WATER COHERENCE AND CONSCIOUSNESS

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W. J. Freeman and G. Vitiello, Physics of Life Reviews 3, 93 (2006)
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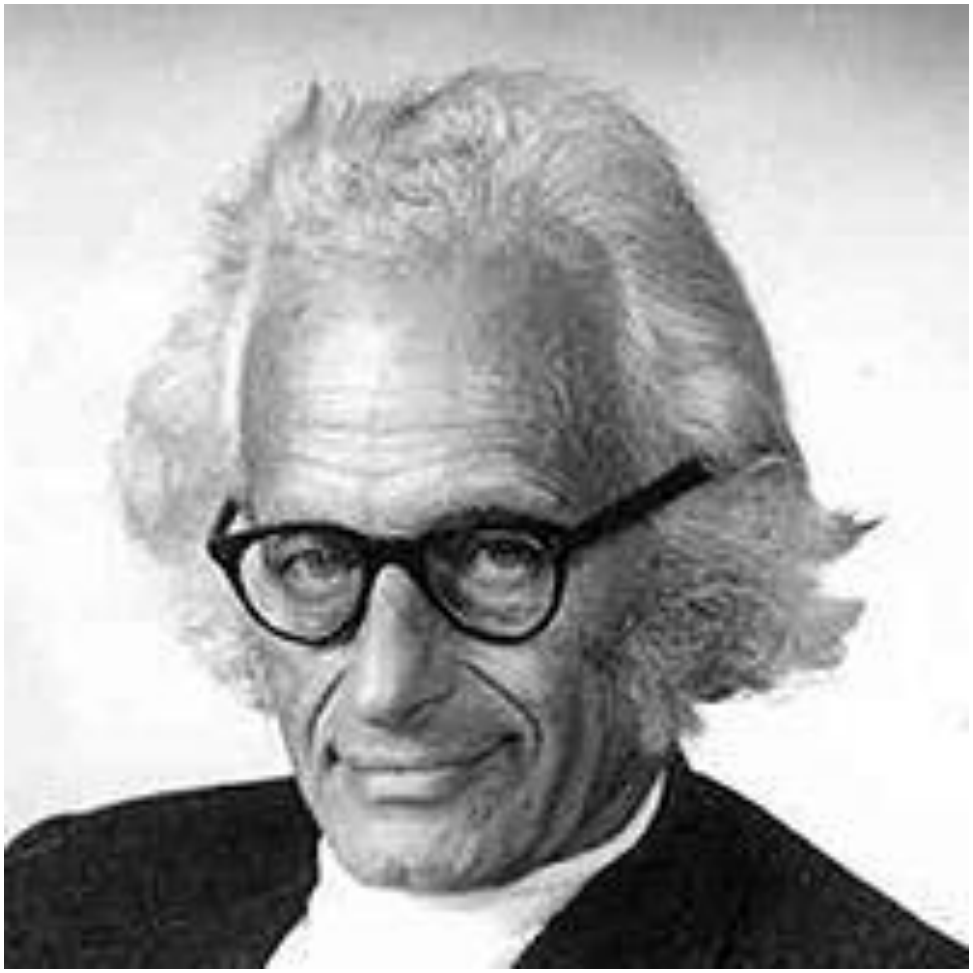
T.Re and G. Vitiello, Non-linear Dynamics and Chaotic Trajectories in Brain-Mind Visual Experiences during Dreams, Meditation, and Non-Ordinary Brain Activity States *OBM Neurobiology* 2020; 4(2), IJCNN, Glasgow *Proc.* 2020



Herbert Fröhlich, Long Range Coherence and Energy Storage in Biological Systems, Int. J. Quantum Chem., v.II, 641–649 (1968)

What is needed is the passage from the naturalistic description to the discovery and understanding of dynamical unifying laws.

In the study of living matter of crucial relevance is the distinction between two ways of producing orderliness (Schrödinger, p.80): ordering generated by the "statistical mechanisms" and ordering generated by "dynamical" interactions.

"...it needs no poetical imagination but only clear and sober scientific reflection to recognize that we are here obviously faced with events whose regular and lawful unfolding is guided by a "mechanism" entirely different from the "probability mechanism of physics" (p.79).

The "regularities only in the average" (Schrödinger, *What is Life*?1944, p.78) emerging from the "statistical mechanisms" are not enough to explain the "enigmatic biological stability" (p.47).

The attempt to explain biological functional stability in terms of regularities of statistical origin would be the "classical physicists expectation" that "far from being trivial, is wrong" (p.19).

The "naïve physicist" (Schrödinger, p. 20), does not bring to concrete advancements on answering such a basic question.

The collection of data, sophisticate observations of the properties of the components, their connections in larger entities characterizes the *naturalistic* level of the research, which is absolutely *necessary*.

However, it is *not sufficient* to the *comprehension* of the system at the level of their *collective* behavior.

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SPONTANEOUS SYMMETRY BREAKDOWN AND BOSON CONDENSATION IN BIOLOGY

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Nuclear Physics B251 [FS13] (1985) 375-400

A QUANTUM FIELD THEORETICAL APPROACH TO THE COLLECTIVE BEHAVIOUR OF BIOLOGICAL SYSTEMS

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ELECTROMAGNETIC FIELD AND SPONTANEOUS SYMMETRY BREAKING IN BIOLOGICAL MATTER

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Water as a Free Electric Dipole Laser

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The mesoscopic activity of neocortex:

dynamical formation of spatially extended domains of amplitude modulated (AM) synchronized oscillations with near zero phase dispersion.

These "packets of waves" form in few ms, have properties of location, size, duration ($80-120\ ms$) and carrier frequencies in the beta-gamma range ($12-80\ Hz$),

re-synchronize in frames at frame rates in the theta-alpha range ($3-12\ Hz$) through a sequence of repeated collective phase transitions.

Such patterns of oscillations cover much of the hemisphere in rabbits and cats and over domains of linear size of $19\ cm$ in humans

