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TUTORIAL

The Challenge of Thriving on Uncertainty in Systems Research and Innovation

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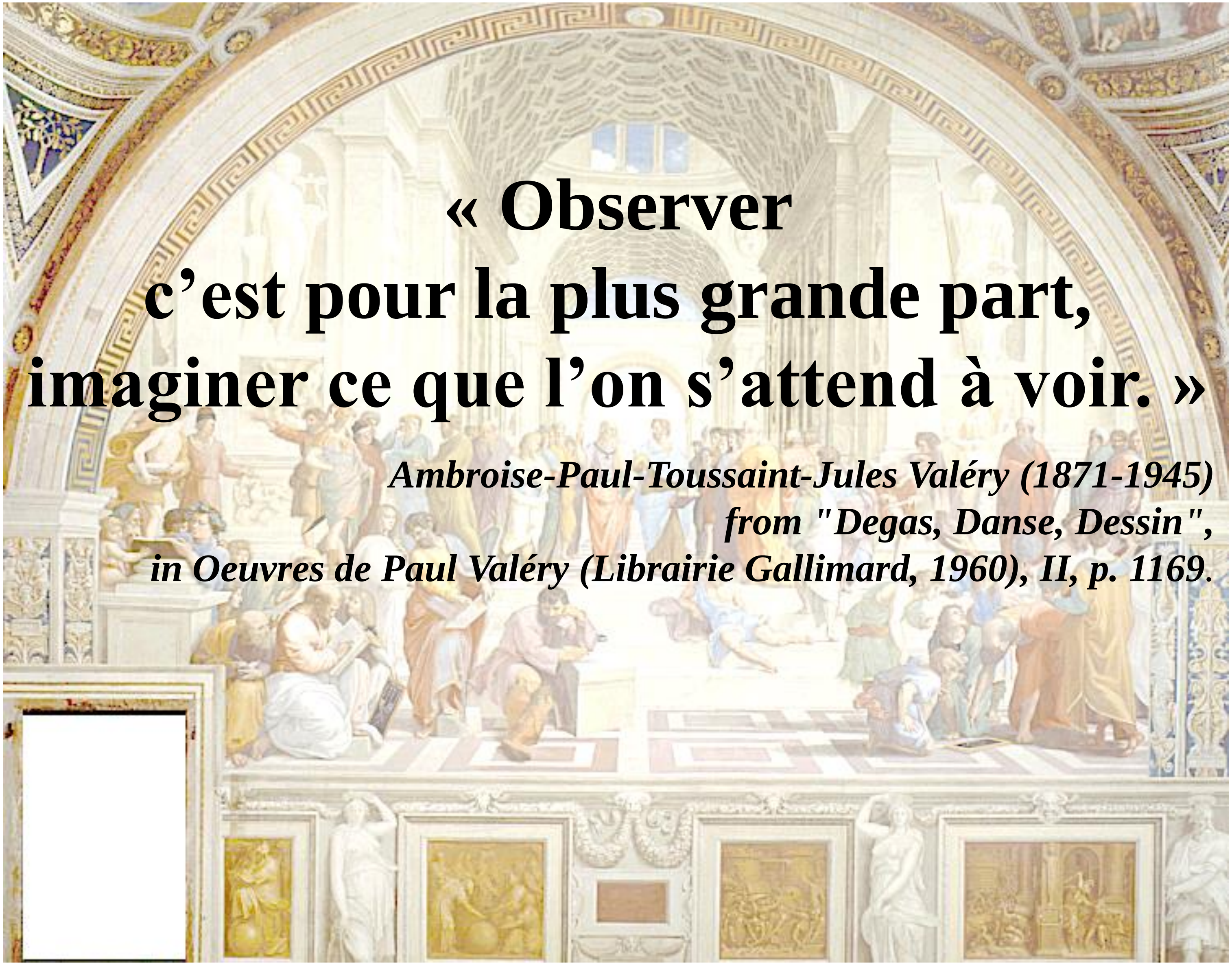
« Le seul véritable voyage
ce ne serait pas
d'aller vers de nouveaux paysages,
mais d'avoir d'autres yeux… »

Valentin Louis Georges Eugène Marcel Proust (1871-1922)
***from La Prisonnière (1923)**.*

