Origin of Quantum Mechanical Results and Life: A Clue from Quantum Biology

Biswaranjan Dikshit

ABSTRACT

Although quantum mechanics can accurately predict the probability distribution of outcomes in an ensemble of identical systems, it cannot predict the result of an individual system. All the local and global hidden variable theories attempting to explain individual behavior have been proved invalid by experiments (violation of Bell's inequality) and theory. As an alternative, Schrodinger and others have hypothesized existence of free will in every particle which causes randomness in individual results. However, these free will theories have failed to *quantitatively* explain the quantum mechanical results. In this paper, we take the clue from quantum biology to get the explanation of quantum mechanical distribution. Recently it was reported that mutations (which are quantum processes) in DNA of *E. coli* bacteria instead of being random were biased in a direction such that the chance of survival of the bacteria is increased. Extrapolating it, we assume that all the particles including inanimate fundamental particles have a will and that is *biased to satisfy the collective goals of the ensemble*. Using this postulate, we mathematically derive the correct spin probability distribution without using quantum mechanical formalism (operators and Born's rule) and exactly reproduce the quantum mechanical spin correlation in entangled pairs. Using our concept, we also mathematically derive the form of quantum mechanical wave function of free particle which is conventionally a postulate of quantum mechanics. Thus, we prove that the origin of quantum mechanical results lies in the will (or consciousness) of the objects biased by the collective goal of ensemble or universe. This biasing by the group on individuals can be called as "coherence" which directly represents the extent of life present in the ensemble. So, we can say that life originates out of establishment of coherence in a group of inanimate particles.

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Introduction

Classical or Newtonian mechanics is deterministic and if it were perfectly correct, we could predict all the future events of the universe by feeding in the data of all particles of universe to a huge machine (so called "Laplace demon") which has infinitely large calculating power. But unfortunately, it has been experimentally proved that classical mechanics is only an approximate theory which fails at the microscopic level whereas quantum mechanics wins both at the micro and macroscopic level. Since the discovery of Schrodinger's equation in 1926, quantum mechanics has established itself as a robust theory of nature explaining nearly all the phenomena observed in the universe. But intrinsically, it is able to provide only a probabilistic prediction of experimental results. The accuracy of its prediction can be confirmed only if an infinitely large number of experiments are carried out in identical systems. In a single experiment on an individual system, the present-day quantum mechanics cannot predict the result with probability one (i.e. with 100% accuracy). That's why in their famous paper, (Einstein *et al.,* 1935) expressed the view that present day.

Corresponding author: Biswaranjan Dikshit
Address: Laser and Plasma Technology Division, Bhabha Atomic Research Centre, Mumbai-400085, India
e-mail ✉ bdikshit73@yahoo.co.in
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quantum mechanics is incomplete and hoped that it may be completed in future by including some local hidden *realistic* (or *pre-existing*) variables in the system being measured. By assuming these local hidden variables to be the cause of outcomes, (Bell, 1964) derived an inequality expression for the spin correlation among entangled pairs of particles which contradicted the quantum mechanical spin correlation

Consequently, Initially Aspect (Aspect *et al.,* 1982; 1982b; 1999) and then a large number of other researchers (Tittel *et al.,* 1998; Ou *et al.,* 1988; Shih *et al.,* 1988; Weihs *et al.,* 1998; Colbeck *et al.,* 2011; Merali *et al.,* 2011) carried out experiments which decisively violated the Bell's inequality and thus ruled out the future possibility of local hidden variables to complete the quantum theory. Recently, non-local (global) hidden variable theories like deterministic Bohmian mechanics (Bohm *et al.,* 1952; Genovese, 2005) have also been proved to be incompatible with quantum mechanics and relativity, theoretically by (Leggets, 2003) and (Gisin, 2011) and experimentally by Groblacher and Paterek (Groblacher *et al.,* 2007; Paterek *et al.,* 2007). While reporting the experimental results demonstrating the inconsistencies of non-local hidden variable theories, Groblacher (Groblacher *et al.,* 2007) wrote, "Our result suggests that giving up the concept of locality is not sufficient to be consistent with quantum experiments, unless certain intuitive features of realism are abandoned". To escape from this no-go situation, originally Schrodinger and then Conway and Kochen proposed that every elementary particle in the universe has some amount of *free will* which causes the uncertainty or randomness in the experimental result (Schrodinger, 1936; Conway *et al.*, 2006, 2009). This is a kind of expression of creativity by the particle. However, this free will theory could neither quantitatively prove the quantum mechanical results nor provide any basis for postulates of quantum mechanics. The free will theory based on stochastic model developed by Conway and Kochen has also been refuted later on by (Goldstein *et al.,* 2010).

