1 Preliminaries

In this section we look at the basic ideas and definitions underlying composite quantum systems. The quantum mechanical view of reality takes on a very different approach regarding how to model composite systems mathematically, instead of taking the standard direct product between the Hilbert Spaces underlying each of the systems at stake it instead takes the tensor product. This leads to the very counterintuitive phenomenon of entanglement, which will be the essential culprit in this paper.

The reader is encouraged to refer to the references for further information regarding tensor products between states, for our purposes we will lay out the elementary construction through what are called equivalence classes and outline a few interesting properties the Tensor Product.

What’s interesting about this new formalism is that the reservoir of states that we allow for far exceeds the states that we allow for in classical theory, the reason for this being that we now allow for superpositions to come into play. There are two interesting classes of states in this new world:

Entangled States:

\[ |\psi\rangle = \sum_i^n \sum_j^m |\psi_i\rangle \otimes |\psi_j\rangle \]

Non-Entangled States:

\[ |\psi\rangle = |\psi_1\rangle \otimes |\psi_2\rangle \]

Key Observations: “Spooky Action at a distance”

The interesting thing about Entangled States—which happen to be the flavour most of our states take on, is that measurements preformed on these class of states have the very peculiar effect that probabilities appropriate to the first particle being
in some state tell us about the probabilities of the second particle being in some state. Non-Entangled states on the other hand do not share this property.

Measurement on an Entangled State:

$$\beta(|\uparrow\rangle \otimes |\uparrow\rangle) + \alpha(|\downarrow\rangle \otimes |\downarrow\rangle)$$

Suppose for sake of argument that I measure my first particle to be in the state $|\uparrow\rangle$ we may immediately tell that the other particle need be in the $|\uparrow\rangle$ state sinc it’s the only compatible possibility. In this bizarre sense measurement outcomes on the second particle are conditions on measurement outcomes of the first. Very spooky indeed.

Measurement on Non-Entangled State:

$$(\beta |\uparrow\rangle + \alpha |\downarrow\rangle) \otimes (\psi |\uparrow\rangle + \xi |\downarrow\rangle) = \beta \psi |\uparrow\rangle \otimes |\uparrow\rangle + \beta \xi |\uparrow\rangle \otimes |\downarrow\rangle + \alpha \psi |\downarrow\rangle \otimes |\uparrow\rangle + \alpha \xi |\downarrow\rangle \otimes |\downarrow\rangle$$

The above follows from the tensor product properties established apriori: Suppose for sake of argument that my experimental apparatus measures the first particle to be in $|\uparrow\rangle$$

$$\Rightarrow$$ My state collapses to $\beta \psi |\uparrow\rangle \otimes |\uparrow\rangle + \beta \xi |\uparrow\rangle \otimes |\downarrow\rangle$ since these are the only compatible possibilities with the prior measurement, Notice, however that this in no way provides me with information about the counterpart system. In other words by preforming a measurement on the first particle I have not gained anything in terms of the knowledge of the probabilities appropriate the particle in the second slot of the tensor product.

Up to now we have only worked through the mathematical formalism underlying the idea of entanglement, we will in the later sections consider experimental aspects of this out of the world phenomenon to say the least.

Picture:

The above will serve to be the key underlying argument on which this paper is based on, In is what Einstein Rosen and Podolsky where in conflict with.

\section{Local Realism and The Einstein Podolsky Rosen Hidden Variable Theory}

It’s well worth noting that Albert Einstein, Nathan Rosen and Boris Podolsky never set to argue that Quantum Theory was incorrect in the sense that it made predictions that were in conflict with experiment, instead their true desire or at least belief was that the underlying picture of quantum mechanics that particles can be in this fuzzy probabilistic mixture was too spooky for them to accept, In order to do away with this idea of spooky action at a distance they decided that there must be something else under the hood, this is the inception of Einstein’s Hidden Variable Theory,
where he considers that particles do have definite features that can fully determine the physics of the system, just like how in classical mechanics we can determine the motion of a particle or later times if we know its position and velocity at some particular moment, the difference being that they supposed these hidden variables could not be determined.

Here we present a rough outline of the assumptions on which Hidden Variable Theory was built upon. Although there is no general consensus about the precise underlying theory the rough argument consists in the following:

**Completeness**

Every element of the physical-reality must have a counter part in the physical theory.

