

# **A Conclusive Conceptual Framework for Consciousness**

Roadmap for the Development of a Fundamental Theory

Toward a Science of Consciousness 2013

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# Introduction and Overview

- ▶ Toward a Theory of Consciousness
  - ▶▶ Consciousness research has made considerable advances in the last two decades
  - ▶▶ Research activities are dominated by the mindset of neuroscience
  - ▶▶ Core problem of how brain processes cause consciousness is still outstanding
  - ▶▶ Clarification of the mechanisms behind conscious processes is a prerequisite for the development of a theory of consciousness
  - ▶▶ New mindset is urgently required
  
- ▶ Starting Point: Conceptual Framework for Consciousness
  - ▶▶ Novel synthesis of Western and Eastern insights
  - ▶▶ Based on three cornerstones
    - 1 Physics
    - 2 Neurophysiology
    - 3 Eastern philosophy
  
- ▶ Focus: Implications and Roadmap for the Development of a Theory

# 1 Stochastic Electrodynamics (SED)

- ▶ Vacuum of SED is Imbued with Permanent Activity
  - ▶▶ Real, all-pervasive stochastic radiation field: Zero-point field (ZPF)
  - ▶▶ Infinite sea of light, ocean of pure energy and potential
  - ▶▶ All phenomena come into existence through selective filtering of the ZPF
- ▶ Specification of the ZPF
  - ▶▶ Several symmetries are imposed on the field equations
  - ▶▶ Homogeneity, isotropy, Lorentz invariance, scale invariance

$$\mathbf{E}_{\text{ZP}}(\mathbf{r},t) = \sum_{\lambda=1}^2 \int d^3\mathbf{k} \left( \frac{\hbar \omega}{2 \pi^2} \right)^{1/2} \boldsymbol{\varepsilon}(\mathbf{k},\lambda) \cos(\mathbf{k}^*\mathbf{r} - \omega t + \theta(\mathbf{k},\lambda))$$

$$\mathbf{B}_{\text{ZP}}(\mathbf{r},t) = \sum_{\lambda=1}^2 \int d^3\mathbf{k} \left( \frac{\hbar \omega}{2 \pi^2} \right)^{1/2} (\mathbf{k} \times \boldsymbol{\varepsilon}(\mathbf{k},\lambda)) \cos(\mathbf{k}^*\mathbf{r} - \omega t + \theta(\mathbf{k},\lambda))$$

$$\rho_{\text{ZP}}(\omega) = \frac{\hbar \omega^3}{2 \pi^2 c^3}$$

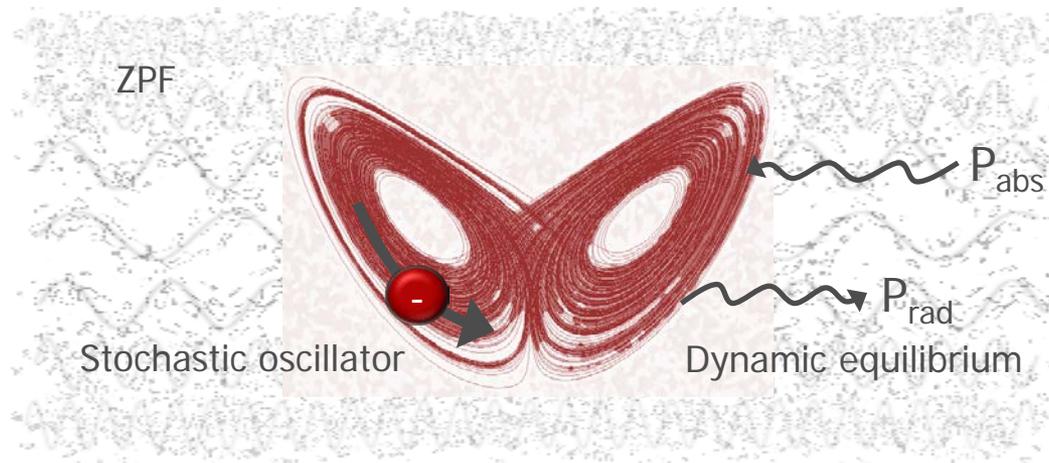
random phase

characteristic power spectrum

(Marshall, 1963; Boyer, 1975; De la Peña and Cetto, 1996)