In this paper, instead of taking the *will* of nature as completely free, we take it to be *biased to maximally satisfy the laws of universe and collective goals of the ensemble*. Because there is a *will* (or consciousness) in each particle, there will be some amount of randomness in the outcomes of individual experiments. However, the *biasing* of the *will* by nature generates a specific pattern or distribution in the outcomes of repeated experiments carried out on identical systems. We get this clue from surprising experimental results in quantum biology in which it was recently reported that adaptive mutation happens in DNA of bacteria (Merali, 2014; McFadden *et al.,* 1999).

In response to a changing environment, mutations in *E. coli* bacteria (which are quantum processes) instead of being random were found to be biased in a direction such that the chance of survival of the bacteria is increased.

Using our biased will approach, we will form a foundation on which the postulates of quantum mechanics can stand and for some cases we will directly derive the established quantum mechanical results without using quantum mechanical formalism. In section-2, we will first see how by considering the biased will of the system and without using quantum mechanical formalism (such as operators and Born's rule), we can correctly predict the probability distribution of spin along any arbitrary direction that agrees with the quantum mechanical predictions. In section-3, using the biased will approach, we will derive the expression for expectation value of spin correlation between two entangled particles that again exactly matches with the conventional quantum mechanical relation. We will also discuss how opposite spin may be understood in a single pair of entangled particles separated by huge (space-like) distances without need of superluminal information transfer. In section-4, we theoretically justify the form of generalized quantum mechanical wave function of a free particle using biased will so that interference of matter waves and expressions for quantum mechanical operators can be explained. Thus, by means of three different cases, we prove that the origin of quantum mechanical results is the *will* (or consciousness) of the objects biased by the collection or universe. Finally in conclusion, we try to find out the basic structural distinction between non-living and living bodies (or life and death) based on the concept outlined in this paper. We infer that in non-living bodies, the constituent parts have minimal quantum coherence striving to satisfy only the basic laws of the universe such as conservation of angular momentum, energy, maintaining symmetry of space etc. But, living bodies have greater extent of quantum coherence among its constituent parts so that more complex goal oriented behaviors are exhibited (for self-preservation, pain avoidance etc).

Derivation of spin probability distribution from biased will

Consider a fundamental particle such as an electron whose spin angular momentum '*s*' is quantized that can be of either $+\hbar/2$ or $-\hbar/2$ along the direction of measurement (reason for quantization will be explained in end of section 4). Let the electron initially passes through a Stern-Gerlach magnet so that its spin is aligned along Z-axis and let it be $+\hbar/2$. Of course, in this case spin along other two perpendicular directions are undefined. Now we want to find out the probability that its spin is found to be $+\hbar/2$ when measured along any arbitrary direction making an angle θ with Z-axis as shown in Fig.1.

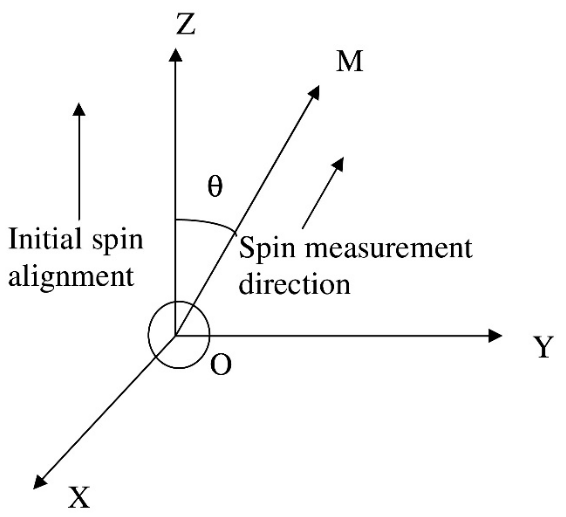

Figure 1. Direction of spin measurement (Initially particle spin is aligned along OZ and then spin is measured along OM)

