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Quantum Coherence: A New Aspect to Probe the Quorum Sensing

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Abstract

In this article, we anticipate the effect of quantum coherence in quorum sensing mechanism.

Keywords: Quantum coherence; Biology; Quorum sensing

Commentary

Theoretical and experimental physics have come a long way since the emergence of human civilization. In the beginning of the early twentieth century scientists discovered quantum physics to understand the deeper aspects of nature going beyond the classical physics. Now-a-days the areas of research in quantum mechanics are being driven by a shared goal to harness and exploit quantum coherence and entanglement [1]. For a sufficiently long time the capability of quantum mechanics in explaining the complex biological phenomena has been underestimated. But the recent developments and emergent trends of research show the potential of quantum physics when it is successfully applied in the biological arena. Over the past few decades the biology has succeeded in providing ever more and refined explanations of macroscopic phenomena that were based on the advanced understanding of molecular structures and mechanisms. The quantum physics, which is originally rooted in a world-view of quantum coherences, entanglement, and other non-classical effects, consequently has become the leading aspect towards the systems of increasing complexity [2].

Quantum biology is a new field of research where the researchers study the complex biological process with the understandings of quantum physics. Amongst various complex biological processes, Quorum sensing in recent days has already shown its remarkable features. It is in fact a brilliant mechanism of bacterial world through which they communicate with each other using chemical signaling molecules called quorum sensing molecules. The studies of cell-to-cell bacterial communication were initiated almost half a century ago, it was not earlier than by a decade, we have been introduced with the phrase quorum sensing, which has potential strength to answer such questions [3,4]. After sufficient classical model of quorum sensing [4-12], still some preliminary questions are not clearly addressed [13]. Questions like the origin of quorum sensing, effect of noise, viscosity of the bacterial fluid and the information storage and processing are yet to be understood. The sufficient progresses in quantum biology demands to explain these questions from the quantum perspective as non-trivial quantum effects already have manifested in various biological processes like photosynthesis, magneto-reception etc. Erwin Schrödinger noted in his famous book , “What is Life? “that quantum mechanics accounts for the stability of living things and their cellular processes through our understanding via quantum mechanics of the stability of molecules, and the fact that quantum effects create, sometimes large, energy gaps between different states of chemical systems [14]. Coherence demands the wave patterns to be persistent for a very long time. But in the noisy and uncertain realm of cell communication, coherence fails to retain for a microsecond and that’s why it needs review and more efforts to understand the bacterial world from quantum point of view [15]. The very tiny (micro) length scale and uncertain nature of bacterial world will enhance the scope of quantum mechanism in quorum sensing and consequently it can have more powerful explanation based on quantum coherence which needs redefinition in more challenging way [15]. Besides the variations in quorum sensing molecules contain significant information about the environment in which bacteria exist. To understand how non-trivial quantum effects are still maintained in living organisms, we need to investigate the coherence and entanglement in this biochemical system.

So far, our understanding of quorum sensing has been limited up to classical analysis. But to explain the efficient transfer of information through several autoinducers in the quorum sensing mechanism the interference of different autoinducers should be minimum and the concept of coherence comes into play. It has already been found that bacteria use more than one autoinducers and integrate the information. A natural question then comes into mind that despite the presence of noise and fluctuations in the environment how does the bacteria become able to continue the process like quorum sensing so efficiently with several autoinducers? This question leads us towards the assumption of quantum coherence and the coherent role played by the autoinducers can shed some light into bacterial communication near future. Though at this point, it may seem counter-intuitive when one demands to observe the quantum behavior on macroscopic scale at finite temperature, the strong evidence of quantum coherence in electronic energy transfer in photosynthesis [16,17] recently give the mear idea a better realization.

Quantum coherence in biology is quite a new concept and the intricate role of it in biochemical systems is yet to be understood. Having no classical analogue, one can hope it being able in gaining some important insights in the dynamical process of quorum sensing. In this respect, coherence and decoherence can be of high interest as after all they are the most basic division for any phenomenon of this universe. When we observe some phenomena, and try to explain it with classical or quantum physics, it is the length and time scale associated with the phenomena that helps us in choosing either classical or quantum views. The length scale of bacterial world and the time scale at which this communication occurs is sufficient to have the observable quantum effects. Few months ago, we observed wave pattern of the quorum sensing molecules (autoinducers) and realized that they can possess dual nature. When these molecules behave like wave quantum effects can be manifested in macroscopic domain. However, we should remember that cells are hot and wet and at the same time they are within very complex and noisy environment which can produce significant decoherence effect. Thus, the detection of coherence in bacterial communication process needs a high precision experiment with all the advantages of cancelling the major decoherence factors and dissipations. This experimental success can open a fascinating and challenging route towards ultrafast control of quantum devices.

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