Lashley dilemma

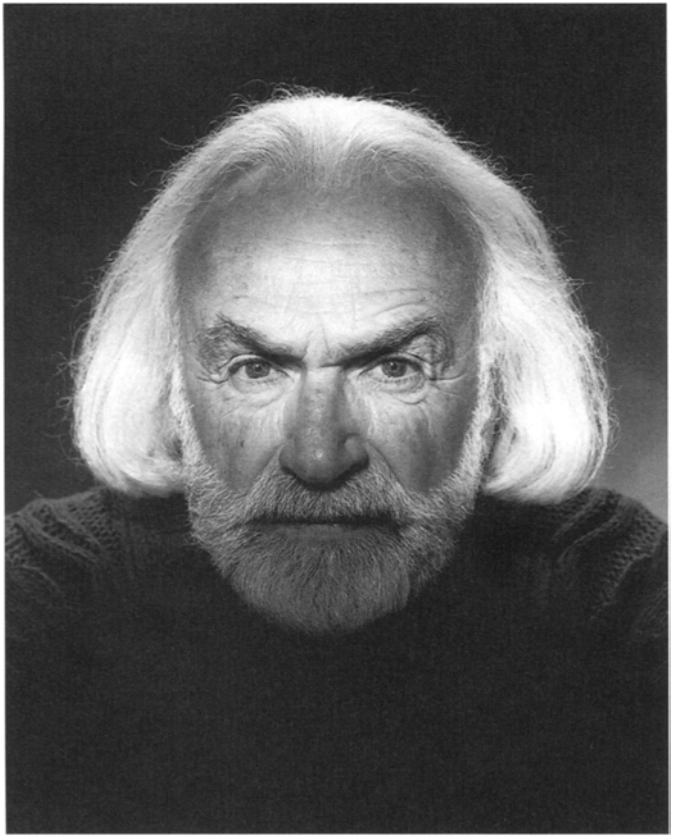
Concept of "mass action" in the storage and retrieval of memories in the brain:

"...Here is the dilemma. Nerve impulses are transmitted ...form cell to cell through definite intercellular connections. Yet, all behavior seems to be determined by masses of excitation...within general fields of activity, without regard to particular nerve cells... What sort of nervous organization might be capable of responding to a pattern of excitation without limited specialized path of conduction? The problem is almost universal in the activity of the nervous system." *

Pribram: analogy between the fields of distributed neural activity in the brain and the wave patterns in holograms †.

*K. Lashley, The Mechanism of Vision, Journal Press, Provincetown MA, 1948, pp. 302-306

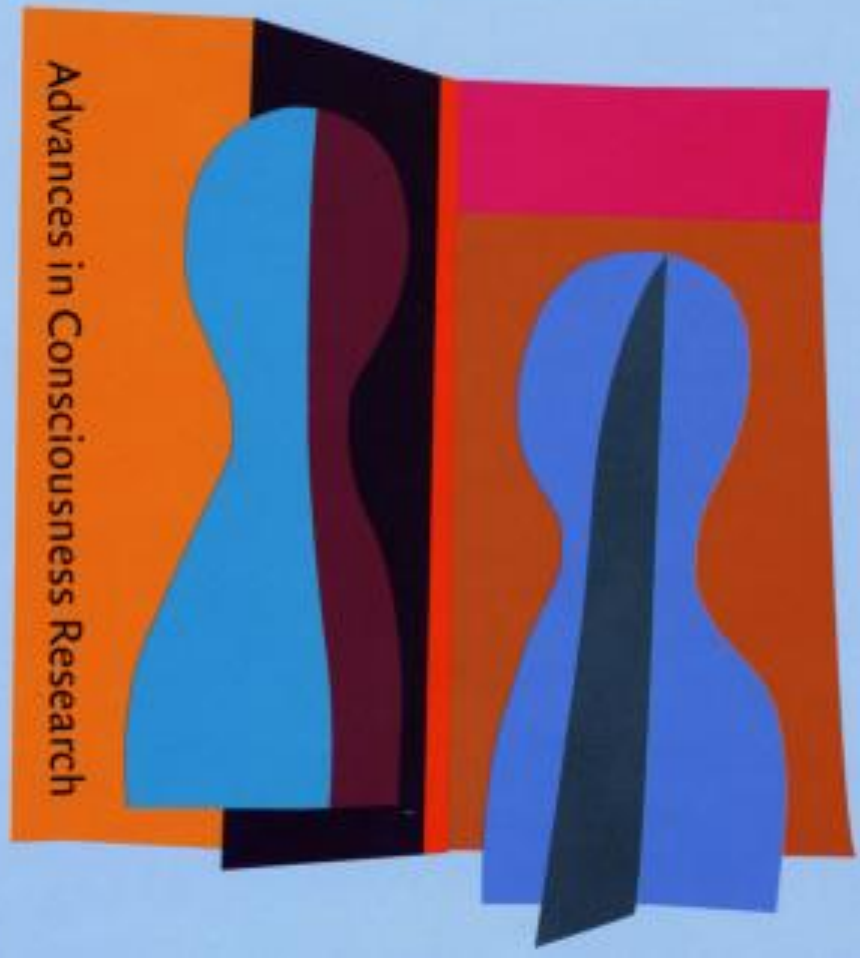
†K. H. Pribram, Languages of the Brain. Engelwood Cliffs NJ: Prentice-Hall, 1971



Brain and Being

At the boundary between science, philosophy, language and arts

Edited by
Gordon G. Globus, Karl H. Pribram
and Giuseppe Vitiello



Hiroomi Umezawa and his collaborators (Stuart, Takahashi, & Umezawa 1979) pointed out that not only quantum but "classical" processing can be derived from quantum field theory. The relevance of all this to the brain/mind issue is that both Umezawa and Giuseppe Vitiello (2004) have, on the basis of mathematical insights, proposed that interactions among these two quantum brain fields is necessary for self-reflective consciousness to occur. Hiley notes: "this is part of a bigger mathematical structure of bi-algebras that Umezawa and Vitiello are exploring. The doubling arises from a natural duality." I add, could this doubling arise from the nature of the Fourier relationship? The Fourier transformation results in a complex number that represents both a real and a virtual line, a built-in duality.

K.H.Pribram, Brain and Mathematics, Chapter 12 in "Brain and Being", Edis. G.G.Globus,K.Pribram and G. Vitiello, John Benjamins Publ. Co., Amsterdam 2004, p.215-239