The Challenge of Thriving on Uncertainty in Systems Research and Innovation



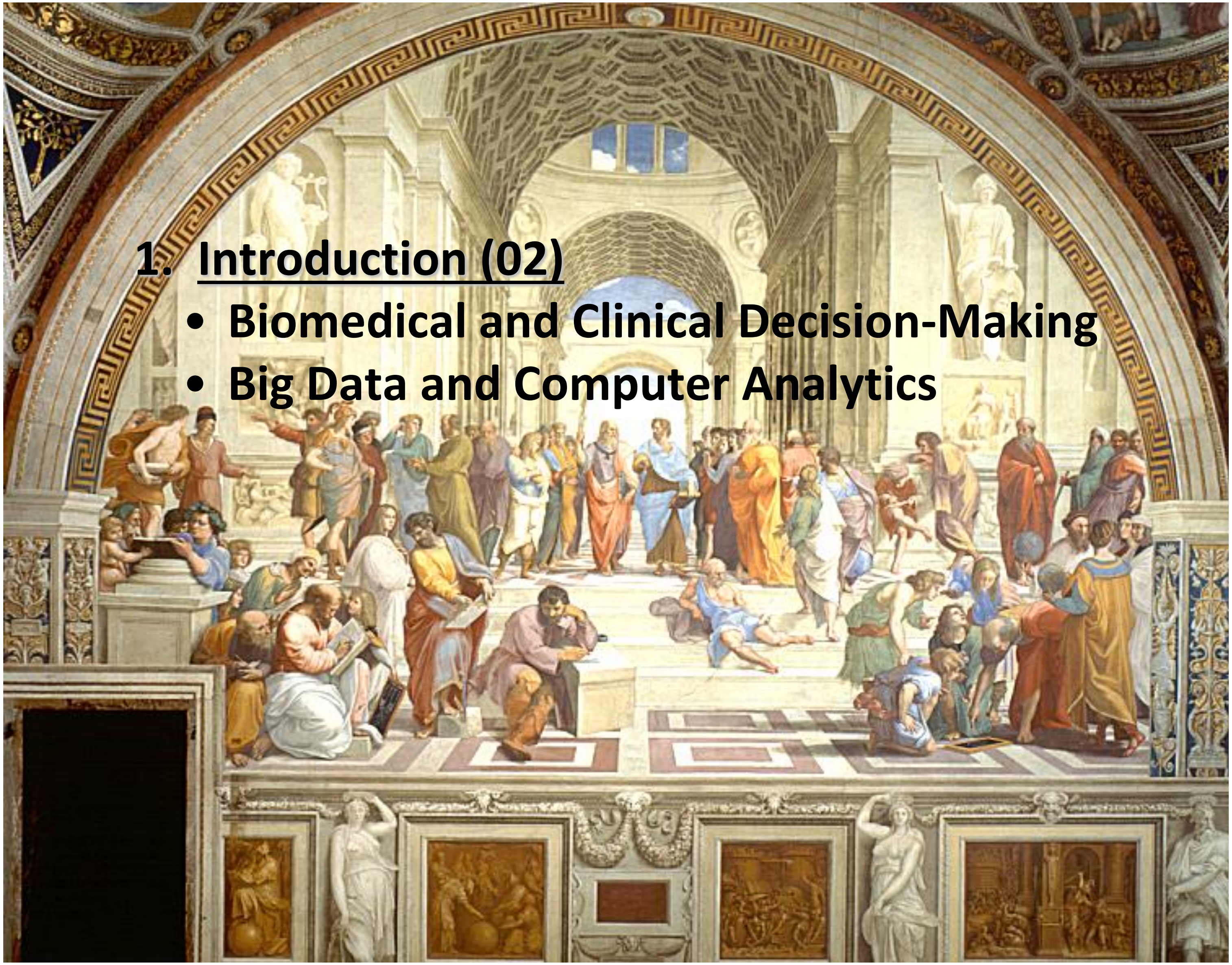
« Observer
c’est pour la plus grande part,
imaginer ce que l’on s’attend à voir. »

Ambroise-Paul-Toussaint-Jules Valéry (1871-1945)
from "Degas, Danse, Dessin",
in Oeuvres de Paul Valéry (Librairie Gallimard, 1960), II, p. 1169.

