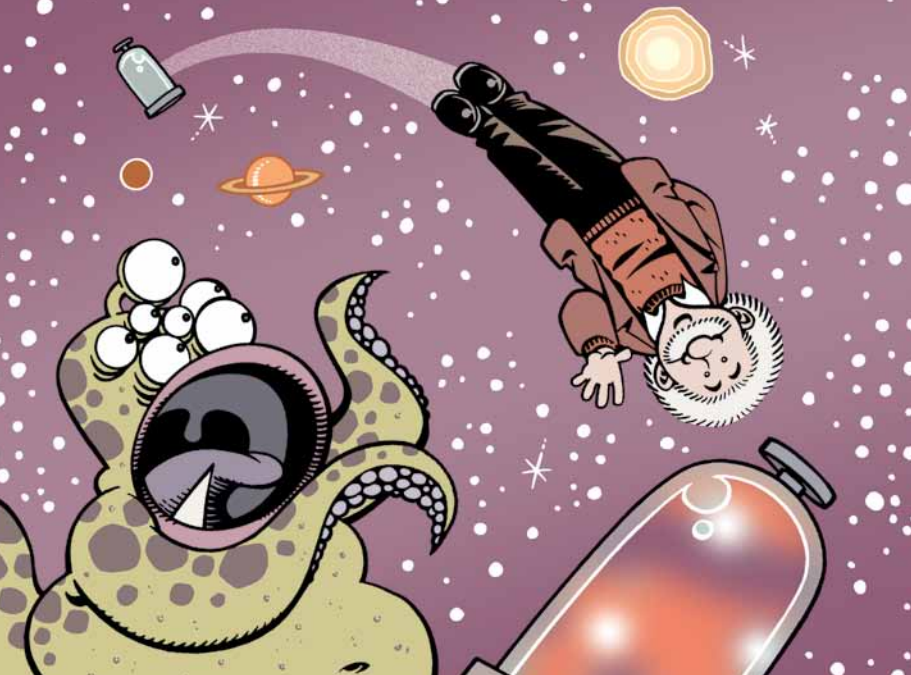


# QUANTUM ENTANGLEMENT, SPOOKY ACTION AT A DISTANCE, TELEPORTATION, AND YOU



# Quantum Entanglement, Spooky Action at a Distance, Teleportation, and You a.k.a.

THE OFFICIAL G.T. LABS GUIDE TO TELEPORTATION VIA QUANTUM ENTANGLEMENT AND SPOOKY ACTION AT A DISTANCE (INCLUDING A BRIEF BUT HELPFUL SECTION ON WHY, PERHAPS, YOU SHOULD NOT TRY THIS AT HOME).

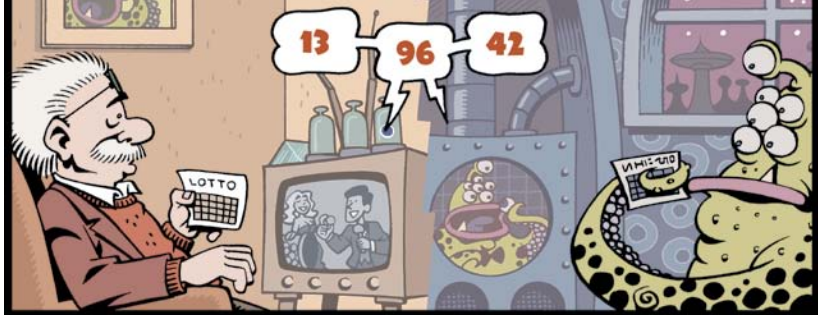
DISCLAIMER: Jim Ottaviani and Roger Langridge (the Authors) do in fact know the difference between bosons (photons, for example) and fermions (protons, neutrons, and electrons) and are cognizant that they are not so completely interchangeable and interconvertible as might be inferred from what you see here. However, for those inclined to pick that nit, note that one could quite easily make the argument that the  $10^{37}$  photons enumerated in the narrative, while not the actual constituents of Our Hapless Teleportee (O.H.T.), could instead act as carriers of information about the specific states of the individual fermions of which O.H.T. is comprised, and could therefore be used to reconstruct to perfection his precise physical and psychic configuration without a substantial increase in the likelihood of O.H.T.'s demise. And in late breaking news, researchers at the University of Århus in Denmark have entangled large groups of atoms at room temperatures, making the prospects for teleportation a modicum less dicey should O.H.T. fall into their, rather than the Authors', clutches.

