FOOTHILL COLLEGE

Artificial Intelligence Workshop Series

Quantum Physics for Machine Learning

Dr. Bill Pezzaglia

2018Feb 26 @ 1:30-2:30
STEM Center Rm 4218

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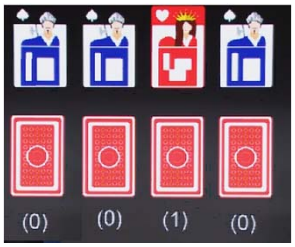
Find the Queen

Given: 4 Cards, one is a queen

Find it!

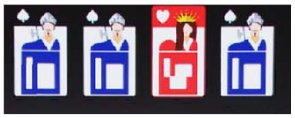
Average search is 2.25 steps



Reference 4:38-6:01 at https://www.youtube.com/watch?v=yy6TV9Dntlw

Hidden Variables

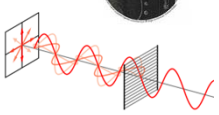
- **The 4 "states" are entangled by a RULE**
- **If the queens is in slot 3, then all the other slots must be NOT queens**
- **This is "law of excluded middle"**
- *Simpler example: Two Suitcases (demo in class)*

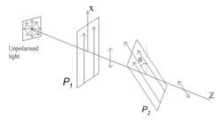


Classically, we assume the queen was in slot 3 all the time, we just didn't know where it was. This is a "hidden" variable model.

Malus's Law 1808

- **50% of light will get through polarizer**
- The light is now polarized
- **Amount of light passed through 2nd polarizer tilted at angle θ is given by Malus's Law**
- Polarization axis is also changed!

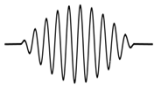




$$I = I_0[\cos\theta]^2$$

Quantum Polarization

- **A SINGLE unpolarized photon has 50/50 chance of getting through one polarizer**
- **It either ALL gets through, or NOTHING gets through (it doesn't get through with half the intensity).**
- **If it gets through its now polarized along the axis**



Hidden Variable Experiment

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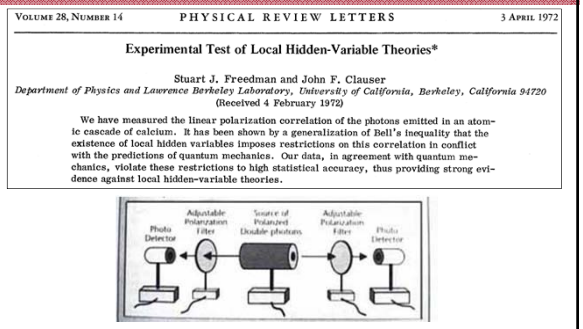

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Experimental Test of Local Hidden-Variable Theories*

Stuart J. Freedman and John F. Clauser
Department of Physics and Lawrence Berkeley Laboratory, University of California, Berkeley, California 94720
(Received 4 February 1972)

We have measured the linear polarization correlation of the photons emitted in an atomic cascade of calcium. It has been shown by a generalization of Bell's inequality that the existence of local hidden variables imposes restrictions on this correlation in conflict with the predictions of quantum mechanics. Our data, in agreement with quantum mechanics, violate these restrictions to high statistical accuracy, thus providing strong evidence against local hidden-variable theories.

- 2 photons emitted have same (unknown) polarization

Hidden Variable Experiment

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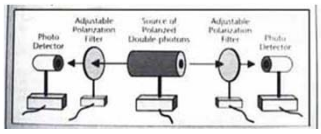

- Unknown polarization angle α (hidden variable)
- Right polarizer is tilted angle β relative to left

Left	Right	Probability	Integrated
0	0	sin^2(α)sin^2(α-β)	[1+2cos^2(β)]/8
0	1	sin^2(α)cos^2(α-β)	[1+2sin^2(β)]/8
1	0	cos^2(α)sin^2(α-β)	[1+2sin^2(β)]/8
1	1	cos^2(α)cos^2(α-β)	[1+2cos^2(β)]/8

No Hidden Variable

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- Photons are correlated but indeterminate polarization
- Measure L photon first. It has 50/50 chance of getting through or not.
- It now has either 0 (perpendicular) or 1 (parallel) polarization
- Instantaneously (???) the R photon gets SAME polarization
- Different Statistics!

Left	Right	Probability
0	0	[cos^2(β)]/2
0	1	[sin^2(β)]/2
1	0	[sin^2(β)]/2
1	1	[cos^2(β)]/2

Results Favor No Hidden Variable

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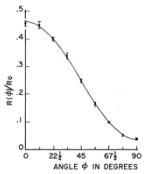
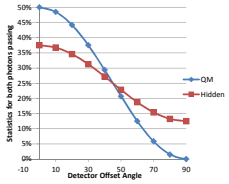
- Hence L and R photons are entangled, even though separated, i.e. quantum mechanics is NON LOCAL



Experiment, Freedman & Clauser



Theory

Superluminal Communication?

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- Somehow measuring L photon affects the measurement of the R photon, faster than the speed of light!
- 1978 Jack Sarfatti files patent for faster than light communication device based on this experiment.

- 1977 Costa de Beauregard (student of deBroglie) suggests measurement of L photon travels back in time (retrocausality) to the emission of photons and sets polarization of R photon

Find the qubit of the Queen

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Store location of queen in qubits

$$\begin{pmatrix} 0 & 0 \\ 1 & 0 \end{pmatrix}$$

UP
Down
Left Right

Ask if Up or Down

Ask if Left or Right

Search is 2 steps!

So location of Queen is encoded as 2 binary bits:

00 01

10 11

Or as a single complex qubit

References

- Costa de Beauregard, Olivier (1977). "Time Symmetry and the Einstein Paradox" Il Nuovo Cimento (42B).
- www.costa-de-beauregard.com/fr/wp-content/uploads/2011/11/OCB-1977-5.pdf