Presentation Outline

1. Introduction (02)
   - Information Double-Bind Problem
   - Relational Competence for Innovative Solutions
2. Current Approach (16)
   - Paradigmatic Confusion
   - Statistics Can Fool You, Unfortunately
3. Information & Learning (17)
   - Information Concept
   - Main Approaches to Learning & Awareness
4. Information Geometry Theory (25)
   - Information Geometry
   - Example in Image Processing
5. A Fresh Approach to Decision Making (31)
   - R. Rosen Fundamental Modeling Relation
   - A Five-Level Cybernetics Framework
6. An Antifragile HICT Natural Framework (36)
   - Natural Living Organism Antifragility
   - Final Antifragile HICT Natural Framework
7. Summary and Conclusions (07)
   - Quick Recap
   - Main References

1. Introduction (00)



1. Introduction (02)
   - Biomedical and Clinical Decision-Making
   - Big Data and Computer Analytics

1. Introduction (01)

Over the last few years, we saw a few attempts for integration of stochastic methods into a multi-scale system modeling framework (from macro-scale to nano-scale).

The development of **multi-scale models** in a stochastic setting for **epistemic uncertainty quantification** (UQ) is becoming an emerging research frontier for systems modeling, innovation and competitive development in Science and Technology.

Traditional human approach to experience is based on decision making in a natural uncertain environment by incomplete knowledge.

Stochastic vs. Combinatorically Optimized Noise ambiguity emphasises the current **information double-bind problem**, even in most advanced research laboratories and instrumentation systems. (R.A. Fiorini, 2014)

This is still the major problem just at the inner core of human knowledge extraction by experimentation.

1. Introduction (02)

To grasp a more reliable representation of reality and to get more resilient and antifragile techniques, researchers and scientists need two intelligently articulated hands: **both stochastic and combinatorial approaches synergically articulated by natural coupling.**

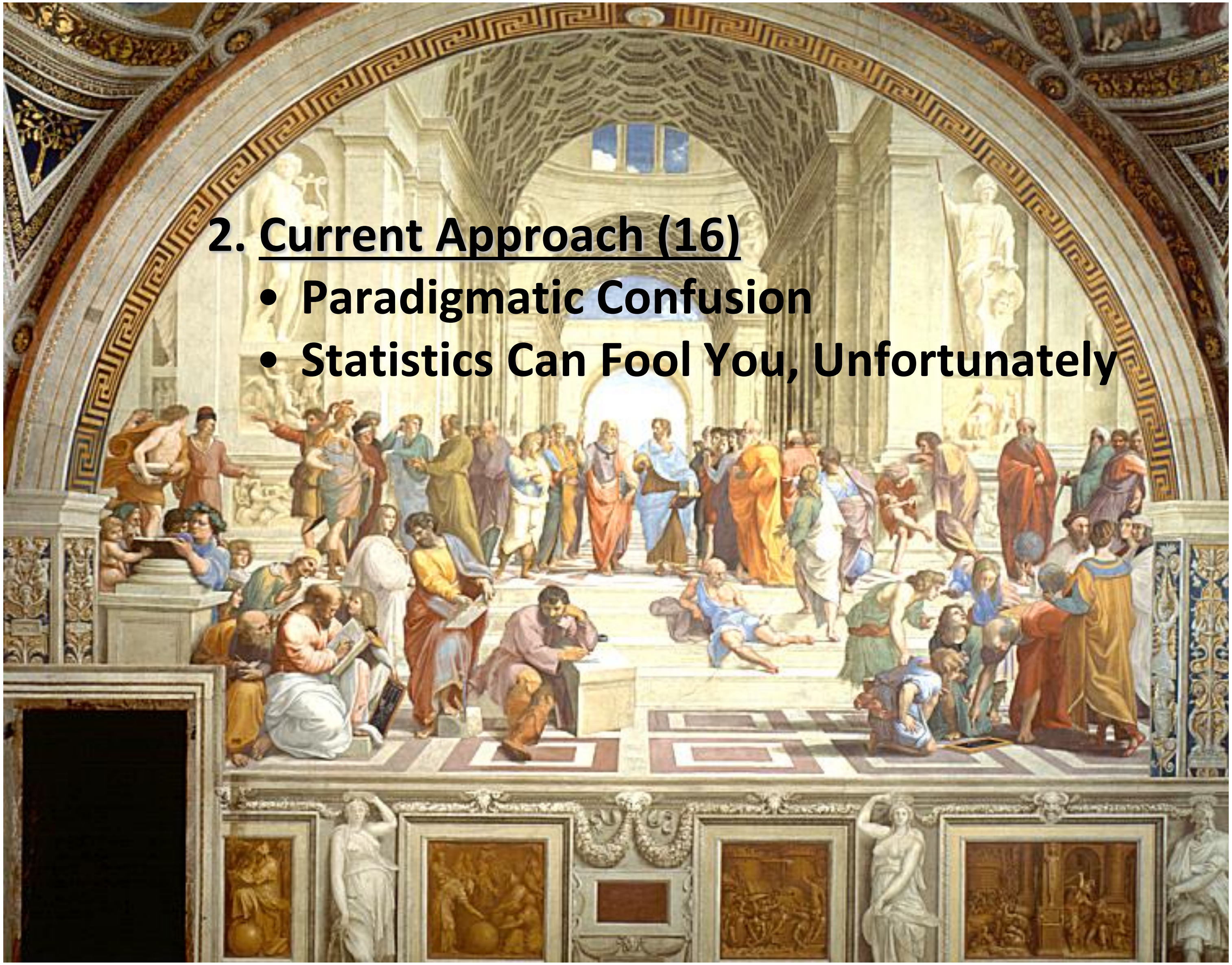
In order to take robust and reliable decision in a complex world, we need to educate and train people to use simple, but effective and powerful strategies and strategic tools, in many different critical application areas.

