Experiments: Classical fields masquerade as quanta

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Entangled electric fields are used to perform three elementary experiments in quantum mechanics: Entanglement, "spooky action at a distance" and violation of Bell's or CHSH inequality. The complete success raises questions.

1. Introduction

In this work it is proved that classical electric fields can behave like quanta. For this purpose we will replace the terms of classical physics by terms of quantum mechanics, the classical experiments will be replaced by the experiments of quantum mechanics and the classical mathematics will be replaced by the statistics of quantum mechanics.

Since electric fields can be entangled in a trivial way and measured as voltages, there is not much room for "interpretation": The tools of quantum mechanics simply do not realize that they are dealing with classical physics.

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2. *Entanglement of electric fields*

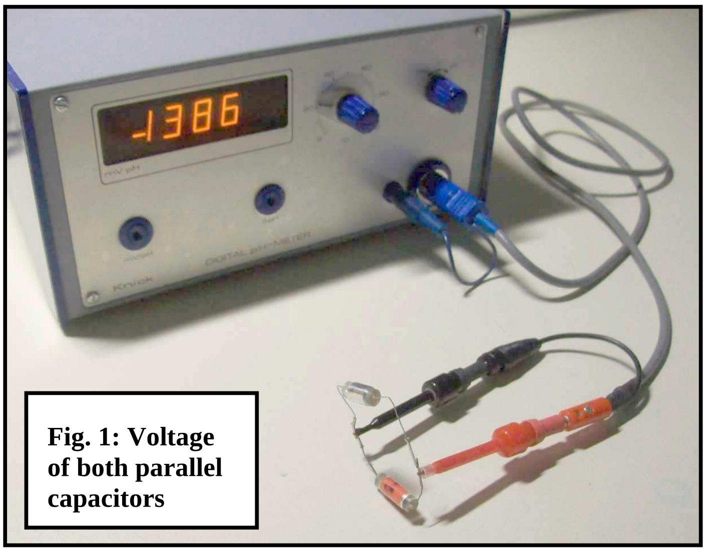


Fig. 1: Voltage of both parallel capacitors

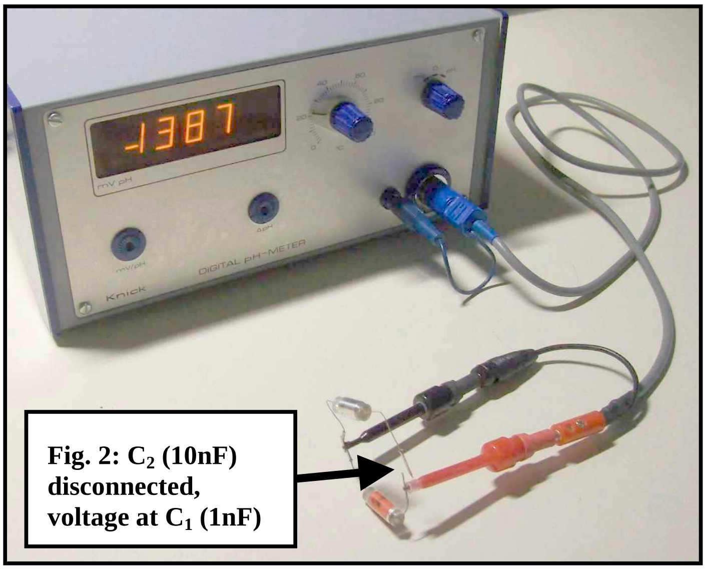


Fig. 2: C_2 (10nF) disconnected, voltage at C_1 (1nF)

Two different capacitors (C_1=1nF and C_2=10nF) are connected in parallel, arbitrarily charged together with “Q_1+Q_2“ and the voltage “$U_1=U_2$“ is measured. Since “$C=Q/U$“ and “$U_1=U_2$“, it results **“$U_1=Q_1/C_1=U_2=Q_2/C_2$“. (1)**

The interaction is terminated by disconnecting the parallel connection. Nevertheless, both capacitors retain their voltage equality.

Even a high impedance electrometer destroys this voltage equality in a few seconds by measurement.

