Resolving the EPR Paradox and Bell's theorem

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To start with, consider three types of classical objects, a pair of balls (white and black) a pair of gloves (right and left handed) and a pair of coins. If one of the balls, gloves and coins is given to Alice and the other, from each pair, is given to Bob, then both Alice and Bob will instantly know the color of the other's ball and the handedness of the other's glove (assuming they were told beforehand, that the paired balls are always white and black, and that the paired gloves are always right and left handed), regardless of how far apart they are; no "spooky action at a distance."

But they will not know the other's coin state (or even their own!), because that state, unlike the color of the balls and the handedness of the gloves, is not an attribute of the object itself. Rather, it is an attribute of the relative, geometric relationship, between the observer and the coin; when they look at the coin from one aspect angle, they observe it as being in the state "heads", but when they look at it from the opposite angle, they observe the state "tails".

So before they can even determine the state of their own coin, they have to make a decision, about which angle to observe the coin from. Making this decision and observing the result, is what is mistakenly called a "collapse of the wave-function". But there is no wave-function, there is only a decision-making process, for determining which state, of several possible, states, the object is in, relative to the observer. Unlike the balls and gloves, objects like coins are not in ANY state, until an observer "makes it so." Note also that even after the decision is made, the two-sided coin did not mysteriously "collapse" into a one-side coin. There is no physical collapse, there is only an interpretational collapse - a decision.

But suppose that the coins were so tiny and delicate, that the mere act of observing one, totally altered its state - it gets "flipped" every time you observe it. Now it becomes impossible to ever repeat any observation of any coin's relative state. So it is impossible to make a second measurement of such a coin's original state.

This brings us to the EPR paradox. Since it is now impossible to remeasure any coin, as when attempting to measure a second "component", EPR suggested, in effect, to create pairs of coins that were "entangled", such that they are always known, a priori, to be either parallel or anti-parallel. Hence, a measurement of one coin, should not perturb the measurement of the other. The relative orientation of the coins, relative to any observer, is assumed to be completely random. But relative to each other, the coins are either parallel or anti-parallel.

It turns out that for small particles like electrons, it is much easier to create entangled-pairs that are anti-parallel, than parallel, so we will restrict the following discussion to the anti-parallel case.

Now, whenever Alice and Bob measure each coin (one from each anti-parallel, entangled-pair) in a sequence of coins, they obtain a random sequence of "heads" or "tails", since, regardless of what angles they decide to observe a coin from, all the coins are in different, random orientations.

But what happens if they record both their individually, decided measurement angles and the resulting, observed states of their respective coins, and subsequently get together and compare their results?

As expected, whenever they had both, by chance, decided to observe their entangled-coins from the same direction, they observe that their results are always anti-parallel; if one observed "heads", then the other observed "tails." And if they had both, by chance, decided to observe their entangled-coins from exactly opposite directions, they observe that their results are always parallel.

But what happens when they, by chance, happened to observe their coins at other angles? This is where things start to get interesting - and subject to mis-interpretation! Because what happens, is critically dependent upon how accurately Alice and Bob can actually decide upon the observed state of their respective coins.

If both observers can clearly observe their coins, and make no errors in their decisions, even when the coins are perfectly "edge-on", then you get one result (Figure 1, in this paper: A Classical System for Producing Quantum Correlations), when the observers get together and compute the correlations between their observations.

