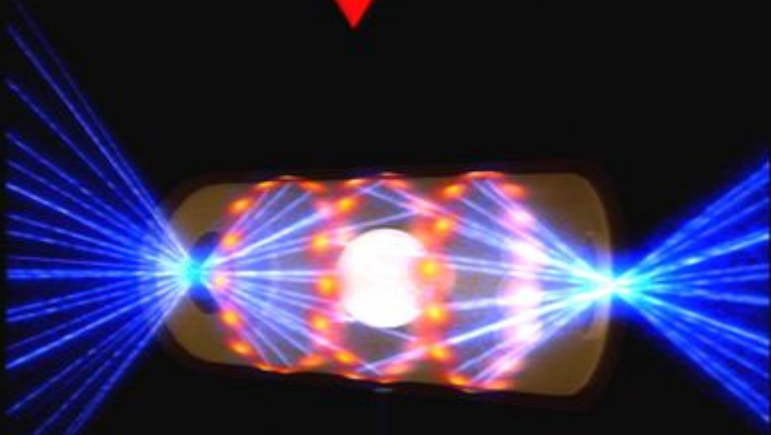
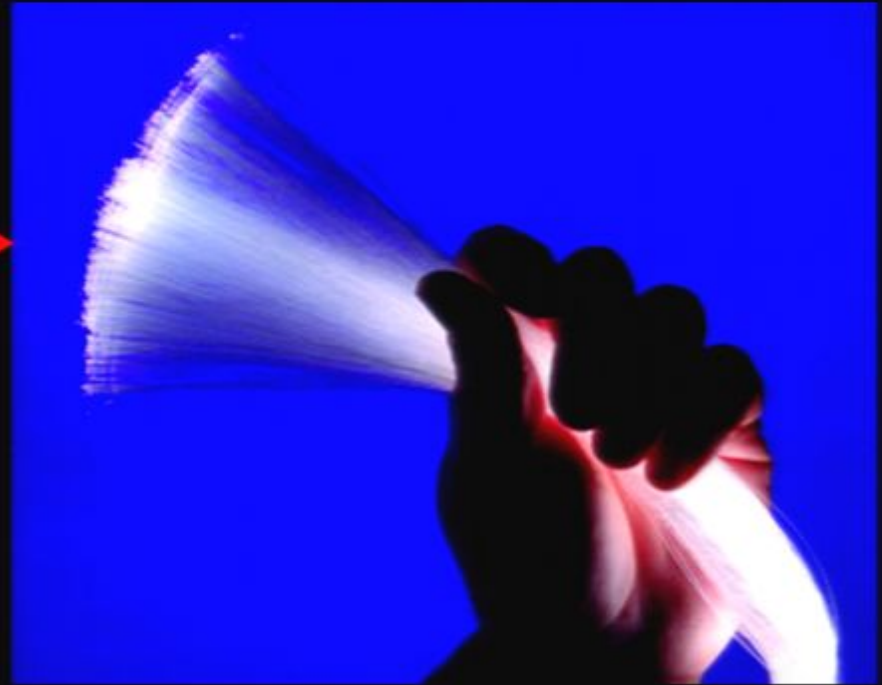
putting the ghost to work:



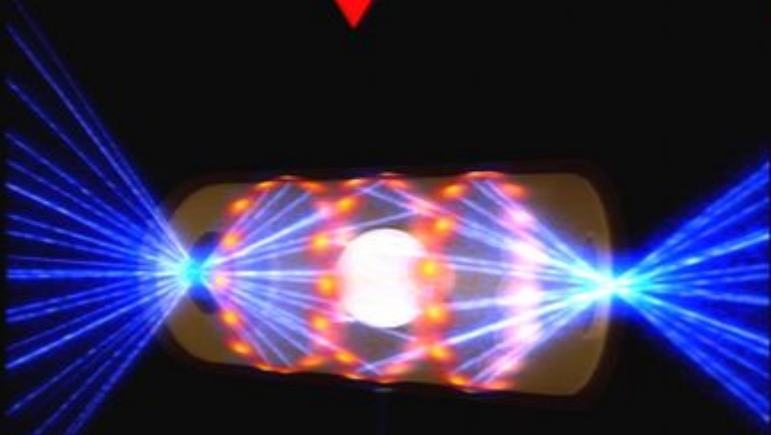
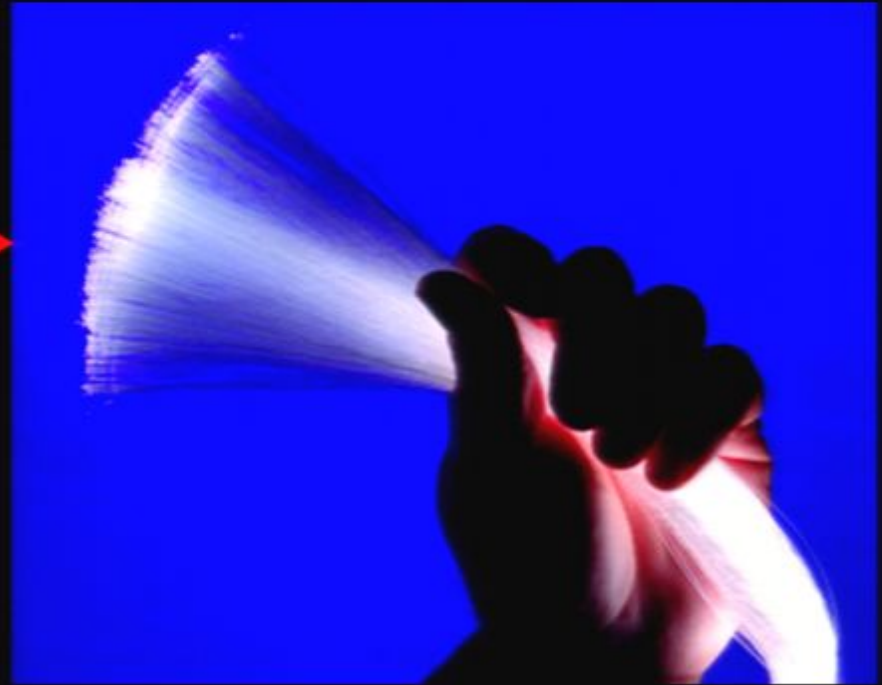
putting the ghost to work:



putting the ghost to work:



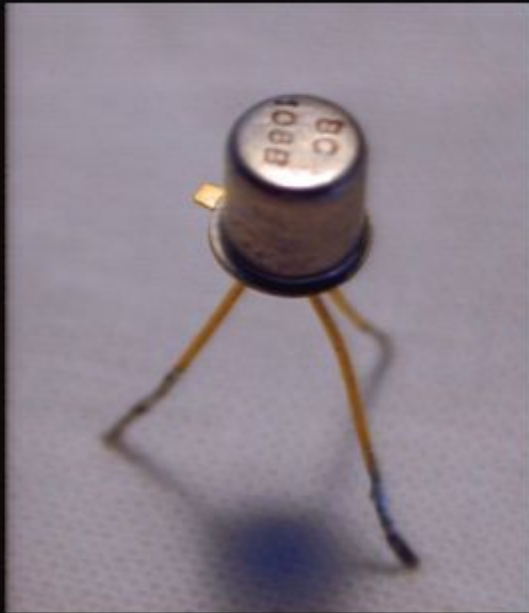
putting the ghost to work:



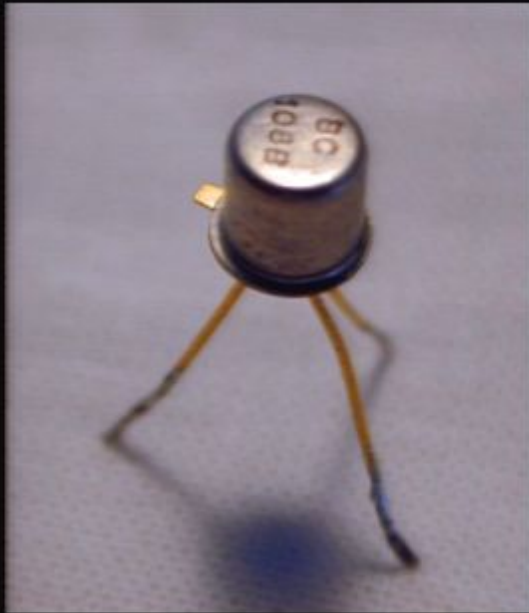
+ DVD, Blu-ray, printers,
medicine, industry...

and we've only just begun:

and we've only just begun:

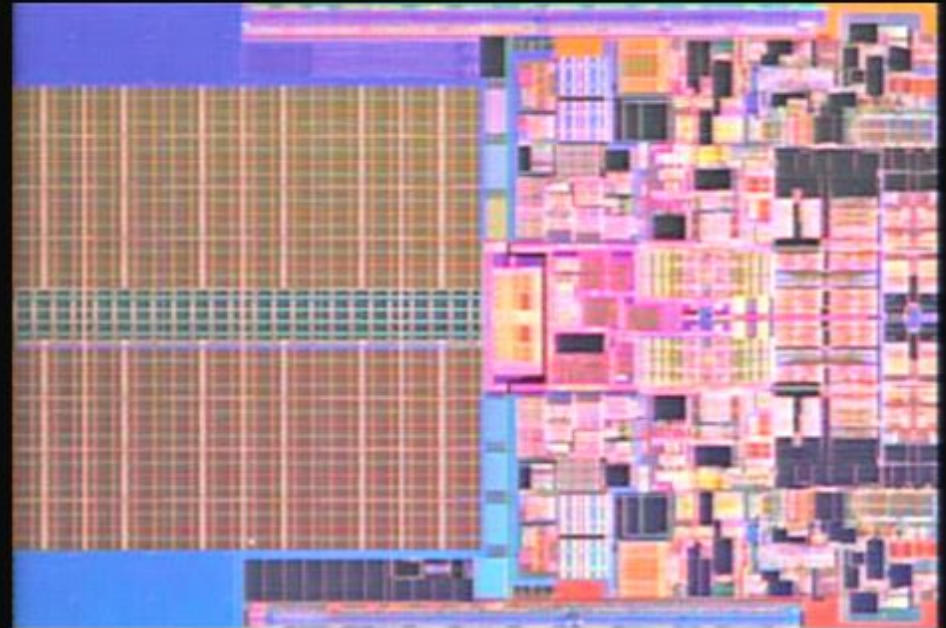
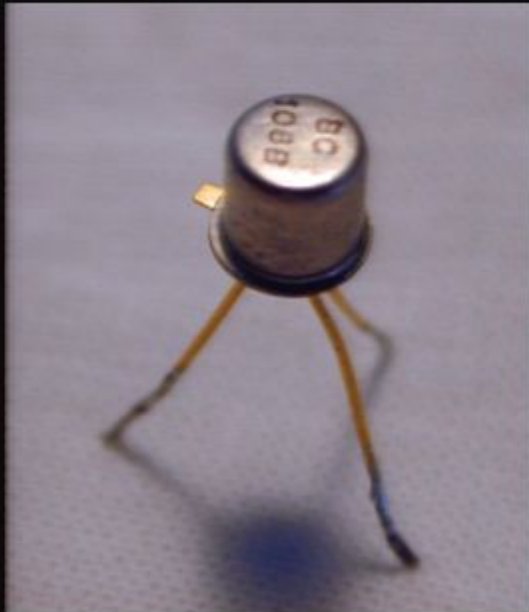


and we've only just begun:



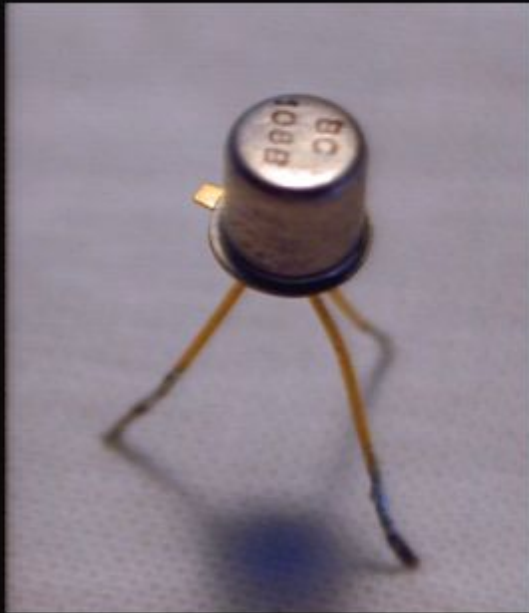
one transistor
0.5 cm in size

and we've only just begun:

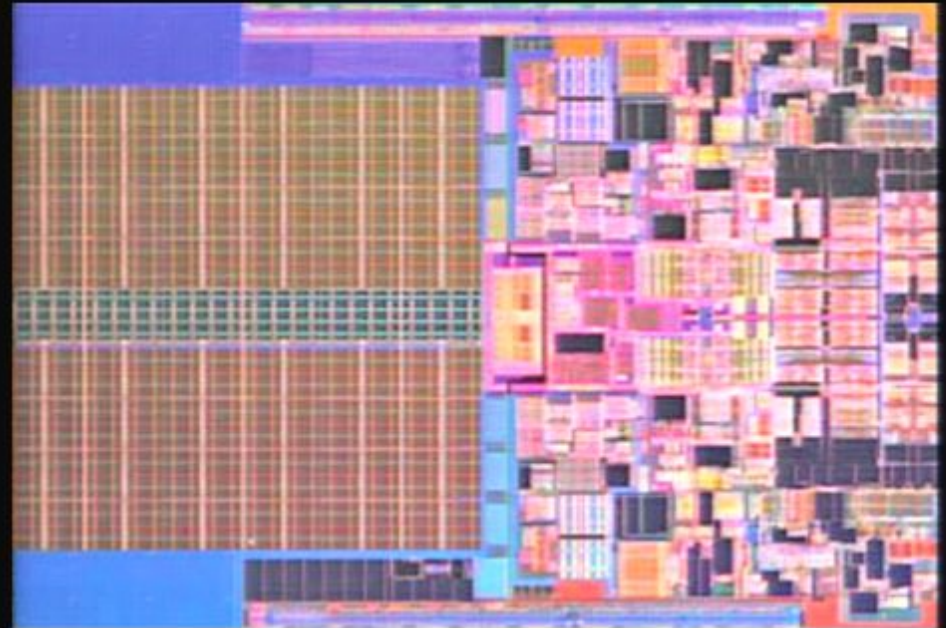


one transistor
0.5 cm in size

and we've only just begun:

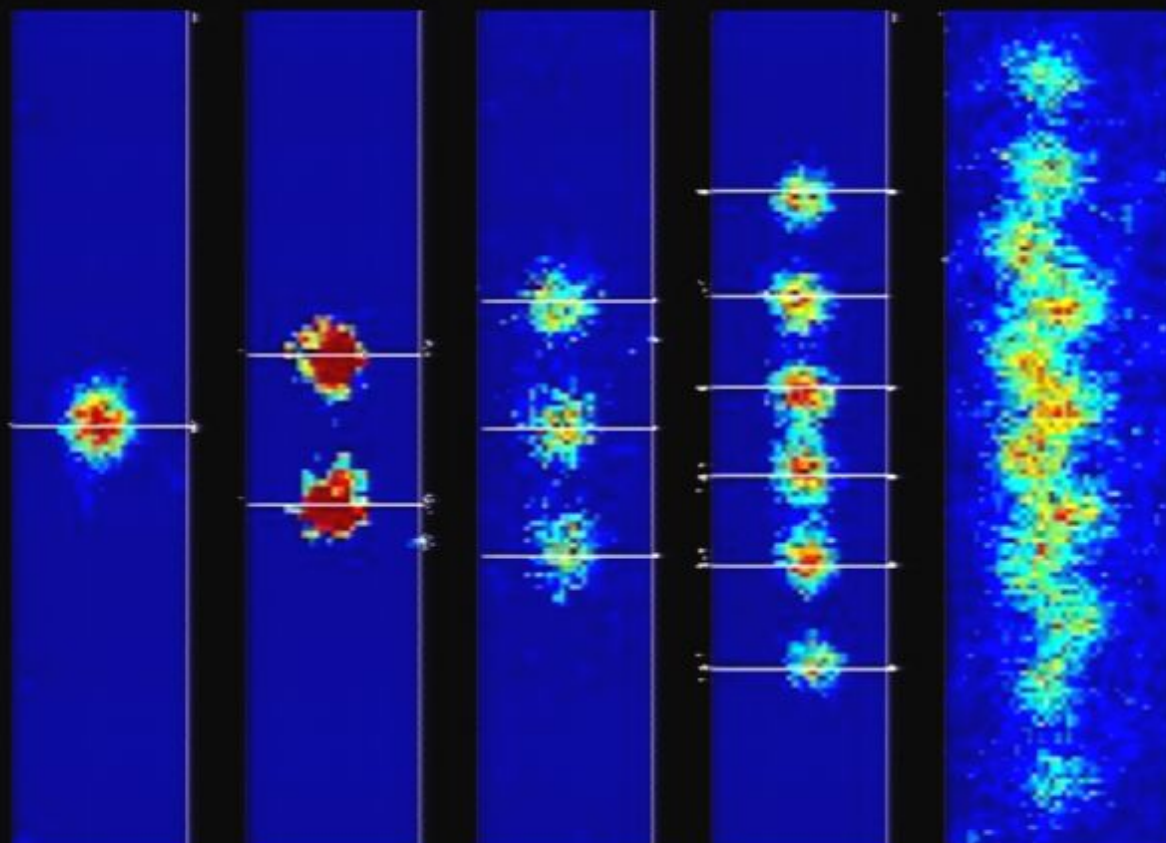


one transistor
0.5 cm in size

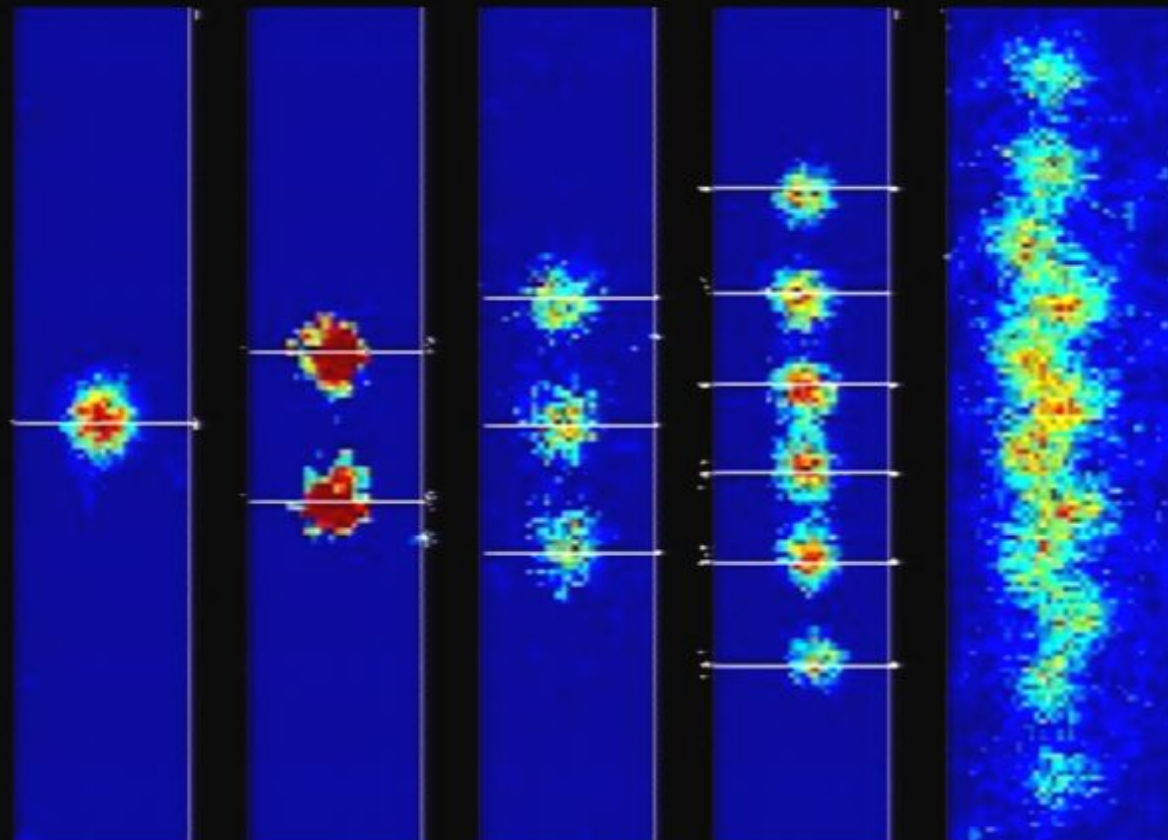


a *billion* transistors
100 atoms in size

and we've only just begun:

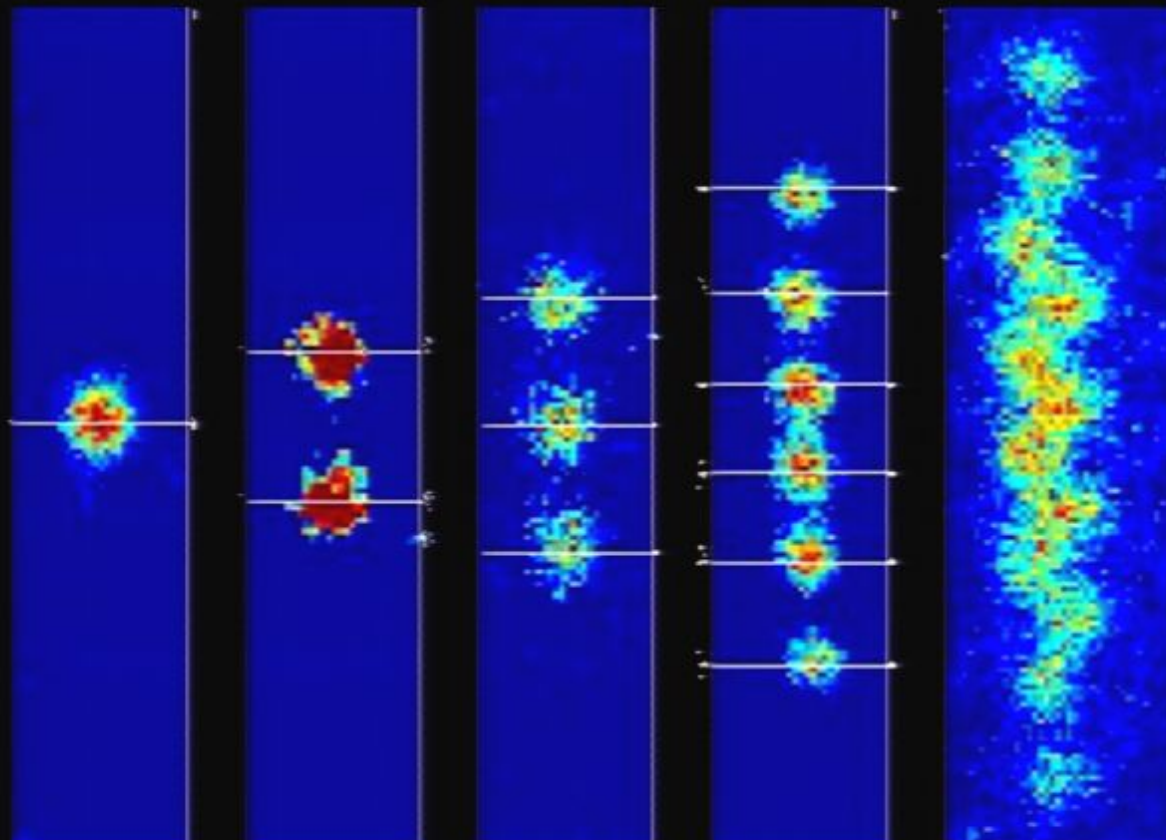


and we've only just begun:



individual atoms

and we've only just begun:



individual atoms
(where the ghost lives)



technology has brought us
face-to-face with the ghost



humanity has entered a new era:
the *quantum* information age

quantum cryptography:

quantum cryptography:



quantum cryptography:



quantum cryptography:



quantum cryptography:



absolute security ensured
by quantum laws of nature



quantum cryptography:



absolute security ensured
by quantum laws of nature

banks + governments +
military + ... = \$\$\$

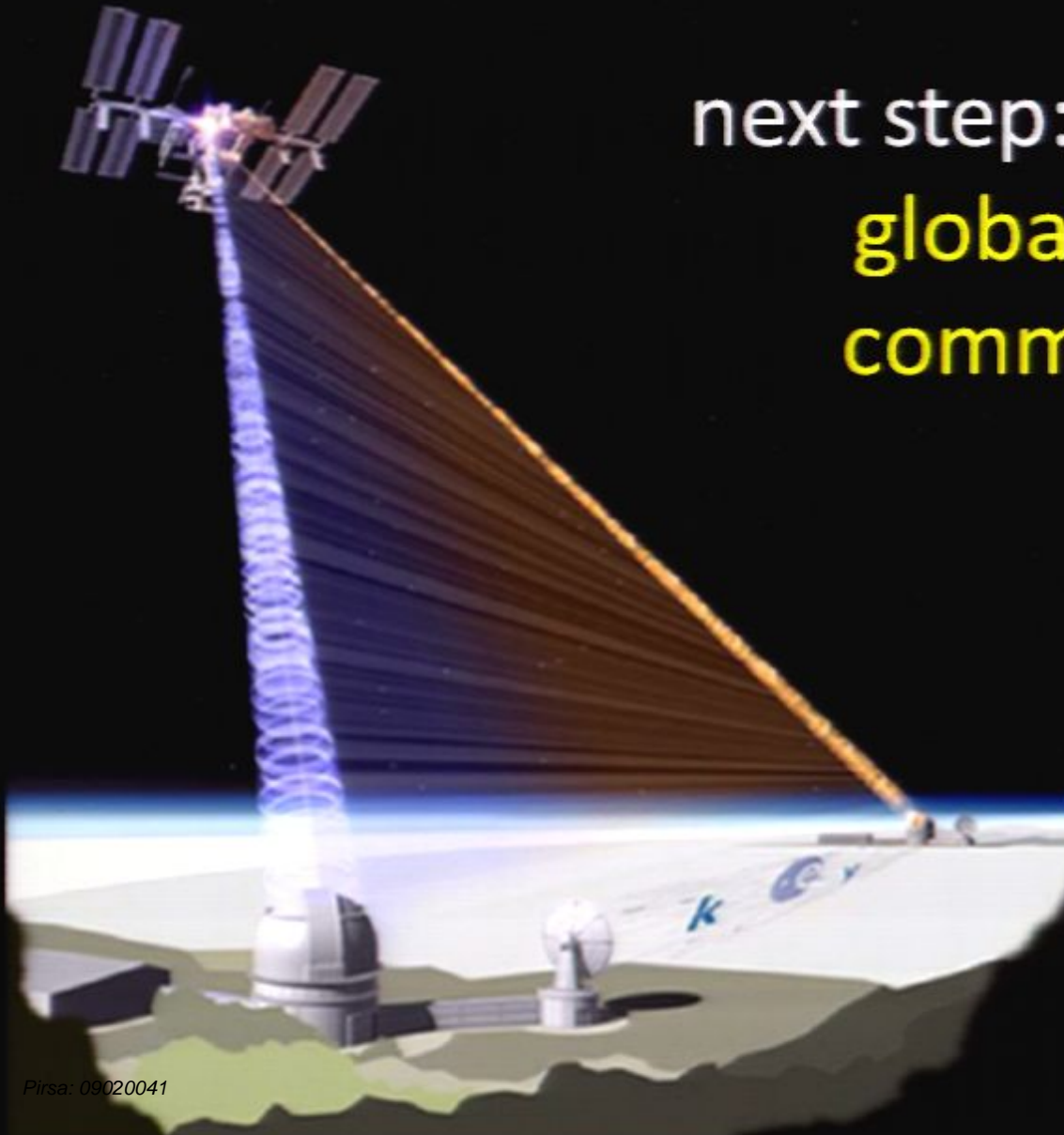


quantum cryptography:

next step: absolutely secure
global satellite quantum
communication network

quantum cryptography:

next step: absolutely secure
global satellite quantum
communication network



quantum cryptography:

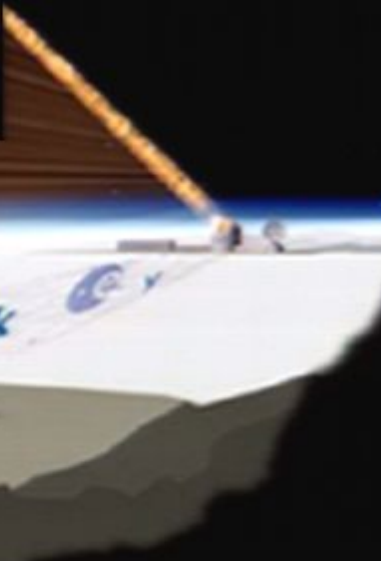
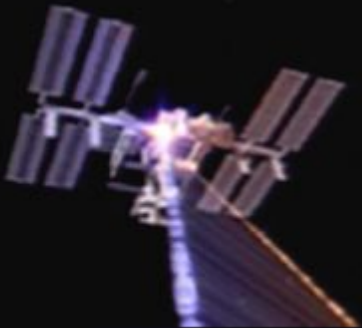
next step: absolutely secure
global satellite quantum
communication network



quantum cryptography:

next step: **absolutely secure
global satellite quantum
communication network**

very 21st century!