To design and develop more robust, resilient and antifragile cyber-physical system, **we need novel tools to combine effectively and efficiently analytical asymptotic exact global solution panoramas to deep local computational precision achievement.**

This tutorial presents fundamental concepts, inter and trans-disciplinary examples to show how both information science and engineering can give a **fundamental contribution to enhance relational competence** (**RC**).

RC is key component in problem solving to current innovative system development and beyond, towards a more sustainable economy and wellbeing, in a global competition scenario.

2. Current Approach (00)



2. Current Approach (16)
- Paradigmatic Confusion
- Statistics Can Fool You, Unfortunately

2. Current Approach (01)

To face the challenge of complex system understanding and reliable modeling (AMS system modeling), we need to be able to control system uncertainty quantification from macroscale, through mesoscale, till nanoscale and beyond.

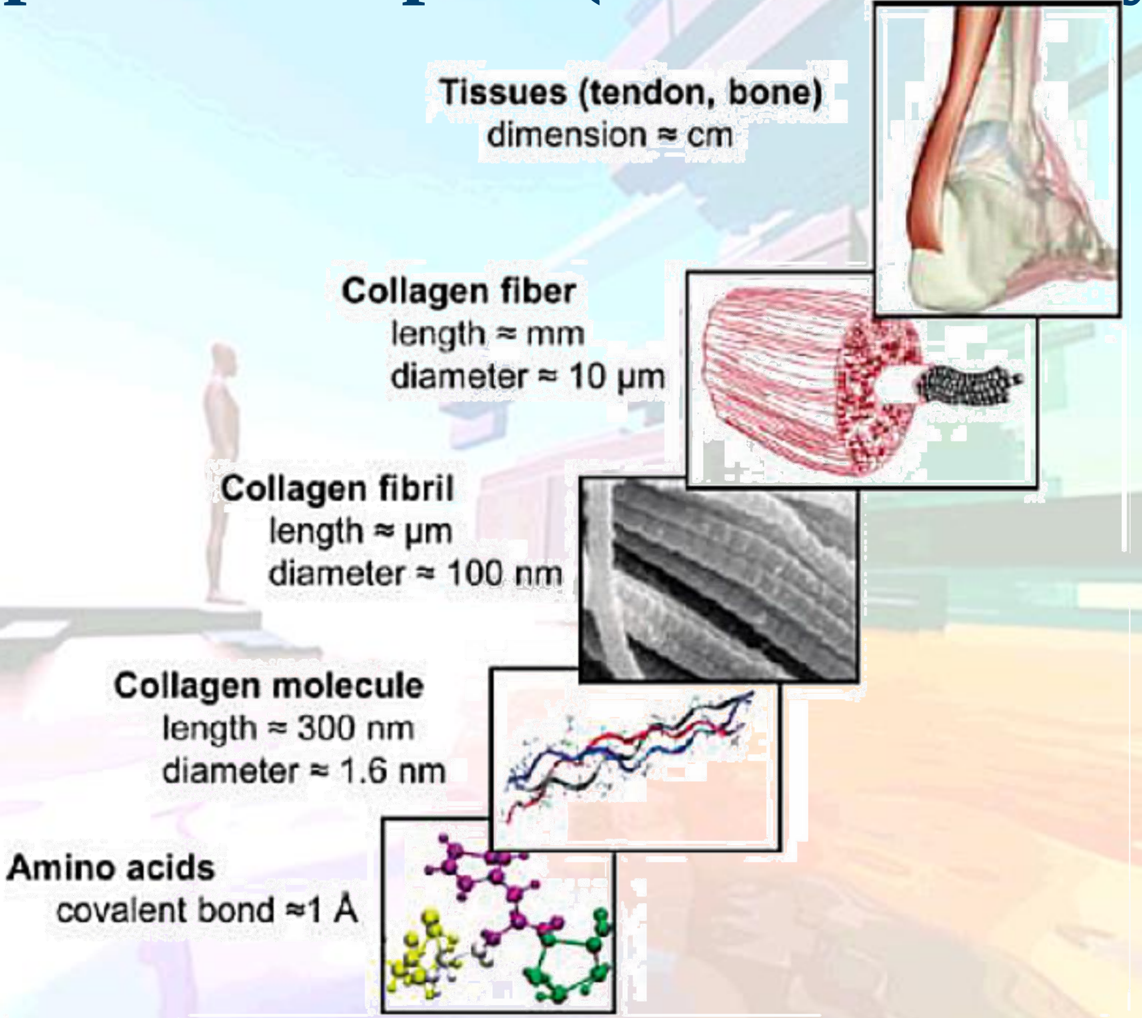
We need more robust, resilient and antifragile application to be ready for next generation systems. Attempts to optimize multi-scale systems in a top-down (TD) point-of-view (POV) will be less and less effective, and cannot be done in real time.