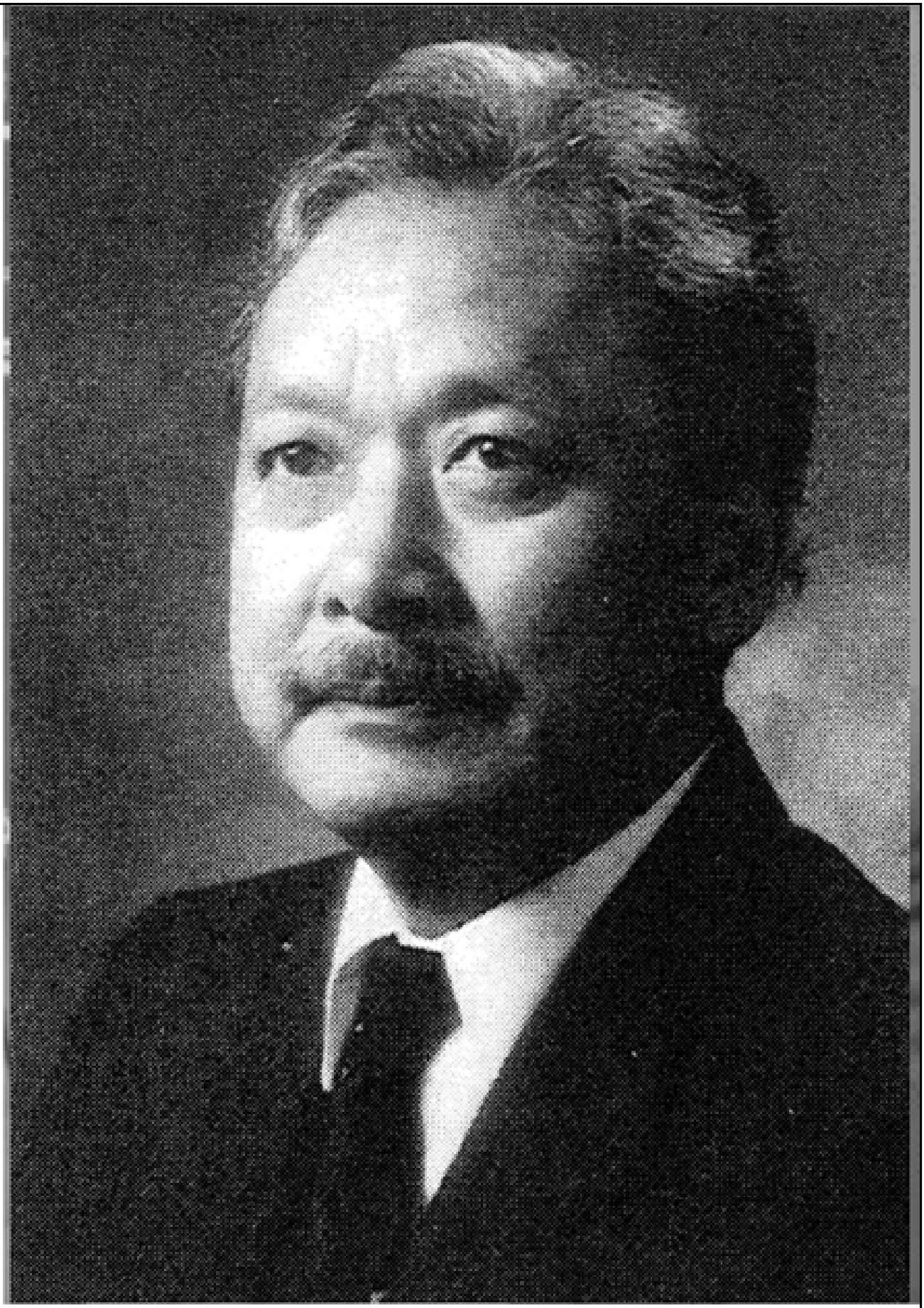
The dissipative quantum model of brain

is the extension to the dissipative dynamics of the many-body model proposed in 1967 by Ricciardi and Umezawa *

the extended patterns of neuronal excitations may be described by the spontaneous breakdown of symmetry (SBS) formalism in QFT. Umezawa †: "In any material in condensed matter physics any particular information is carried by certain ordered pattern maintained by certain long range correlation mediated by massless quanta. It looked to me that this is the only way to memorize some information; memory is a printed pattern of order supported by long range correlations..."

*L. M. Ricciardi and H. Umezawa, Kibernetik 4, 44 (1967)
C. I. J. Stuart, Y. Takahashi and H. Umezawa, J.Theor. Biol. 71, 605 (1978); Found. Phys. 9, 301 (1979)

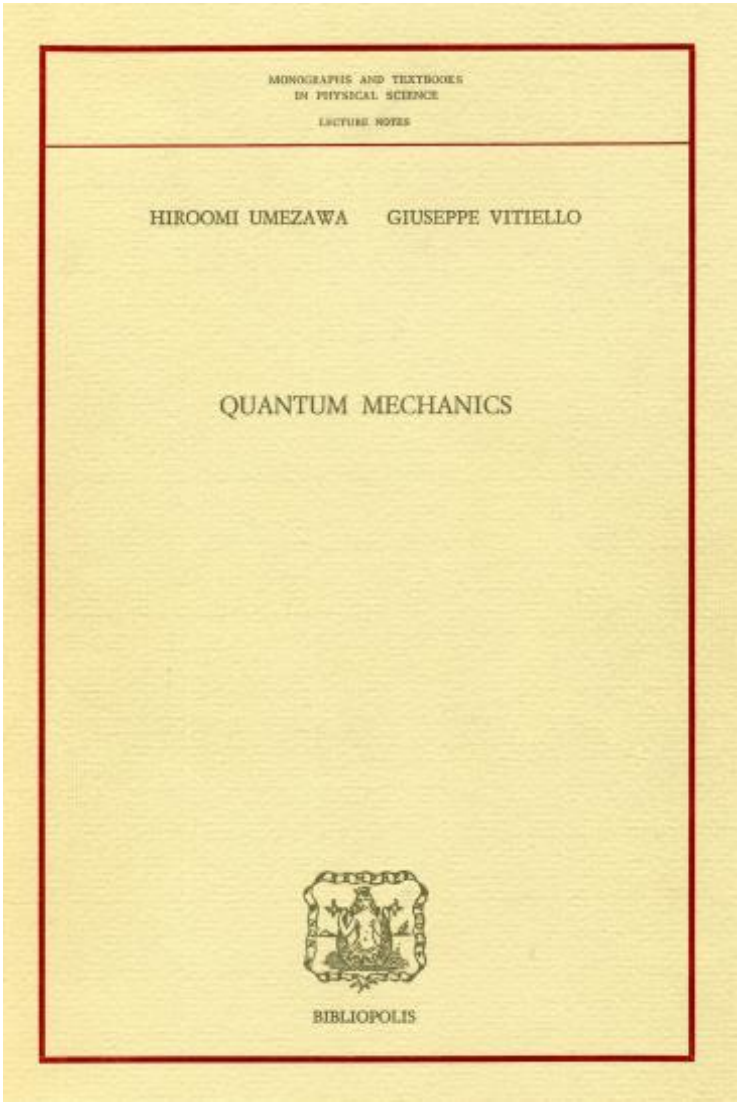
†H.Umezawa, Math. Japonica 41, 109 (1995)



H. Umezawa: Q F T

dipole interaction. In parallel to this, in 1968, H. Frölich proposed a long range correlation in protein net("Long-range coherence and energy storage in biological systems" Int. J. Quantum Chem. 2, 641) in living systems and it was supposed to be caused by electric dipoles. This research was carried over by many Italian scientists including Vitiello; they came to the idea that the water molecules surrounding the protein net deforms themselves, giving rise to an electric polarization. This leads to a dipole-dipole interaction. In 1992 M. Jibu and K. Yasue who followed our approach, also discovered the electric dipole-dipole interaction. They called this theory quantum brain dynamics (QBD). In this way Frölich approach and our approach converged to one theory. Furthermore, since the same structure spread wide over human body, the long range correlation might be controlling a large domain.