This is where the hidden variable aspect of the theory comes into the picture, and is where Einstein argued that having a fundamental theory of the world that was inherently probabilistic didn’t seem quite right, as he once said “God does not play dice”. To get a further sense to what he was getting at it is particularly useful to make the connection with Statistical Mechanics, where one makes probabilistic approximations, that in some limit converge to extraordinarily precise predictions, however precisely because it works in this kind of probabilistic framework it would not be considered a fundamental theory—although of course extremely useful, it was in this kind of light that Einstein thought of Quantum theory in.

**Locality**

Measurements made one one system sufficiently far away from another are unaffected by measurements on the distant system.

This seems fair enough, at least in the world we live in this assumption seems to hold true. If I place an experimentalist on planet Mars and another in France, I would not expect that measurements on Mars would effect measurements in France or vice versa, we would say that these two physical systems are sufficiently far apart that they can be considered disconnected. This is something that is used in practically any calculation you do in any other field of physics such as Electromagnetic Theory, Statistical Mechanics or Classical Mechanics—life would be very tedious if such were not true.

### 3 Break-Down of Local Realism

Visual image of John Bell:
Then enters this character into the picture, Irish physicist John Stuart Bell, he is the key culprit in disproving the possible existence of a local hidden variable theory reminiscent of Einstein’s Ideas. To be more precise, he did not disprove that there could not exist a hidden variable theory, however he did disprove the condition of locality which served to be the main essence in the first place.

We will show that the requirement of locality as put forth in the Einstein-paper is in disagreement with quantum mechanical predictions and more importantly in disagreement with experiment.

3.1 John Bell’s Paper

In this section we lay out the essential arguments made by Bell in his famous 1964 paper on the EPR paradox, the essence of the paper was to show that a hidden variable theory reminiscent of Einsteins idea’s would reproduce statistics incompatible with those provided by Quantum Mechanics. In the section following this we will outline a visual experiment that illustrates the fact that the statistics as predicted by Quantum theory fits the data much better than those predicted by the Hidden Variable Theory.

Claim No local hidden-variable theory reminiscent of Einsteins Idea’s can reproduce quantum mechanical predictions

\[ A(\vec{a}, \lambda) = \pm 1 \]
\[ B(\vec{b}, \lambda) = \pm 1 \]

The clever trick is that now we can recover our prior quantum mechanical correlation coefficients from \( \rho(\lambda) \) by integrating it out:
\[ C(\vec{a}, \vec{b}) = \int d\lambda \rho(\lambda) A(\vec{a}, \lambda) B(\vec{b}, \lambda) = \langle \vec{\sigma}_1 \cdot \vec{a}, \vec{\sigma}_2 \cdot \vec{b} \rangle = -\vec{a} \cdot \vec{b} = -ab \cos \theta_{ab} \]

Since by the argument laid out in the former sections, it must be the case that if one of the particles is up, that the other be down. Whatever the Hidden Variable Theory predicts with regards to the above distribution should allign with the probability prescribed by quantum theory. We will now show
that this is not possible. The key idea behind the proof arose in now bringing a third random variable into the picture, call it $\vec{c}$ and considering the following expression:

$$C(\vec{a}, \vec{b}) - C(\vec{a}, \vec{c}) = -\int d\lambda \rho(\lambda)[(A(\vec{a}, \lambda)A(\vec{b}, \lambda) - A(\vec{a}, \lambda A(\vec{c}, \lambda))]$$

$$= \int d\lambda \rho(\lambda)[(A(\vec{a}, \lambda)A(\vec{b}, \lambda)]A(\vec{b}, \lambda)A(\vec{c}, \lambda) - 1]$$

$$= \Rightarrow |C(\vec{a}, \vec{b}) - C(\vec{a}, \vec{c})| \leq \int d\lambda \rho(\lambda)[1 - A(\vec{b}, \lambda)A(\vec{c}, \lambda)]$$

$$\iff 1 + C(\vec{b}, \vec{c}) \geq |C(\vec{a}, \vec{b}) - C(\vec{a}, \vec{c})|$$

Now that we have established this inequality we can plug in the correlation coefficient as predicted by the quantum view $C(\vec{a}, \vec{b}) = -ab \cos(\theta_{ab})$. If one plugs in the numbers one finds that for $\theta \leq \frac{\pi}{2}$ the inequality is violated.

