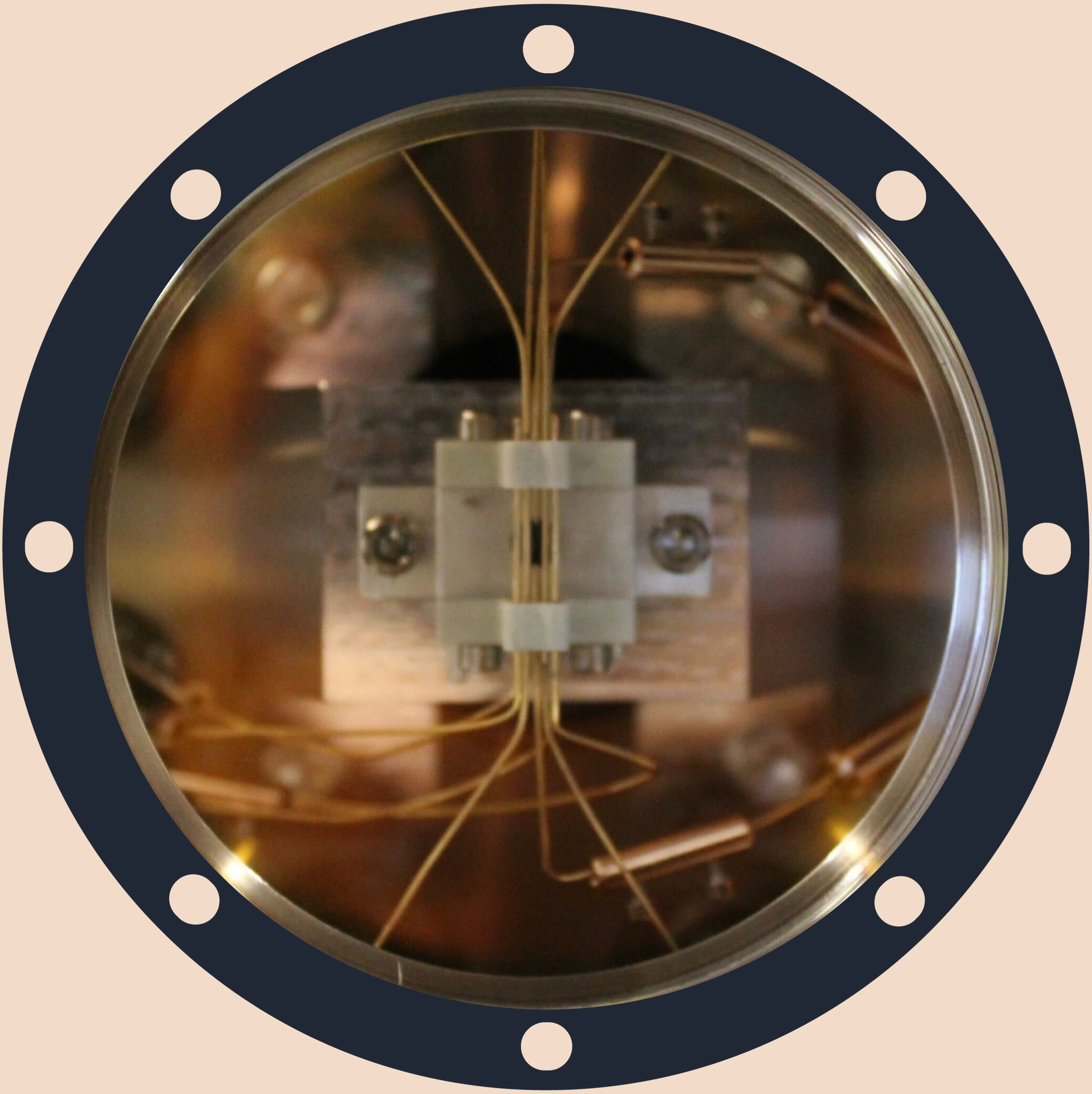