Because of presence of will of the particle, there will be a uncertainty in result in the individual experiment which can be $\pm\hbar/2$. But whatever be the result, angular momentum of the particle is not conserved (it is initially $+\hbar/2$ along Z-axis and finally $\pm\hbar/2$ along OM as shown in Fig.1). This happens because of superiority of law of quantization of spin over the law of conservation of angular momentum. However, if we carry out the experiment on a large number of identical particles, *the probability* ***p*** *will be so biased by nature that total angular momentum of the collection is maximally conserved along OM in which direction the particles have freedom to have any one of the two possible spin values*. If ***p*** is the probability of getting spin $+\hbar/2$ along OM, then (1-***p***) is probability of getting spin $-\hbar/2$. For N number of identical particles on which experiment is carried out, to satisfy the law of conservation of angular momentum along OM in addition to the existing law of quantization,

Initial total angular momentum along OM= Final total angular momentum along OM

Or $$N\frac{\hbar}{2}\cos\theta = pN\left(+\frac{\hbar}{2}\right)+(1-p)N\left(-\frac{\hbar}{2}\right)$$

Or $$p=\frac{1+\cos\theta}{2}$$

Or $$p=\cos^2\left(\theta/2\right) \qquad (1)$$

Thus, Eq. (1) exactly reproduces the conventional quantum mechanical probability distribution to get spin $+\hbar/2$ along any arbitrary direction. We have derived it by use of the concept of biased will of nature without applying quantum mechanical operators and Born's rule.

Derivation of spin correlation in quantum entangled particles using theory of biased will

Spin correlation in a pair of entangled particles A and B is given by the product of their measured spins along pre-decided directions (spins are taken to be +1 or -1 excluding the constant part $\hbar/2$ or $\hbar$). If we select to measure the spin of particle A along unit vector $\vec{a}$ and spin of particle B along $\vec{b}$, quantum mechanics predicts that expectation (or average) value of spin correlation is given by,

$$\left\langle P(\vec{a},\vec{b}\,)\right\rangle = -\vec{a}\cdot\vec{b} = -\cos\theta \qquad (2)$$

Where θ is the angle between unit vectors $\vec{a}$ and $\vec{b}$.

Above quantum mechanical spin correlation has been experimentally validated by numerous authors. Now we will derive the same average spin correlation given by Eq. (2) using the concept of biased will of nature without using quantum mechanical formalism.

Let us consider N number of entangled pairs (or twins) of particles A_1B_1, A_2B_2, A_3B_3,….. A_NB_N emerging from a common source of spin zero. Particles in each pair A_iB_i move in opposite directions before being exposed to experimental setups for measurement of spin along certain directions $\vec{a}$ and $\vec{b}$ as shown in Figure 2.

