Time Crystals – Synataxis and Homology of Constellatory Temporal Bonds

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In our recent book "Concept and Formalization of Constellatory Self-Unfolding", (A.v. Müller and E. Zafiris, Springer 2018), we argued that the phenomenon of quantum entanglement, being at the very heart of quantum coherence, should not be interpreted at the factual level, i.e. in local spacetime terms, but most appropriately, should be considered as a chrono-topological binding process, called a temporal bond. More precisely, maximal GHZ entanglement is characterized by the linking properties of the Borromean rings. The proposed temporal interpretation of the Borromean link as a temporal bond at a pre-factual level, via which quantum entanglement can be spatially manifested, suggests that it is the notion of time, i.e. the scrutinization of the global temporal aspects of quantum theory that should be at focus. In general, a temporal bond is not of a reversible and symmetric chain-like or sequential form, but it based on the irreversible ordering of potential temporal actions. In the quantum theoretic framework the notion of a temporal action is formalized in terms of a one-parameter unitary group. The group-theoretic qualification of this notion is expressed precisely by the Weyl-Heisenberg group, which provides the precise means to qualify the extent of non-commutativity of conjugate unitary actions in terms of the "quantum of action", i.e. Planck's constant. In this context, we first show that the quantum Weyl-Heisenberg group constitutes the nilpotent avatar of the free group on two generators that prescribes the formation of potential temporal bonds in terms of the Borromean link. Second, we show that the spontaneous symmetry breaking of a temporal bond, signifying the transition to the factual level, always factorizes via the Weyl-Heisenberg group. Third, based on this factorization, we show that the transition to the factual level is conditioned on the manifestation of a boundary, i.e. an "epiphaneia" bounding the composition of potential unitary actions in terms of an Abelian periodic cellular structure. In effect, this cellular periodic structure breaks spontaneously the symmetry of a temporal bond, but preserves quantum coherence in the form of a holonomic memory, i.e. in terms of a geometric phase factor. We argue that the above gives a firm foundation to the notion of a time-crystal proposed by Frank Wilczek recently, and point out how it may be utilized in quantum computation as a means of evading decoherence. Finally, we attempt a connection with some concrete, but very little noticed and discussed ideas of the late David Bohm, who was striving for a non-spacetime formulation of quantum theory based on cohomology theory.