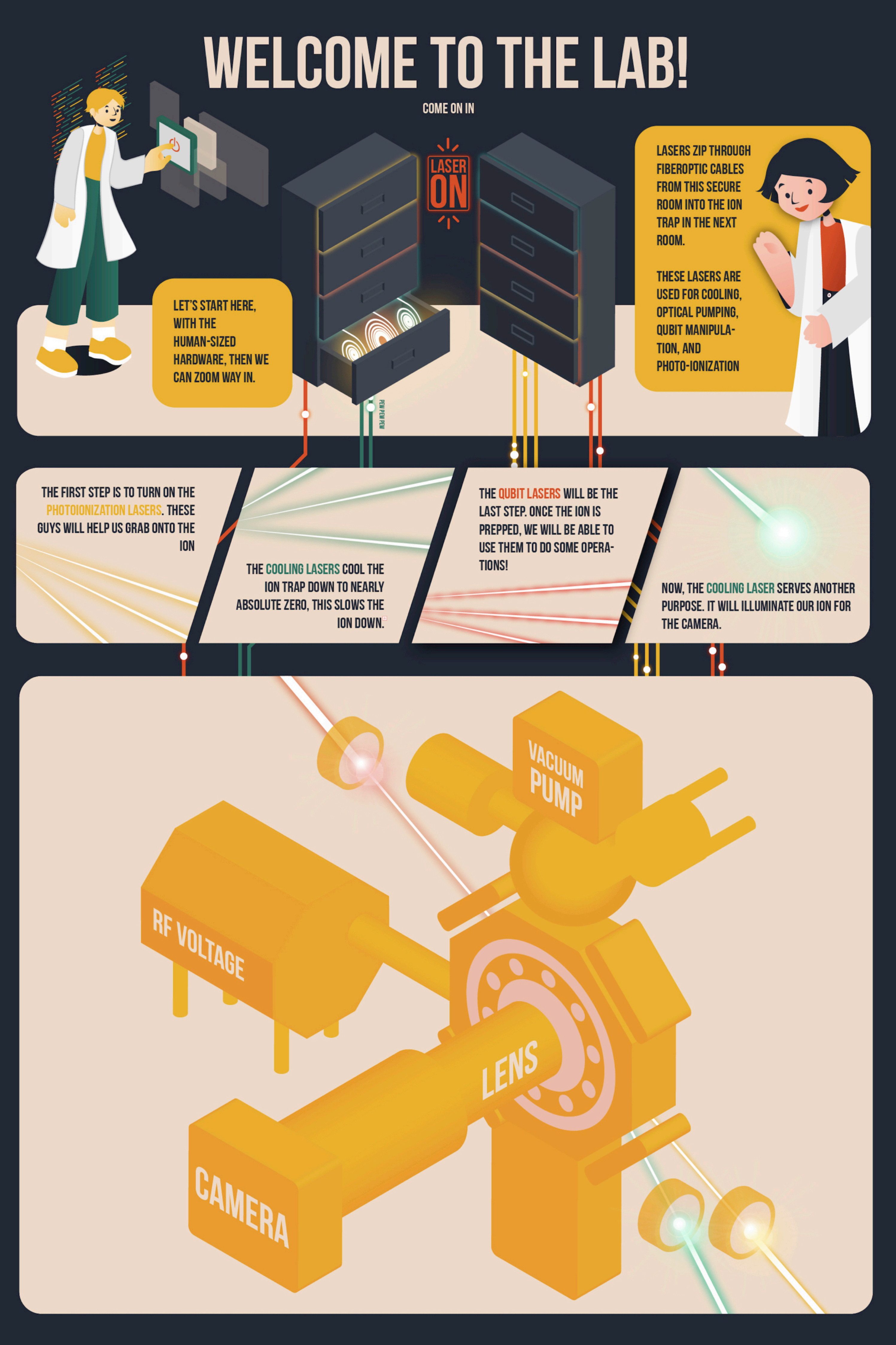
OREGON IONS