*Bon voyage!*

Don't believe any of this? Check our references, which include: a whole bunch of books, the most prominent of which was C. Emiliani's 2nd edition of *The Scientific Companion* (NY: Wiley, 1995); articles like A. Zeilinger's "Quantum Teleportation" (*Scientific American*, vol. 282, no. 4, April 2000, 50-59); Jim's calculator (not a Curta, alas!), and; Roger's imagination.

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# STEP 1: ENTANGLED PHOTONS



**17**, WHICH COMPLETES TONIGHT'S LOTTERY DRAW...

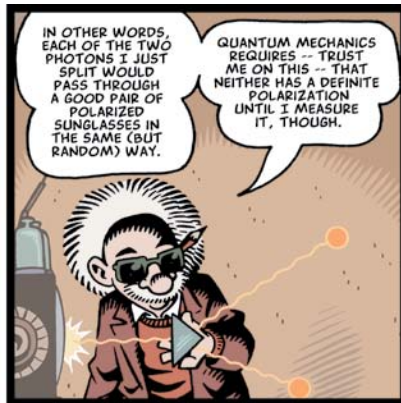
YOU'RE PROBABLY THINKING, "WHAT ARE THE ODDS OF **THAT** HAPPENING?"

WELL, THE PROBABILITY THAT MY NUMBERS CAME UP EXACTLY THE SAME AS MY BUDDY DRANK'S COULD IN FACT BE EXCELLENT... THANKS TO SOMETHING CALLED "ENTANGLEMENT." HERE'S HOW IT WORKS:

To my pal - Best anyway XX



IF I USE A PRISM TO SPLIT ONE PARTICLE OF LIGHT COMING OUT OF MY TV, I CAN GET AN ENTANGLED PAIR OF POLARIZED PHOTONS.



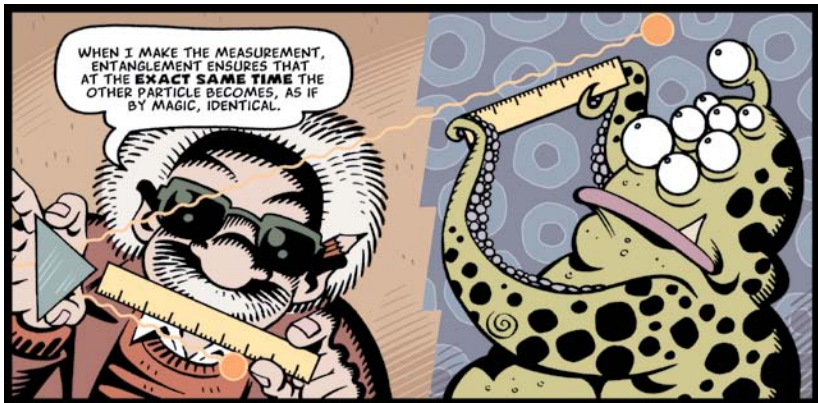
IN OTHER WORDS, EACH OF THE TWO PHOTONS I JUST SPLIT WOULD PASS THROUGH A GOOD PAIR OF POLARIZED SUNGLASSES IN THE SAME (BUT RANDOM) WAY.

QUANTUM MECHANICS REQUIRES -- TRUST ME ON THIS -- THAT NEITHER HAS A DEFINITE POLARIZATION UNTIL I MEASURE IT, THOUGH.



SO, IF BEFORE I MEASURE THE POLARIZATION OF EITHER I LET ONE OF THEM TRAVEL LIGHT YEARS AWAY...

... SAY TO MY FRIEND'S HOUSE...



WHEN I MAKE THE MEASUREMENT, ENTANGLEMENT ENSURES THAT AT THE **EXACT SAME TIME** THE OTHER PARTICLE BECOMES, AS IF BY MAGIC, IDENTICAL.



"THE INFORMATION ON HOW TO MAKE IT IDENTICAL SOMEHOW GETS THERE INSTANTLY, EVEN IF OUR PARTICLES ARE BILLIONS OF LIGHT YEARS AWAY FROM EACH OTHER."