That is the main reason why, over the last few years, integration of stochastic methods into a multi-scale framework (from macro-scale to nano-scale) or development of multi-scale models in a stochastic setting for **epistemic uncertainty quantification** (UQ) is becoming an **emerging research frontier for systems modeling**, innovation and competitive development in Science and Technology.

What is a complex System?

2. Current Approach (02)

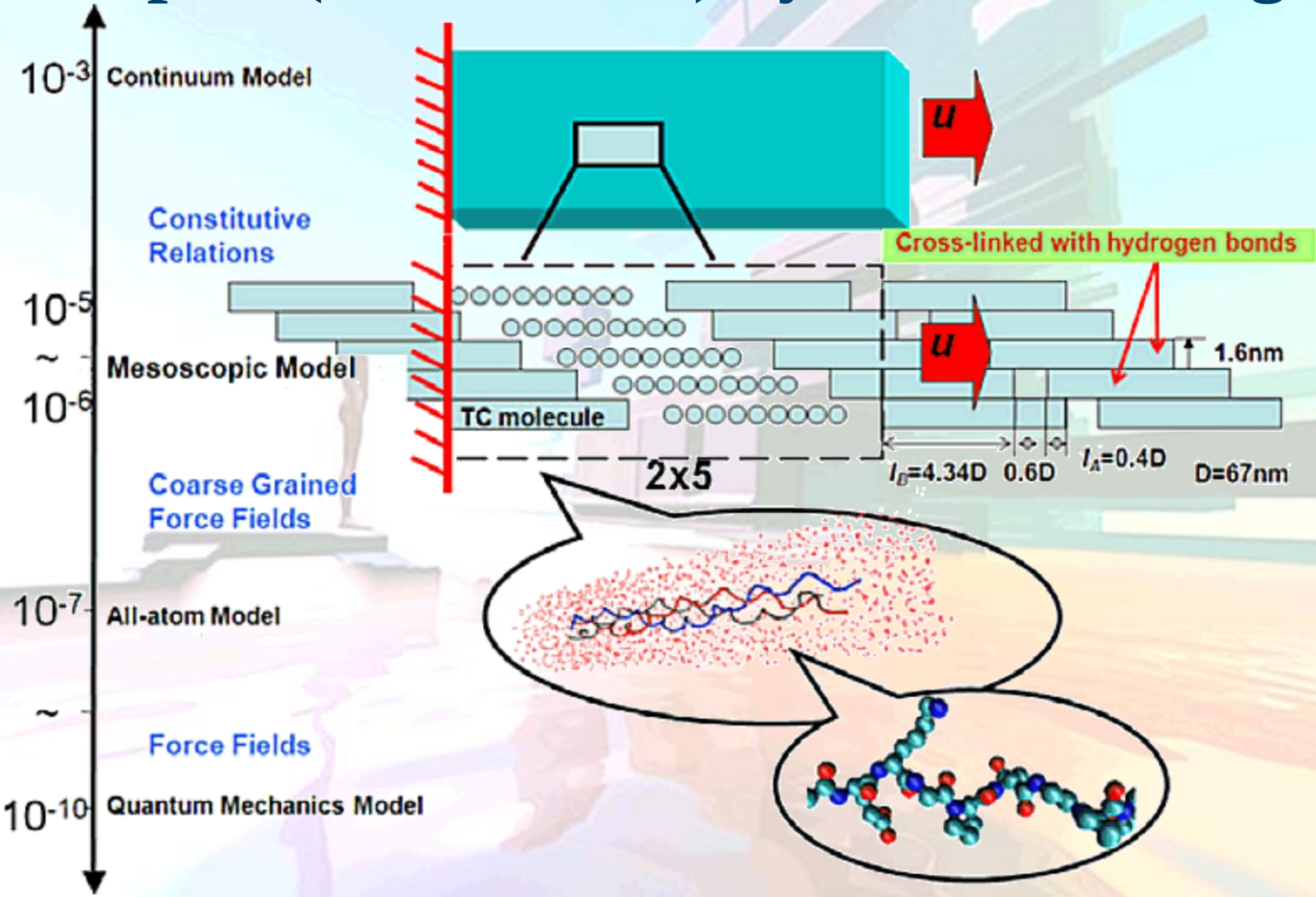
Example of Complex (Multi-Scale) System



(R.A. Fiorini, 2015)