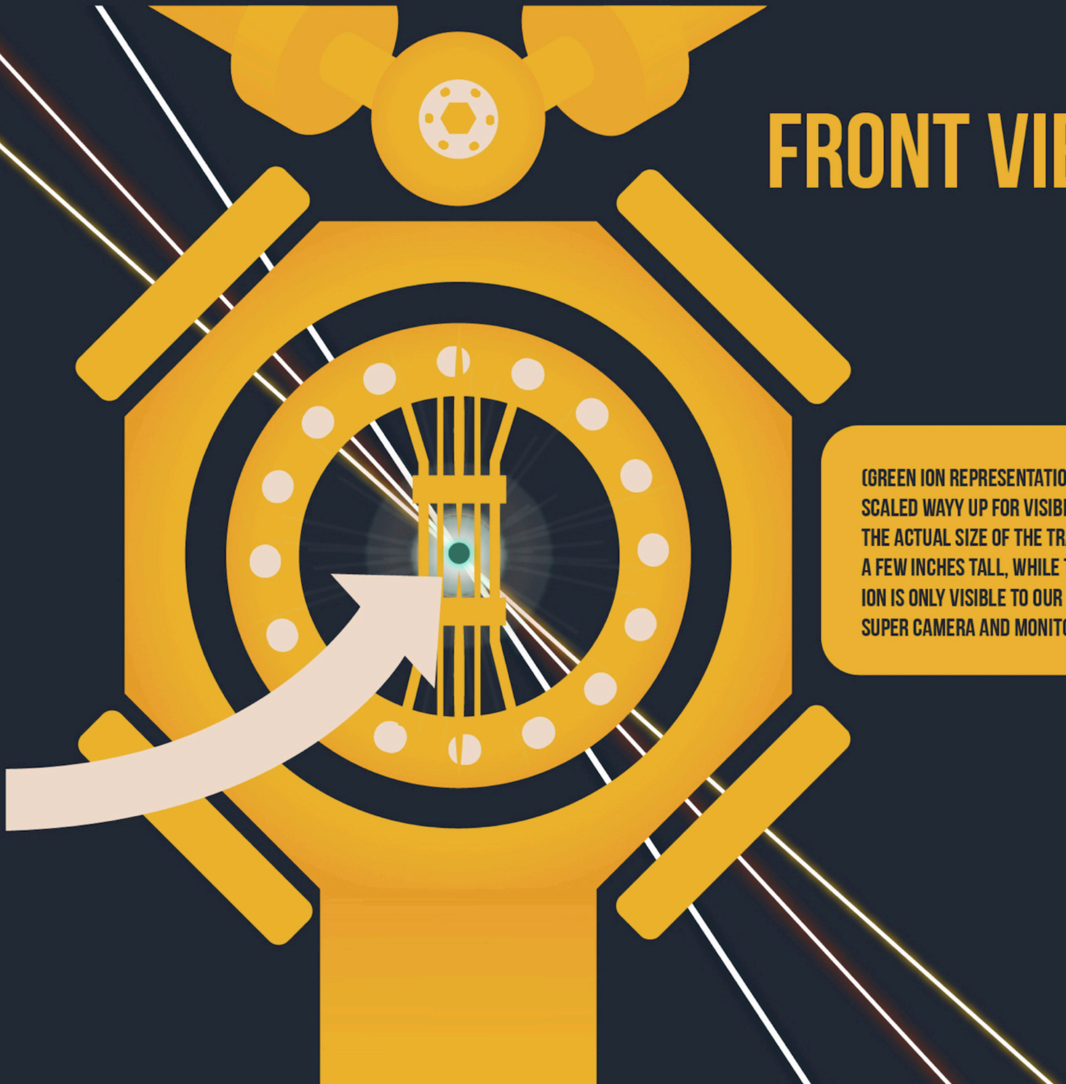


ANJA BEDRICK

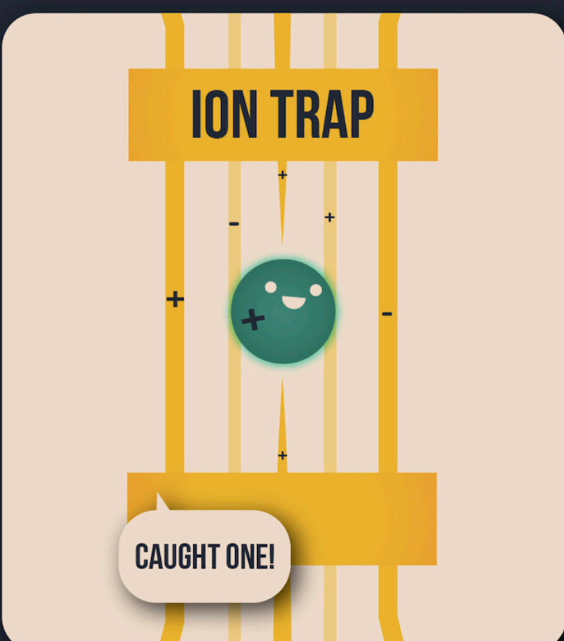
DAVID ALLCOCK


WELCOME TO THE LAB!
COME ON IN
LASER ON
LET'S START HERE, WITH THE HUMAN-SIZED HARDWARE, THEN WE CAN ZOOM WAY IN.
PEW PEW PEW
LASERS ZIP THROUGH FIBEROPTIC CABLES FROM THIS SECURE ROOM INTO THE ION TRAP IN THE NEXT ROOM.
THESE LASERS ARE USED FOR COOLING, OPTICAL PUMPING, QUBIT MANIPULA-TION, AND PHOTO-IONIZATION
THE FIRST STEP IS TO TURN ON THE PHOTOIONIZATION LASERS. THESE GUYS WILL HELP US GRAB ONTO THE ION
THE COOLING LASERS COOL THE ION TRAP DOWN TO NEARLY ABSOLUTE ZERO, THIS SLOWS THE ION DOWN.
THE QUBIT LASERS WILL BE THE LAST STEP. ONCE THE ION IS PREPPED, WE WILL BE ABLE TO USE THEM TO DO SOME OPERA-TIONS!
NOW, THE COOLING LASER SERVES ANOTHER PURPOSE. IT WILL ILLUMINATE OUR ION FOR THE CAMERA.
VACUUM PUMP
RF VOLTAGE
LENS
CAMERA

FRONT VIEW

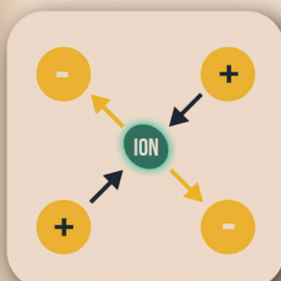


(GREEN ION REPRESENTATION SCALED WAYY UP FOR VISIBILITY) THE ACTUAL SIZE OF THE TRAP IS A FEW INCHES TALL, WHILE THE ION IS ONLY VISIBLE TO OUR SUPER CAMERA AND MONITOR.



TOP DOWN VIEW:

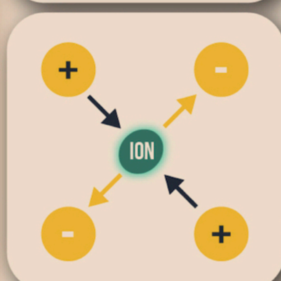
4 WIRES, 2 CHARGES, 1 ION



NOW HOW DO WE KEEP IT THERE?

We have 4 wires set up around the ion. two are positively charged, and two are negatively charged. Positive charges push, and the negative pulls.

two positive needles above and below keep it from slipping up or down.