# 1 Interaction between ZPF and Matter: Impacts on Matter

- ▶ Components of Matter Interact Permanently with the ZPF



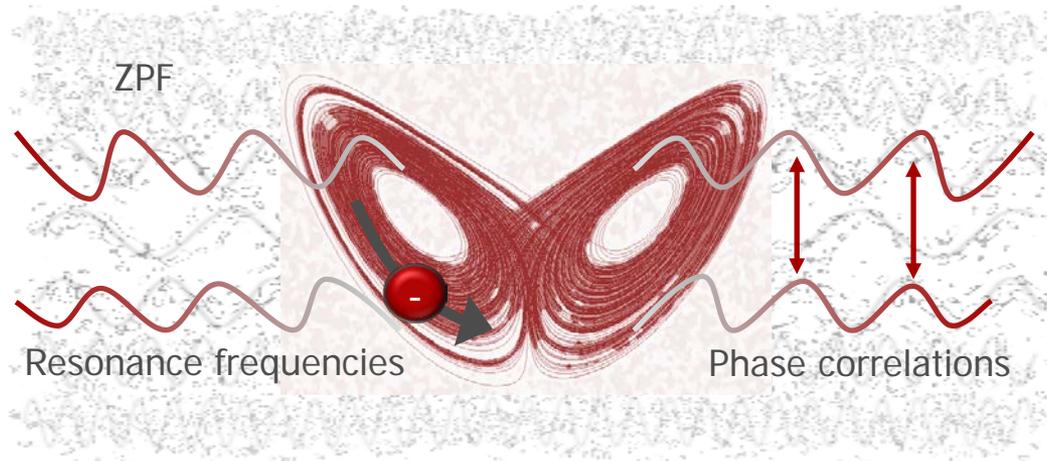
- ▶ Properties of Matter are Emergent Phenomena

- ▶ The stability of a system is created dynamically as soon as the energy exchange between the system components and the ZPF reaches equilibrium.
- ▶ Upon reaching equilibrium, a stationary system falls into a stable attractor and enters the quantum regime.
- ▶ The balance situations are characterized by quantization rules.

(De la Peña and Cetto, 1994, 1995, 2001, 2006)

# 1 Interaction between ZPF and Matter: Impacts on ZPF

- ▶ Presence of Matter Affects the Dynamics of the ZPF



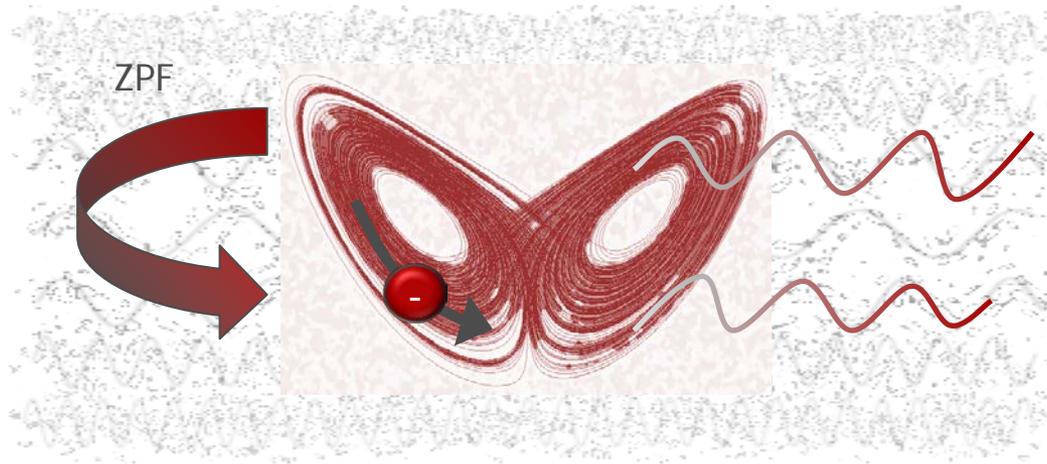
- ▶ ZPF is Modified as soon as a System Reaches a Stable Attractor

- ▶ The characteristic frequency components (resonance frequencies) involved in the maintenance of the equilibrium become highly correlated.
- ▶ This leads to a “de-randomization” and partial organization of the local field.
- ▶ The formation of an attractor imprints a system-specific information state on the local ZPF.

(De la Peña and Cetto, 2001; De la Peña et al., 2009)

# 1 Fundamental Mechanism Underlying Quantum Systems

- ▶ ZPF Orchestrates Matter and Matter Leaves Fingerprints in the ZPF



- ▶ Principles behind Quantum Systems

- ▶ A quantum system functions as a resonant stochastic oscillator that selectively filters its specific resonance frequencies out of the ZPF spectrum.
- ▶ As soon as a quantum system reaches a stable attractor, the system components display collective cooperation (long-range coherence), which is mediated by the information-bearing, partially organized ZPF.