2. Current Approach (03)

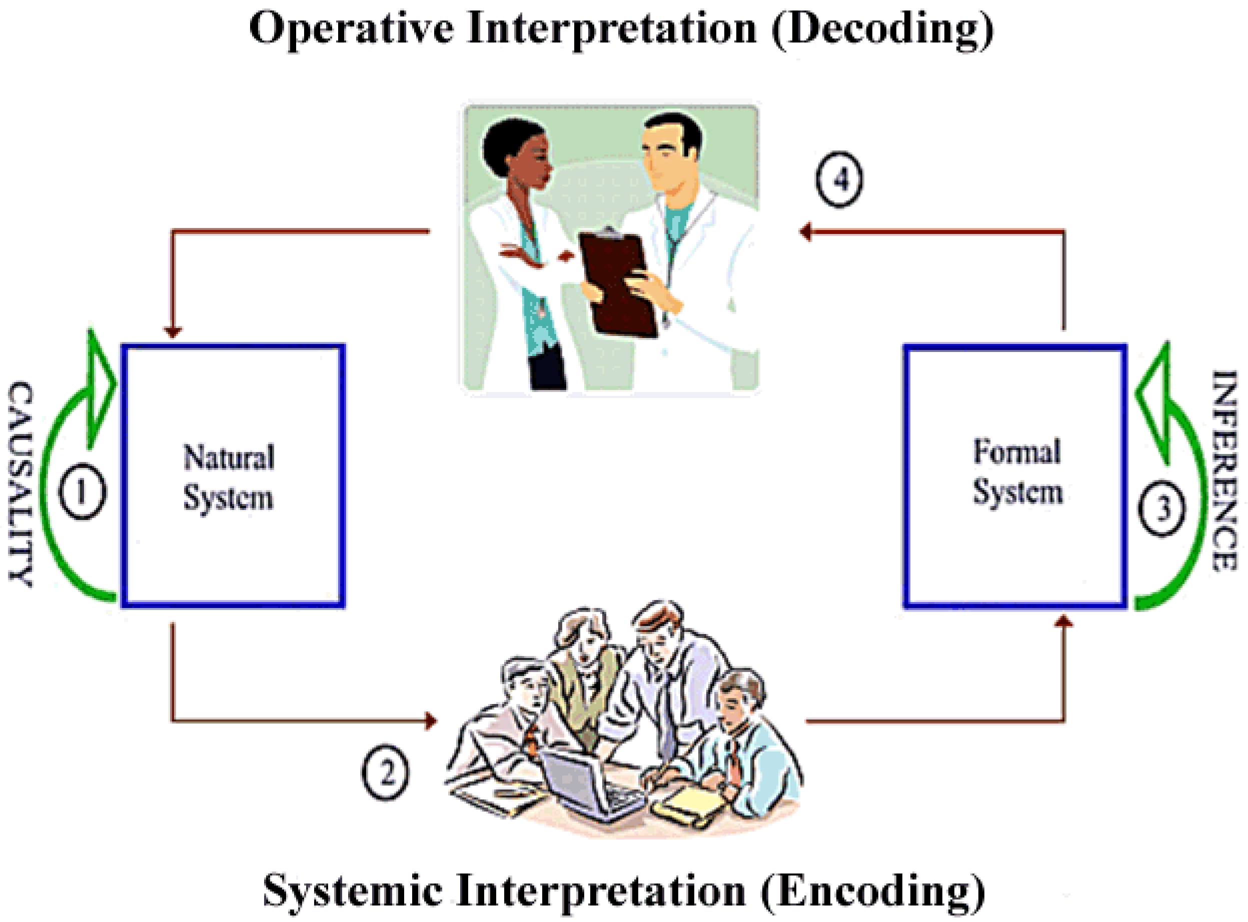
Complex (Multi-Scale) System Modeling



(R.A. Fiorini, 2015)