BUT WAIT, IT GET'S WEIRDER

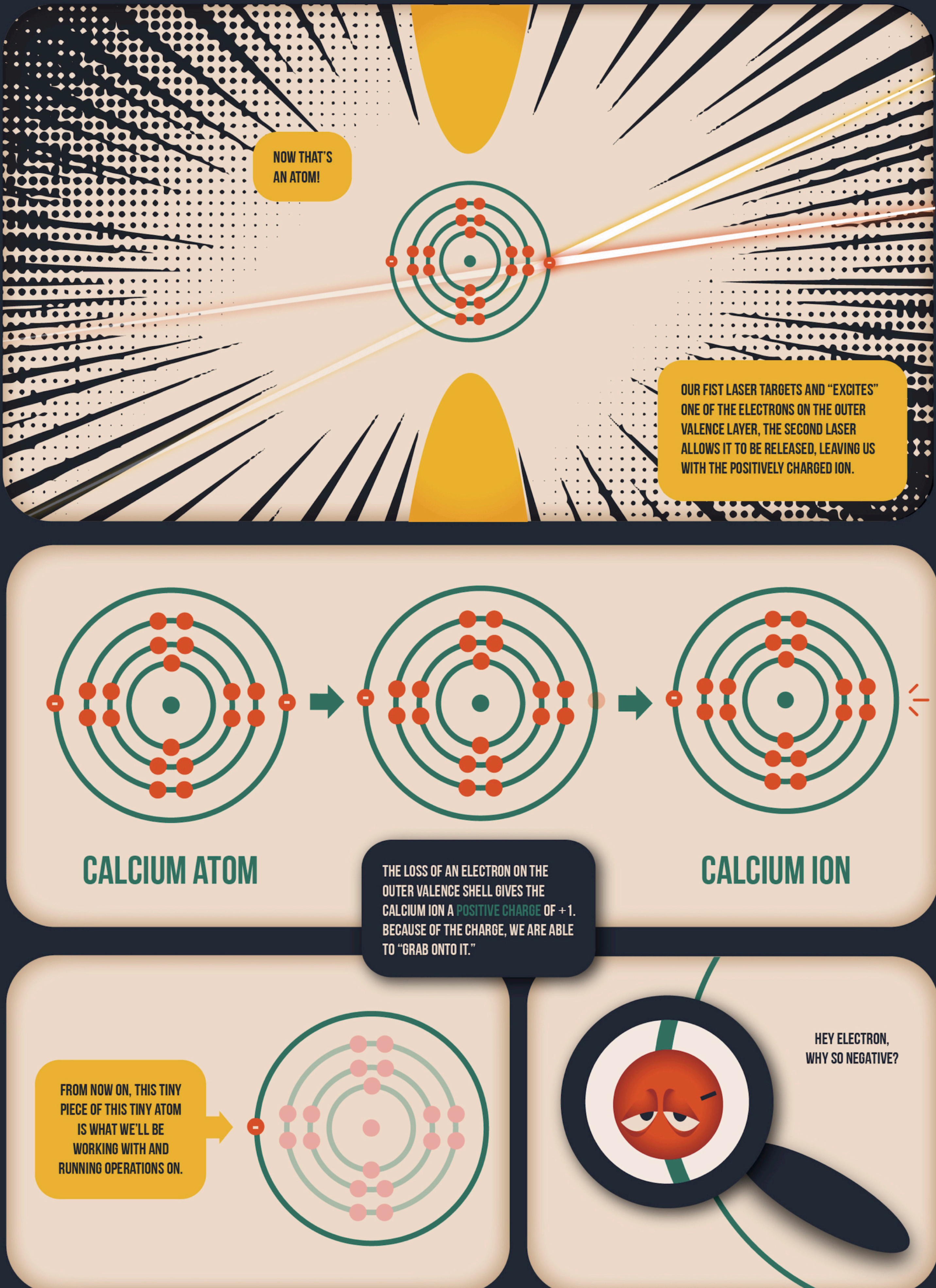
The four wires don't keep their charges the same—they alternate. take a look at the top down view. the same charge will always be opposite each other, but we "occilate" them rapidly to keep the ion from squeezing out.

IMAGINE A SPINNING SADDLE.