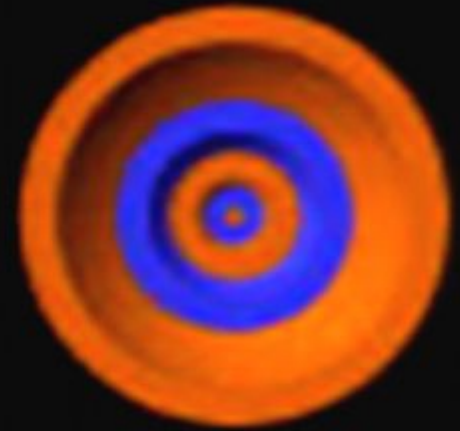
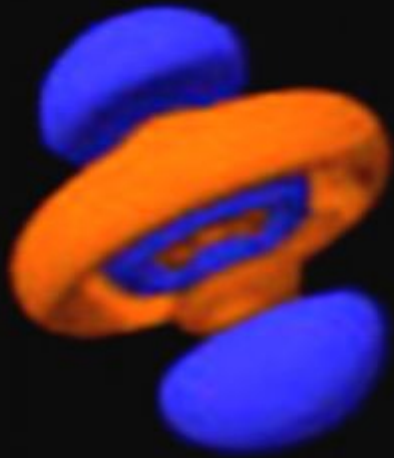


quantum teleportation:

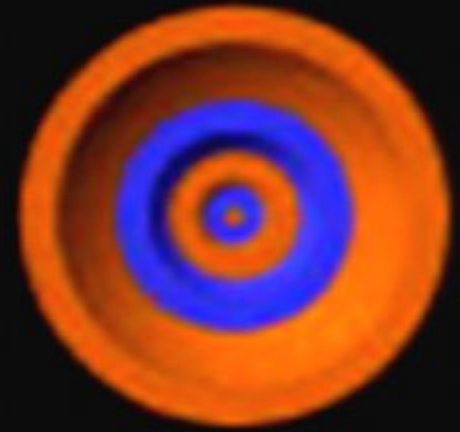
quantum teleportation:



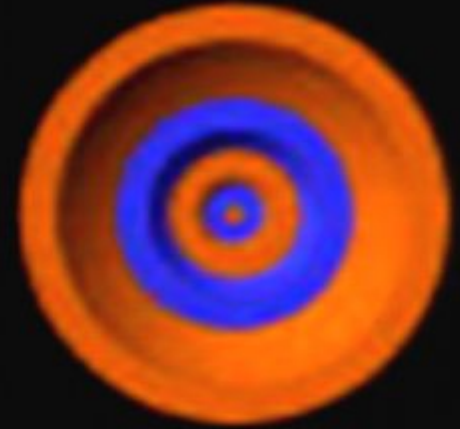
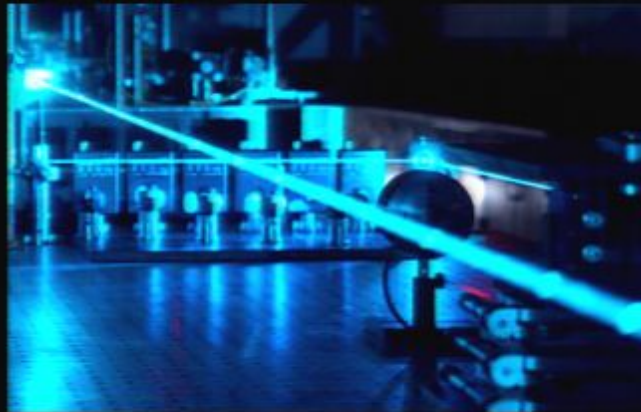
quantum teleportation:



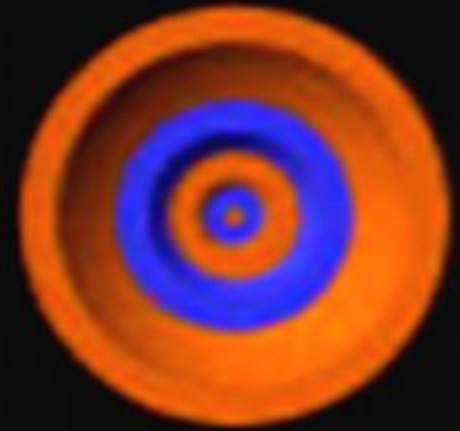
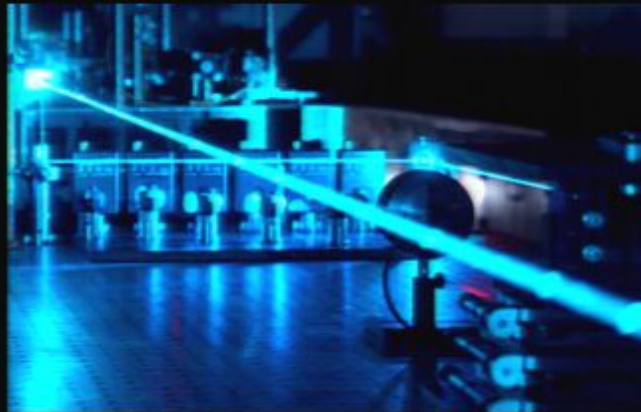
quantum teleportation:



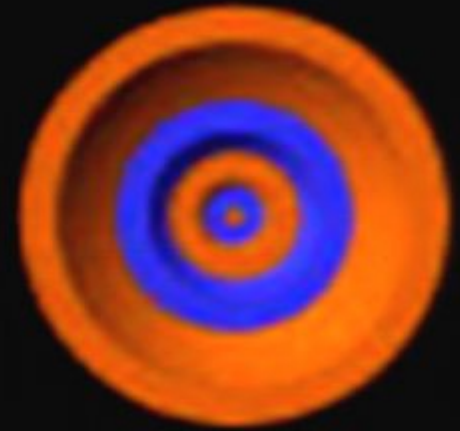
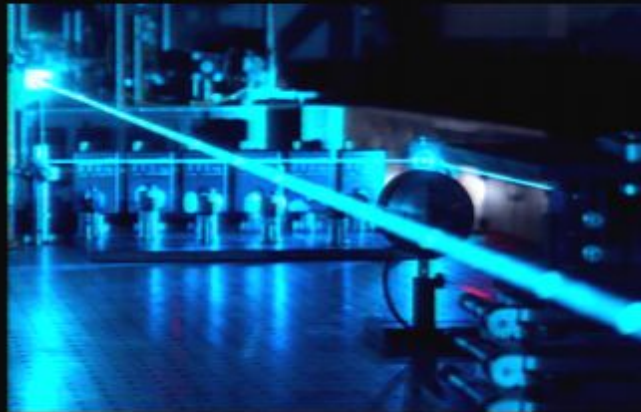
quantum teleportation:



quantum teleportation:



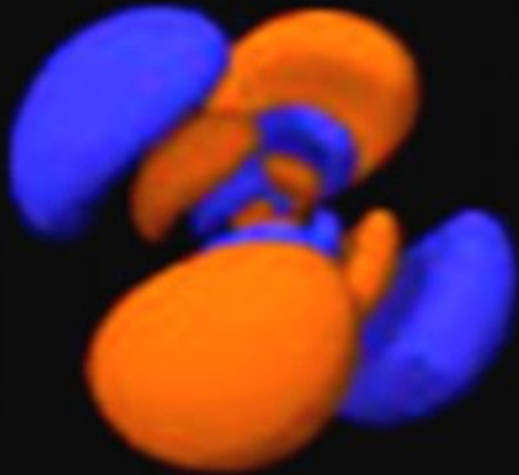
quantum teleportation:



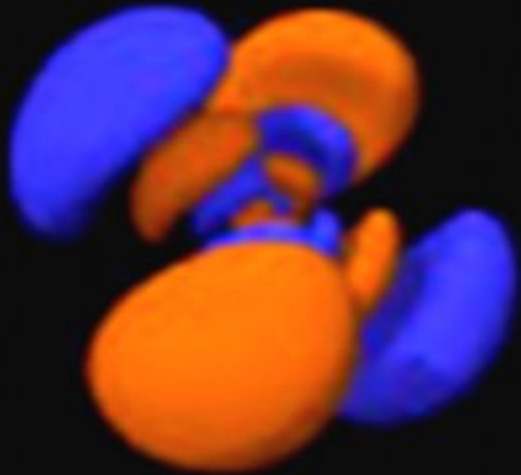
quantum teleportation:



quantum teleportation:



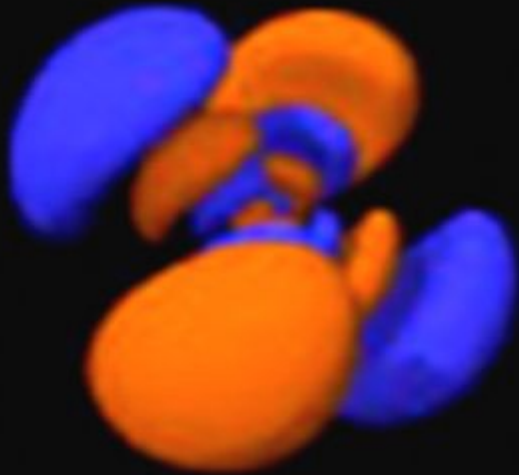
quantum teleportation:



Asher Peres asked: “Teleport not only the body, but also the soul?”



quantum teleportation:

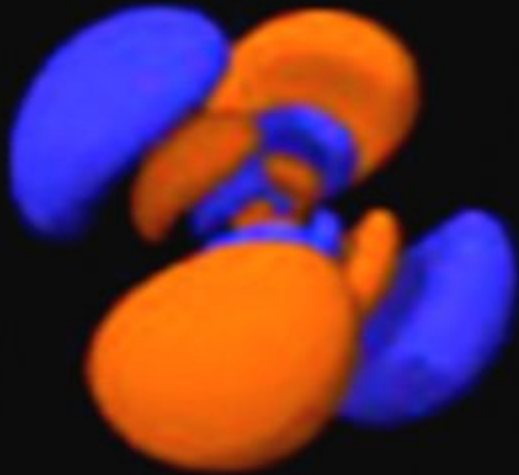


Asher Peres asked: "Teleport not only the body, but also the soul?"



Replied: "*Only* the soul."

quantum teleportation:



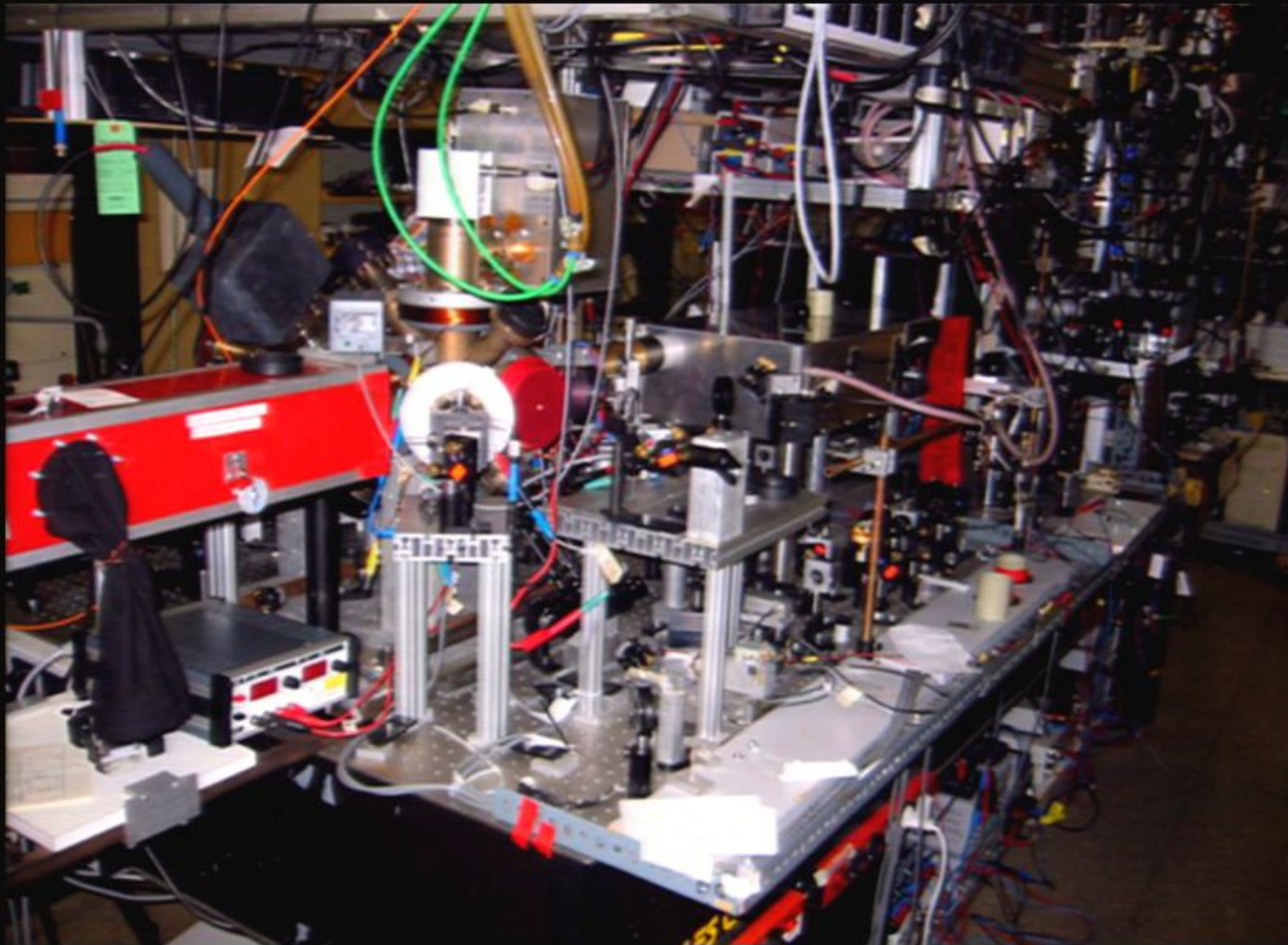
Asher Peres asked: "Teleport not only the body, but also the soul?"