H.Umezawa, Development in concepts in quantum field theory in half century, Math. Japonica 41, 109-124 (1995)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変換理論と散乱理論
日本評論社

INTERNATIONAL JOURNAL OF
MODERN PHYSICS B

Volume 10, Numbers 13 & 14
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Memorial Issue for H. Umezawa

Giuseppe Vitiello, Guest Editor

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CONDENSED MATTER PHYSICS • STATISTICAL PHYSICS • APPLIED PHYSICS

In QFT long range correlations are indeed dynamically generated through the mechanism of SBS.

These correlations manifest themselves as the Nambu-Goldstone (NG) boson particles or modes,

which have zero mass and therefore are able to span the whole system.

The NG bosons are coherently condensed in the system lowest energy state, the vacuum or ground state (Bose-Einstein condensation).

Due to such correlations the system appears in an ordered state.

The vacuum density of the NG bosons provides a measure of the degree of ordering or coherence: the order parameter, a classical field specifying (labeling) the observed ordered pattern.

QFT self-focusing leads* to the damped e.m. vector potential A(x):

$$A(x) = e^{-\frac{cMx}{\hbar}} A(0)$$

with x the transverse (to the filament) direction and

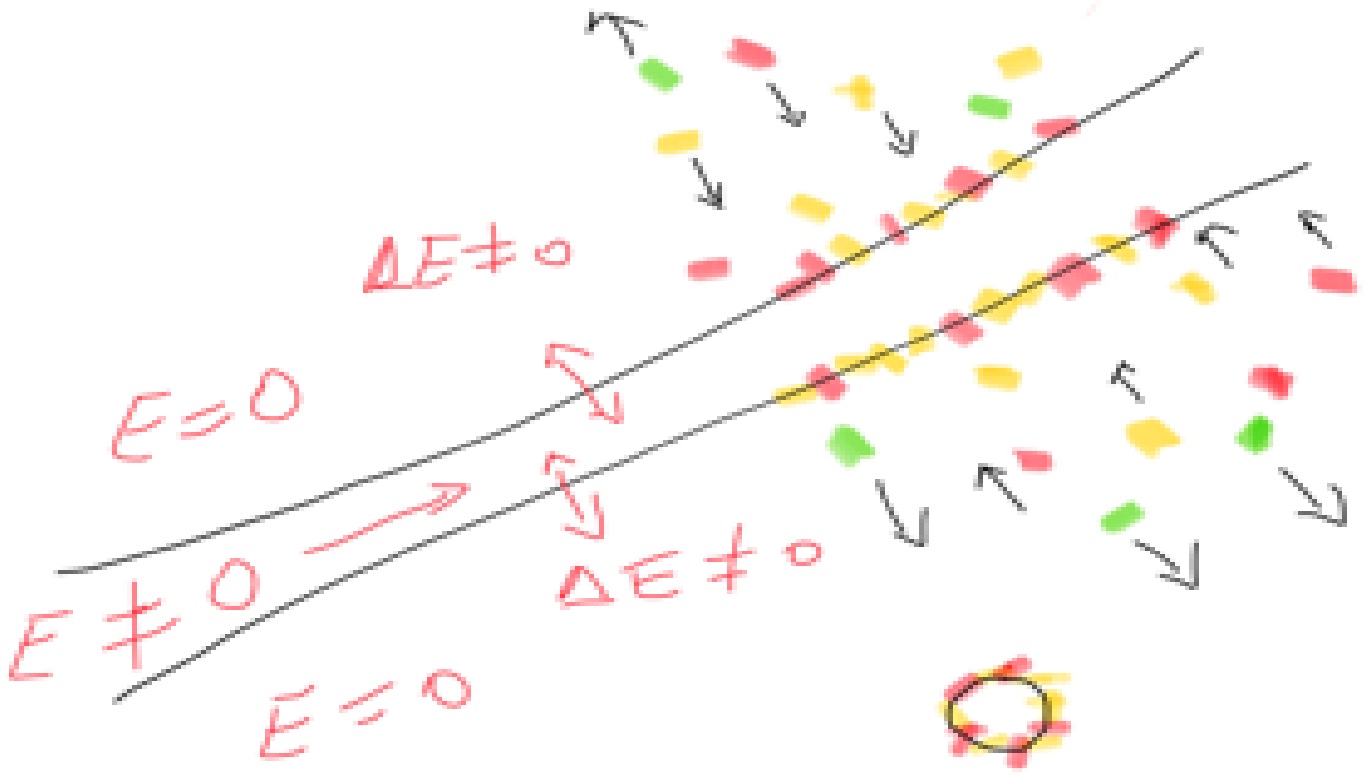
$$M^2 = \frac{2qP}{m\delta\epsilon_0 c^2} = \frac{4ne^2}{m_e\epsilon_0 c^2}$$

with the polarization density P = qδ x n; n the number of oriented dipoles per unit volume; m = 2m_e , q = 2e. Use of d = $\hbar$/Mc , in the (extreme) case of all oriented dipoles n = N/18, N the Avogadro number, is M_{photon} = 13,60 eV and

d = 14.6 nm !! the observed value: 11 -15 nm!**

*Del Giudice, Doglia, Milani, Vitiello, Nucl. Phys. 1986

**Chalfie M, Thomson JN, Journal of Cell Biology, 1979



In the case of microtubules: M_{photon}= 13,60 eV (i.e the hydrogen ionization energy); diameter d = 146 Å (internal diameter of the microtubulus = 140 Å = 14 nm; external diameter is 25 nm).

E. Del Giudice, S. Doglia, M. Milani and G. Vitiello, Nucl. Phys. B 251 (FS 13), 375 (1985); Nucl. Phys. B 275 (FS 17), 185 (1986).

- The many-body model fails in explaining the observed coexistence of AM patterns and also their irreversible time evolution.

- One shortcoming of the model is that any subsequent stimulus would cancel the previously recorded memory by renewing the SBS process, thus overprinting the 'new' memory over the previous one ('memory capacity problem').

- The fact that the brain is an open system in permanent interaction with the environment was not considered in the many-body model.

$\Rightarrow$ Include Dissipation!!

In the QFT formalism for dissipative systems the environment is described as the time-reversal image of the system [*].