The fields are interference capable, because one can connect them in series. Depending on the polarity one measures **“$U_1+U_2=2U_1=2U_2$“** or **“$U_1-U_2=0V$“. (2)**

One can charge both capacitors randomly, then separate them and send them to two distant laboratories ("Alice" and "Bob"). It is undetermined what absolute voltage the two labs will measure with their electrometers. But they will find voltage equality, if it was not destroyed on the way by an unauthorized measurement.

Further, one can sequentially charge many such double capacitors with random voltage in rapid sequence, disconnect them, and ship them to the labs in two chains of equal length. Alice and Bob will then find voltage equality of the alternating voltages at each instant.

This dynamic approach will be shown in the next experiment.

3. *“Spooky action at a distance“ with electric fields*

In the center of two parallel copper bars, alternating voltages are fed in rapid sequence. The two copper bars can be imagined as a string of small capacitances. The voltages of these capacitances move from the central source to the left to the Alice lamp and to the right to the Bob lamp.

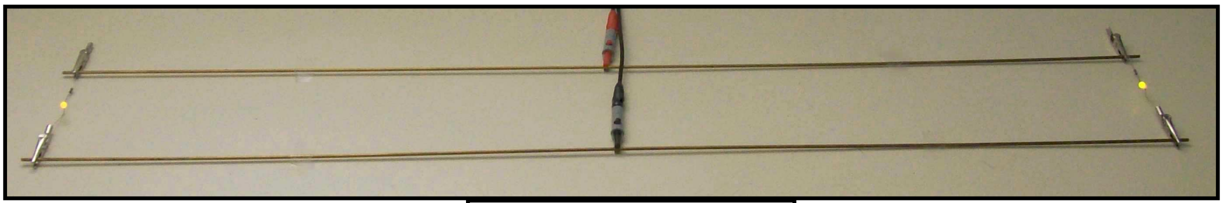
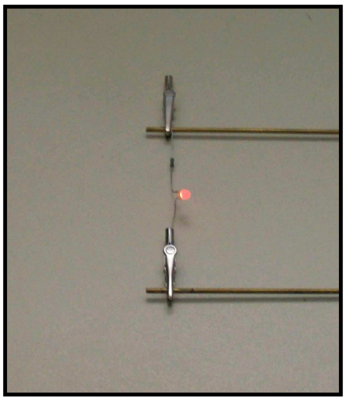


Fig. 3 : Yellow light at ← Alice and Bob →

Positive voltages produce red, negative voltages produce green, and voltages that are too low produce no light. Alternating voltages produce yellow light because all three states are superimposed. This indeterminate state is called the "wave function".

Alice stops the voltage generator at an arbitrary time. The wave function collapses and Alice can see the color of her lamp. Whether it is red, green or dark is undetermined. But Alice and Bob will always find voltage equality.



It seems that a "spooky action at a distance" [AE47] between the two independent lamps always causes the same indication.

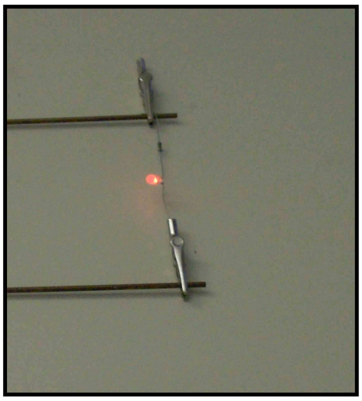
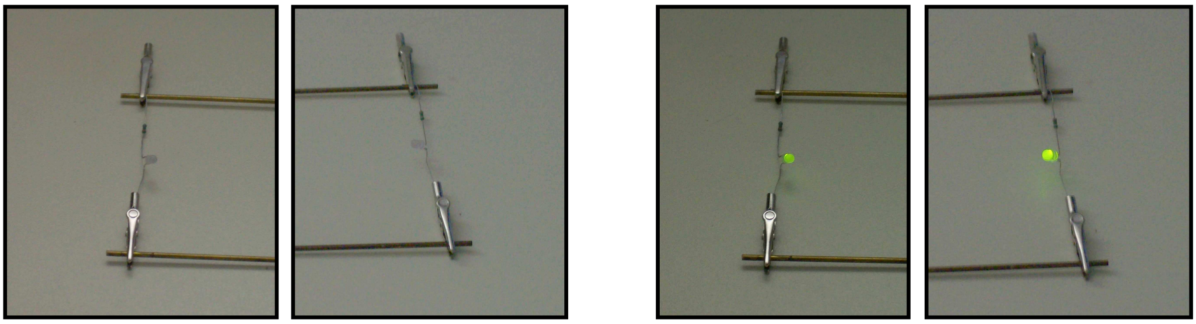