It is worth making note of the fact that in this discussion we have not ruled out the possibility of a hidden variable theory, we have however proved that a hidden variable theory restoring locality would be incompatible with quantum mechanical predictions, an alternate hypothesis that restores locality gives us even more bizarre consequences than are presented by Quantum Entanglement, which is hard to believe-search Everettes Many Worlds Interpretation. On the other hand this discussion has not ruled out the possibility of developing a non-local hidden variable theory.

3.2 Thought Experiments Realized

Consider the following setup:

(i) Alice and Bob

(ii) Each with their handy detectors
(iii) Each on planets sufficiently far away that they can be considered causally disconnected.

(ii) Apparatus that creates entangled particles

To summarize: The Einsteinian framework tries to do away with the idea that particles inhabit a fuzzy probabilistic mixture, instead it argued that particles have definite features which are revealed only upon measurement and that there exist supplementary hidden variables that control the probability of these features being expressed, thereby eliminating the need for entanglement. This is quite tricky to understand and can often be misunderstood so don’t worry if it takes several attempts at reading.

The Quantum View:

What haunted people for so many decades was the fact that the Einsteinian Framework seemed so philosophical that it was deemed untestable, since by assumption the variables are hidden, therefore, there doesn’t seem to be any way in which we can measure them...so is all hope lost? The insight that allowed people to put EPR ideas to the test involved preforming measurements of the binary property called spin along different orientations. At a higher level we can see that allowing for further orientations gives rise to a much broader collection of combinatorial possibilities for different spin outcomes, the reason being that as we run each and every experiment that we can choose to
measure the spin of one of the particles with respect to axis $I$ and the spin of the other particle with respect to an axis $J$, therefore it follows that the more axis we have available the more outcomes we can pull of. This was buried under the hood in John Bell’s paper, where measuring along three directions gave him enough freedom to develop an inequality based on the Einsteinian Framework of Hidden Variables which could then be backtested against the probabilities prescribed by quantum mechanics. They found experimentally that for certain orientations the probability distributions as quantum theory predicts violated the inequality. In these section we present a more user-friendly approach to understanding Bell’s theorem, one which involves preforming iterative measurements along 3 orientations which give rise to 9 possible joint settings. The interesting thing is that we can run these experiments over a large number of trials and see whether they favour the Einsteinian prescription or the quantum prescription.

**Einsteinian Framework**

To test this framework we will follow an experiment layed out by David-Merman.

In the middle is a source of entangled particles and at the ends are identical sets of apparatus’s that measure the spin of a particle in 3 different directions $\{I, J, K\}$

The suggestion given by the hidden-variables approach is to fix the spin configuration of one of the particles, for instance $\{↑, ↓, ↑\}$ and consequently the other need have $\{↓, ↑, ↓\}$. One could imagine doing this for all possible configurations and laying out a table- which is what we will do.
We now have all the possible configurations layed out. If we decide to also compare measurements of the detector now at different settings, we can compute a table describing when the measured spins are alligned and when they are anti-alligned. We will represent alligned by $\otimes$ and anti-alligned by $\times$.

\[
\begin{array}{cccccc}
\otimes & \otimes & \otimes & \otimes & \otimes & \otimes \\
\times & \times & \times & \otimes & \times & \otimes \\
\times & \otimes & \times & \times & \otimes & \times \\
\otimes & \times & \otimes & \times & \times & \times \\
\times & \times & \times & \otimes & \times & \otimes \\
\times & \otimes & \times & \times & \otimes & \times \\
\otimes & \times & \otimes & \times & \times & \times \\
\otimes & \otimes & \otimes & \otimes & \otimes & \otimes
\end{array}
\]

All in all we find that a little over $\frac{1}{3}$ of the time we find ourselves with spins that are alligned, and consequently $\frac{2}{3}$ of the time we find ourselves with spins that are anti-alligned.

**Quantum Mechanical Framework**

*Proof.*

\[ P(\theta) = \cos^2\left(\frac{\theta}{2}\right) \]

Concerning the orientations of the different axis they were each 120 degrees apart. if we plug this into our quantum formula we find that

\[ P(120^0) = 0.75 \]

\[\square\]
We therefore would expect that 75\% of the time our particles come out in the same orientation, and 25 \% of the time they come out in opposite orientations. If we again refer to the conclusions we drew using the EPR-perspective, we find complete disagreement to say the least.