## 2 Neurophysiological Body of Evidence

- ▶ Conditioned stimuli are associated with specific activity patterns representing attractors in an **attractor landscape**
- ▶ **Attractors are the NCC**
- ▶ Vast collections of neurons shift **abruptly and simultaneously** between different attractors
- ▶ Rapid and efficient formation and dissolution of attractors resembles **cinematographic frames**

(Freeman, 1991; 2005; 2007)



- ▶ Analysis of background activity shows that spontaneous oscillations in the brain exhibit **1/f power-law scaling behavior**
- ▶ Brain operates in a **scale-free state of self-organized criticality**

(Linkenkaer-Hansen et al., 2001; Freeman et al., 2003)

- ▶ Consciousness is associated with **long-range coherence** in the brain
- ▶ Synchronized activity in the gamma frequency band (**gamma synchrony**)

(Crick and Koch, 1990; Engel and Singer, 2001; Melloni et al., 2007)

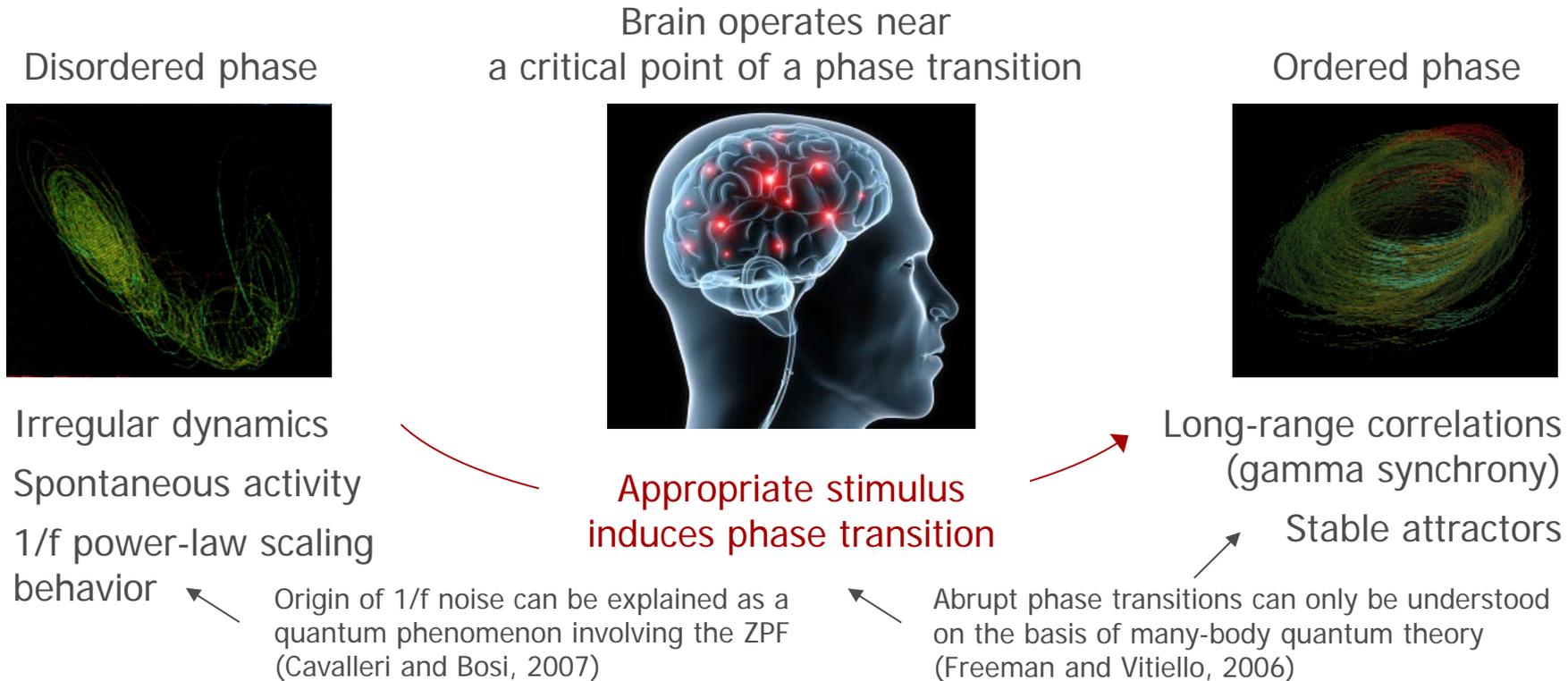
- ▶ Time-frequency analysis of LFP reveals that the source of gamma-band peaks is of **stochastic nature**
- ▶ Brain should be viewed as a **resonant stochastic oscillator**

(Burns et al., 2010, 2011)

- ▶ Experiments investigating stochastic resonance (SR) imply that **SR-mediated neural synchronization** is a general mechanism of brain functioning
- ▶ **Noise** plays a **fundamental role** in the generation of gamma synchrony

(Ward et al., 2006; Kitajo et al., 2007)

## 2 Brain as a Macroscopic Quantum System



- ▶ The brain is a resonant stochastic oscillator driven by the ZPF.
- ▶ The ZPF is the ubiquitous noise source causing the spontaneous background activity.
- ▶ A suitable sensory input prompts the brain to fall into an attractor. In this regime it displays long-range coherence and imprints an information state on the local ZPF.