2. Current Approach (04)

Basic Operative Reference Scenario

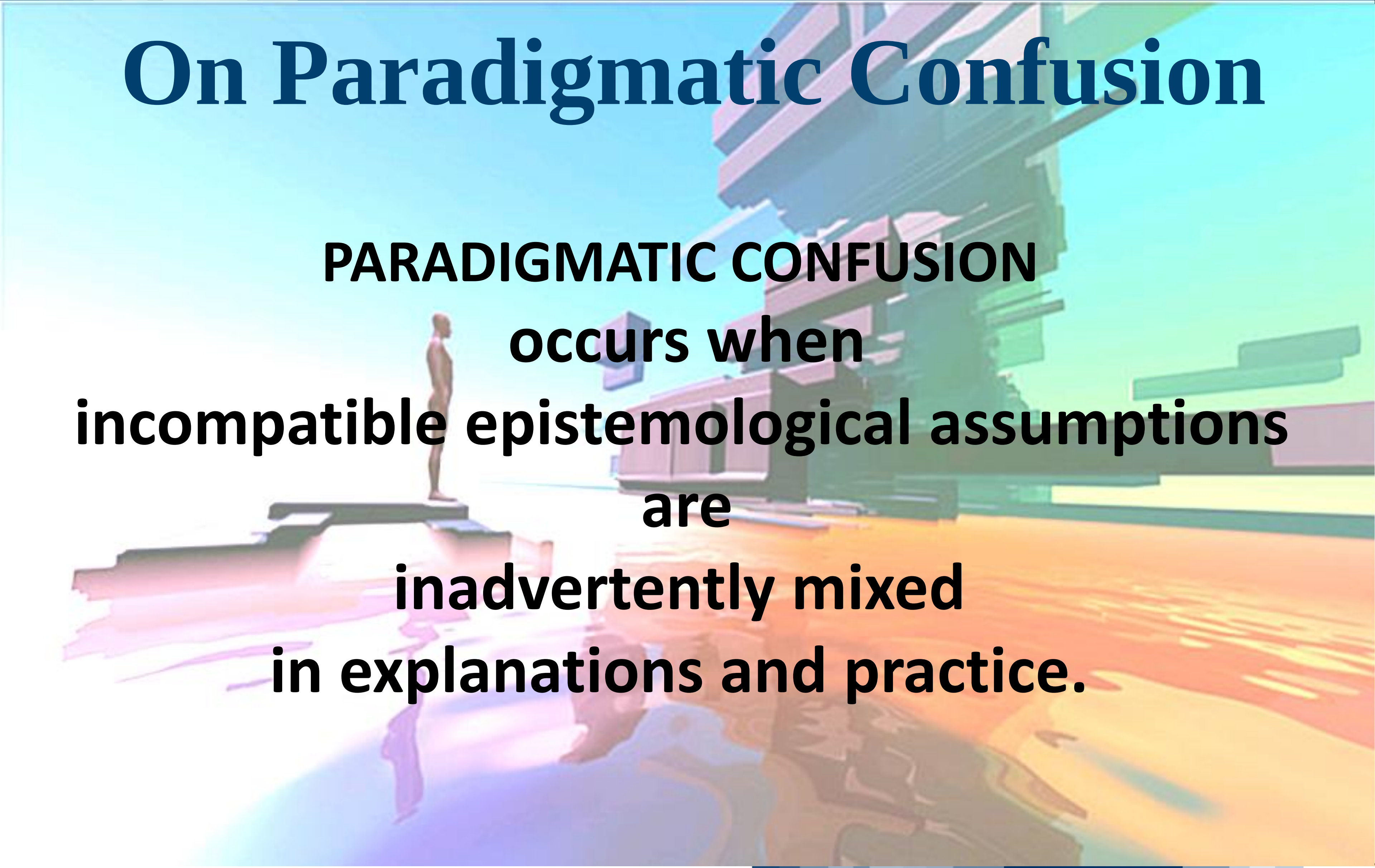


2. Current Approach (05)

Systemic Reference Paradigms

- ☐ **Naturalistic DaVincian (1478): sxt.**
- ☐ **Relativistic Galileinian (1632): t ≡ A; s ≡ R.**
- ☐ **Reductionist Positivist (1687): t ≡ A; s ≡ A.**
- ☐ **Relativistic Einsteinian (1921): sxt.**
- ☐ **Quantum Stochastic (1924–1927): E(f(sxt)).**
  (The Copenhagen Interpretation: Niels Bohr, Werner Heisenberg.)
- ☐ **Quantum Causal (1992): sxt (Open System).**
  (The de Broglie–Bohm theory Interpretation: Louis de Broglie, David Bohm.)
- ☐ **Quantum Transactional (1986-2013): (Open Systems).**
  (TIQM: John G. Cramer, R. Kastner.)
- ☐ **Quantum Relational (1994-1997): (Open Systems).**
  (The RQM Interpretation: Carlo Rovelli, Basvan Fraassen and by Michel Bitbol.)

2. Current Approach (06)



On Paradigmatic Confusion

PARADIGMATIC CONFUSION
occurs when
incompatible epistemological assumptions
are
inadvertently mixed
in explanations and practice.

2. Current Approach (07)

Mankind's best conceivable **worldview** is **at most a partial picture of the real world**, a picture, a representation centered on man. We inevitably see the universe from **a human point of view** and communicate in terms shaped by the exigencies of human life in a natural uncertain environment.

Although there are many sources of uncertainty, two basic areas of uncertainty that are fundamentally different from each other were recognized as traditional reference knowledge: **natural** and **epistemic uncertainty**.

Intrinsic randomness of a phenomenon (e.g. throwing a dice) or **natural uncertainty cannot be reduced** by the collection of additional data and it stems from variability of the underlying stochastic process (if any).

Unlike natural uncertainty, **epistemic uncertainty can be reduced** by the collection of additional data. Statistical and applied probabilistic theory is the core of traditional scientific knowledge; it is **the logic of "Science 1.0"**; it is **the traditional instrument of risk-taking**.