3.3 Generating Entangled States

3.4 Preliminaries

In the sections that follow we will work with binary systems-meaning that our states will have only two possible outcomes, these are known as qubits in Quantum-Information-Science. We will be particularly interested in seeing how we can use entanglement as an aid to teleport qubit’s of information.

Bell-States

Bell states are another orthonormal basis that we can use to describe states of our composite system. They are useful for the reason that they are entangled, we will see how they factor into the picture of quantum teleportation and non-local games, but the basic idea being, that re-writing our state using the Bell-Basis, allows us to entangle states at the mathematical level.

\[
|\phi_0\rangle = \frac{1}{\sqrt{2}}(|+\rangle \otimes |+\rangle - |--\rangle \otimes|--\rangle)
\]

\[
|\phi_i\rangle = (1 \otimes \sigma_i |\phi_0\rangle)
\]

We could likewise invert and get our original basis states in terms of the bell states:

\[
|+\rangle \otimes |+\rangle = \frac{1}{\sqrt{2}}(|\phi_0\rangle + |\phi_3\rangle)
\]

\[
|+\rangle \otimes |--\rangle = \frac{1}{\sqrt{2}}(|\phi_1\rangle - i |\phi_2\rangle)
\]

\[
|--\rangle \otimes |+\rangle = \frac{1}{\sqrt{2}}(|\phi_1\rangle + i |\phi_2\rangle)
\]

\[
|--\rangle \otimes |--\rangle = \frac{1}{\sqrt{2}}(|\phi_0\rangle - |\phi_3\rangle)
\]
4 Non-Local Games/Using Entanglement to Beat the Odds!

Non-locality and entanglement paved the way for many interesting developments in computer science, now known as the field Quantum Information. One of the very useful implications of Non-locality are the kinds of games we can play. Here we provide a basic introduction to Non-local games.

Having access to entanglement will give us a very interesting new framework through which we can play games. We first define the framework in which we will be playing Non-local games in:

(i) We have two players, Alice and Bob and a referree
(ii) Alice and Bob are not allowed to communicate
(iii) Bob and Alice are asked binary questions by the referee and their answers are modelled by the following random variables: $a_i \in (1, 0)$ $b_i \in (1, 0)$

4.1 Game 1: Easy Mode

Challenge: Alice and Bob must give the same answers if questions match, and different answers when the questions differ

Solution: Alice and Bob have to choose the same strategy

4.2 Game 2: Easy Mode

Challenge: Alice and Bob must give different answers if their questions are the same and the same answer if their questions are different

Solution: Alice and Bob have to choose different strategies, in this way they invert each time.

4.3 Game 3: Impossible Mode

Challenge: Alice and Bob must give the same answer for all scenarios except if their both asked 1 in which case their answers must differ

Solution:
Assume that the referee hands Alice a bit $x$, and Bob a bit $y$. Then denote $a(x)$ as the output of Alice given the bit, and $b(y)$ the output of Bob, given the bit. We essentially want:

$$a + b \equiv xy \mod (2)$$

Winning works when $a = b$—either both 1 or both 0. Consequently the left hand side is zero for all cases except $x=y=1 \implies$ Optimal Success probability is $\frac{3}{4}$.

Entanglement-Strategy:
If we now further suppose that Alice and Bob were allowed to communicate through the means/resource of non-locality—by assuming for instance that they have quantum memory in their phones, we can actually build a more compelling strategy.

Consider the entangled state:

$$|\Psi\rangle = \frac{1}{\sqrt{2}} (|+\rangle \otimes |+\rangle + |-\rangle \otimes |-\rangle)$$

Now Alice and Bob will devise a quantum-strategy by using this shared entangled pair.
They will use the following set of basis:

Alice:

$$|v_0^x\rangle \equiv \cos \frac{\alpha_x}{2} |+\rangle + \sin \frac{\alpha_x}{2} |-\rangle$$

$$|v_1^x\rangle \equiv -\sin \frac{\alpha_x}{2} |+\rangle + \cos \frac{\alpha_x}{2} |-\rangle$$

Bob:

$$|w_0^y\rangle \equiv \cos \frac{\beta_y}{2} |+\rangle + \sin \frac{\beta_y}{2} |-\rangle$$
\[ |w^y_1\rangle \equiv -\sin \frac{\beta_y}{2} |+\rangle + \cos \frac{\beta_y}{2} |-\rangle \]

Note: It’s important to observe that since our bits \( \{x,y\} \in \{0,1\} \) both Alice and Bob have two sets of basis so to speak.