Fig. 4: Always the same voltages



4. Violation of Bell's or CHSH inequality

With a sophisticated optical experiment, one can entangle two photons whose polarization in space is unknown, but of which one knows that their polarization differs from each other by 90°. This allows the application of the statistical tests developed by Bell[Bell64] and CHSH[CHSH69], which are usually used to prove quantum mechanical entanglement.

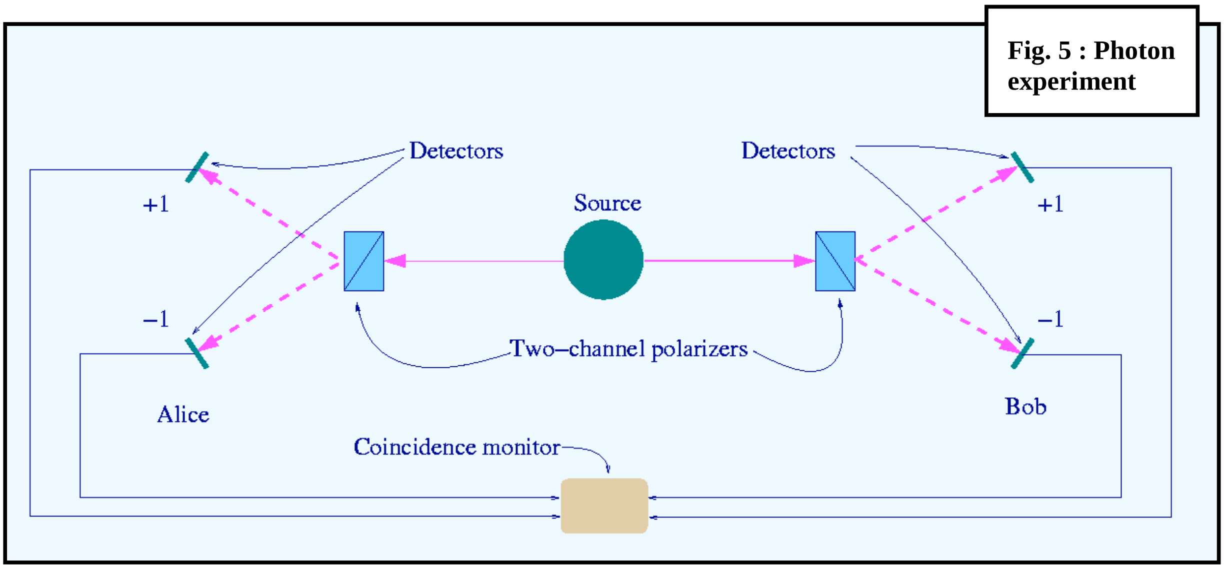


Fig. 5 : Photon experiment

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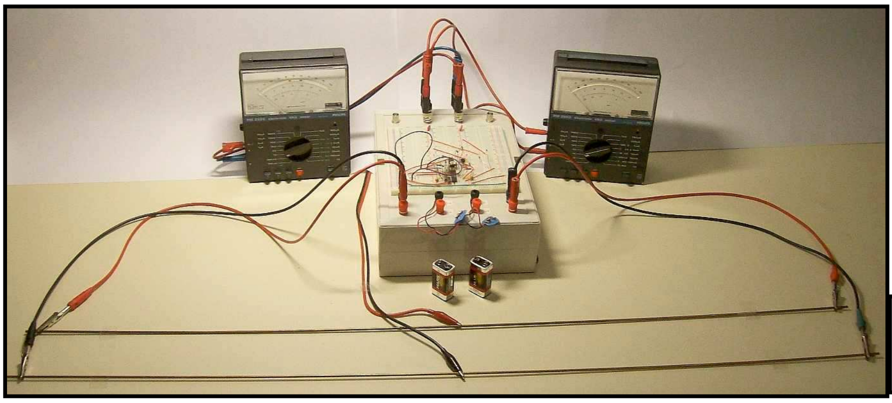

The electric fields entangled by 0° must also pass an equivalent test.