This is realized by doubling the system degrees of freedom:

external stimulus $\Rightarrow$ SBS $\Rightarrow$ dynamical generation of DWQ A_κ

dissipation $\Rightarrow$ doubling: $\quad A_\kappa \rightarrow (A_\kappa \ , \ \tilde{A}_\kappa)$

$\tilde{A}_\kappa \equiv$ "time-reversed mirror image" or "doubled modes"

energy flux balance $\Leftrightarrow E_0 = E_{Syst} - E_{Env} = \sum_\kappa \hbar\Omega_\kappa(\mathcal{N}_{A_\kappa} - \mathcal{N}_{\tilde{A}_\kappa}) = 0$

[*] E. Celeghini, M. Rasetti and G. Vitiello, Annals Phys. 215, 156 (1992)

The canonical commutation relations are the usual ones and

$$[\, A_\kappa, \tilde{A}^\dagger_\lambda \,] = 0 = [\, A_\kappa, \tilde{A}_\lambda \,] \quad \text{etc..} \tag{1}$$

The Hamiltonian for the infinite collection of damped harmonic oscillators A_κ (a simple prototype of a dissipative system) and the $\tilde{A}_\kappa$ is

$$\begin{aligned} H &= H_0 + H_I \\ H_0 &= \sum_\kappa \hbar\Omega_\kappa (A^\dagger_\kappa A_\kappa - \tilde{A}^\dagger_\kappa \tilde{A}_\kappa) \ , \\ H_I &= i \sum_\kappa \hbar\Gamma_\kappa (A^\dagger_\kappa \tilde{A}^\dagger_\kappa - A_\kappa \tilde{A}_\kappa) \ , \end{aligned} \tag{2}$$

Ω_κ is the frequency, Γ_κ the damping constant.

κ generically labels degrees of freedom such as, e.g., spatial momentum, etc..

The A_κ and $\tilde{A}_\kappa$ modes are actually quasi-massless, i.e. they have a non-zero effective mass, due to finite volume effects.

- $\{|\mathcal{N}_{A_\kappa}, \mathcal{N}_{\tilde{A}_\kappa}\rangle\} \equiv$ **simultaneous eigenvectors of** $A_\kappa^\dagger A_\kappa$ **and** $\tilde{A}_\kappa^\dagger \tilde{A}_\kappa$**,**

- $\mathcal{N}_{A_\kappa}$ **and** $\mathcal{N}_{\tilde{A}_\kappa}$ **non-negative integers**

- $|0\rangle_0 \equiv |\mathcal{N}_{A_\kappa} = 0, \mathcal{N}_{\tilde{A}_\kappa} = 0\rangle$ **the vacuum state for** A_κ **and** $\tilde{A}_\kappa$**:** $A_\kappa|0\rangle_0 = 0 = \tilde{A}_\kappa|0\rangle_0$ **for any** κ**.**

The balanced nonequilibrium state is a ground state.

At some initial time $t_0 = 0$**, we define it to be a zero energy eigenstate of** H_0 **and denote it by** $|0\rangle_{\mathcal{N}}$
$\Rightarrow$ **the "memory state"** $|0\rangle_{\mathcal{N}}$ **is a condensate of** *equal number* **of** A_κ **and mirror** $\tilde{A}_\kappa$ **for any** κ**:** $\mathcal{N}_{A_\kappa} - \mathcal{N}_{\tilde{A}_\kappa} = 0$**.**

label $\mathcal{N} \equiv \{\mathcal{N}_{A_\kappa} = \mathcal{N}_{\tilde{A}_\kappa}, \forall\ \kappa, at \quad t_0 = 0\} \equiv$ *order parameter* **identifying the vacuum** $|0\rangle_{\mathcal{N}}$ **(the "memory state") associated to the information recorded at time** $t_0 = 0$**.**

Balancing E_0 to be zero, does not fix the value of either E_{A_κ} or $E_{\tilde{A}_\kappa}$ for any κ. It only fixes, for any κ, their difference.

$\Rightarrow$ at t_0 we may have infinitely many perceptual states, each one in one-to-one correspondence to a given $\mathcal{N}$ set: a huge memory capacity.

The important point is:

$\{|0\rangle_{\mathcal{N}}\}$ and $\{|0\rangle_{\mathcal{N}'}\}$, $\mathcal{N} \neq \mathcal{N}'$, are ui in the infinite volume limit:

$$_{\mathcal{N}}\langle 0|0\rangle_{\mathcal{N}'} \underset{V\to\infty}{\longrightarrow} 0 \qquad \forall\ \mathcal{N},\ \mathcal{N}'\ , \qquad \mathcal{N} \neq \mathcal{N}'\ . \tag{3}$$

In contrast with the non-dissipative model, a huge number of sequentially recorded memories may *coexist* without destructive interference since infinitely many vacua $|0\rangle_{\mathcal{N}}, \forall\ \mathcal{N}$, are independently accessible.

The commutativity of H_0 with H_I ($[H_0, H_I] = 0$) ensures that the number $(\mathcal{N}_{A_\kappa} - \mathcal{N}_{\tilde{A}_\kappa})$ is a constant of motion for any κ, which also guaranties that H_0 remains bounded from below if this has been assumed to hold at t_0.

The state $|0\rangle_{\mathcal{N}}$ is given, at finite volume V, by $|0\rangle_{\mathcal{N}} = \exp(-iG(\theta))|0\rangle_0$, with generator

$$G(\theta) = -i \sum_{\kappa} \theta_\kappa (A_\kappa^\dagger \tilde{A}_\kappa^\dagger - A_\kappa \tilde{A}_\kappa) \ . \tag{4}$$

and $_{\mathcal{N}}\langle 0|0\rangle_{\mathcal{N}} = 1 \ \forall \mathcal{N}$.

The average number $\mathcal{N}_{A_\kappa}$ is given by

$$\mathcal{N}_{A_\kappa} = {}_{\mathcal{N}}\langle 0|A_\kappa^\dagger A_\kappa|0\rangle_{\mathcal{N}} = \sinh^2 \theta_\kappa \ , \tag{5}$$

which relates the $\mathcal{N}$-set, $\mathcal{N} \equiv \{\mathcal{N}_{A_\kappa} = \mathcal{N}_{\tilde{A}_\kappa}, \forall \kappa, at \quad t_0 = 0\}$ to the θ-set, $\theta \equiv \{\theta_\kappa, \forall \kappa, at \quad t_0 = 0\}$.

We also use the notation $\mathcal{N}_{A_\kappa}(\theta) \equiv \mathcal{N}_{A_\kappa}$ and $|0(\theta)\rangle \equiv |0\rangle_{\mathcal{N}}$.

The θ-set is conditioned by the requirement that A and $\tilde{A}$ modes satisfy the Bose distribution at time $t_0 = 0$:

$$\mathcal{N}_{A_\kappa}(\theta) = \sinh^2 \theta_\kappa = \frac{1}{e^{\beta E_\kappa} - 1} \quad , \tag{6}$$

$\beta \equiv \frac{1}{k_B T}$ is the inverse temperature at $t_0 = 0$. $\{|0\rangle_{\mathcal{N}}\}$ is recognized to be a representation of the CCR's at finite temperature: $|0\rangle_{\mathcal{N}}$ is a thermo field dynamics (TFD) state in the real time formalism and can be shown to be an $SU(1,1)$ squeezed coherent state.

The mirror $\tilde{A}$ modes actually account for the quantum noise of Brownian nature in the fluctuating random force in the system-environment coupling (entanglement).