◀EINSTEIN CALLED IT "SPOOKY ACTION AT A DISTANCE."▶

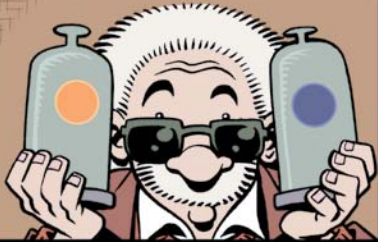
## STEP 2: TELEPORTING STUFF

I CAN SEND MORE THAN JUST INFORMATION ABOUT A PHOTON'S STATE THIS WAY, THOUGH!

FIRST, I SEND ONE HALF OF MY ENTANGLED (ORANGE) PAIR TO MY PAL DRAKX -- IT'S THE "TRANSLATOR" FOR MY TELEPORTATION DEVICE.

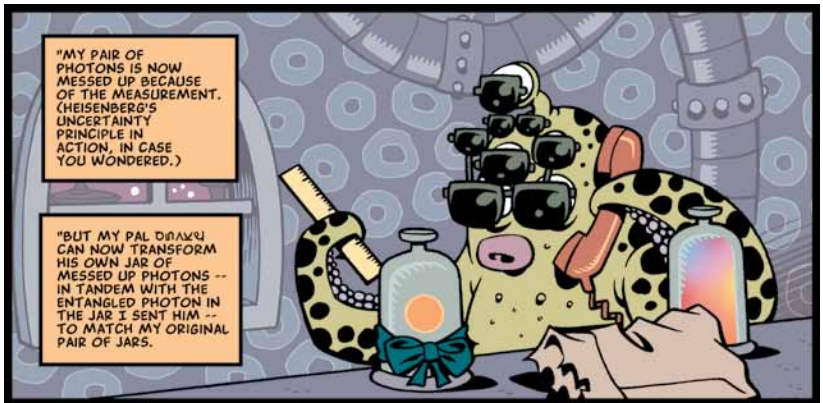


NOW, I WANT TO TELEPORT THIS PURPLE ONE. TO DO IT, I FIRST MEASURE ITS POLARIZATION **JOINTLY** WITH MY REMAINING (ENTANGLED) PHOTON.



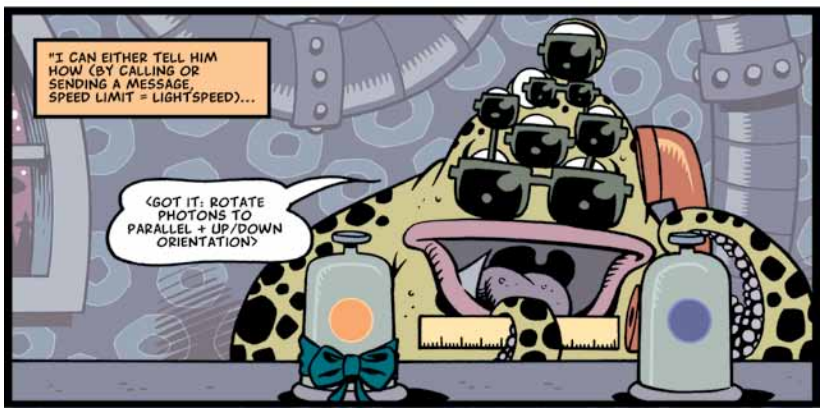
WHEN I DO THAT, I'VE MADE A "BELL STATE" MEASUREMENT. LET'S SAY IT TELLS ME THE TWO PHOTONS I'M HOLDING ARE POLARIZED PARALLEL TO EACH OTHER.





"MY PAIR OF PHOTONS IS NOW MESSED UP BECAUSE OF THE MEASUREMENT. (HEISENBERG'S UNCERTAINTY PRINCIPLE IN ACTION, IN CASE YOU WONDERED.)"

"BUT MY PAL DRAXX CAN NOW TRANSFORM HIS OWN JAR OF MESSED UP PHOTONS -- IN TANDEM WITH THE ENTANGLED PHOTON IN THE JAR I SENT HIM -- TO MATCH MY ORIGINAL PAIR OF JARS."



"I CAN EITHER TELL HIM HOW (BY CALLING OR SENDING A MESSAGE, SPEED LIMIT = LIGHTSPEED)..."