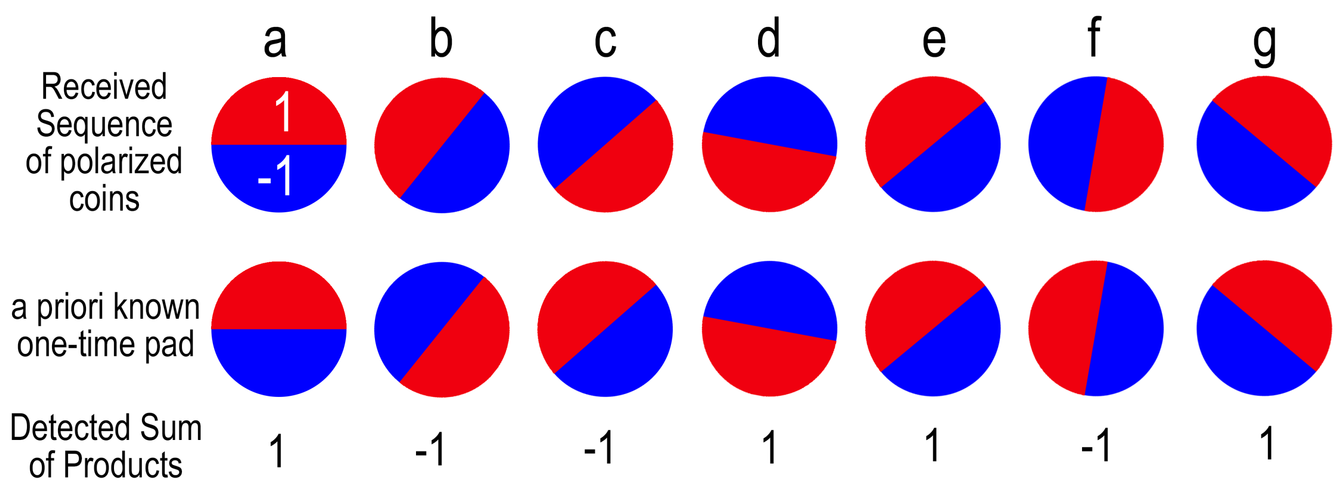
But if the coins are worn-down, dirty and bent-out of shape, and can only be observed, for a brief instant, far away, and in the dark, through a telescope (AKA with limited bandwidth, duration, and signal-to-noise ratio - the parameters specifying their information content, in Shannon's Capacity theorem), then a completely different type of correlation will appear (Figure 12), due to the fact that many of the observer's decisions are erroneous; they mistakenly decided to call the coin a "head" when it was really a "tail" or vice-versa. Or they may even totally fail to detect the existence of some of the coins (fail to make any decision), as the coins whiz past them, never to be seen again.

And if they attempt to mitigate these "bit-errors", by attempting to assess the quality of their observations, and eliminating all those measurements of the worst quality, then they will get yet another correlation (Figure 2) - one that perfectly matches the so-called "quantum correlations", when analogous, Bell-type experiments, are performed on subatomic particles, like photons or electrons.

So, should quantum correlations be interpreted as a "spooky action at a distance", or just a misunderstood classical phenomenon? Given the (little known) fact that the limiting case of the Heisenberg Uncertainty Principle can be shown to (just an amazing coincidence !!!???) correspond to a single-bit-of-information being present, which thereby guarantees that every set of multiple observations must be "strangely correlated", "spooky action at a distance" seems to be an implausible interpretation, at best.

It is worth pointing-out, that a classical coin, as described above, is simultaneously BOTH a heads and a tails - that is what a superposition of two states looks like - a coin - until an observer makes a decision, and "calls it" - either a heads or a tails. Perhaps it should be called Schrödinger's coin.

The figure below depicts the fundamental problem with all Bell tests. Imagine you have received a message, in the form of a sequence of polarized coins, as shown in the top line of the figure below. Your task is to decode this message, by determining the bit-value (either 1 or -1) of each coin (a-g). If you know, a priori, the One-Time Pad that must be used for the correct decoding (the second line



in the figure), then you can correctly decode the message, by simply performing a pixel-by-pixel multiplication of each received coin and the corresponding coin in the one-time pad, and sum all those product-pixels, to determine if the result is either positive (1) or negative (-1) as in the third line of the figure. (Red = +1, Blue = -1).

But what happens if the coins are "noisy" and you do not know the one-time pad, so you use randomly phased (randomly rotated polarity) coins instead of the correct one-time pad, in a misguided attempt to determine the coin's polarization? You get a bunch of erroneous bit-values, particularly when the received coin's polarity and its "pad" are orthogonal and thus cancel out (sum to zero). But the noise does not cancel out, so in those cases, you end up with just random values, due to the noise. The statistics of these randomized bit-errors is what is being mistaken, for "quantum correlations" and spooky action at a distance.