(2) write correct Bell Basis for state $|1\rangle \otimes |0\rangle$
or $|\uparrow\rangle \otimes |\downarrow\rangle$

$$= \frac{1}{\sqrt{2}}\left(|\phi_1\rangle - i\,|\phi_2\rangle\right) \quad [\text{Ans}]$$

(3) In the product of spin states, $\frac{1}{\sqrt{2}}\left(|\uparrow\rangle \otimes |\uparrow\rangle + |\uparrow\rangle \otimes |\downarrow\rangle\right)$ what's the probability that a bell measurement will find the Bell state $|\phi_1\rangle$?

In order to solve this question, rewrite the given equation as superposition of Bell states

Recall bell states are $|\phi_0\rangle, |\phi_1\rangle, |\phi_2\rangle, |\phi_3\rangle$

The given 4 states can be seen equivalent to $\boxed{\frac{1}{2}|\phi_0\rangle + \frac{1}{2}|\phi_1\rangle - \frac{i}{2}|\phi_2\rangle + \frac{1}{2}|\phi_3\rangle}$ hence among 4 finding any one bell state, probability of finding any one of 4 will be $1/4$

Process : using algorithm for teleportation :-

Suppose Alice starts with C, which she wants to send to B, state C can be written as

$$|\psi\rangle_C = c_1|\uparrow\rangle_C + c_2|\downarrow\rangle_C$$

with c_1 and c_2 are normalized constants.

(4) Generate an entangled pair of electrons A, B

in the Bell state.

$$|\phi\rangle_{AB} = \frac{1}{\sqrt{2}}\left(|\uparrow\rangle_A \otimes |\uparrow\rangle_B + |\downarrow\rangle_A \otimes |\downarrow\rangle_B\right)$$

or $|\psi\rangle_{ABC} = |\phi\rangle_{AB} \otimes |\psi\rangle_C$ This is a product state between entangled pair AB and non-entangled C.

(2) Alice measures the bell state of AC, entangling A and C while disentangling B. The process of measuring the bell state projects non entangled state into an entangled state, since all four bell states are entangled.

(3) To send Bob, the state particle C, Alice does not need to send bob the possibly infinite amount of information contained in coefficients c_1 and c_2 which may be real numbers out to arbitrary precision. She needs only to send integer (i) of the Bell state of A and C, which is a maximum of 2 bits of information. Alice can send this information to Bob in classical way.

(4) [IMP] Bob recieves the integer i from Alice that labels the Bell state which need to be measured and that she measured

[illegible] implementation. After Alice measurement

before teleportation. After Alice measures,
the overall system looks like:

$$|\psi\rangle_{ABC} = |\phi_i\rangle_{AC} \otimes \sigma_i |\psi\rangle_B$$

Bob ∴ applies σ_i to the disentangled $|\psi\rangle_B$ state on his end, by measuring the spin along axis i, since $\sigma_i^2 = I$ for all i. Bob is left with overall state

$$|\psi\rangle_{ABC} = |\phi\rangle_{AC} \otimes |\psi\rangle_B$$

∴ Bob has

$$|\psi\rangle_B = c_1|\uparrow\rangle_B + c_2|\downarrow\rangle_B$$

which is identical to original particle C.
However the particles involved never changed b/w observers. Alice always has A and C and Bob has B.
(No deleting, no cloning Theorem.)