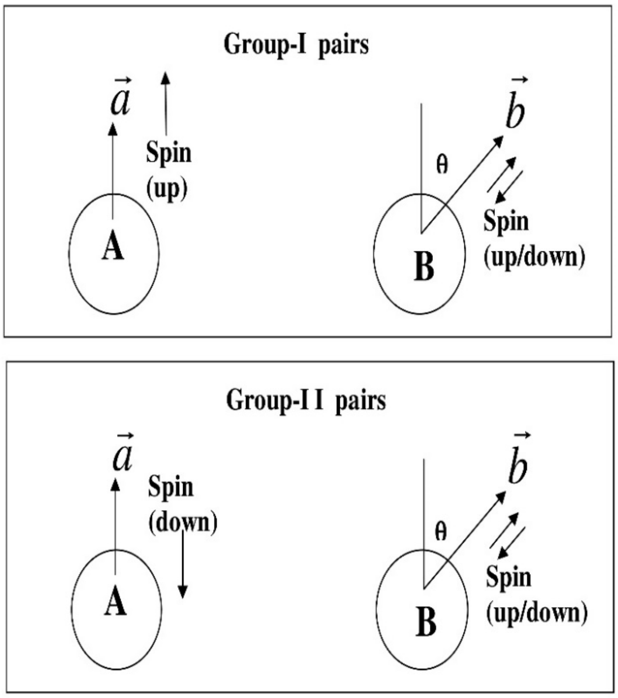

Figure 2. Two different groups of members in ensemble of entangled pairs

(For Group-I pairs, first measurement result is spin-up and for Group-II it is spin-down)

Although spin is a property of individual particle, the correlation (or product) of spins in a twin is only a *property of twin* which can be +1 (if A_i and B_i both are aligned along or opposite to $\vec{a}$ and $\vec{b}$ respectively) or -1 (if either of A_i and B_i is aligned along and other is opposite to pre-decided direction). So, for the measurement of correlation, each twin or pair A_iB_i represents a *single member* (or coherent pair) in statistical ensemble of N number of twins. However, measurement of spin is a two-step process in which at first we have to measure the spin of (say) A_i and then go for B_i. Only after knowing the spin state of B_i, we get to know the spin correlation. Just after the spin measurement of A_i (and before measuring B_i), all the members in the ensemble cannot be considered identical since some of A_i's have spin along unit vector $\vec{a}$ and others have spin opposite to it. If p_A is the probability of getting spin of A_i along direction $\vec{a}$, $p_A N$ members are exactly identical in the sense that all of them have A_i along $\vec{a}$ before expressing their spin correlation. Let us call this group of members which are identical before experiment on B_i as Group-I. Similarly, $(1-p_A)N$ numbers of pairs constitute identical members of Group-II all of which have spin oppositely aligned to direction of $\vec{a}$ as shown in Fig.2.

Now for Group-I, if p_B is the probability of getting spin along the direction of $\vec{b}$, as per our axiom of biased will of nature, p_B will be such that total angular momentum in group-I along the measurement direction $\vec{b}$ is conserved (As in this direction only B_i has freedom to have any spin). Since, initial angular momentum of all twins before birth is zero, final angular momentum along the direction of $\vec{b}$ in Group-I which has $p_A N$ members is also zero. So mathematically from Fig. 2, we get,

$$p_A N\cos\theta + p_B(p_A N)(+1) + (1-p_B)(p_A N)(-1) = 0$$

Or $$p_B = \frac{1-\cos\theta}{2} \quad (3)$$

Now, all of $p_A N$ members in group-I have one partner spin along $\vec{a}$ and $p_B p_A N$ members have other partner spin along the direction $\vec{b}$. So, correlation or product of spin for each of $p_B p_A N$ members is +1. Hence, $(1-p_B)p_A N$ members have correlation equal to -1.

Expectation (or average) value of spin correlation in Group-I is then given by,

$$\left\langle P(\vec{a},\vec{b})\right\rangle_I = \frac{\text{sum of correlations of all members}}{\text{Number of members}}$$

Or

$$\left\langle P(\vec{a},\vec{b})\right\rangle_I = \frac{p_B p_A N(+1) + (1-p_B)p_A N(-1)}{p_A N}$$

Or $$\left\langle P(\vec{a},\vec{b})\right\rangle_I = 2p_B - 1$$

Putting the value of p_B from Eq. (3) in above,

$$\left\langle P(\vec{a},\vec{b})\right\rangle_I = -\cos\theta \quad (4)$$

Similarly, we can proceed to calculate the average correlation for Group-II which has $(1-p_A)N$ number of identical members all of which have spin oppositely aligned to direction of $\vec{a}$ as shown

