Abstract

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Quantum Electrodynamics (QED) and Field Perspective Applied to Water and Living Systems

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(1) The "Hydrogen Bond" (HB) conceived as a real short-range, directional, electrostatic, attractive interaction is the point that – in every disciplinary field (chemical physics, spectroscopy, biology) – prevents a true understanding not only of water and its role in aqueous systems, but also of how living matter can arise and function. In our talks we aim to help colleagues and people to reframe the nature of the HB through the non-approximate view of condensed matter offered by a Quantum Electro-Dynamic (QED) perspective. We focus our attention on water, as a prime case to show the effectiveness of this 40-year-old theoretical background, which represents water as a two-fluid system (where one of the two phases is coherent). The HB turns out to be the result of the electromagnetic field gradient in the coherent phase of water, whose vacuum level is lower than in the non-coherent (gas-like) fraction. In this way, the HB can be properly considered, i.e. no longer as a "dipolar force" between molecules, but as the phenomenological effect of their collective thermodynamic tendency to occupy a lower ground state, compatible with temperature and pressure. This perspective allows to explain many "anomalous" behaviours of water and to understand why the calculated energy associated with the HB should change when considering two molecules (water-dimer), or the liquid state, or the different types of ice. The appearance of a condensed, liquid, phase at room temperature is indeed the consequence of the boson condensation as described in the context of spontaneous symmetry breaking (SSB). For a more realistic and authentic description of water, condensed matter and living systems, the transition from a still semi-classical Quantum Mechanical (QM) view in the first quantization to a Quantum Field Theory (QFT) view embedded in the second quantization is advocated.

(2) The previous topic, however, is the basis for grounding any realistic "Quantum biology" (QB) that tries to address questions about how living systems are able to unfold dynamics that can't be solved on a chemical basis, or seem to violate some fundamental laws (e.g., thermodynamic yield, morphogenesis, adaptation, autopoiesis, memory, teleology, biosemiotics, etc.). Current "quantum" approaches in biology are still very basic and "corpuscular", being based on a semi-classical and approximate view. We review important theoretical and experimental considerations from the recent past in condensed matter, water, physics of living systems, and biochemistry, in order to integrate them into a unified picture applicable to the life sciences. Within quantum field theory (QFT), the field has primacy, with the particle, or "quantum", being a derivative of it.

(3) In addition, a fruitful paradigm shift within Life Sciences must overcome an intractable inadequacy that is only possible within the perspective offered by QFT and symmetry breaking. Such an inadequacy is the dualistic and Cartesian distinction between *function and structure*, which is based on thinking of living beings as systems made of "matter" and "information", as if these two things were "separable components" – a view predominant in Information Technology (IT) that differentiates between *software and hardware*. The common notion of "information" (as it is generally

conceived in science, in a digital-like binary fashion) is too simplistic and not consistently applicable to the living state as open system and not reducible to any kind of "portion" ascribed to the category of quantity. Moreover, in biological systems, contrary to Shannon's definition of information that is well suited for telecommunications and computer science, "information" is something opposite to internal entropy since it depends directly on order and, on the contrary, it is associated to distinction and differentiation. Biology requires more than just statistical measures—it needs context, meaning, and function, which are beyond classical information theory.

Keywords: quantum field theory; phase; coherence; water; symmetry-breaking; dynamical order; resonance; non-thermal effects; Hydrogen bond. Quantum Field theory, phase, coherence, water, symmetry-breakings, dynamical order, resonance, non-thermal effects, hormesis. Configuration, dissipation, meaning, symmetry breaking, order, coherence, stimulus-response, perception, qualities, relationship.