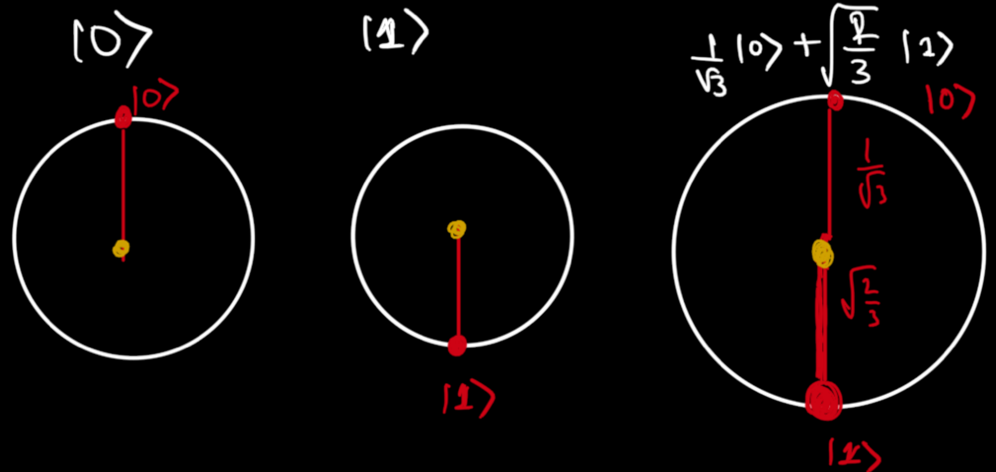
Q - sphere :

Bloch sphere can only illustrate the state of 1 qubit, so if we have multiple qubits we use q- sphere.

⊕ for one qubit: the "North pole" represents the state $|0\rangle$, while the "south pole" represents $|1\rangle$

⊕ The size of them blob is proportional to the probability of measuring respective state .

⊕ There are different colours for the blobs as well, these colours, indicates the relative phase compared to state $|0\rangle$.



for n-qubits we have 2^n basis states, eg for $n=3$ we have

$$\begin{bmatrix} 000 \\ 001,\ 010,\ 100, \\ 011,\ 101,\ 110, \\ 111 \end{bmatrix}$$

we put these basis states as equally distributed points on a sphere

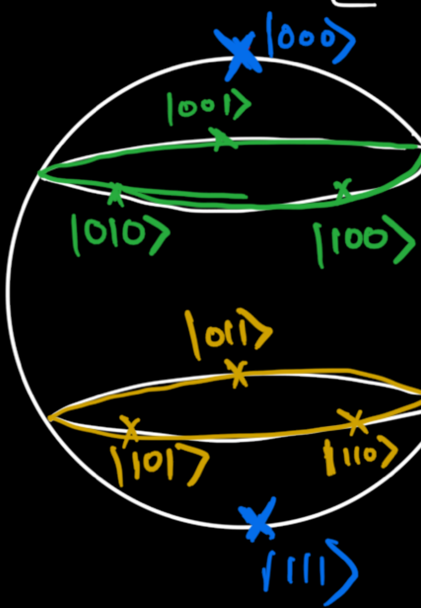
with $0^{\otimes N}$ on the north Pole

I on the south Pole and all other states aligned are parallel such that the number of '1's' on each latitude is constant and increasing from North to South.

Example: for $n=3$

for $n=3$, to represent on q-sphere we have

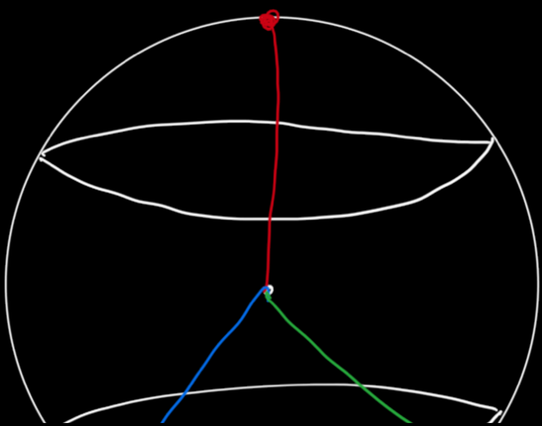
$$\begin{bmatrix} 000 \\ 001,\ 010,\ 100, \\ 011,\ 101,\ 110, \\ 111 \end{bmatrix}$$



size and color of the blobs as before

eg

$$\frac{1}{2}\left(|000\rangle - |011\rangle + \sqrt{2}\cdot i\cdot|101\rangle\right)$$



Now

Qiskit