PUT A MARBLE IN THE MIDDLE

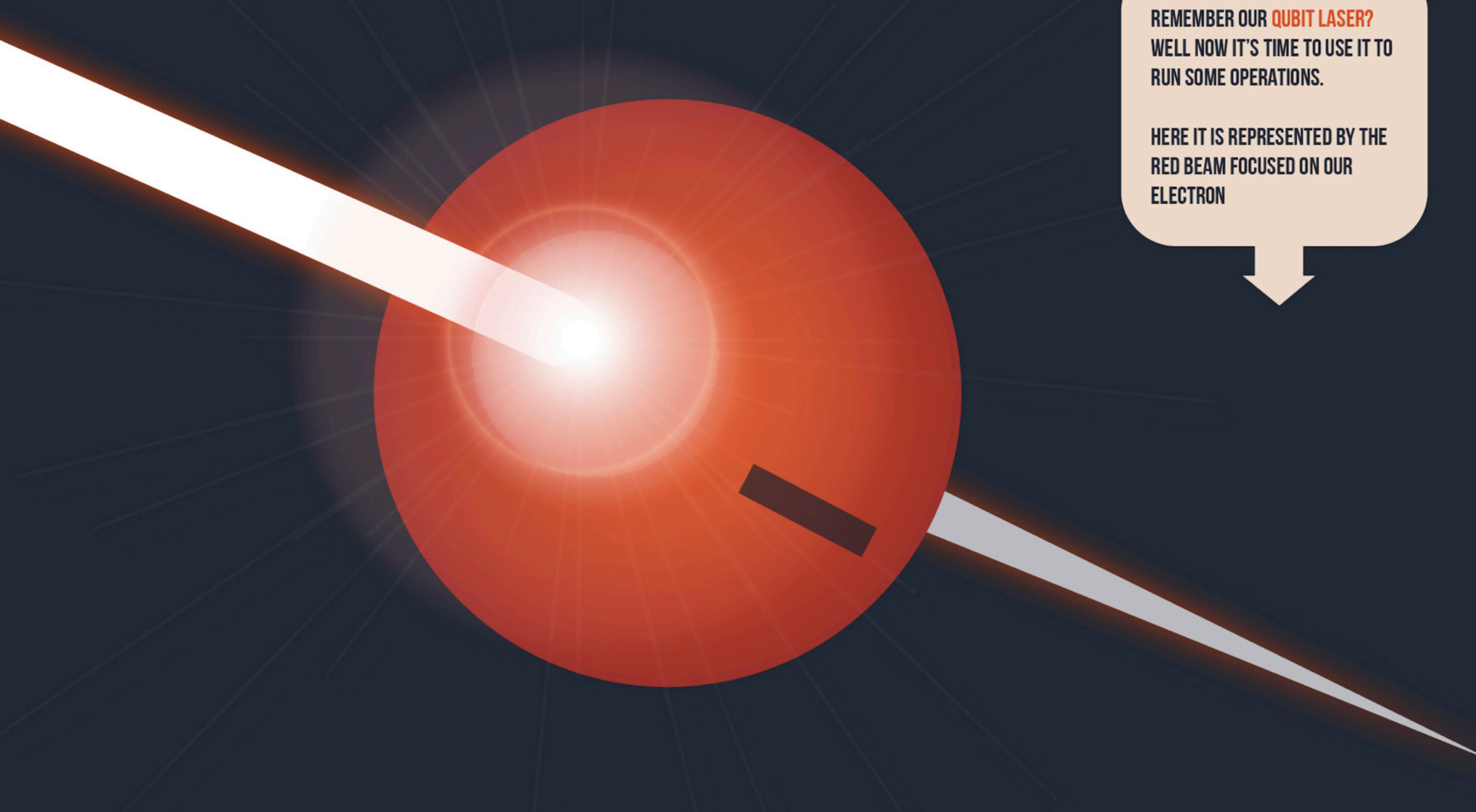
IF THE SADDLE SUDDENLY STOPS SPINNING, GRAVITY WILL ALLOW THE MARBLE TO ESCAPE. IF WE STOP OSSILATING THE PUSH/PULL FORCES ON THE ION, THE SAME THING WILL HAPPEN. THIS TYPE OF TRAP IS CALLED AN RF TRAP, A QUADROPOLE ION TRAP, OR A PAUL TRAP.

LET'S ZOOM IN A LITTLE MORE.



REMEMBER OUR QUBIT LASER? WELL NOW IT'S TIME TO USE IT TO RUN SOME OPERATIONS.

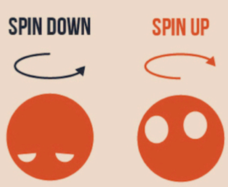
HERE IT IS REPRESENTED BY THE RED BEAM FOCUSED ON OUR ELECTRON



"ELECTRON SPIN" IS A QUANTUM PROPERTY OF ELECTRONS. IF THE ELECTRON SPINS CLOCKWISE ON ITS AXIS, ITS STATE IS DESCRIBED AS "SPIN UP." COUNTERCLOCKWISE IS "SPIN DOWN."

WE CAN USE OUR QUBIT LASER TO "EXCITE" THE ELECTRON, PUTTING IT IN STATE "SPIN UP."

SO WHAT?



HOW DOES THIS LEAD TO QUANTUM COMPUTING?

THINK ABOUT A CLASSICAL COMPUTER. ALL ITS OPERATIONS ARE BASED ON A BINARY SYSTEM. IF YOU ZOOM IN TO THE SMALLEST UNIT OF DATA A CLASSICAL COMPUTER CAN STORE, YOU GET A "BIT," IN ONE OF TWO STATES: ZERO OR ONE.

WELL, FOR NOW, THE ELECTRON'S SPIN STATES SIMILARLY REPRESENT EITHER A ZERO OR ONE, SPIN DOWN OR SPIN UP.

NOW THINGS GET A LITTLE MORE COMPLICATED. THE SPIN VALUE OF AN ELECTRON CAN ACTUALLY HAVE ANY VALUE BETWEEN ZERO AND ONE, REPRESENTED BY POINTS ON THE BLOCH SPHERE BELOW. UNTIL OBSERVED, THE ELECTRON HAS A CERTAIN CHANCE OF BEING IN EITHER STATE

ONLY ONCE MEASURED DOES IT HAVE A SPECIFIC VALUE.

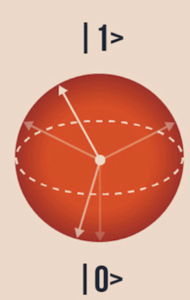
CLASSICAL COMPUTING BINARY:

ZEROS AND ONES. THAT'S IT.