"The quantum strategy consists in the following. For any given \( x \) Alice measures her entangled spin along the basis \( (|v^x_0\rangle, |v^x_1\rangle) \). If she finds the spin along the first basis vector she outputs \( a = 0 \), if she finds the spin along the second basis vector she outputs \( a = 1 \). For a given \( y \) Bob measures his entangled spin along the basis \( (|w^y_0\rangle, |w^y_1\rangle) \). If he finds 0 the spin along the first basis vector he outputs \( b = 0 \), if he finds the spin along the second basis vector he outputs \( b = 1 \). The strategy requires fixing \( \alpha_0, \alpha_1, \beta_0, \) and \( \beta_1 \)."

Using this strategy the probability amounts to:

\[
P(a = b|x, y) = \cos^2 \frac{1}{2}(\alpha_x - \beta_y)\]

Which we can re-write in terms of our angles \( \alpha_0, \alpha_1, \beta_0, \beta_1 \) as follows:

\[
\alpha_x = \frac{\alpha_0 + \alpha_1}{2}; \quad \beta_y = \frac{\beta_1 + \beta_0}{2}
\]

Consequently for \( \alpha_0 = 0 \), \( \alpha_1 = \frac{\pi}{2} \) and \( \beta_0 = \frac{\pi}{4} \) and \( \beta_1 = -\frac{\pi}{4} \)

\[
P = \cos^2 \frac{\pi}{8} = \frac{1}{2} + \frac{1}{2\sqrt{2}} \approx 0.85355
\]
5 Quantum Teleportation

5.1 Teleportation Theory

Teleportation in its generality can be understood as teleporting matter or energy from one place to another without the need of traversing the medium in between, there are three ways in which one might think to do this.

(i) The kind where the thing you want to teleport is instantaneously moved from one place to another

(ii) The kind where you disassemble the thing you want to teleport and then reassemble it in another location by sending the pieces to that other location

(iii) The kind where you scan the object and transmit the instructions elsewhere so that someone can recreate the object with other atoms and molecules while the old object is destroyed in the meanwhile.

Quantum teleportation deals with the third case. The important observation in all of this we are not teleporting physical objects faster than the speed instead.

Theorem 1. No-Cloning Theorem
Quantum states cannot be cloned

No-cloning means in the mathematical sense that we can’t be handed an entangled state and transform it in yet another entangled state with the clone in spot of the ladder state. In other words.

\[ U |\psi\rangle |\xi\rangle = |\psi\rangle |\psi\rangle \]

Is not allowed.

Proof. Here are the three properties we will make use of in the proof

(i) Quantum Superpositions

|\psi\rangle + |\phi\rangle

(ii) Quantum Composite systems

|\psi\rangle \otimes |\phi\rangle

(iii) Linearity of Unitary Transformations

\[ U_c (\alpha |\psi\rangle + \beta |\phi\rangle) = \alpha U_c |\psi\rangle + \beta U_c |\phi\rangle \]

Suppose by way of contradiction that such a cloning transformation exists. By assuming it’s existence it must be the case that this transformation be linear and behave properly under “cloning” quantum superpositions and composite systems, this we will see is at the heart of the argument.
\[ U_c(\alpha |\psi\rangle + \beta |\phi\rangle) = (\alpha |\psi\rangle + \beta |\phi\rangle) \otimes (\alpha |\psi\rangle + \beta |\phi\rangle) \]

Using properties of the tensor product gives us:
\[ \alpha |\psi\rangle \otimes \alpha |\psi\rangle + \alpha |\psi\rangle \otimes \beta |\phi\rangle + \beta |\phi\rangle \otimes \beta |\phi\rangle \beta \otimes \alpha |\psi\rangle \]

Now comparing this with what we expect to get from linearity:
\[ \alpha U_c |\psi\rangle + \beta U_c |\phi\rangle = \alpha(|\psi\rangle \otimes |\psi\rangle) + \beta(|\phi\rangle \otimes |\phi\rangle) \]

Which ends in a contradiction since we get extra interference terms in the first case while we don’t in the ladder. From this we can conclude that cloning and quantum mechanics are incompatible, it must be either one or the other and with the success of quantum mechanics it isn’t looking so good for cloning.