Fig. 6: Equivalent field measurement

The "coincidence monitor" (analog 4-quadrant multiplier) and the "polarizers" (phase shifters) are located on the battery powered board. Separate detectors are not needed as voltages are correlated.

The left meter shows the mean value of the positive multiplications (“++“ and “--“). The right meter shows the mean value of the negative multiplications (“+-“ and “-+“).

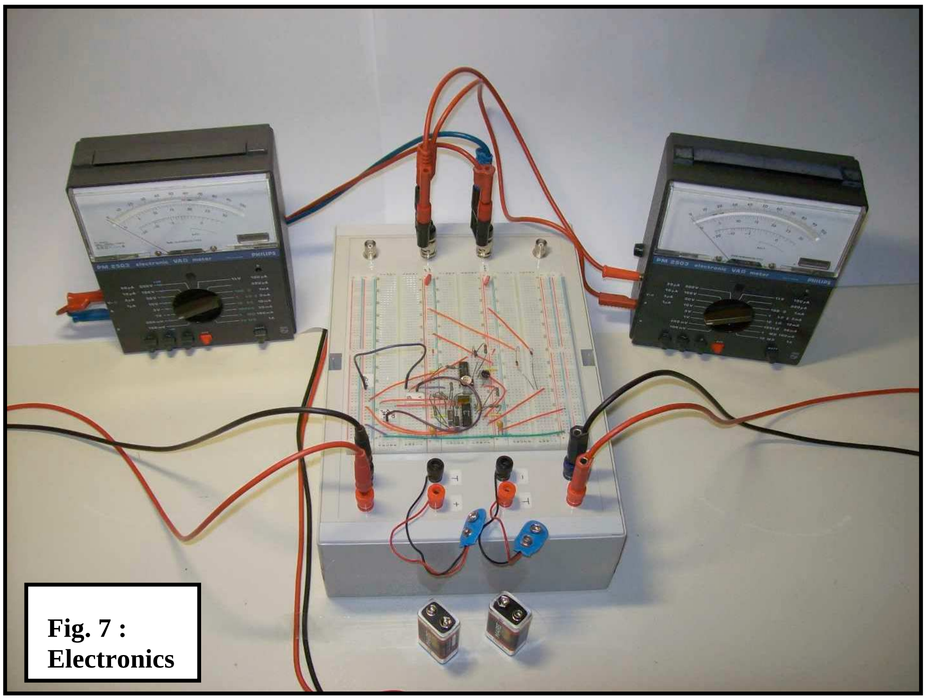

Fig. 7 : Electronics

The "polarizers" allow the separate selection of 0°, 45°, 90° and 135° in front of the two Alice and Bob inputs of the multiplier.

This angle selection fits perfectly to the 0° field entanglement.

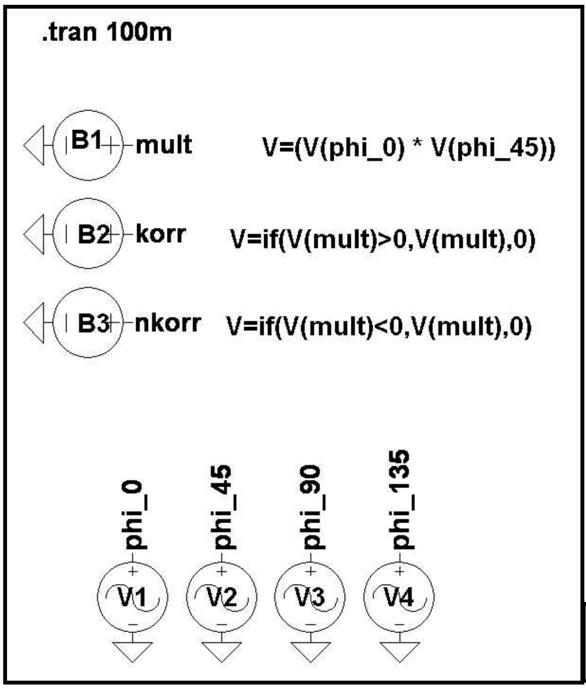

Fig. 8: Simulation

One can also simulate the experiment with the free software LTSpice.