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in Fig.2. If p'_B is the probability of getting spin along the direction of $\vec{b}$ in group-II, as per our theory of biased will of nature, it will be such that total angular momentum in group-II along the measurement direction $\vec{b}$ is conserved. Since, initial angular momentum of all twins before birth is zero, final angular momentum along the direction of $\vec{b}$ is also zero. From Fig.2, mathematically we get,

$$-(1-p_A)N\cos\theta + p'_B(1-p_A)N(+1) + (1-p'_B)(1-p_A)N(-1) = 0$$

Or $$p'_B = \frac{1+\cos\theta}{2} \tag{5}$$

Product of spin for each of $p'_B(1-p_A)N$ members is -1. Hence, $(1-p'_B)(1-p_A)N$ members have correlation equal to +1. Average value of spin correlation in Group-II is then given by,

Or

$$\left\langle P(\vec{a},\vec{b})\right\rangle_{II} = \frac{p'_B(1-p_A)N(-1)+(1-p'_B)(1-p_A)N(+1)}{(1-p_A)N}$$

Or $$\left\langle P(\vec{a},\vec{b})\right\rangle_{II} = -2p'_B + 1$$

Putting the value of p'_B from Eq. (5) in above,

$$\left\langle P(\vec{a},\vec{b})\right\rangle_{II} = -\cos\theta \tag{6}$$

Thus from Eq. (4) and (6), we find that irrespective of whether the twin is in Group-I or II, the average value of correlation is ($-\cos\theta$). So, we can generalize the result and write the expectation value of correlation as,

$$\left\langle P(\vec{a},\vec{b})\right\rangle = -\cos\theta \tag{7}$$

Thus, we could derive the expectation value of spin correlation in entangled pairs of particles which exactly matches with the relation derived by conventional quantum mechanical formalism.

We can prove that Eq. (7) is relativistically invariant i.e. it holds independent of state of motion of observer. The proof is as follows. If measurements of spin of A_i and B_i are carried out in space like separated regions, certainly for some observers, event at B_i will happen before A_i. In that case, those observers will classify the members to Group-I and Group-II as per the spin result at B_i and apply the law of conservation of angular momentum along direction $\vec{a}$ since they can know about the correlation only after spin measurement of A_i. Thus, adopting a similar procedure as before, they will also derive the same spin correlation given by Eq. (7).

It is interesting to analyze the case of a single pair of entangled particles when spin is measured along same direction for both of them ($\theta = 0$). It has been a surprise to everyone how one particle in the pair gets knowledge about the spin of other partner so that it can be aligned in opposite direction relative to other especially if both are separated by space-like region and superluminal speed of information is not allowed. We can understand this from Eq. (7) which dictates that for $\theta = 0$, average spin correlation is perfect i.e. $\left\langle P(\vec{a},\vec{a})\right\rangle = -1$. So, if there are millions of pairs of particles with which experiments are carried out, each of them must contribute a spin correlation of -1 (none +1) to the sum of correlations so that average remains -1 otherwise it will shift towards +1. *This means, each of the millions of pairs must have opposite spin which we can state in terms of probability that "probability for getting opposite spin must be one".* So, even if we carry out the experiment on a single entangled pair, it must show opposite spins in its partners. Thus we conclude that opposite spin observed in a single pair of entangled particles is not due to superluminal information transfer from one to other, rather it is due to the fact that *spin correlation is a property of pair as a whole* (which can be called quantum coherence) and it becomes exactly -1 due to Eq. (7). Avoiding the superluminal information transfer is important as when speed of information exceeds that of light, causality principle is violated since ordering of two events occurring in space-like separated regions can be changed by state of motion of observer.

Quantum mechanical wave function of a free particle from biased will of nature:

It is well known that interference of matter waves can be explained only if generalized quantum mechanical wave function of a free particle of momentum *p* and energy *E* is taken as,

$$\psi(r,t) = Ae^{\frac{i}{\hbar}(\vec{p}\cdot\vec{r}-Et)} \tag{8}$$

Where *r* is space coordinate, *t* is time, *A* is a constant and $\hbar$ is reduced plank's constant. Fundamental justification for the above form of wave function is also very important as it is the only basic equation from which the two conventional quantum mechanical operators in formalism (momentum and energy operators) are derived. In this section, by using our biased will approach, we will theoretically derive the generalized form of wave function given by Eq. (8).