<GOT IT: ROTATE PHOTONS TO PARALLEL + UP/DOWN ORIENTATION?>

"... OR HE CAN GUESS AND HAVE A ONE IN FOUR CHANCE OF APPLYING THE RIGHT TRANSFORMATION... BUT BY GUESSING HE HAS HIS ANSWER INSTANTLY!"

<%#\*@33@!!  
... LOOKS LIKE  
PERPENDICULAR  
+ SIDE-TO-SIDE  
WAS WRONG.>

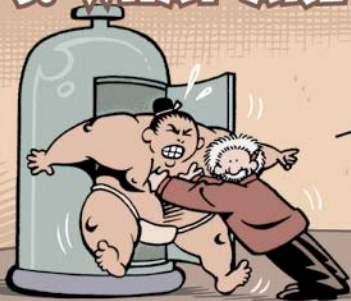


ONE IN FOUR  
ODDS FOR  
TELEPORTING A  
SINGLE PHOTON  
(WHICH IS  
PRETTY LIGHT)  
ISN'T TOO BAD.

IT'S STILL A  
GAMBLE, THOUGH,  
SINCE IF YOU TRY TO  
MOVE A PHOTON  
INSTANTLY FROM  
ONE PLACE TO  
ANOTHER YOU'LL  
JUST DESTROY  
IT THREE TIMES  
OUT OF EVERY  
FOUR.



# STEP 3: WHAT ARE THE ODDS?



YOU COULD DO IT WITH MASSIVE STUFF TOO, OF COURSE.

BUT SINCE THE TELEPORTED OBJECT HAS TO BE IN A PURE QUANTUM STATE, TO HAVE ANY CHANCE OF SUCCESS AT ALL YOU'LL NEED TO KEEP IT AT ABSOLUTE ZERO AND IN A VACUUM.

LET'S DEMONSTRATE WITH SOMETHING A BIT LARGER THAN A PHOTON -- 150 kg\* IS A NICE ROUND NUMBER.



\*150 kg = 330 lb

THE GOOD OL'  $E=mc^2$  EQUATION LETS US DO A ROUGH CONVERSION BETWEEN THE MASS IN THE CHAMBER AND ITS EQUIVALENT IN PHOTONS.



APPLYING APPROPRIATE FACTORS TO CONVERT A 150 kg MASS INTO PHOTONS OF VISIBLE LIGHT (THAT IS, WITH A FREQUENCY OF  $\sim 10^{15}$  Hz)...

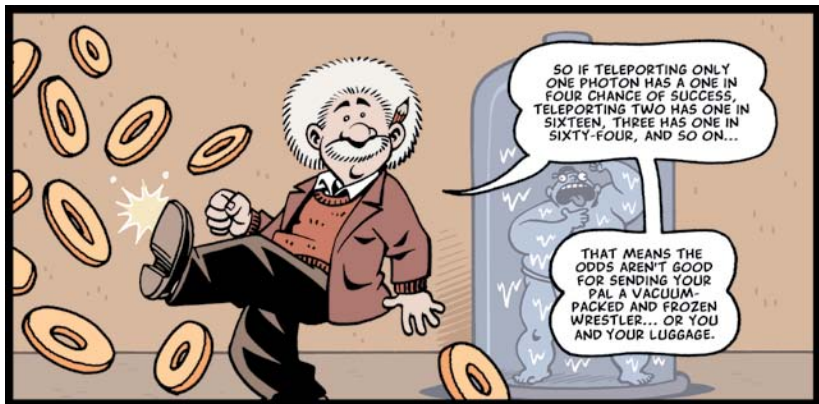


... WE GET ABOUT  $10^{37}$  PHOTONS AS AN EQUIVALENT.

THAT'S 1 FOLLOWED BY 37 ZEROS.

OR, AS WE SCIENTISTS WOULD SAY, "A LOT".





A public service announcement offered separately and as a supplement to *Suspended in Language*, a book about Niels Bohr sporting that catchy ISBN (0-9660106-5-5) all the hippest kids are dancing to, and brought to you by Jim Ottaviani (courtesy of G.T. Labs) and Roger Langridge (courtesy of Hotel Fred Press).

**\$2**

(or its mass equivalent in entangled photons...as long as their better halves are at least as far away as *Epsilon Eridani*)