Two differently polarized (= phase-shifted) sinusoidal voltages are fed to the B1 multiplier. The positive value of the multiplication corresponds to the left meter “korr“. And the negative value of the multiplication corresponds to the right meter “nkorr“.

For the application of the usual statistics, sixteen values are required for four angles:

$$E(\alpha,\beta)=\frac{C(\alpha,\beta)-C(\alpha^{\perp},\beta)-C(\alpha,\beta^{\perp})+C(\alpha^{\perp},\beta^{\perp})}{C(\alpha,\beta)+C(\alpha^{\perp},\beta)+C(\alpha,\beta^{\perp})+C(\alpha^{\perp},\beta^{\perp})} \qquad \textbf{(3)}$$

Since two measured values were combined into "korr" and "nkorr", eight values remain, from which four expectation values are calculated.

Real $E(\alpha,\beta)$	**α = 0° (180°)**	**α' = 90° (270°)**
β = 45° (225°)	0.82 – 0.06 = 0.76	0.79 – 0.05 = 0.74
β' = 135° (315°)	-0.75 + 0.1 = -0.65	0.81 – 0.05 = 0.76

Simu $E(\alpha,\beta)$	**α = 0° (180°)**	**α' = 90° (270°)**
β = 45° (225°)	0.853 – 0.145 ≈ 0.7	0.854 – 0.145 ≈ 0.7
β' = 135° (315°)	-0.853 + 0.145 ≈ -0.7	0.853 – 0.145 ≈ 0.7

The S values of the CHSH inequality are calculated as follows:

$$S = E(\alpha,\beta) - E(\alpha,\beta') + E(\alpha',\beta) + E(\alpha',\beta') \qquad \textbf{(4)}$$

The reality results: S = 0.76 - -0.65 + 0.74 + 0.76 = 2.91.

The simulation results: S = 0.7 - -0.7 + 0.7 + 0.7 = 2.8.

Amounts > 2 violate the inequality and prove the entanglement. The maximum should be 2.8. Surprisingly the statistics show that entangled fields are perfect quanta.

5. Summary and discussion

Entangled electric fields behave like entangled quanta, although a field with many charge carriers is formed. The fields (and also their simulation) can violate the inequalities just like photons. Only the optical polarizers have to be represented as electronic phase shifters. Both types of analyzers exhibit sinusoidal nonlinearities at angle settings and can project.

The “spooky actions at a distance“ were demystified. And with it, all the related issues (hidden variables, locality, reality, loopholes and paradoxes). The equality of entangled alternating fields has its cause in the entanglement and the simultaneity of the measurement.

The fact that Bell/CHSH mathematics has not recognized that it is dealing with macroscopic electric fields may point to structural flaws[GEU23] in these tools.

[AE47] Coined by Albert Einstein as spukhafte Fernwirkungen (“spooky actions at a distance”) in a letter to Max Born on 3 March 1947 to describe the strange effects of quantum mechanics, where two particles may interact

[Bell64] John Stewart Bell: On the Einstein Podolsky Rosen Paradox. In: Physics. Band 1, Nr. 3, 1964, S. 195–200

[CHSH69] J. F. Clauser, M. A. Horne, A. Shimony, R. A. Holt: Proposed Experiment to Test Local Hidden-Variable Theories. In: Physical Review Letters. Band 23, Nr. 15, 1969, S. 880–884

[GEU23] Han Geurdes: Bell’s Theorem and Einstein’s Worry About Quantum Mechanics. 2022, https://vixra.org/abs/2212.0045