Let us suppose that the complex function related to the extent of presence of a single free particle at any point of space-time is given by,

$$\psi(r,t) = f(r,t)e^{ig(r,t)} \tag{9}$$

Where, magnitude $f(r,t)$ and phase $g(r,t)$ are two arbitrary real functions of space-time. If we consider the extent of presence of particle at each point of space '*r*' as an independent variable, then each of these values of $\psi(r,t)$ can be represented as an orthogonal vector $\psi(r,t)|r\rangle$ (where $|r\rangle$ is unit eigen vector) in a multidimensional mathematical space (called Hilbert space) and the total $|\psi\rangle$ is represented as a vector sum of these components. But due to quantization of the presence of the particle, it can only be detected at a single point in space at any time. So, each point of space will have a probability for appearance of the particle. To have a probabilistic interpretation of $\psi(r,t)$, *total presence must be equal to one (i.e.* $|\psi\rangle$ *must be a unit vector) and it must be written as a sum of its scalar components. In any multidimensional vector space, the resultant can be written as a scalar sum of projections of its vector components along itself (i.e.* $|\psi\rangle$*) as all of them are collinear.*

Using definition of projection operator, projection of $|\psi\rangle$ on $|r\rangle$ is $|r\rangle\langle r|\psi\rangle$, Similarly, projection of $|r\rangle\langle r|\psi\rangle$ along $|\psi\rangle$ is $|\psi\rangle\langle\psi|r\rangle\langle r|\psi\rangle = |\psi\rangle|\psi(r,t)|^2$.

From above we conclude that each projection of the total system along position eigen vectors contributes a collinear component to constitute the total system. So, all these magnitudes can be added to get,

$$|\psi(r_1,t)|^2 + |\psi(r_2,t)|^2 + |\psi(r_3,t)|^2 + \dots\dots\dots = 1 \tag{10}$$

Now since the above Eq. (10) is a scalar equation, we can have probabilistic interpretation and conclude that $|\psi(r,t)|^2$ is the probability density of physically finding the particle at *r* at time *t* (Here, we have actually proved Born's rule).

Since for a *free* particle, space must be physically *symmetric a*nd particle must *continue to exist* with time (*these are the biasing by the universe*), probability density $|\psi(r,t)|^2 = \psi^*(r,t)\psi(r,t)$ must be independent of *r* and *t*. This indicates, using Eq. (9), $\psi^*(r,t)\psi(r,t) = (f(r,t))^2$ must be independent of space-time i.e. $f(r,t) = A$, where *A* is a constant. Thus Eq. (9) reduces to,

$$\psi(r,t) = Ae^{ig(r,t)} \tag{11}$$

To know the mathematical form of function $g(r,t)$ i.e. whether it is a linear or nonlinear function of space-time, for simplicity, let us consider only one coordinate, say *x*.

So, $\psi(x) = Ae^{ig(x)}$

Generally, the phase is given with respect to a reference angle which can be arbitrarily chosen by different observers. But, difference of phase between any two points in space must be same for all observers stationary with respect to each other irrespective of their location (*required for symmetry of space*). If $g(x_1)$ and $g(x_2)$ are phases at points x_1 and x_2 as recorded by a stationary observer located at *O* and $g(x_1')$ and $g(x_2')$ are phases recorded at same points by another stationary observer having a shifted origin *O'*, then,

$$g(x_2) - g(x_1) = g(x_2') - g(x_1') \tag{12}$$

and $$x_2 - x_1 = x_2' - x_1' \tag{13}$$

Dividing Eq. (12) by (13),

$$\frac{g(x_2) - g(x_1)}{x_2 - x_1} = \frac{g(x_2') - g(x_1')}{x_2' - x_1'}$$

In differential form,

$$\frac{dg(x)}{dx} = \frac{dg(x')}{dx'}$$

Since both sides of above equation are functions of different variables, the ratio must be a constant, say '*k*'. So, $\frac{dg(x)}{dx} = k$