### 3 Additional Input from Eastern Philosophy

#### ▶ Core Messages of Eastern Philosophy

- ▶▶ All-pervasive energy field is the foundation of our existence
- ▶▶ All physical phenomena spring forth from this field through a transformation process, a dynamic flow of interactions
- ▶▶ On this fundamental level physical phenomena and consciousness are linked by interdependence
- ▶▶ Shades of consciousness correspond to modifications of the all-pervasive field

#### ▶ Interpretation in the Light of SED

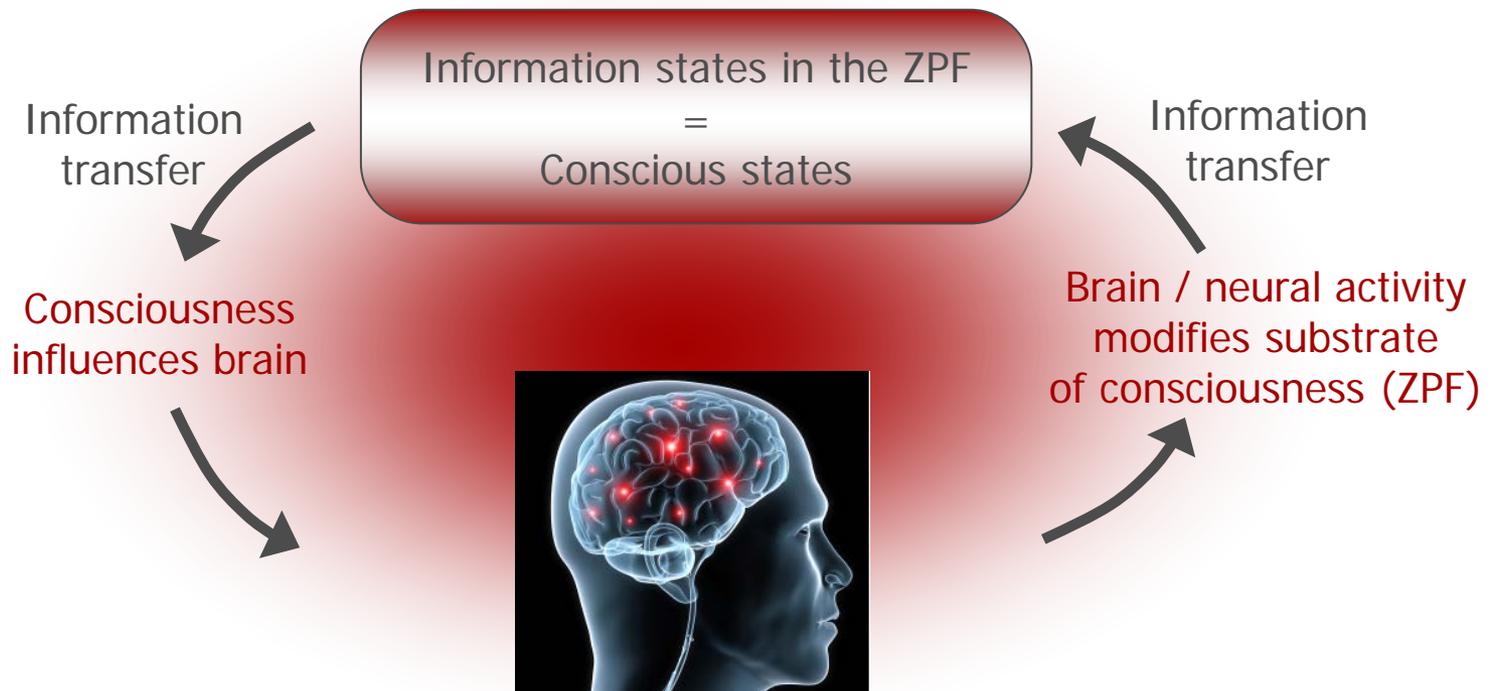
- ▶▶ Corroboration: findings of SED agree perfectly with the world view of Eastern philosophy (principles underlying the physical world)
- ▶▶ Hint: Mind and matter are based on the same substrate
- ▶▶ Conclusion: ZPF is an eminently suitable candidate for this substrate