Stability of order parameter $\mathcal{N}$ against quantum fluctuations is a manifestation of the *coherence* of boson condensation.

$\Rightarrow$ memory $\mathcal{N}$ not affected by quantum fluctuations. In this sense, it is a macroscopic observable. $|0\rangle_{\mathcal{N}}$ is a "macroscopic quantum state".

$\Rightarrow$ "change of scale" (from microscopic to macroscopic scale) dynamically achieved through the coherent boson condensation mechanism.

At finite volume V, time evolution of $|0\rangle_{\mathcal{N}}$ is formally given by

$$|0(t)\rangle_{\mathcal{N}} = \exp\left(-it\frac{H_I}{\hbar}\right)|0\rangle_{\mathcal{N}} \tag{7}$$

$$= \prod_{\kappa} \frac{1}{\cosh\left(\Gamma_\kappa t - \theta_\kappa\right)} \exp\left(\tanh\left(\Gamma_\kappa t - \theta_\kappa\right) A^\dagger \tilde{A}^\dagger\right)|0\rangle_0 \ ,$$

obtained by using the commutativity between H_I and $G(\theta)$.

$|0(t)\rangle_{\mathcal{N}}$ is an $SU(1,1)$ generalized coherent state, it is specified by the initial value $\mathcal{N}$, at $t_0 = 0$, and $_{\mathcal{N}}\langle 0(t)|0(t)\rangle_{\mathcal{N}} = 1, \quad \forall t$.

Provided $\sum_\kappa \Gamma_\kappa > 0$,

$$\lim_{t\to\infty} {}_{\mathcal{N}}\langle 0(t)|0\rangle_{\mathcal{N}} \propto \lim_{t\to\infty} \exp\left(-t\sum_{\kappa}\Gamma_\kappa\right) = 0 \ . \tag{8}$$

In the infinite volume limit we have (for $\int d^3\kappa\, \Gamma_\kappa$ finite and positive)

$$\begin{aligned} &{}_{\mathcal{N}}\langle 0(t)|0\rangle_{\mathcal{N}} \underset{V\to\infty}{\longrightarrow} 0 \qquad \forall\, t \neq 0 \ , \\ &{}_{\mathcal{N}}\langle 0(t)|0(t')\rangle_{\mathcal{N}} \underset{V\to\infty}{\longrightarrow} 0 \qquad \forall\, t, t' \ , \quad t \neq t' \ . \end{aligned} \tag{9}$$

In agreement with observations:

the QFT dissipative dynamics $\Rightarrow$

$*$ **(quasi-)non-interfering degenerate vacua (AM pattern textures)**

$*$ **(phase) transitions among them (AM patterns sequencing)**

$*$ **huge memory capacity**

The original many-body model could not describe these features.

In the "memory space", or the *brain state space* (the space of uir), $\{|0\rangle_{\mathcal{N}}\}$, for each $\mathcal{N}$-set, describes a physical phase of the system and may be thought as a "point" identified by that specific $\mathcal{N}$.

The system may shift, under the influence of one or more stimuli acting as a control parameter, from vacuum to vacuum in the collection of brain-environment equilibrium vacua ($E_0 = 0$), i.e. from phase to phase,

$\Rightarrow$ the system undergoes an extremely rich sequence of phase transitions, leading to the actualization of a sequence of dissipative structures formed by AM patterns, as indeed experimentally observed.

Let $|0(t)\rangle_{\mathcal{N}} \equiv |0\rangle_{\mathcal{N}}$ at t, specified by the initial value $\mathcal{N}$ at $t_0 = 0$.

Time evolution of $|0(t)\rangle_{\mathcal{N}}$ = trajectory of "initial condition" specified by the $\mathcal{N}$-set in the space of the representations $\{|0(t)\rangle_{\mathcal{N}}\}$.

Provided changes in the inverse temperature β are slow, the changes in the energy $E_a \equiv \sum_k E_k \mathcal{N}_{a_k}$ and in the entropy $\mathcal{S}_a$ are related by

$$dE_a = \sum_k E_k \dot{\mathcal{N}}_{a_k} dt = \frac{1}{\beta} d\mathcal{S}_a = dQ \quad , \tag{10}$$

i.e. the minimization of the free energy $d\mathcal{F}_a = 0$ holds at any t

$\Rightarrow$ change in time of the condensate, i.e. of the order parameter, turns into heat dissipation dQ.

Dissipation $\Rightarrow$ time-evolution of $|0(t)\rangle_{\mathcal{N}}$ at finite volume V controlled by the entropy variations $\Rightarrow$ irreversibility of time evolution (breakdown of time-reversal symmetry) $\Rightarrow$ arrow of time (a privileged direction in time evolution)

Other predictions in agreement with experiments :

- very low energy required to excite correlated neuronal patterns,

- AM patterns have large diameters, with respect to the small sizes of the component neurons,

- duration, size and power of AM patterns are decreasing functions of their carrier wave number k,

- there is lack of invariance of AM patterns with invariant stimuli,

- heat dissipation at (almost) constant in time temperature,

- the occurrence of spikes (vortices) in the process of phase transitions,

- the whole phenomenology of phase gradients and phase singularities in the vortices formation,

- the constancy of the phase field within the frames,

- the insurgence of a phase singularity associated with the abrupt decrease of the order parameter and the concomitant increase of spatial variance of the phase field,

- **the onsets of vortices *between* frames, not *within* them,**

- **the occurrence of phase cones (spatial phase gradients) and random variation of sign (implosive and explosive) at the apex,**

- **that the phase cone apices occur at random spatial locations,**

- **that the apex is never initiated *within* frames, but *between* frames (during phase transitions).**

- **The model leads to the classicality (not derived as the classical limit, but as a dynamical output) of functionally self-regulated and self-organized background activity of the brain.**

In the dissipative model of brain:

Step 1. Spontaneous breakdown of the rotational symmetry of electrical dipoles of water and other molecules $\Rightarrow$ existence of Nambu-Goldstone quanta (NG) (the dipole wave quanta (DWQ)).

non-vanishing polarization density $\mathcal{P} = \rho\delta$

ρ and δ: charge density and (average) dipole length

coherent condensation of the DWQ in the system ground state

Step 2. Spontaneous breakdown of the phase symmetry

charge density wave function $\sigma(x) = \sqrt{\rho(x)}e^{i\theta(x)}$

The "phase" $\theta(x)$ is the NG field associated with the breakdown of global phase symmetry.

The coherent condensation of $\theta(x)$ in the ground state is induced by

$$\theta(x) \to \theta(x) - \frac{e_0 v^2}{Z} f(x) \ . \tag{11}$$

The condensation function $f(x)$ satisfies the same equation satisfied by the $\theta(x)$ field, i.e. $\partial^2 f(x) = 0$.

Z is the wave function renormalization constant, e_0 and v are the electron charge and the constant entering the symmetry breakdown condition $< 0|\rho(x)|0 >= v \neq 0$.