Integrating above differential equation and taking $g(x) = 0$ at x=0,

$$\int_0^{g(x)} dg(x) = \int_0^{x} kdx \qquad \Rightarrow \qquad g(x) = kx$$

Thus we see that phase must be a linear function of x. Since, all four coordinates of space time must be considered at par, phase $g(r,t)$ must also be linear function of space-time. Taking into account the opposite sign of time with respect to space in relativistic space-time metric (+---), $g(r,t) = kr - \omega t$

The constant k before r happens to be same as $p/\hbar$ and constant ω before t happens to be same as $E/\hbar$ where p is momentum, E is total energy and $\hbar$ is universal constant equal to reduced Plank constant. So we get,

$$g(r,t) = \frac{1}{\hbar}(\vec{p} \cdot \vec{r} - Et)$$

Putting the above in Eq. (11), we get,

$$\psi(r,t) = Ae^{\frac{i}{\hbar}(\vec{p}\cdot\vec{r} - Et)} \qquad (14)$$

Above equation is same as the desired Eq. (8) for free particle wave function with fixed momentum and energy. Using this equation, as mentioned in conventional text books (Beiser, 1987), we can now prove the quantum mechanical momentum operator to be $(-i\hbar\nabla)$ and energy operator to be $(i\hbar \partial/\partial t)$. Using Eq. (14), we can also generate interference pattern and form wave packets for localized particles. If Eq. (14) is used in Einstein's relativistic energy expression, we will recover the Dirac equation which will lead to quantization of spin. Thus, we have found that the generalized form of free particle wave function on which the whole of quantum mechanics stands can be derived from our theory of biased will of nature.

Conclusion and Scientific Implications

In this paper, by assuming that the inanimate particles have a will (or consciousness) and that is biased to maximally satisfy the laws of universe such as conservation laws and symmetry of space, we have derived the correct spin probability distribution with angle without using quantum mechanical formalism such as operators and Born's rule. Similarly, by using the biased will, we have exactly reproduced the quantum mechanical spin correlation in entangled pairs of particles. We have also explained the opposite spin in a single entangled pair when it is measured along same axis without requiring the superluminal information transfer so that relativistic causality is not violated. Finally, we have developed a theoretical justification for the form of generalized quantum mechanical wave of a free particle using biased will of nature so that interference and quantum mechanical operators can be derived on which the whole of quantum mechanics stands. Thus, we have proved that origin of quantum mechanical results lies in the *will* of the objects biased by the whole.

Scientific implications of the above analysis are significant since we could extrapolate our observations in living organisms to inanimate matter to infer that motivations of the universe both in form of conservation laws and collective goals of systems can affect the quantum mechanical results. This biasing by the group on its individual member can be called as "coherence of will" which directly represents the extent of life present in the ensemble. *Thus, life originates out of establishment of coherence in a group of inanimate particles*. We are now in a position to state the basic structural distinction between non-living and living bodies based on the concept outlined in this paper. In a non-living entity, the constituent parts have minimal quantum coherence among themselves and they try to satisfy only the basic laws of the universe such as conservation of angular momentum, maintaining symmetry of space etc. But in living bodies, the constituent parts have greater extent of quantum coherence in the will (or consciousness) so that more complex goal oriented behaviors are exhibited for self-preservation, pleasure enhancement, pain avoidance etc. Death of an organism indicates the destruction of this coherence and tendency of living organism to preserve itself is truly tendency to preserve its coherence. It has been recently reported by (Hameroff, 2004) that the origin of cancer in cells can also be traced to the impairment of quantum coherence during mitosis. To make a dead cell alive or to find a cure for cancer, we have to search for ways to reestablish the coherence or macroscopic entanglement in its constituents. Of course, much more research is required in interdisciplinary subjects like quantum entanglement in macroscopic systems (Vedral, 2008) and quantum biology (Lambert *et al.,* 2013; Josephson *et al.,* 1991; Strapp, 1982; Hameroff *et al.,* 2014) to mathematically model and modify the processes and behaviors exhibited by living organisms.

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