ZPF is the carrier of consciousness

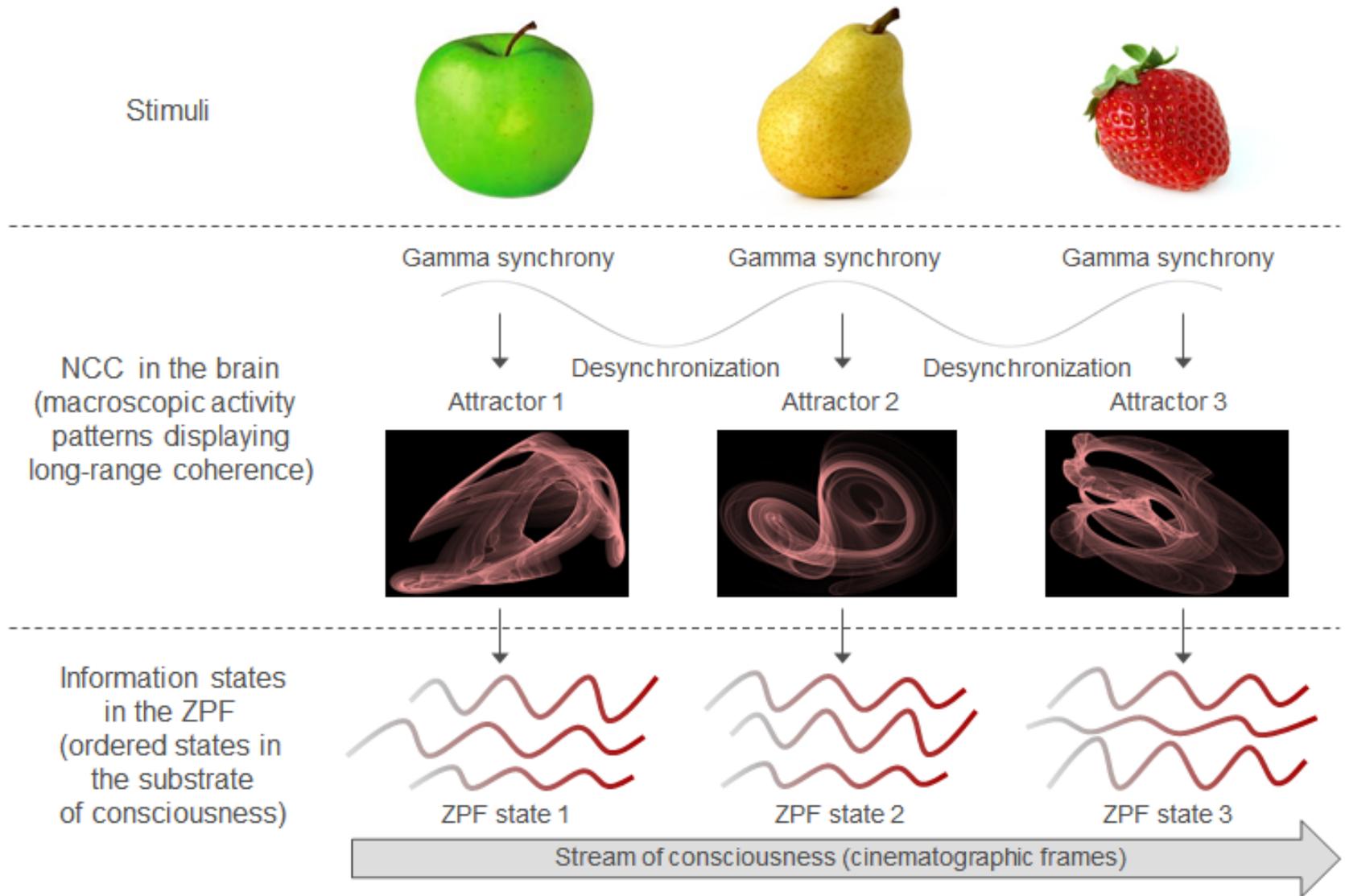
### 3 Conceptual Framework for Consciousness

- ▶ Principle 1: Consciousness is a fundamental property of the universe.
- ▶ Principle 2: The ZPF is the substrate of consciousness.
- ▶ Principle 3: Our individual consciousness is the result of an interaction process that causes the realization of information states in the ZPF.



(Kepler, 2012)

### 3 Fundamental Mechanisms behind Conscious Processes



# Implication 1: Consciousness and Matter

- ▶ The conceptual framework provides an elegant solution to the mind-body problem.
- ▶ All the phenomena of matter and consciousness are based on one and the same fundamental substrate.
- ▶ The framework explains how matter and consciousness communicate in a causally closed functional chain.