From this we have concluded that after teleportation initial states must necessarily be destroyed beyond repair.

### 5.2 Theoretical Underpinnings

The culprits in this story are once again Alice and Bob, and in this journey their out to quantum-teleport a state. The idea of Quantum Teleportation was first introduced in a paper by Bennet and others in 1993. The conclusion from their analysis was that you could take particles in a certain arrangement and shift their quantum condition onto a state onto particle arbitrarily far away, by making clever use of entanglement.

**Algorithm for Quantum Teleportation**

(i) Entangled Source that creates entangled pairs of particles with similar features to the state that Alice wishes to teleport must be readily available

(ii) Send part of the entangled state from the entangled source to Alice and the other part of the entangled state to Bob

(iii) Alice will comingle here entangled particle with the information/quantum state she wants to teleport, with that then Alice will perform a ‘partial measurement’ and use classical communication channels to send a signal to Bob that in some way indicates the results of this partial measurement, from which Bob can then use to evolve his entangled state as he received it initially from the reservoir in a way that reproduces Alice’s state.
We will now explore these ideas quantitatively. Once we dive into the math it will be more clear what exactly sneaky measurements are, but their use is that they give us enough information about what’s going on inside the box that allow us to communicate an important piece of information to Bob without collapsing the state- which would have the effect of ruining the teleportation.

We start with a reservoir of entangled pairs with similar features to Alice’s Initial state. Mathematically the clever thing to do here is to start off with her initial state now understood in the world of composite systems and then to entangle it by re-writing it in a smarter basis, namely the Bell-Basis

Alice’s state she wishes to teleport:

\[ \alpha |+\rangle + \beta |-\rangle \]

The idea is to throw the entangled state from the source into the same box as Alice’s state and then entangle this newly found composite system by expressing it in the Bell-Basis.

\[ |\psi\rangle_{tot} = |\phi_0\rangle_{AB} \otimes (\alpha |+\rangle_{C} + \beta |-\rangle_{C}) \]

\[ |\phi_0\rangle = \frac{1}{\sqrt{2}}(|+\rangle \otimes |+\rangle - |-\rangle \otimes |-\rangle) \]

We further simplify things using some tensor algebra:

\[ |\psi\rangle_{tot} = |\phi_0\rangle_{AB} \otimes (\alpha |+\rangle + \beta |-\rangle) \]

\[ = \frac{1}{\sqrt{2}} (\alpha |+\rangle_{A} \otimes |+\rangle_{C} \otimes |+\rangle_{B} + \beta |+\rangle_{A} \otimes |+\rangle_{C} \otimes |-\rangle_{B} + \alpha |-\rangle_{A} \otimes |-\rangle_{C} \otimes |+\rangle_{B} + \beta |-\rangle_{A} \otimes |-\rangle_{C} \otimes |-\rangle_{B}) \]

\[ = \frac{1}{2} |\phi_0\rangle \otimes (\alpha |+\rangle_{B} + \beta |-\rangle_{B}) + \frac{1}{2} (|\phi_1\rangle \otimes (\beta |+\rangle_{B} - \alpha |-\rangle_{B}) + \frac{1}{2} |\phi_2\rangle \otimes (\alpha |+\rangle_{B} - \beta |-\rangle_{B}) + \frac{1}{2} |\phi_3\rangle \otimes (\beta |+\rangle_{B} - \alpha |-\rangle_{B}) \]

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\[ \frac{1}{2} |\phi_0\rangle \otimes (\alpha |+\rangle_B + \beta |-\rangle_B) + \frac{1}{2} |\phi_1\rangle \otimes (\sigma_1 |\psi\rangle) + \frac{1}{2} i |\phi_2\rangle \otimes (\sigma_2 |\psi\rangle) + \frac{1}{2} |\phi_3\rangle \otimes (\sigma_3 |\psi\rangle) \]

Having now rephrmed our states in terms of their entangled counterparts will serve to be the essential ingredient to teleportation. Alice can make partial measurements on her system while still keeping her original state in tact, she does this by measuring the Bell component of our tensor product state, from which she can then send a signal to Bob telling him the result of her measurement, from which then Bob can make use of a fancy apparatus that unitarily evolves our state in a way that alligns with the instructions sent by Alice so that we effectively reproduce Alice’s Original state.