Non-homogeneous boson condensation $\Rightarrow$ formation of coherent domains.

In the presence of a gauge field, $f(x)$ has to carry some topological singularity in order for the condensation process to be physically detectable.

In the ordered region: $f(x)$ does not have topological singularities

In the "normal", i.e. disordered region: $f(x)$ presents singularities

e.g. on the line $r = 0$ in the core of a vortex.

On the boundaries between the normal and the ordered regions gradients of the phase field are non-zero.

Instead they are zero in the normal region, i.e. in the vortex core.

We also know that phase transition from one state space to another (unitarily inequivalent) one can be only induced by a singular condensation function $f(x)$.

This is the reason why topologically non-trivial objects, such as vortices, appear in the processes of phase transitions.

Observation: the location of the phase cone apex is a random variable across frames that is determined by the accidents of where the null spike is lowest and the background input is highest.

In the model: the initial site where non-homogeneous condensation starts (the phase cone apex) is not conditioned by the incoming stimulus, but is randomly determined by the concurrence of a number of local conditions.

The apex is never initiated within frames (in the broken symmetry phase or ordered region), but between frames (during phase transitions)

From each frame to the next, it is observed the random variation of the slope of the conic phase gradient, negative with explosion, positive with implosion.

The dissipative model predicts both slopes (explosion and implosion: $(e^{+\Gamma/2\ t}, e^{-\Gamma/2\ t})$)

We thus observe converging (imploding) and diverging (exploding) wave packets.

The exploding gradient is consistent with conventional neurodynamics, e.g., in terms of a pacemaker, but there is no classical explanation for the imploding gradient.

Instead, the dissipative many-body model predicts that the phase cone evolves in time as $\exp(\pm\ t)$, i.e. the converging regime and its time-reversed, diverging, copy, in agreement with the observed phase cone behaviors.

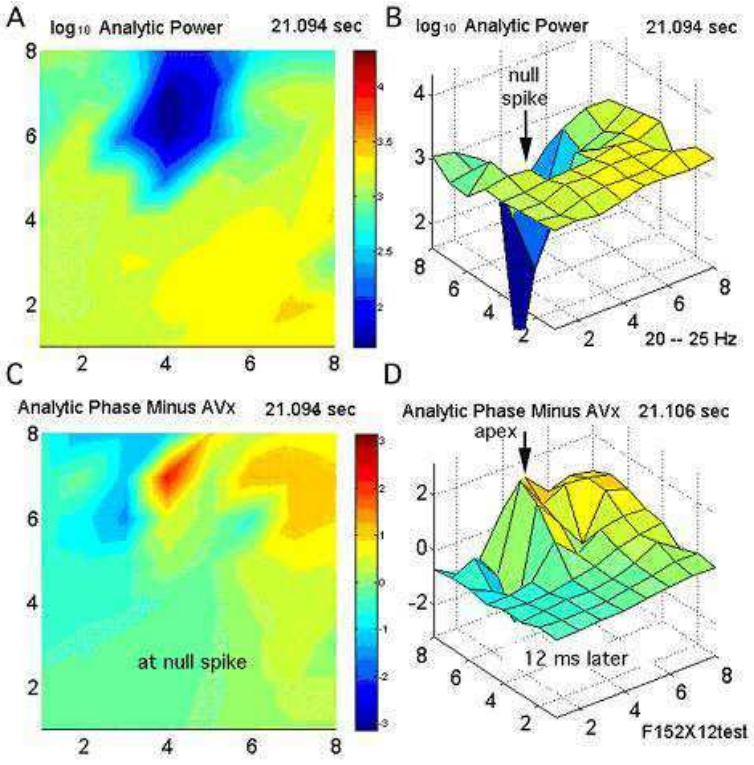


Fig. 4. A. Color-coded contour plot of analytic power (square of amplitude) showing a null spike. B. Perspective view. C. Color-coded plot of analytic phase referenced to spatial average showing phase discontinuity at the site of the null spike. D. Apex of a stable phase cone (sampled 12 ms later) is near the site of the null spike; its negative phase gradient shows the residue of an explosion that occurred in the first quarter cycle after the null spike.

The possibility of deriving from the microscopic (quantum) dynamics the classicality of trajectories in the memory space is one of the merits of the dissipative many-body field model.

These trajectories are found to be classical deterministic chaotic trajectories *

The manifold on which the attractor landscapes sit covers as a "classical blanket" the quantum dynamics going on in each of the representations of the CCR's (the AM patterns recurring at rates in the theta range ($3-8\ Hz$)).

*E. Pessa and G. Vitiello, Mind and Matter 1 59 (2003)
E. Pessa and G. Vitiello, Intern. J. Modern Physics B 18, 841, (2004)
G. Vitiello, Int. J. Mod. Phys. B 18, 785 (2004)

The specific ordered pattern generated through SBS by an external input does not depend on the stimulus features. It depends on the system internal dynamics.

$\Rightarrow$ The stored memory is not a representation of the stimulus.

The model accounts for the laboratory observation of lack of invariance of the AM neuronal oscillation patterns with invariant stimuli

The engagement of the subject with the environment in the action-perception cycle is the essential basis for the emergence and maintenance of meaning through successful interaction and its knowledge base within the brain.

It is an active mirror, because the environment impacts onto the self independently as well as reactively.

The brain-environment "inter-action" is ruled by the free energy minimization processes.

The relations between the self and its surround constitute the meanings of the flows of information exchanged during their interactions.

In this way the brain builds the knowledge of its own world, i.e. its Double.

Memory is not recording of information
(in the Shannon sense).

Memory is recorded through the mechanism of creation of a coherent state.

The process of formation of the meaning consists in the process of dynamical generation of the coherent state and its contextualization in the attractor landscape.

Memory recording is thus always formation of meanings.

The rearrangement of the attractor landscape constitutes the learning process.

The flux of information exchanged with the environment becomes knowledge through such a learning process.

The growth of knowledge is realized at each rearrangement process of the attractor landscape, namely at each new formation of meaning, since in each rearrangement process the past story of the perception experiences is fully taken into account.

This generates the vision of the world and creates expectations which drive the brain in the intentional search of situations considered satisfactorily on the basis of previous experiences.

The problem for brains is that, being finite, they cannot know their environment in its infinite richness;

They can only imagine what the relevant part of the environment may be like, which we describe as making hypotheses.

Brains test them by use of the action-perception cycle.

Action creates the perception of time and simultaneously of causation, because the experience of the body in action is infallibly followed by the experience of changes in the sensorium.

In dissipative quantum field theory each status summary is constructed by cortical field dynamics, and the cortex runs the copy in reverse time.

Time reversal gives brains the best available access to that finite fraction of the infinite environment that is relevant to the organism.

It is the best source of the hypotheses needed by the organism in order to implement the action-perception cycle.