ZPF orchestrates matter and is the source of the enormous diversity of physical manifestations



Interaction process with matter generates ZPF information states that are the basis of our rich spectrum of qualitative experiences; a conscious moment is a ZPF information state experienced from inside

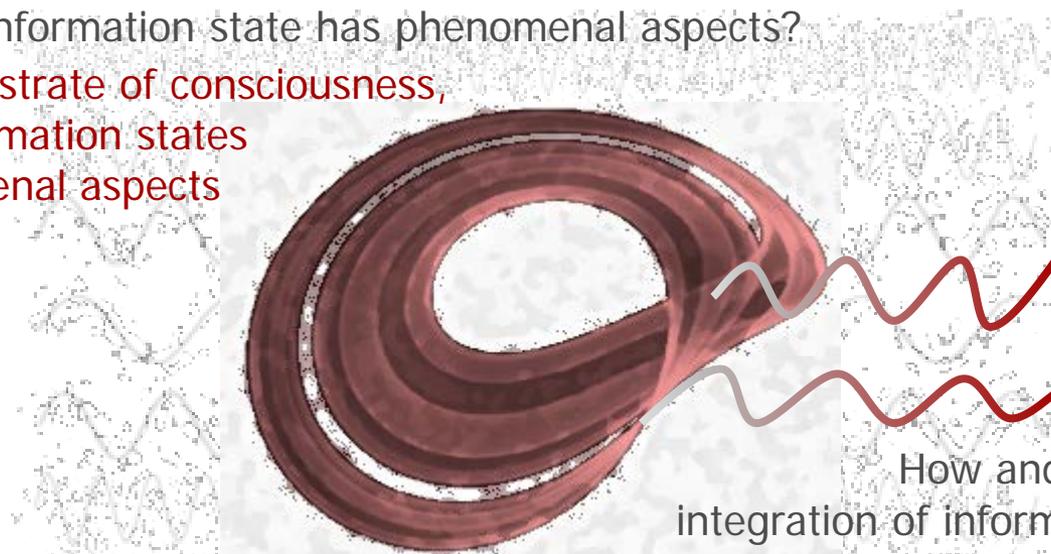
(Kepler, 2012)

## Implication 2: Consciousness and Information

- ▶ Conscious processes can be distinguished from unconscious processes in that only the former processes are accompanied by ZPF information states.
- ▶ The framework is able to specify existing approaches:
  - ▶▶ Double-aspect principle of information (Chalmers, 1995, 1996)
  - ▶▶ Integrated information theory (Tononi, 2004, 2008)

What sort of information state has phenomenal aspects?

ZPF is the substrate of consciousness,  
only ZPF information states  
have phenomenal aspects



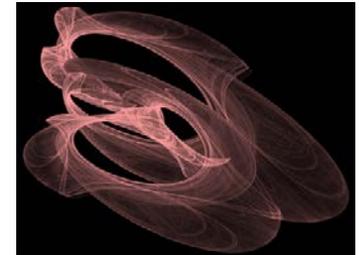
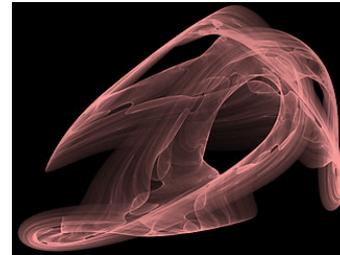
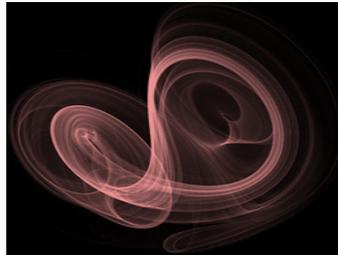
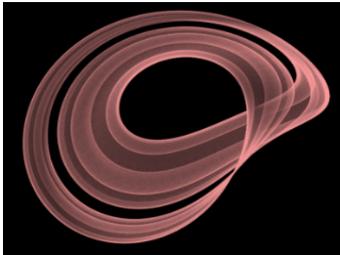
How and where does the  
integration of information take place?

ZPF is the integrating agent and the ordered  
ZPF configuration behind an attractor carries the integrated information

(Kepler, 2012)

## Implication 3: Consciousness and Complexity

- ▶ Every system that generates ZPF information states may be conscious.
- ▶ All microscopic and macroscopic (nonlinear) quantum systems may be conscious.
- ▶ The number of different ZPF configurations (attractors) of a system determines the quantity of consciousness.
- ▶ The characteristics of the ZPF configurations (attractor dynamics) determine the quality of consciousness.