Replied: "*Only* the soul."

very freaky!

quantum teleportation:

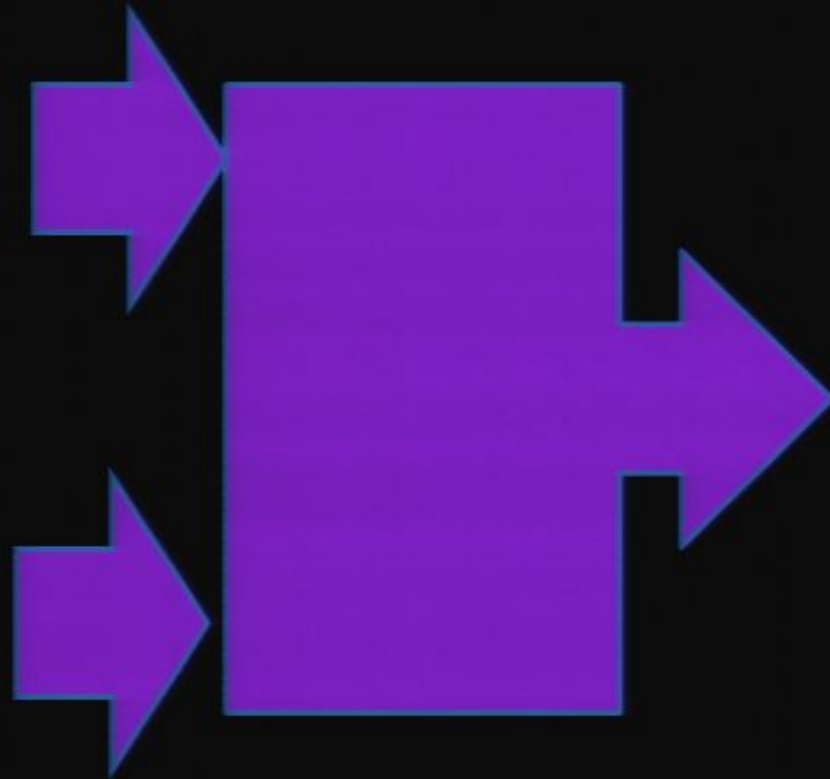


quantum computing:

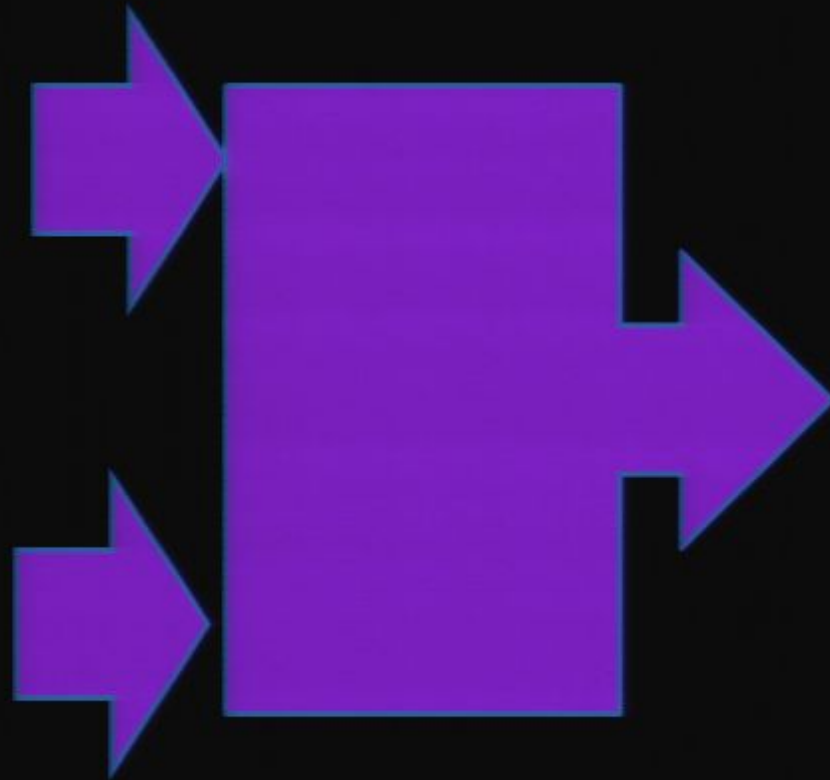
quantum computing:



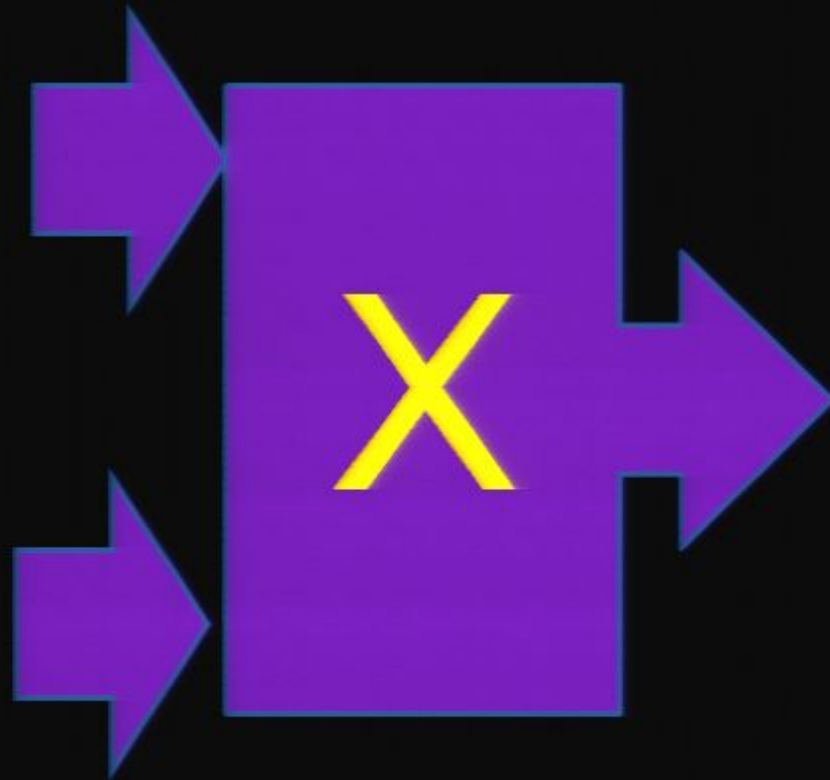
quantum computing:



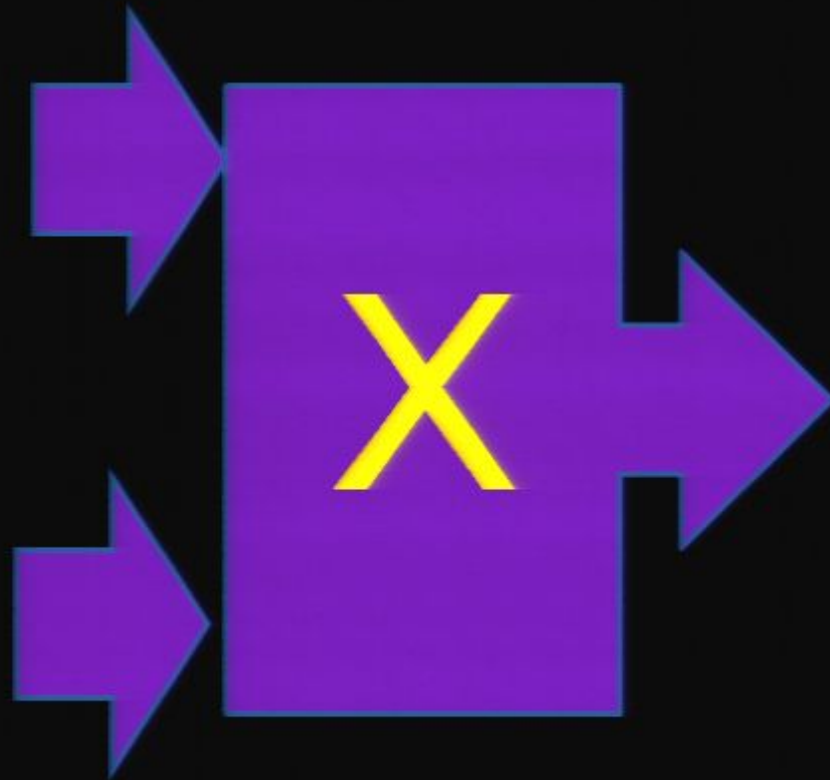
quantum computing:



quantum computing:

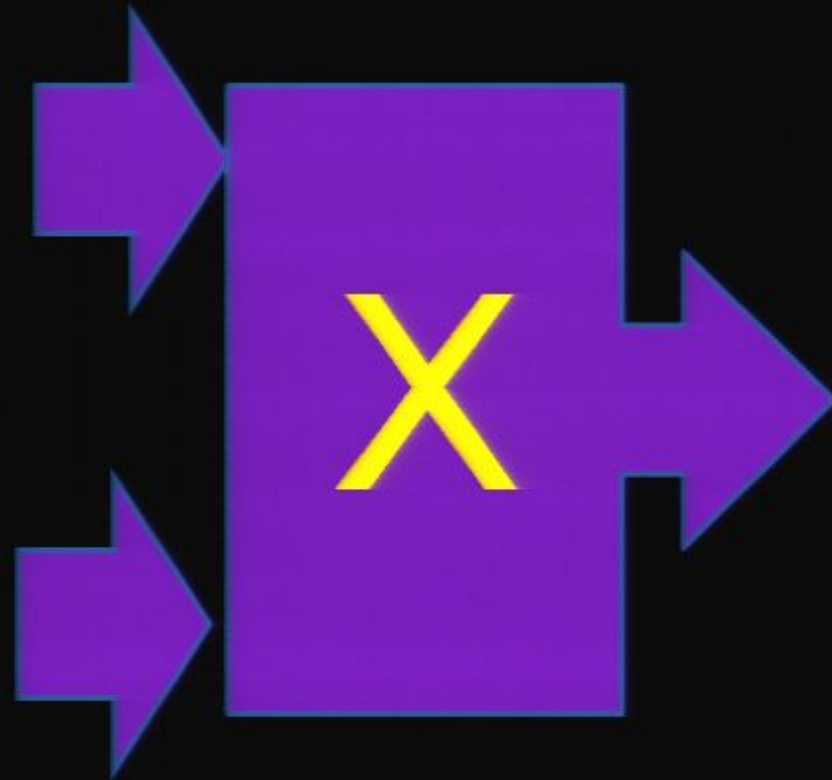


quantum computing:



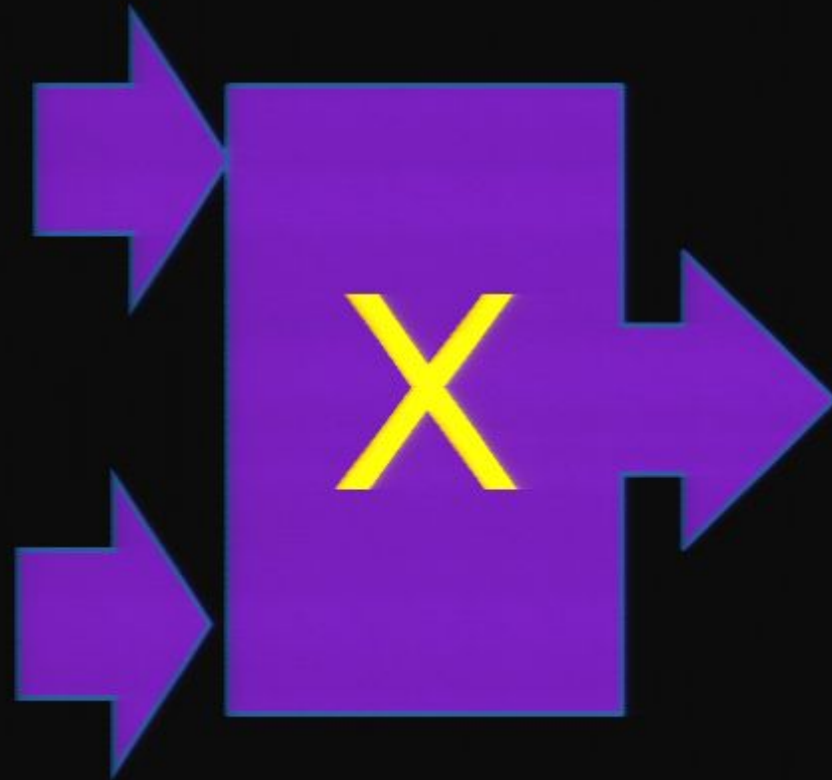
0

quantum computing:



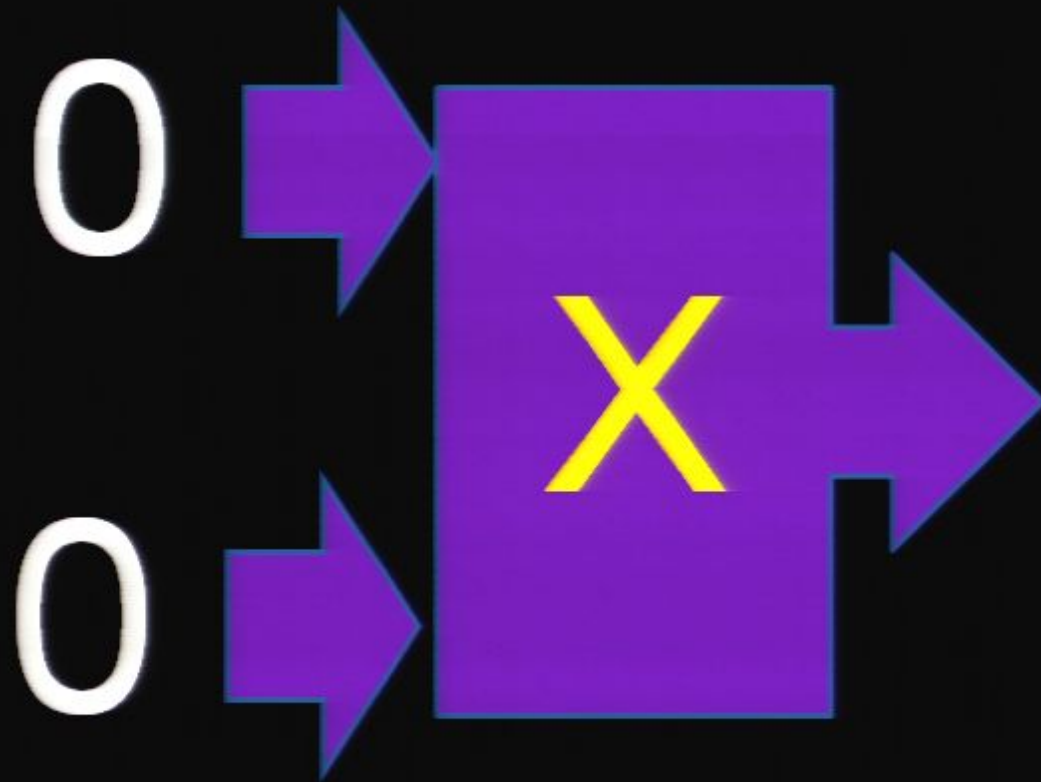
0 or 1

quantum computing:



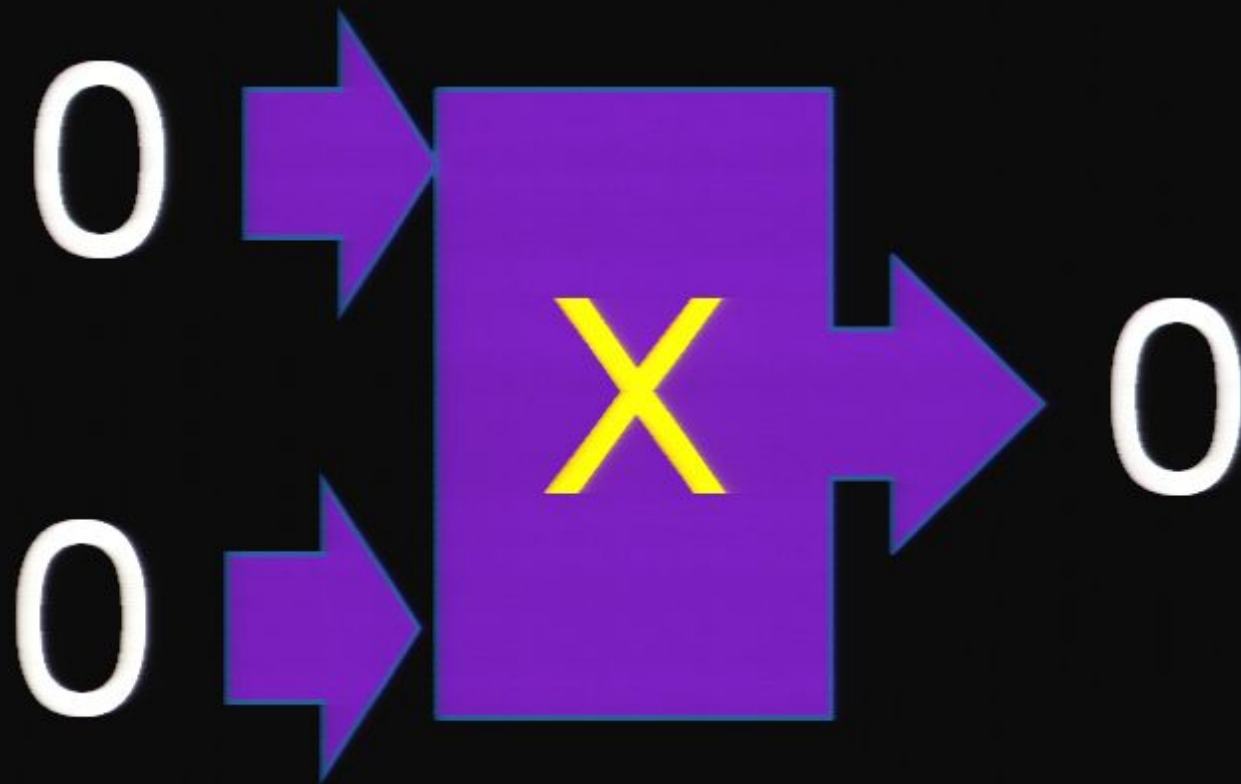
0 or 1

quantum computing:



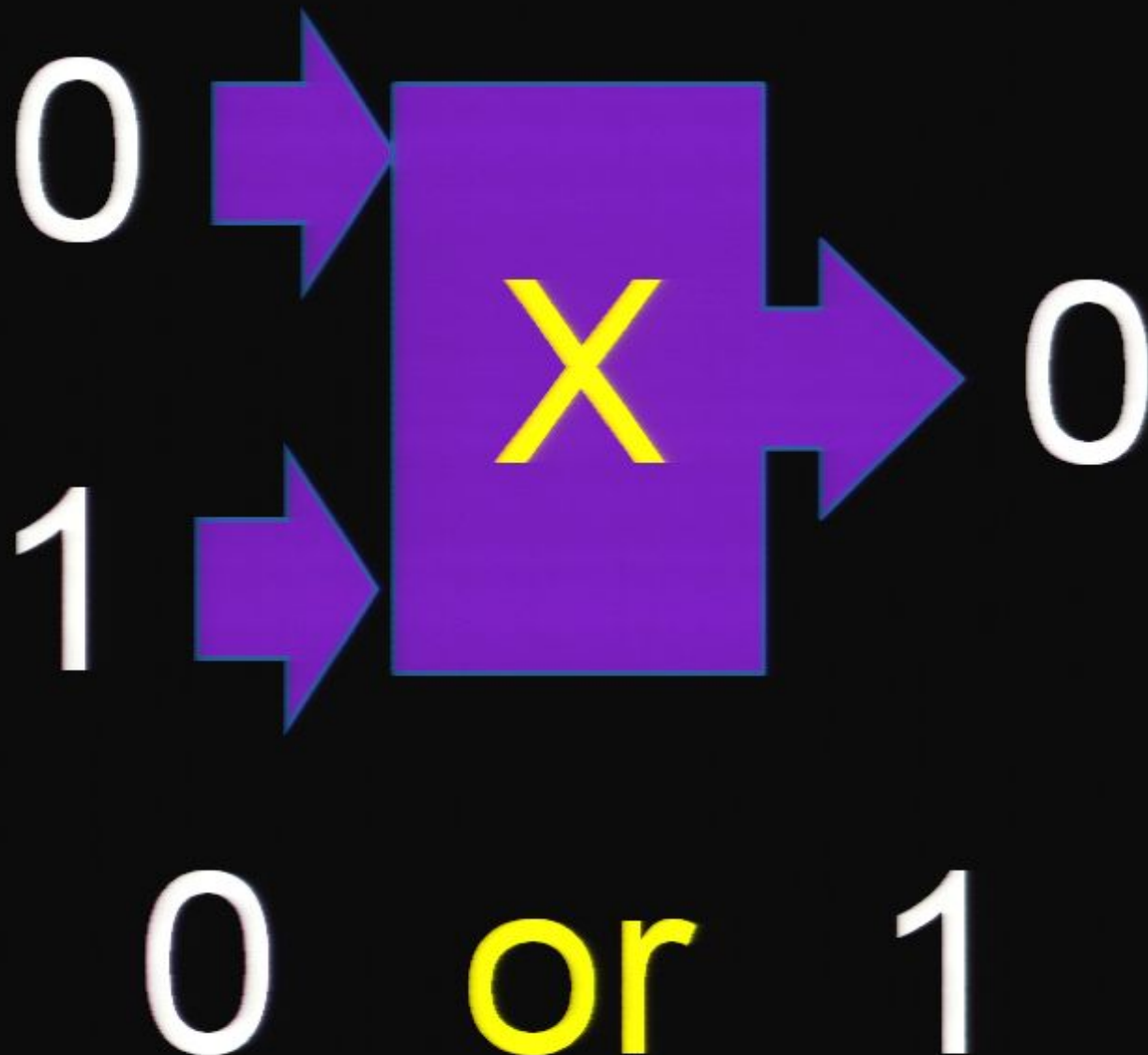
0 or 1

quantum computing:

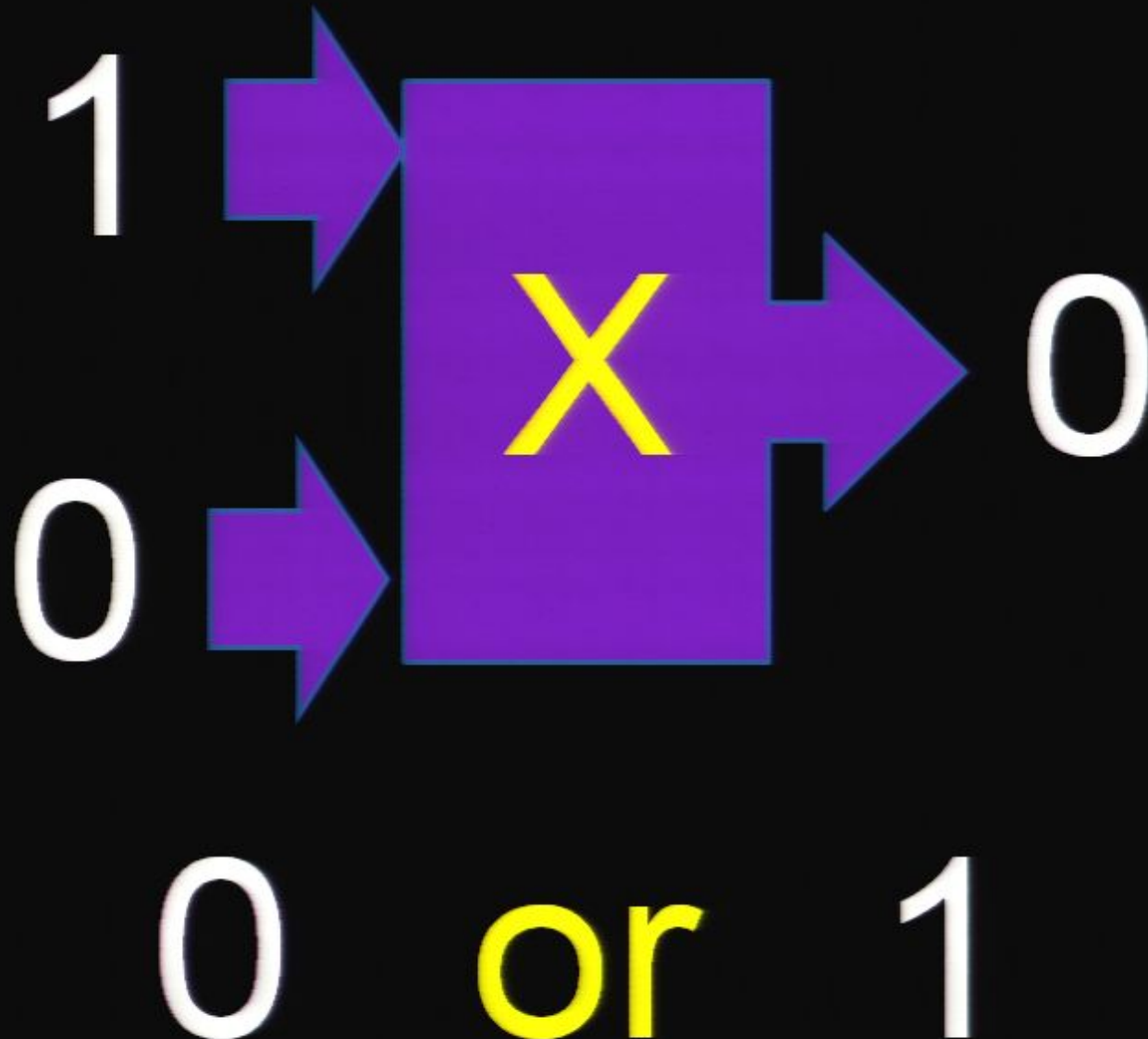


0 or 1

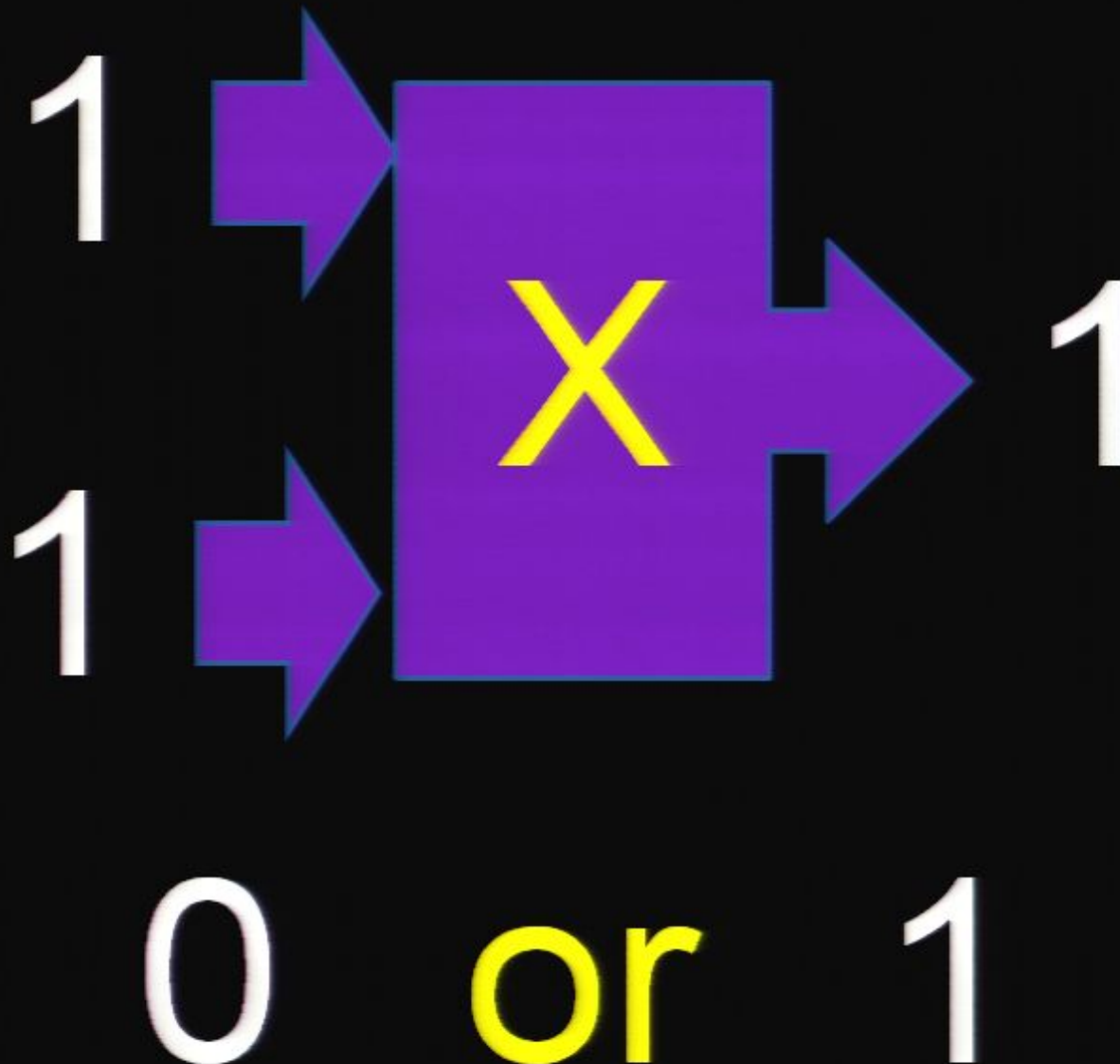
quantum computing:

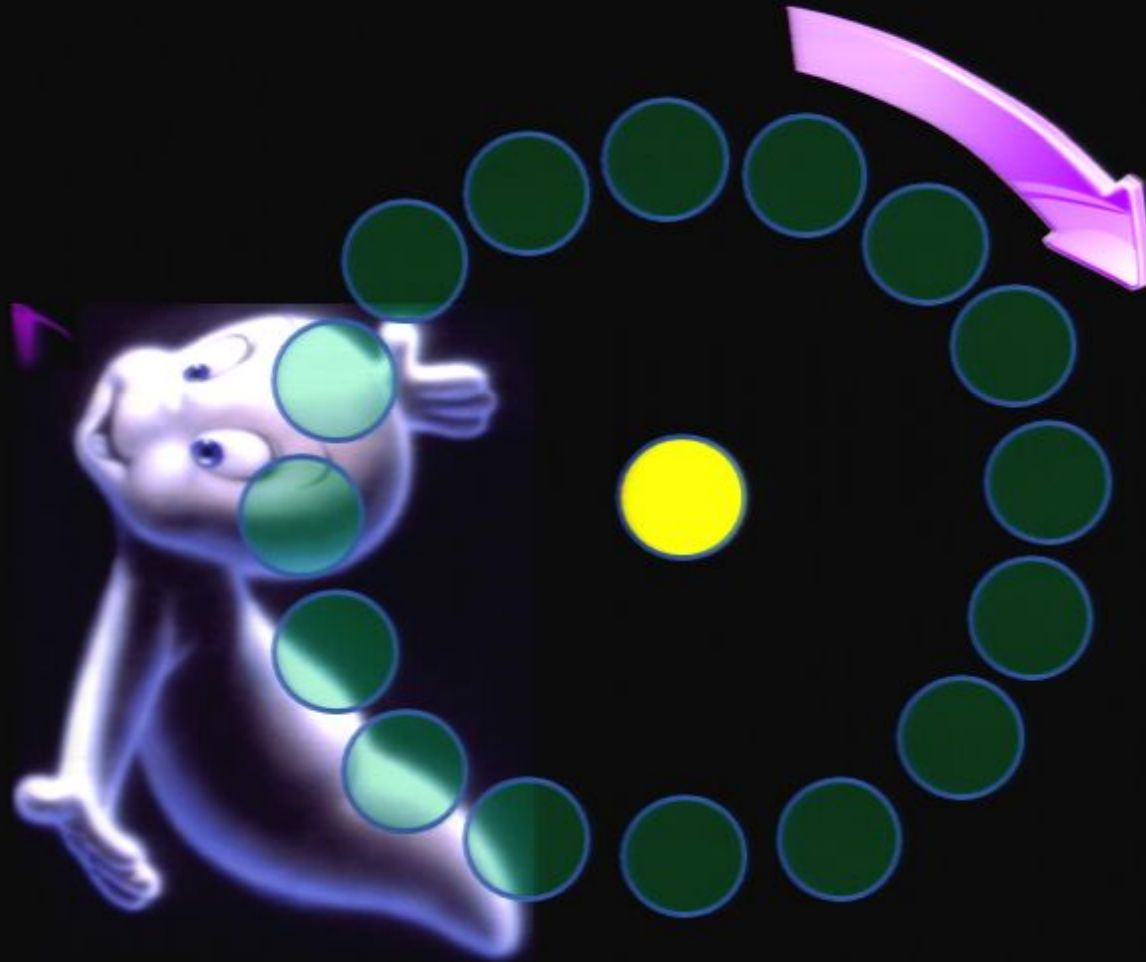


quantum computing:

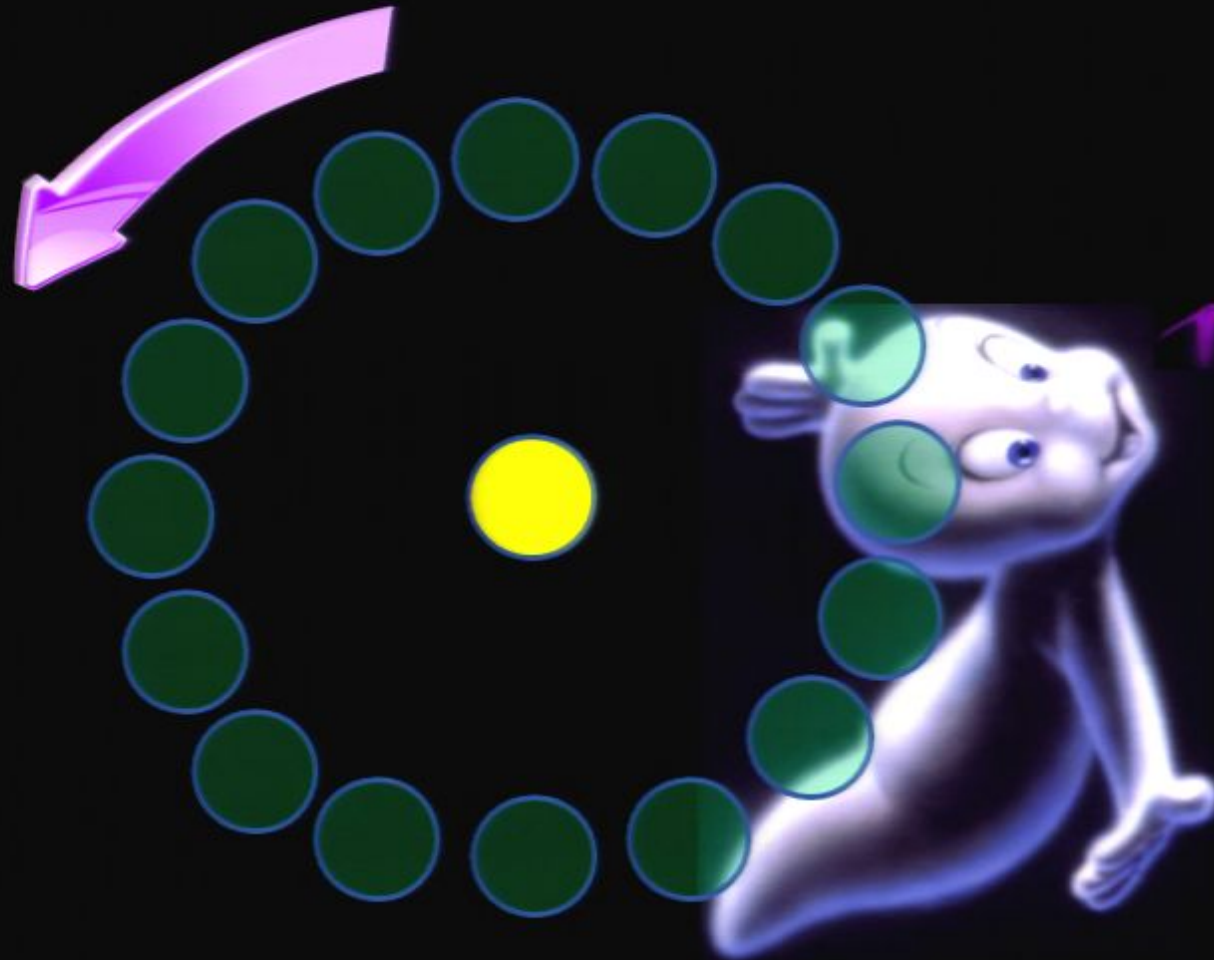


quantum computing:

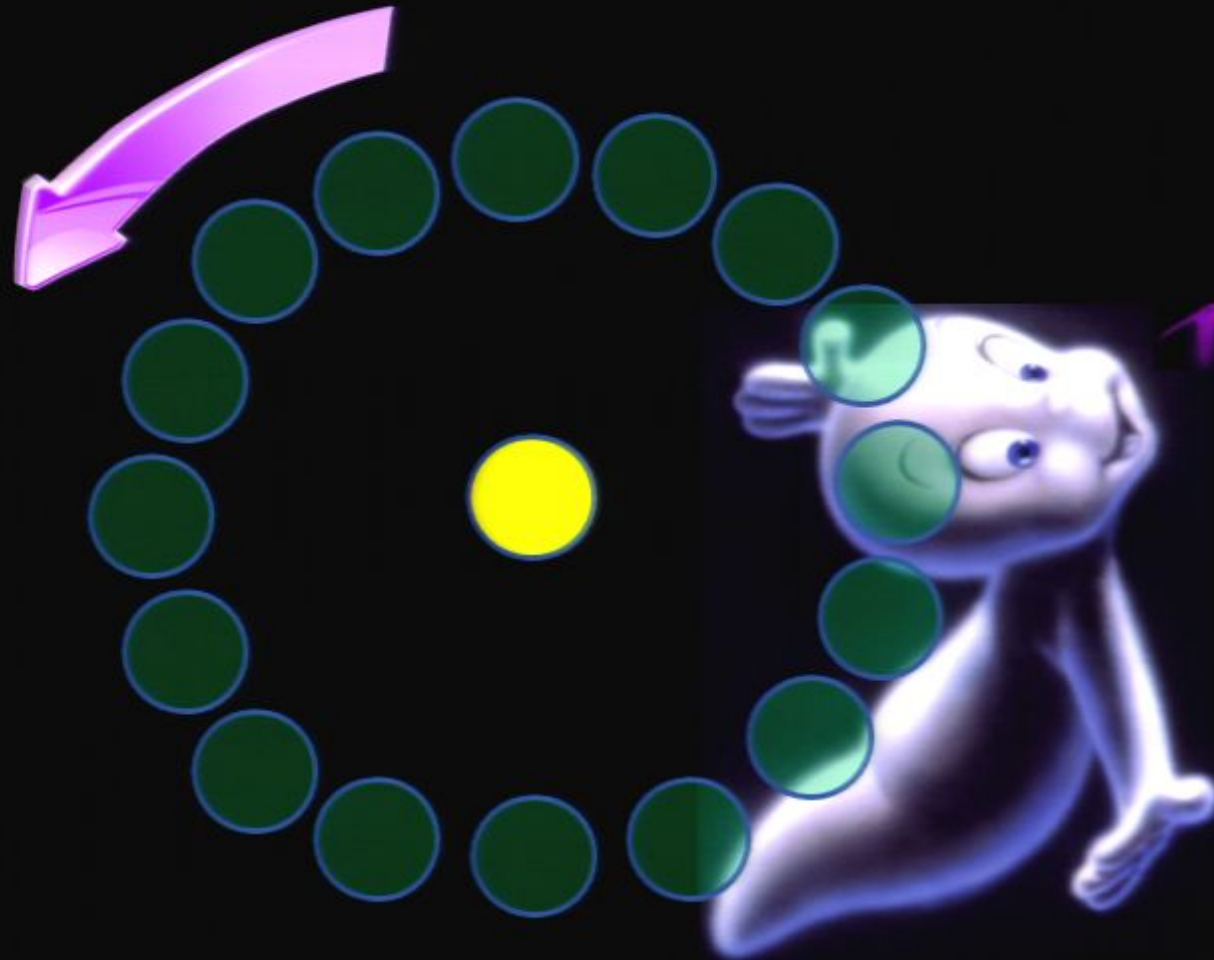




ghost goes right

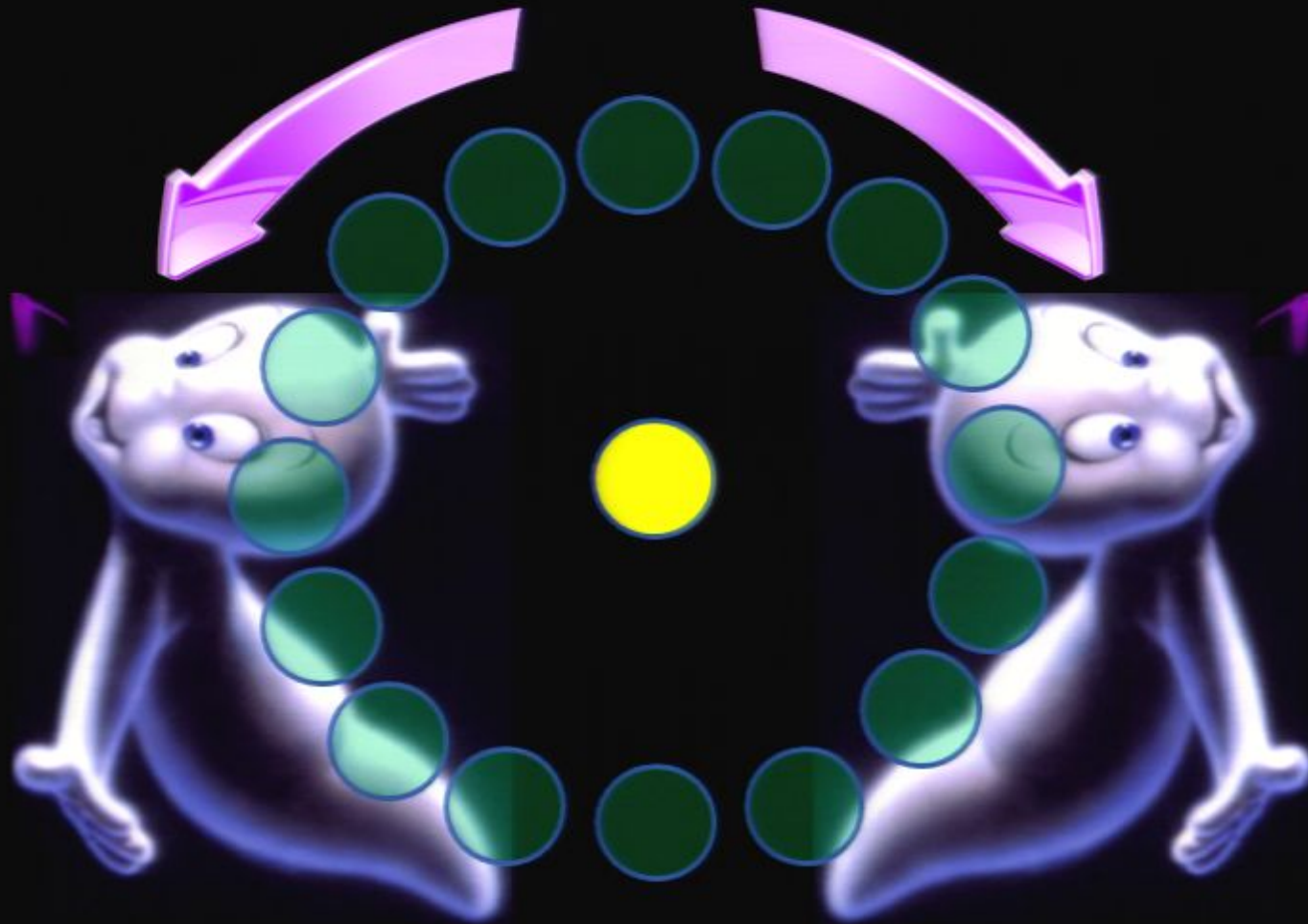


ghost goes left



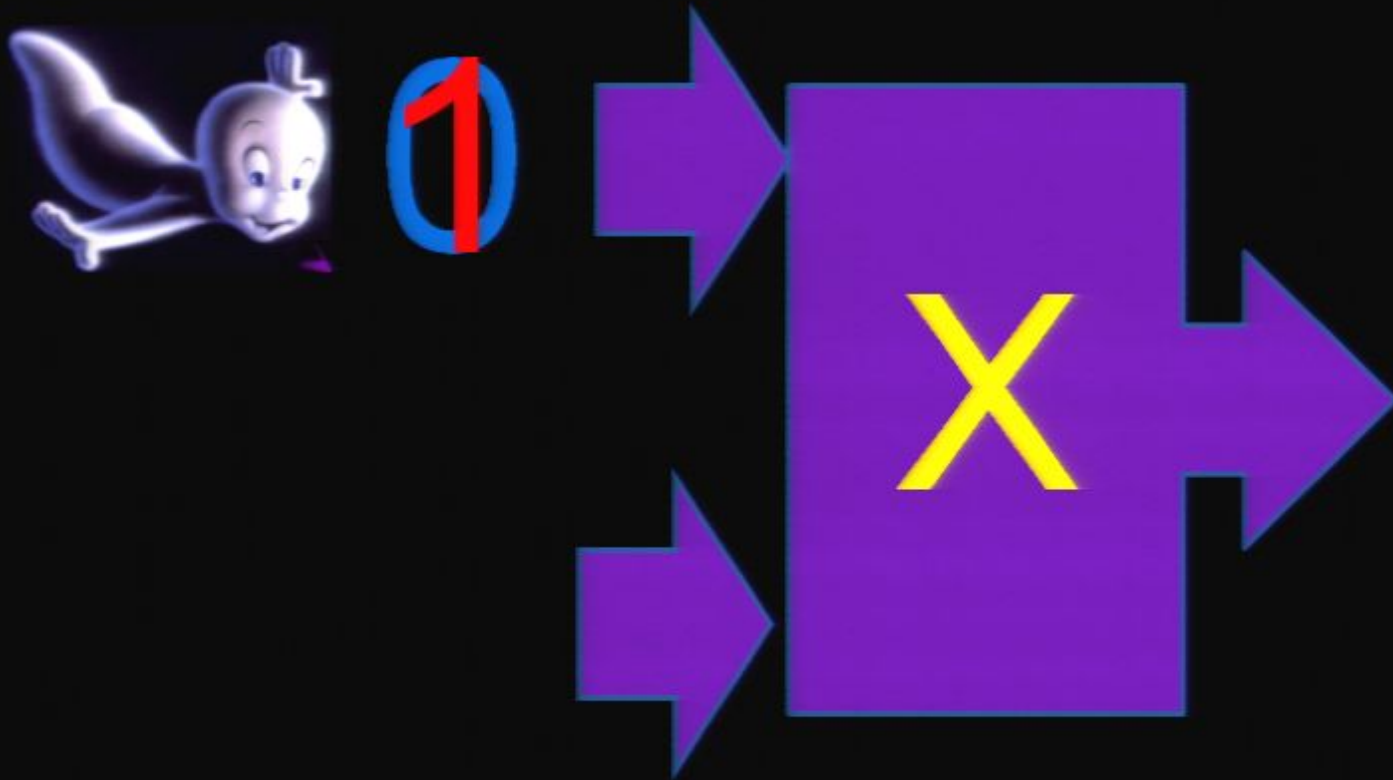
ghost goes left

= 1



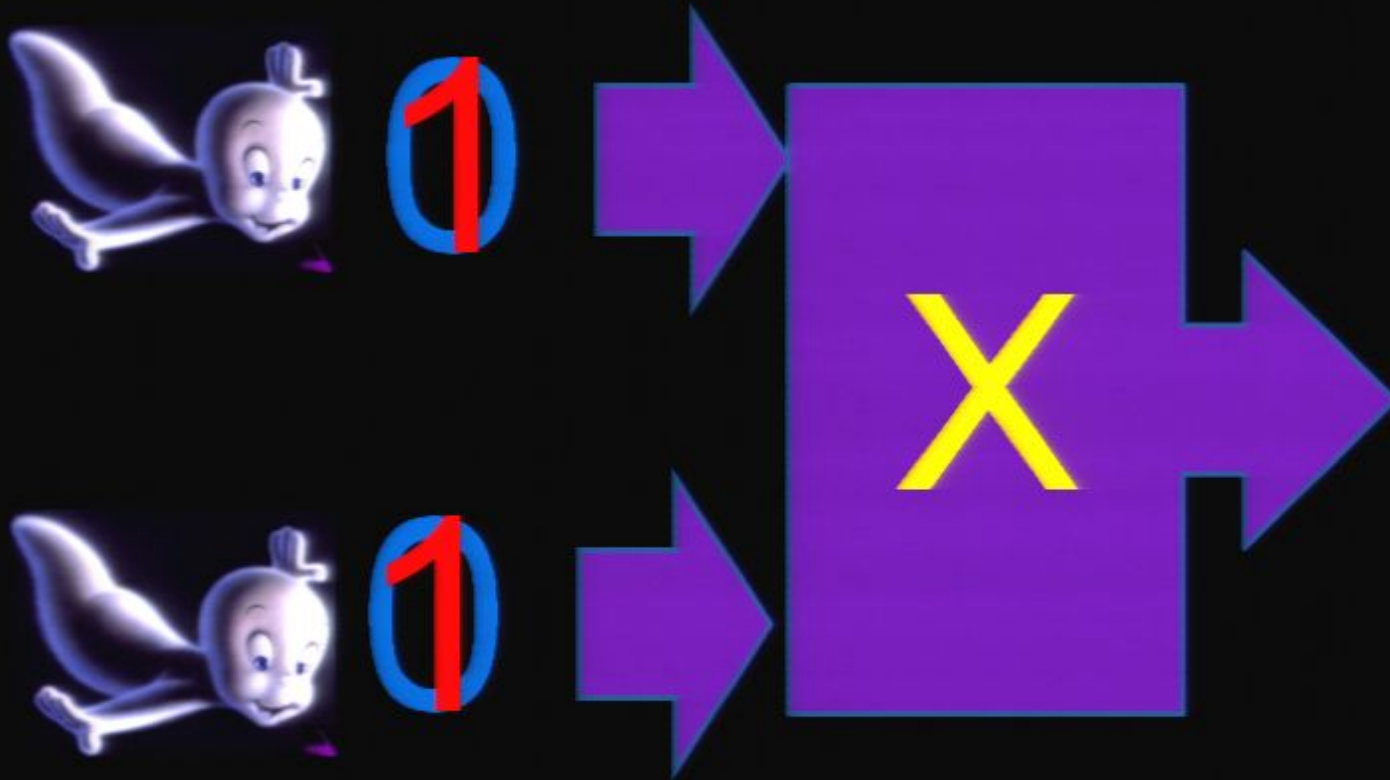
super-ghost goes right **AND** left
...simultaneously = 0 and 1

quantum computing:



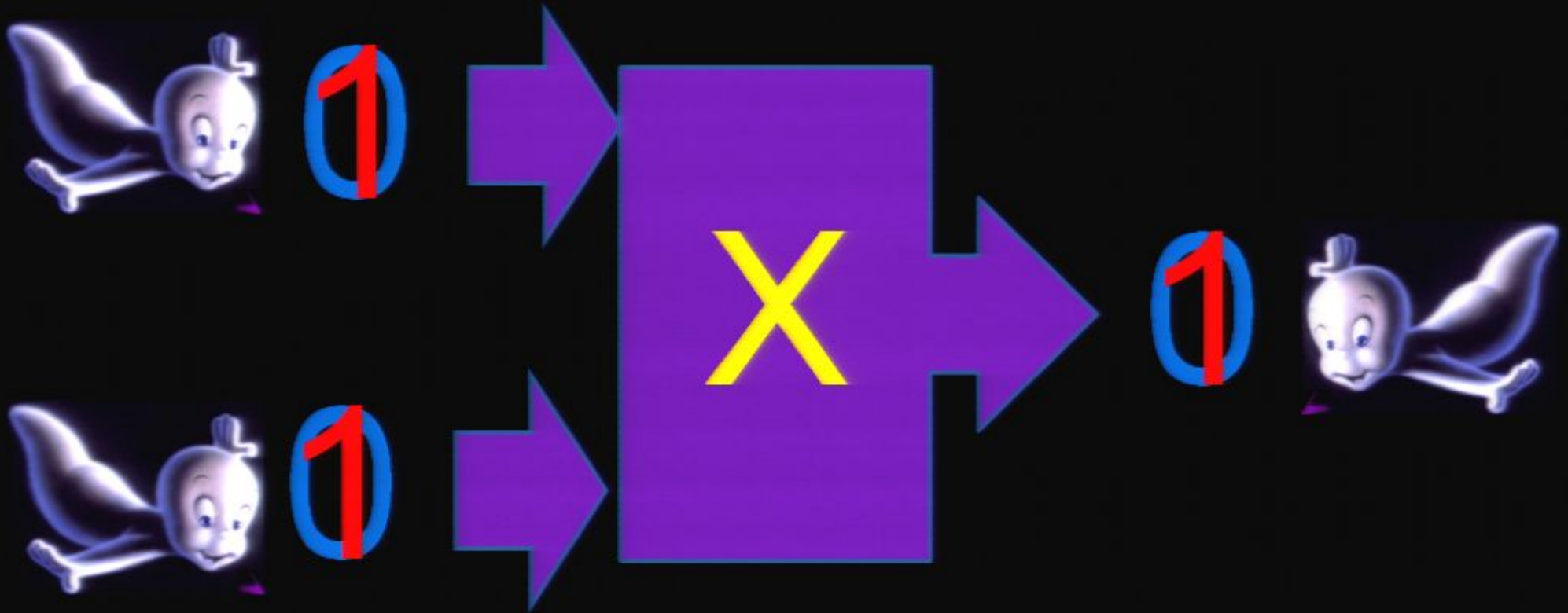
0 and 1

quantum computing:



0 and 1

quantum computing:



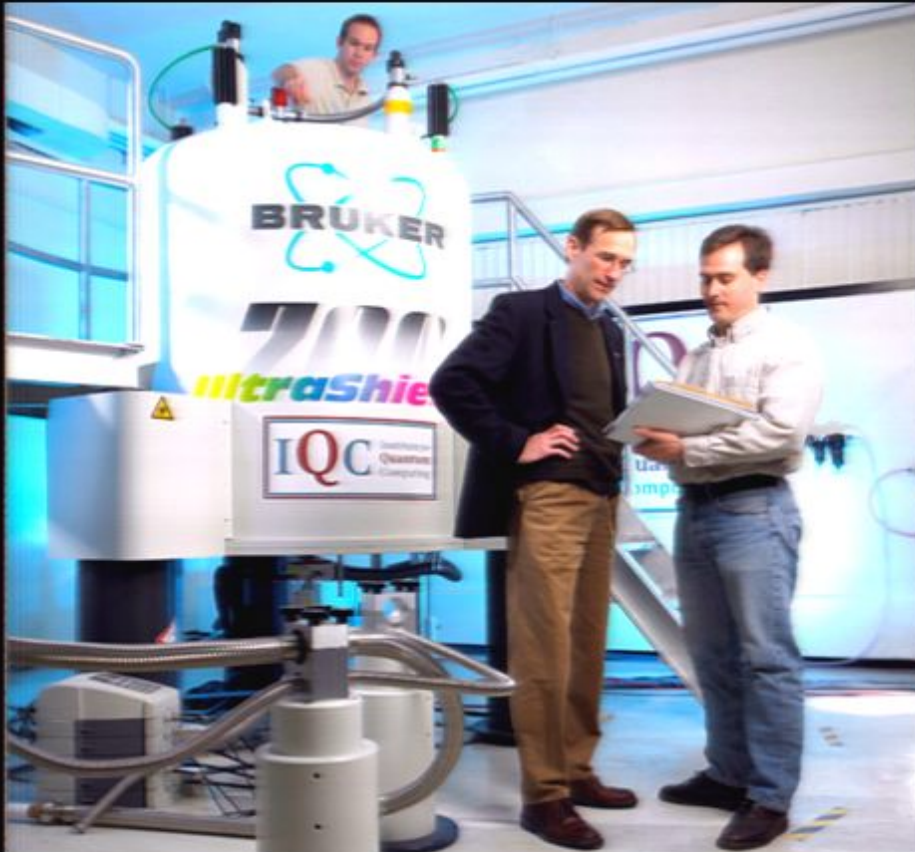
0 and 1

quantum *computing*:

exponential boost in computing power!

quantum computing:

exponential boost in computing power!



quantum *computing*:

exponential boost in computing power!



what can a QC do?

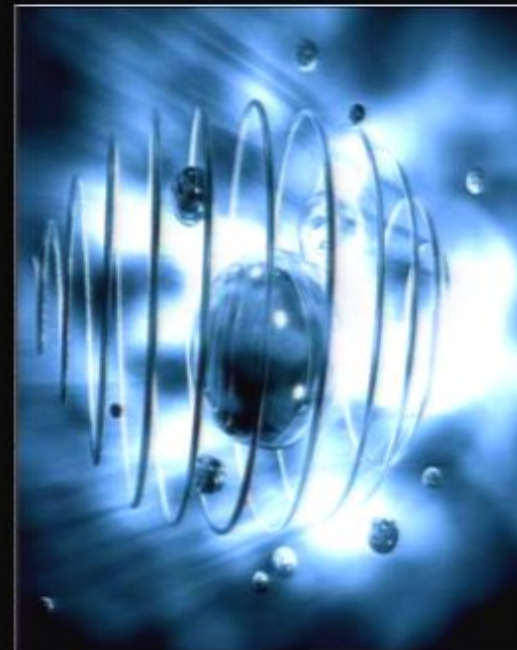
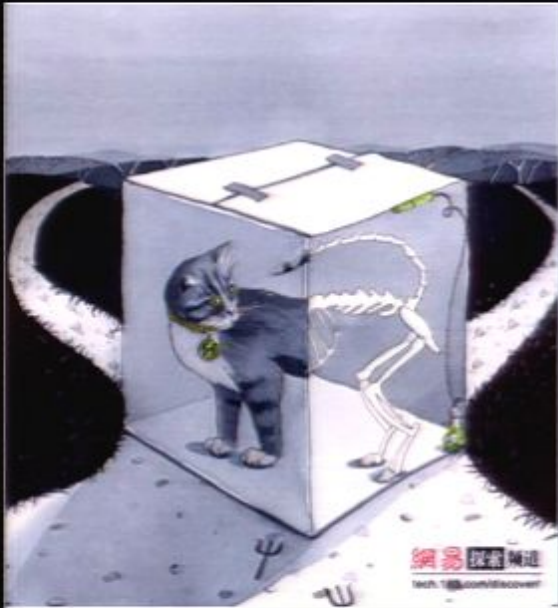
quantum *computing*:

exponential boost in computing power!



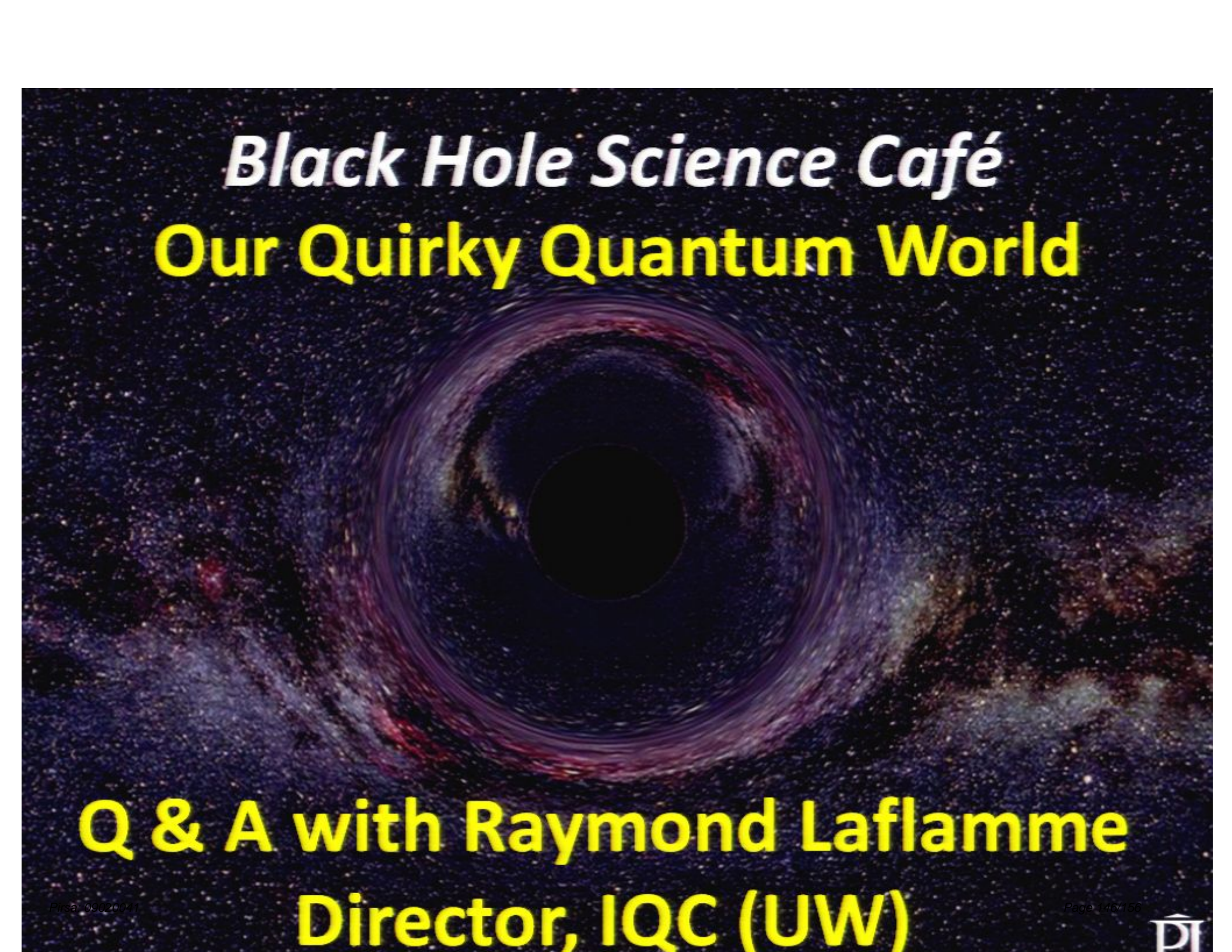
what can a QC do?
how do we build one?

quantum is:



quantum is:

the future

A black hole with a glowing accretion disk against a starry space background.

Black Hole Science Café

Our Quirky Quantum World

Q & A with Raymond Laflamme
Director, IQC (UW)

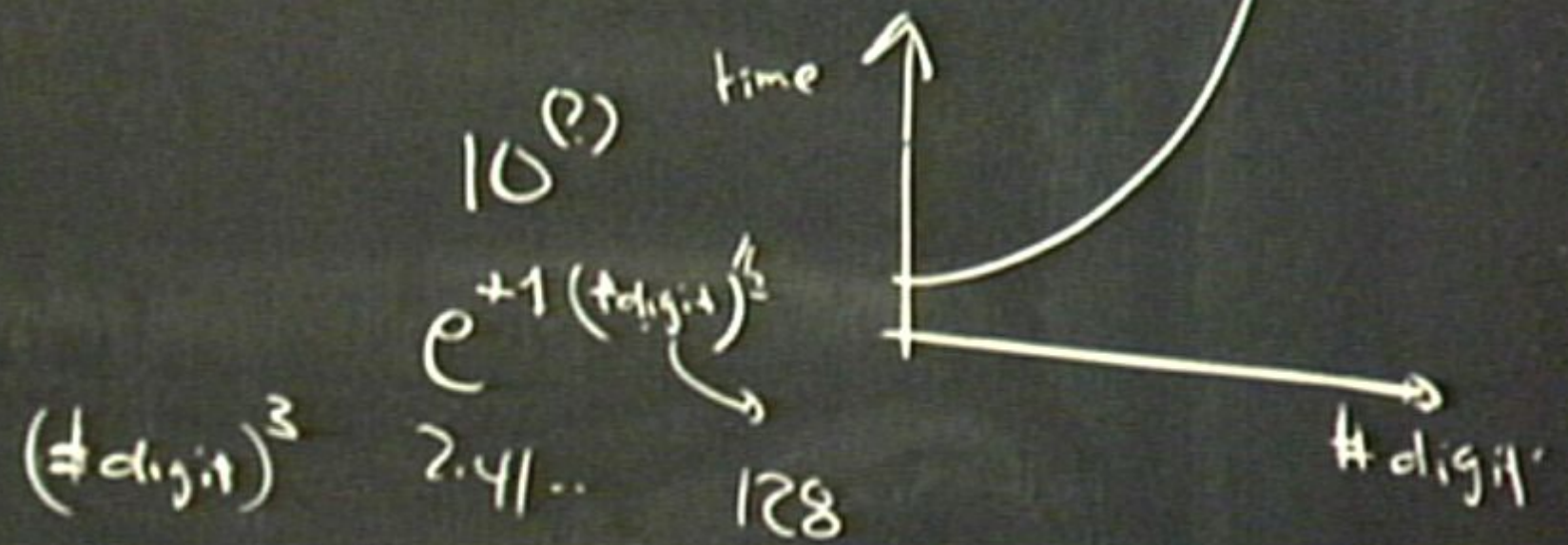
$$\underline{15 = 5 \times 3}$$

$$2401 = 7 \times 7 \times 7 \times 7 \times 7$$



$$15 = 5 \times 3$$

$$2401 = 7^5 = 7^2 \times 7^3$$



Orl Omd1

→ 0101110

00
01
10
11

1110111

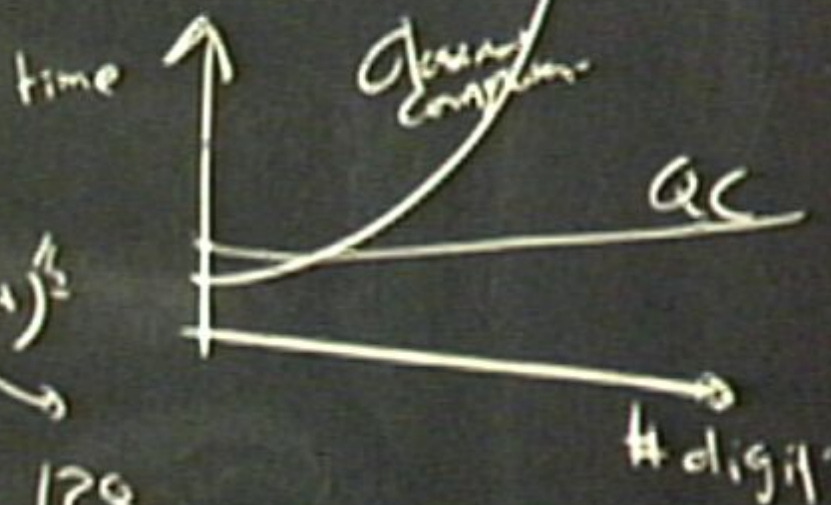
10000 quantum bits
12 qubits

(#digit)³

10^(p)
e^{+1 (#digit)³}
2.41... 128

$$15 = 5 \times 3$$

2401. → 3 × 37



00
01
10
11

- Superposition principle

- A measure affects
always the Q. system.

A \rightarrow B

B \rightarrow X

X \rightarrow Z

m \rightarrow F

Probability A

B

C

E

0 or 1

0 mod 1

M 0101110

^{PN}
Key 1011101

11110011

- Superposition principle

J 1011101

0 or 1

0 mod 1

M: 0101110

PV

Key: 1011101

Encryption

result

1110011

- Superposition principle

J: 1011101

0 or 1

0 mod 1

M: 0101110

PN
Key

1011101

J: 1011101

Encrypted
message

1110011

1110011

0101110

- Superposition principle

Please join us for the next
Black Hole Science Café



...meanwhile, visit the PI website:
public lectures...what we research...

Please join us for the next
Black Hole Science Café



...meanwhile, visit the PI website:
public lectures...what we research...

Please join us for the next
Black Hole Science Café



...meanwhile, visit the PI website:
public lectures...what we research...