QUANTUM COMPUTING

CAN BE AT ANY POINT ON THIS DIAGRAM BETWEEN | 0> (SPIN DOWN) AND | 1> (SPIN UP)

EACH POINT REPRESENTS A LINEAR COMBINATION OF THE TWO STATES



NOW WHAT?

NOW WE HAVE A QUANTUM BIT, OR A QUBIT TO WORK WITH.

UNLIKE OUR CLASSICAL BITS THAT CAN ONLY BE 0 OR 1, A QUBIT CAN EXIST IN SUPERPOSITION OF MULTIPLE STATES AT ONCE.

THIS MEANS QUANTUM COMPUTING CAN STORE AND PROCESS INFORMATION IN DIFFERENT STATES SIMULTANEOUSLY, ALLOWING IT TO WORK ON MULTIPLE OPERATIONS AT THE SAME TIME.

IN 1935 ERWIN SCHRÖDINGER PROPOSED A THOUGHT EXPERIMENT TO ILLUSTRATE THE ABSURDITY OF QUANTUM SUPERPOSITION.

HOW COULD TWO STATES EXIST SIMULTANEOUSLY UNTIL OBSERVATION? IF A CAT EXISTED IN A CLOSED BOX OF POISON WITH A 50-50 CHANCE OF SURVIVAL, COULD THE CAT BE CONSIDERED BOTH ALIVE AND DEAD UNTIL THE BOX WAS OPENED?

SOME FIND IT EASIER TO VISUALIZE AS A COIN TOSS. WHILE IN THE AIR, THE OUTCOME OF THE TOSS REALLY IS OPEN WITH NO DEFINITE VALUE.

ONLY WHEN CAUGHT AND OBSERVED DOES IT TAKE ON A DEFINITE VALUE OF HEADS OR TAILS.

IT'S A LITLE DIFFICULT, THOUGH, TO WORK WITH QUBITS THAT CANNOT BE OBSERVED WITHOUT BEING DISTURBED...

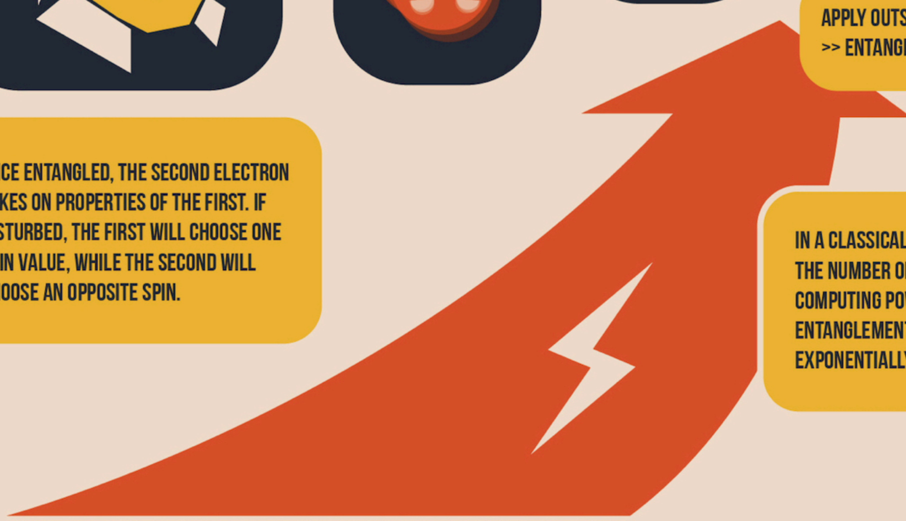
... SO, INSTEAD OF DIRECTLY OBSERVING OUR ELECTRONS, SCIENTISTS MAY USE A PROCESS CALLED QUANTUM ENTANGLEMENT TO LINK A PAIR.

QUANTUM ENTANGLEMENT??

EINSTEIN CALLED IT:

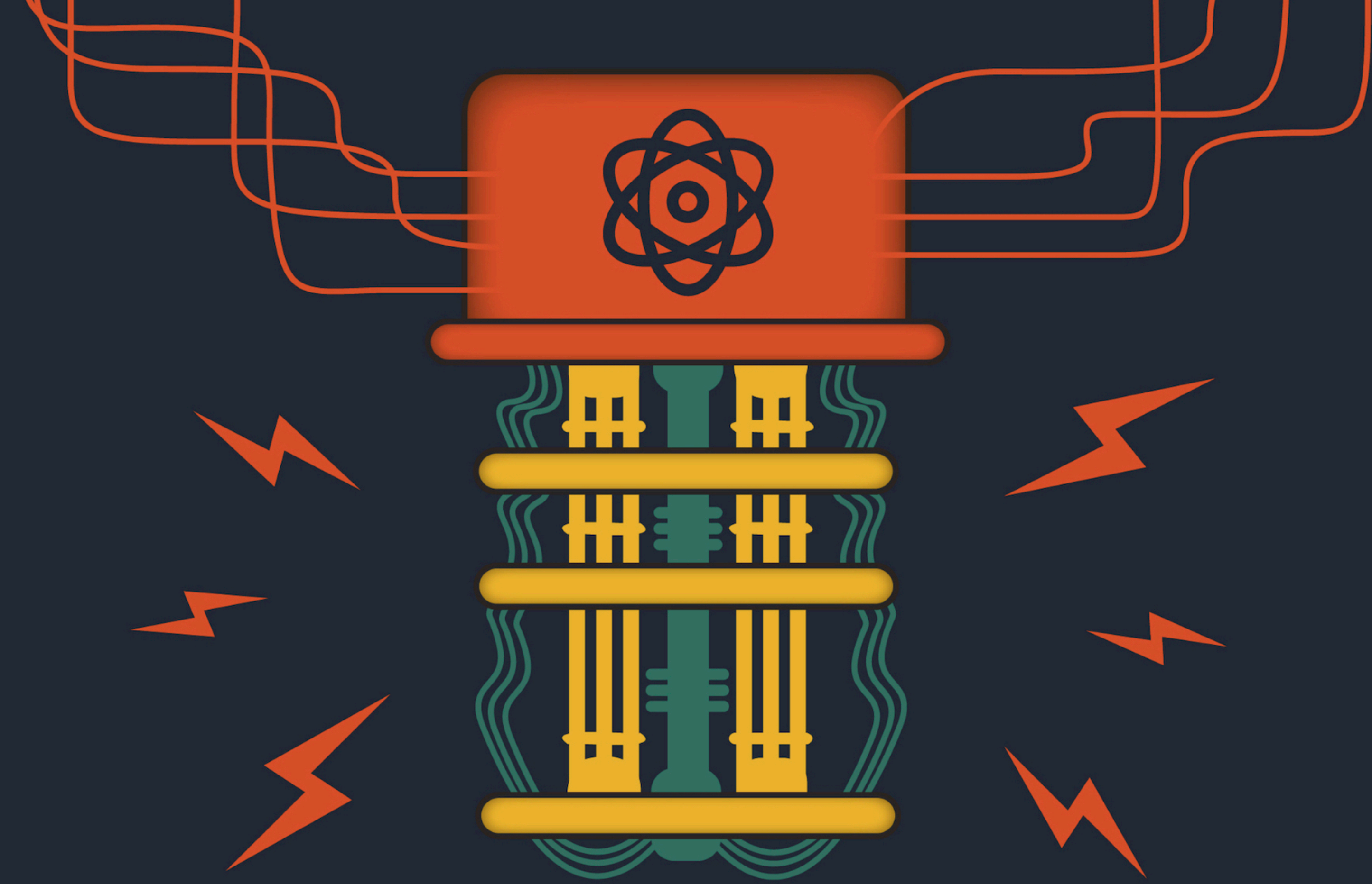
"SPOOKY ACTION AT A DISTANCE."

ONCE ENTANGLED, THE SECOND ELECTRON TAKES ON PROPERTIES OF THE FIRST. IF DISTURBED, THE FIRST WILL CHOOSE ONE SPIN VALUE, WHILE THE SECOND WILL CHOOSE AN OPPOSITE SPIN.

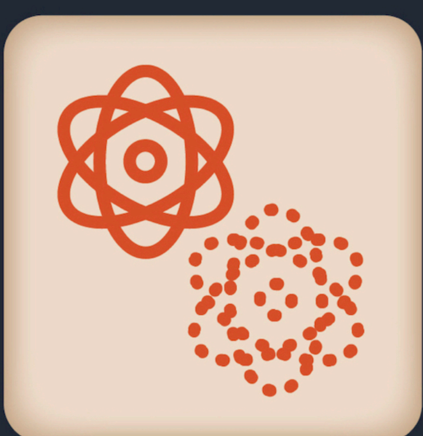


IN A CLASSICAL COMPUTER, IF WE DOUBLE THE NUMBER OF BITS, WE DOUBLE THE COMPUTING POWER. BUT BECAUSE OF ENTANGLEMENT, ADDING MORE QUBITS EXPONENTIALLY INCREASES ITS POWER.

QUANTUM COMPUTERS.

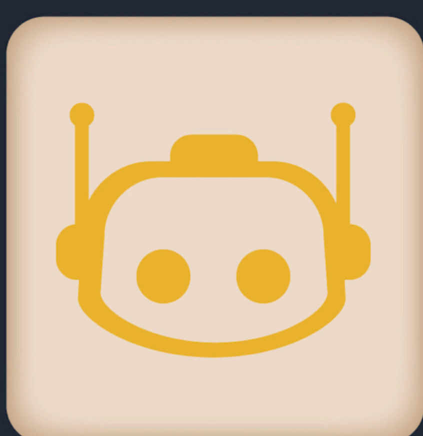


SIMULATIONS & MODELING



THE ORIGINAL PURPOSE OF UUANTUM COMPUTING WAS IN SIMULATING QUANTUM MECHANICS-- OR USING QUANTUM SYSTEMS TO BETTER UNDERSTAND QUANTUM SYSTEMS. "QUANTUM SENSING," OBSERVING THE WAYS IN WHICH QUBITS RESPOND TO THEIR ENVIRONMENT CAN BE USED IN DARK MATTER DETECTION.