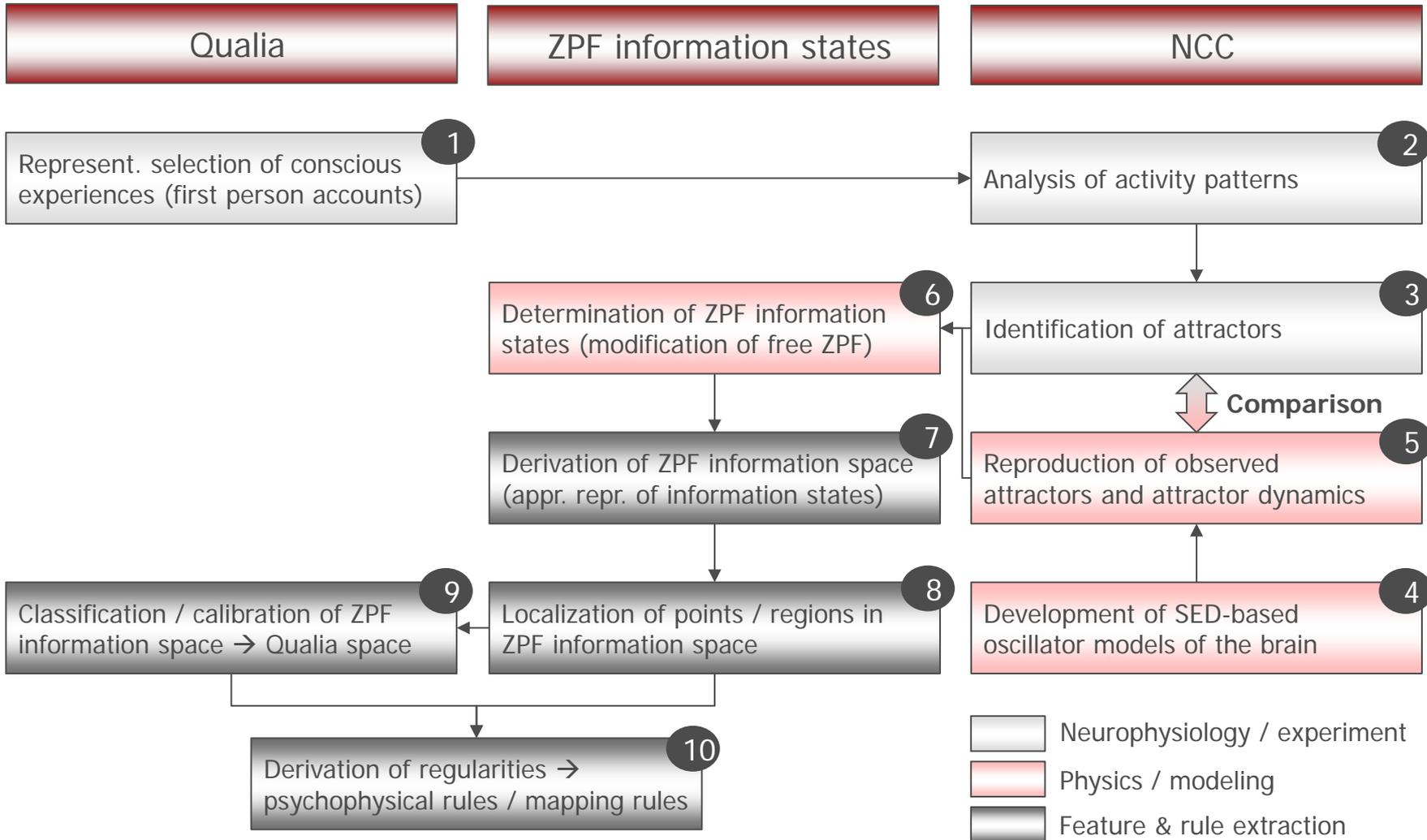


Simple systems have relatively sparse attractor landscapes with relatively simple attractors → they have a rudimentary form of consciousness

Complex systems have a very rich and highly adaptive attractor landscape with complex attractors → they give rise to a broad spectrum of conscious experiences

(Kepler, 2012)

# Roadmap for the Development of a Theory of Consciousness



# Outlook

Qualia

ZPF information states

NCC

1 Represent. selection of conscious experiences (first person accounts)

2 Analysis of activity patterns

6 Determination of ZPF information states (modification of free ZPF)

3 Identification of attractors

Comparison

5 Reproduction of observed attractors and attractor dynamics

4 Development of SED-based oscillator models of the brain

- ▶ Start with toy models
- ▶ Study attractor dynamics of toy systems
- ▶ Understand ZPF information states caused by attractors
- ▶ Pragmatic ideas for test scenarios on the basis of which this conceptual framework can be verified
- ▶ Stimulate interdisciplinary discussion
- ▶ Call for input and support