The AM pattern models the otherwise inaccessible environment.

The Double is conceived as a coherent, highly textured brain activity pattern that by replaying the past can predict the future.

Therefore the Double is Mind, not Matter,

yet it is completely entangled with brain matter that is shaped in the original AM pattern.

The brain functioning is characterized by the continuous effort in pursuing the perfect harmony of the self in the world, the satisfying accomplishment of our relation and trade with our Double

$\Rightarrow$

the aesthetical experience consists in the harmonious "to-be-in-the-world", flavoured by the "emotion" of the perception[†]

The aesthetical experience also enters the construction of knowledge, thus establishing a link with Spinoza's "intuitive science"[‡]

[†] F. Desideri, in F. Desideri and G. Matteucci, Estetiche della percezione. Firenze UP p.13, 2006
F. Desideri, La percezione riflessa, Milano Cortina Editore, 2011
G. Vitiello, Atque 5, 155 (2008)

[‡]R. Diodato, Vermeer, Gngora, Spinosa. L'estetica come scienza intuitiva. Milano:Bruno Mondatori(1997)

The act of thinking, usually synonymous of "rationality", of "logical consequential necessity", acquires a new perspective: "to think" appears much better grounded on the erratic walk described by chaotic trajectories in the attractor space.

The missing of strict consequential necessity in the acts of consciousness and in brain activity gives us the 'privilege' of being able to 'make mistakes', namely to follow unexplored paths, eluding conformity and homologation, thus opening the possibility to 'novelties', contrarily to mechanical machines which by definition are 'broken' if their functioning deviates from planned steps**

Thus, errare e pensare (to err and to think) get along much more and much better than one may suspect.

Maybe, pensare is errare.

**G. Minati, and G. Vitiello, Mistake making machines, in G.Minati, E.Pessa and M.Abram eds., Systemics of emergence. Berlin: Springer. p. 67 (2006)

Aesthetical experience also implies "active responses" of the self to the world and the reciprocal action of the world on the self, and in turn active responses imply responsibility and thus they become moral, ethical responses through which the self and its Double become part of the larger social dialog.

An interpersonal, collective level of consciousness thus arises, a 'social brain',

a larger stage where a common 'culture' is originated from the many individual aesthetical experiences.

One's construction of knowledge, the meanings formed at personal levels produce a higher level of knowledge, in a shared common view of the world; new cultural trends, whose novelty may even acquire a revolutionary character, or simply new 'fashions', may swap over a large assembly of people, which thus become a community.

It has been shown** that the dynamics underlying the formation of self-similar fractal structures is the one of coherent boson condensation in quantum field theory: fractals appear to emerge as the macroscopic result of microscopic coherent local deformation processes.

The result relating the coherent dynamics to the fractal formation accounts for the universality of the recurrence in space and in time of self-similar patterns, including the so widely observed logarithmic spiral and Fibonacci progression.

Coherence appears as the universal morphogenetic paradigm.

An integrated ecological vision thus emerges, where the appearance of forms through coherence becomes the formation of meanings.

** G. Vitiello, New Mathematics and Natural Computation 5, 245 (2009); Phys. Lett. A 376, 2527 (2012)

In conclusion,

John von Neumann noted that

"...the mathematical or logical language truly used by the central nervous system is characterized by less logical and arithmetical depth than what we are normally used to. ...We require exquisite numerical precision over many logical steps to achieve what brains accomplish in very few short steps" *.

The observation of textured AM patterns and sequential phase transitions in brain functioning and the dissipative quantum model describing them perhaps provide a way to the understanding of such a view.

*J. von Neumann, The Computer and the Brain. New Haven: Yale University Press, 1958, pp.80-81

"The other one, the one called Borges, is the one things happen to....It would be an exaggeration to say that ours is a hostile relationship; I live, let myself go on living, so that Borges may contrive his literature, and this literature justifies me....Besides, I am destined to perish, definitively, and only some instant of myself can survive him....Spinoza knew that all things long to persist in their being; the stone eternally wants to be a stone and a tiger a tiger. I shall remain in Borges, not in myself (if it is true that I am someone)....Years ago I tried to free myself from him and went from the mythologies of the suburbs to the games with time and infinity, but those games belong to Borges now and I shall have to imagine other things. Thus my life is a flight and I lose everything and everything belongs to oblivion, or to him.

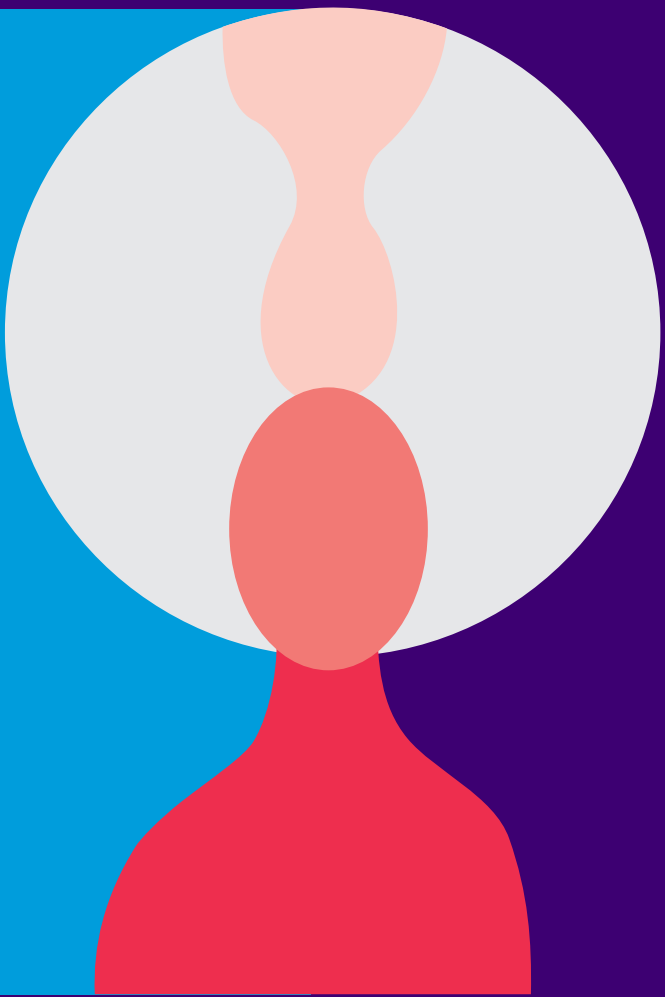
I do not know which of us has written this page."*

*Jorge Louis Borges, "Borges and I", in El hacedor, Biblioteca Borges, Alianza Editorial, 1960.

My Double Unveiled

Giuseppe Vitiello

Advances in Consciousness Research



Quantum Field Theory and its Macroscopic Manifestations

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Massimo Blasone, Petr Jizba & Giuseppe Vitiello

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