PATTERNS AND DATABASES

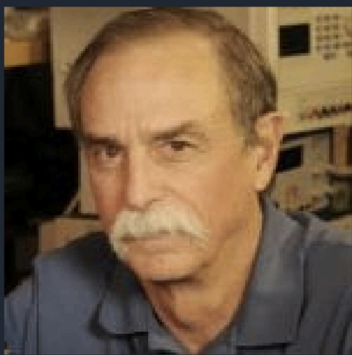


THE ABILITY OF QUANTUM COMPUTERS TO RAPIDLY PROCESS MASSIVE AMOUNTS OF DATA PROVIDES FOR ADVANCES IN MACHINE LEARNING, CLIMATE PREDICTION, AND FINANCIAL MARKET PREDICTIONS TO NAME JUST A FEW EXCITING TOPICS.

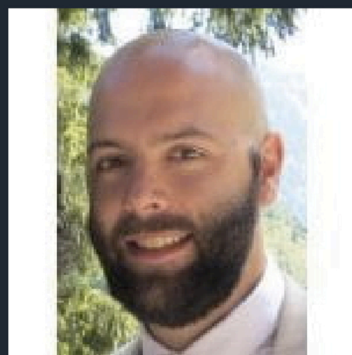
ENCRYPTION & DECRYPTION

MOST GLOBAL CRYPTOGRAPHIC ALGORITHMS, THE TYPE THAT SAFEGUARD OUR DATA AND FINANCIAL INFORMATION FOR EXAMPLE, ARE BUILT ON PRIME NUMBERS, WHICH ARE DIFFICULT FOR CLASSICAL COMPUTERS TO FACTOR. QUANTUM COMPUTERS HAVE THE UNIQUE ABILITY TO CRACK THESE PRIMES QUICKLY, A POTENTIALLY CATOSTROPHIC SECURITY THREAT THAT SCIENTISTS ARE RACING TO SOLVE.

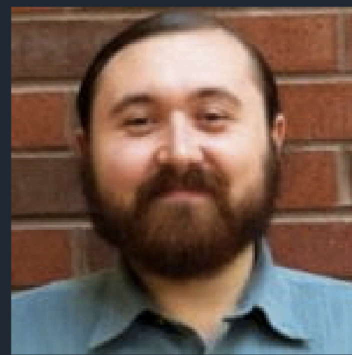
MEET THE OREGON IONS:



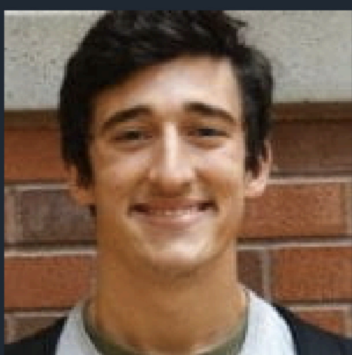
DAVID WINELAND RESEARCH PROFESSOR



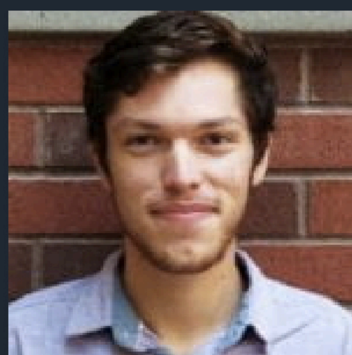
DAVID ALLCOCK ASSISTANT PROFESSOR & LABORATORY PRINCIPAL INVESTIGATOR



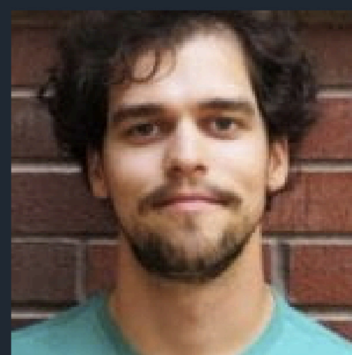
ALEX QUINN GRADUATE STUDENT



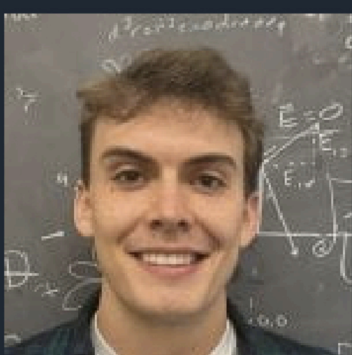
DANIEL MOORE GRADUATE STUDENT



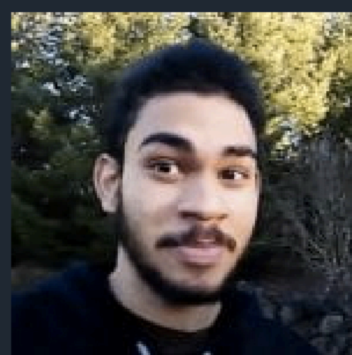
JEREMY METZNER GRADUATE STUDENT



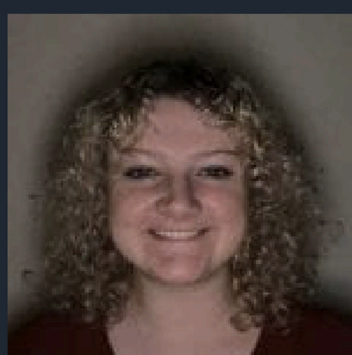
SEAN BRUDNEY GRADUATE STUDENT



GABE GREGORY GRADUATE STUDENT



AARON CASSERLY UNDERGRADUATE STUDENT



GENEVIEVE WAGES UNDERGRADUATE STUDENT

MARCUS POLK UNDERGRADUATE STUDENT

ANJA BEDRICK - ILLUSTRATOR