Adv. Studies Theor. Phys., Vol. 3, 2009, no. 12, 489 - 492

What if Our Three Dimensional Curved Universe Was Embedded in Four Dimensional Space? Consequences on the EPR Paradox

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Abstract

We have shown in a previous article by Olivi-Tran and Gauthier [1] that Heisenberg's uncertainty principle is only an approximation because time can only be equal to zero at the beginning of the constitution of the universe: the Big Bang. Indeed time is related to the local radius of curvature and to the total radius of curvature of the universe for a given location. Moreover, we have shown (see Olivi-Tran's reference [2]) that time has the dimension of a length. So if our three dimensional universe is embedded in a four dimensional universe where the fourth dimension is related to time, it is possible to define a 'universal' system of coordinate (x,y,z,t) for which the precise location of a given object is possible. With these hypothesis, it is possible to make a measure simultaneously on two different locations in the four dimensional space. The EPR paradox comes from the fact that it would not be possible to have two entangled states at two different locations without having to overcome the speed of light to carry information from one particle to the other to which it is intricate. We will see by a simple calculation that the state 'entangled' is only transient as the time is not the same for different locations in our three dimensional universe.

Keywords: EPR paradox, definition of time

1 Summary on entanglement

Consider as above systems A and B each with a Hilbert space H_A, H_B. Let the state of the composite system be:

$$|\Psi >_A \in H_A \otimes H_B \tag{1}$$

In general there is no way to associate a pure state to the component system A. However, it still is possible to associate a density matrix. Let

$$\rho_T = |\Psi >< \Psi| \tag{2}$$

which is the projection operator onto this state. The state of A is the partial trace of Γ_T over the basis of system B:

$$\rho_A \stackrel{\text{def}}{=} \sum_j < j|_B(|\Psi >< \Psi|)|j >_B = \text{Tr}_B \rho_T \tag{3}$$

ρ_A is sometimes called the reduced density matrix of ρ on subsystem A .Colloquially, we "trace out" system B to obtain the reduced density matrix on A.

For example, the density matrix of A for the entangled state discussed above is

$$\rho_A = (1/2)(|0 >_A < 0|_A + |1 >_A < 1|_A) \tag{4}$$

This demonstrates that, as expected, the reduced density matrix for an entangled pure ensemble is a mixed ensemble. Also not surprisingly, the density matrix of A for the pure product state $|\psi >_A \otimes |\phi >_B$ discussed above is

$$\rho_A = |\psi >_A < \psi|_A. \tag{5}$$

In general, a bipartite pure state ρ is entangled if and only if one, meaning both, of its reduced states are mixed states.

2 Theory

Now, we make the hypothesis (as shown in references [1, 2]) that our three dimensional curved universe is embedded in four dimensional space with no curvature: time has the dimension of a length and is related to the curvature of the universe at the point of measurement. Therefore it is possible to apply to the four dimensional space an orthonormal basis (x,y,z,t) which is a 'universal' referential in the four dimensional space. Each of these coordinates are related to time and to the three coordinates of space in our three dimensional universe by making a change of referential.

We showed also that the Heisenberg uncertainty principle is only an approximation because time cannot be equal to zero except at the beginning of constitution of the universe: the Big Bang. Therefore it is possible to make a simultaneous measure in two locations of our universe (taking into account that we defined a universal referential).

Consequently, equation (3) becomes:

$$\rho_A = \sum_{j_t} < j_t|_B(|\Psi >< \Psi|)|j_t >_B \quad (6)$$

$$\rho_B = \sum_{j_{t+\Delta t}} < j_{t+\Delta t}|_A(|\Psi >< \Psi|)|j_{t+\Delta t} >_A \quad (7)$$

$|j_t >$ may be written $\exp(-i\hbar t)$ and $|j_{t+\Delta t} >$ may be written $\exp(-i\hbar(t+\Delta t))$ because at different locations the time is different thus the base vectors are different. So, if time evolves differently for two entangled states separated by space in our three dimensional universe, the density matrix of each state will have different evolutions. As a conclusion, we can say that entanglement for entangled states in different spatial locations is only transient.

3 Conclusion

We showed in previous articles [1, 2] that time is a function of curvature. With this assumption and by making a dimensional analysis of Einstein's Fields equations we found that time had the dimension of a length. Therefore, our three dimensional curved universe may be embedded in a four dimensional universe with no curvature and moreover it possible to define an 'universal' referential. With this referential, as it is universal, two events may be simultaneous.

Moreover, we showed that Heisenberg's uncertainty principle is only an approximation, so it is also possible to measure exactly location and impulsion of a given object at the same time.

With all this hypotheses, all deriving from the fact that our three dimensional universe is embedded in a four dimensional space with an 'universal' referential we showed here that for two entangled states separated by space (at two different locations of the four dimensional space (x, y, z, t) and (x', y', z', t') their state 'entangled' is only transient as time evolves differently for the two states. Indeed one cannot neglect time in the case of entanglement: time is related to the local curvature of our three dimensional universe (and in the local referential of our universe) and this time differs for two different locations due to the fluctuations of the curvature of space due to the presence of objects with mass (and to the non homogeneous character of the universe).

The final conclusion is that entanglement for particles separated by space in our three dimensional universe, is only transient. Therefore, if one measures at time t an entangled particle the corresponding other entangled particle, at time $t + \Delta t$ will not follow the two states law for entanglement because of the difference of time evolution at the two different locations.

References

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Received: April, 2009