Physics / modeling

# References

- ▶ Boyer, T. H. (1975). Random electrodynamics: the theory of classical electrodynamics with classical electromagnetic zero-point radiation. *Phys. Rev. D* 11, 790–808.
- ▶ Burns, S. P. et al. (2010). Searching for autocohereance in the cortical network with a time-frequency analysis of the local field potential. *J. Neurosci.* 30, 4033–4047.
- ▶ Burns, S. P. et al. (2011). Is gamma-band activity in the local field potential of V1 cortex a “clock” or filtered noise? *J. Neurosci.* 31, 9658–9664.
- ▶ Cavalleri, G., and Bosi, L. (2007). Origin of 1/f noise as a runaway phenomenon due to the zero-point field (ZPF) of quantum electrodynamics (QED). *Physica Stat. Sol. C* 4, 1230–1233.
- ▶ Chalmers, D. J. (1995). Facing up to the problem of consciousness. *J. Consci. Stud.* 2, 200–219.
- ▶ Chalmers, D. J. (1996). *The Conscious Mind: In Search of a Fundamental Theory*. New York: Oxford University Press.
- ▶ Crick, F., and Koch, C. (1990). Towards a neurobiological theory of consciousness. *Sem. Neurosci.* 2, 263–275.
- ▶ De la Peña, L., and Cetto, A. M. (1994). Quantum phenomena and the zeropoint radiation field. *Found. Phys.* 24, 917–948.
- ▶ De la Peña, L., and Cetto, A. M. (1995). Quantum phenomena and the zeropoint radiation field II. *Found. Phys.* 25, 573–604.
- ▶ De la Peña, L., and Cetto, A. M. (1996). *The Quantum Dice: An Introduction to Stochastic Electrodynamics*. Dordrecht: Kluwer Academic Publishers.
- ▶ De la Peña, L., and Cetto, A. M. (2001). Quantum theory and linear stochastic electrodynamics. *Found. Phys.* 31, 1703–1731.
- ▶ De la Peña, L., and Cetto, A. M. (2006). The foundations of linear stochastic electrodynamics. *Found. Phys.* 36, 350–368.
- ▶ De la Peña, L. et al. (2009). Quantum mechanics as an emergent property of ergodic systems embedded in the zero-point radiation field. *Found. Phys.* 39, 1240–1272.
- ▶ Engel, A. K., and Singer, W. (2001). Temporal binding and the neural correlates of sensory awareness. *Trends Cogn. Sci.* 5, 16–25.
- ▶ Freeman, W. J. (1991). The physiology of perception. *Scientific American* 264, 78–85.
- ▶ Freeman, W. J. (2005). Origin, structure, and role of background EEG activity. Part 3. Neural frame classification. *Clin. Neurophysiol.* 116, 1118–1129.
- ▶ Freeman, W. J. (2007). Indirect biological measures of consciousness from field studies of brains as dynamical systems. *Neural Networks* 20, 1021–1031.
- ▶ Freeman, W. J., and Vitiello, G. (2006). Nonlinear brain dynamics as macroscopic manifestation of underlying many-body field dynamics. *Phys. Life Rev.* 3, 93–118.
- ▶ Freeman, W. J. et al. (2003). Spatial spectra of scalp EEG and EMG from awake humans. *Clin. Neurophysiol.* 114, 1053–1068.
- ▶ Keppler, J. (2012). A conceptual framework for consciousness based on a deep understanding of matter. *Philosophy Study* 2, 689–703.
- ▶ Kitajo, K. et al. (2007). Noise-induced large-scale phase synchronization of human-brain activity associated with behavioural stochastic resonance. *Europhys. Lett.* 80, 40009.
- ▶ Linkenkaer-Hansen, K. et al. (2001). Long-range temporal correlations and scaling behavior in human brain oscillations. *J. Neurosci.* 21, 1370–1377.
- ▶ Marshall, T. W. (1963). Random electrodynamics. *Proc. R. Soc. London A* 276, 475–491.
- ▶ Melloni, L. et al. (2007). Synchronization of neural activity across cortical areas correlates with conscious perception. *J. Neurosci.* 27, 2858–2865.
- ▶ Ricard, M., and Thuan, T. X. (2004). *The Quantum and the Lotus. A Journey to the Frontiers Where Science and Buddhism Meet*, New York: Three Rivers Press.
- ▶ Tononi, G. (2004). An information integration theory of consciousness. *BMC Neurosci.* 5, 42.
- ▶ Tononi, G. (2008). Consciousness as integrated information: a provisional manifesto. *Biol. Bull.* 215, 216–242.
- ▶ Ward, L. M. et al. (2006). Stochastic resonance modulates neural synchronization within and between cortical sources. *PLoS ONE* 5, e14371.



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