Main epistemic uncertainty sources can be referred to **three core conceptual areas**: **a)** Entropy Generation (Clausius-Boltzmann), **b)** Heisenberg Uncertainty Principle and **c)** Gödel Incompleteness Theorems.

2. Current Approach (08)

- **Entropy Generation (Clausius-Boltzmann):** The term entropy was coined in **1865** by Rudolf Clausius based on the Greek "εντροπία" (entropía), meaning "turning toward." There are two physical related definitions of entropy: the thermodynamic definition (Clausius, in the 1850s) and the statistical mechanics definition (Boltzmann, in the 1870s). In **Quantum Statistical Mechanics** (QSM), the concept of entropy was developed by Hungarian-American mathematician and polymath **John von Neumann** (1903–1957) and is generally referred to as "von Neumann entropy". In **classic Information Theory**, entropy is the measure of the amount of information that is missing before message reception and is sometimes referred to as "Shannon entropy." The concept was introduced by **Claude E. Shannon** in his **1948** paper "A Mathematical Theory of Communication". The link between thermodynamic and information entropy was developed in a series of papers by American physicist **Edwin Thompson Jaynes** (1922–1998), beginning in 1957.
- **Heisenberg Uncertainty Principle:** The more precisely the position of some particle is determined, the less precisely its momentum can be known, and vice-versa.(Elion et al., 1994) The original heuristic argument that such a limit should exist was given by German theoretical physicist **Werner Karl Heisenberg** (1901–1976) in **1927**, after whom it is sometimes named, as the "Heisenberg principle."
- **Gödel Incompleteness Theorems:** Gödel's incompleteness theorems are two theorems of mathematical logic that establish inherent limitations of all but the most trivial axiomatic systems capable of doing arithmetic. The theorems, proven by Austrian American logician, mathematician, and philosopher **Kurt Friedrich Gödel** (1906–1978) in **1931**, are important both in mathematical logic and in the philosophy of mathematics. They prove **the open logic approach of Mathematics**. (Licata, 2008)

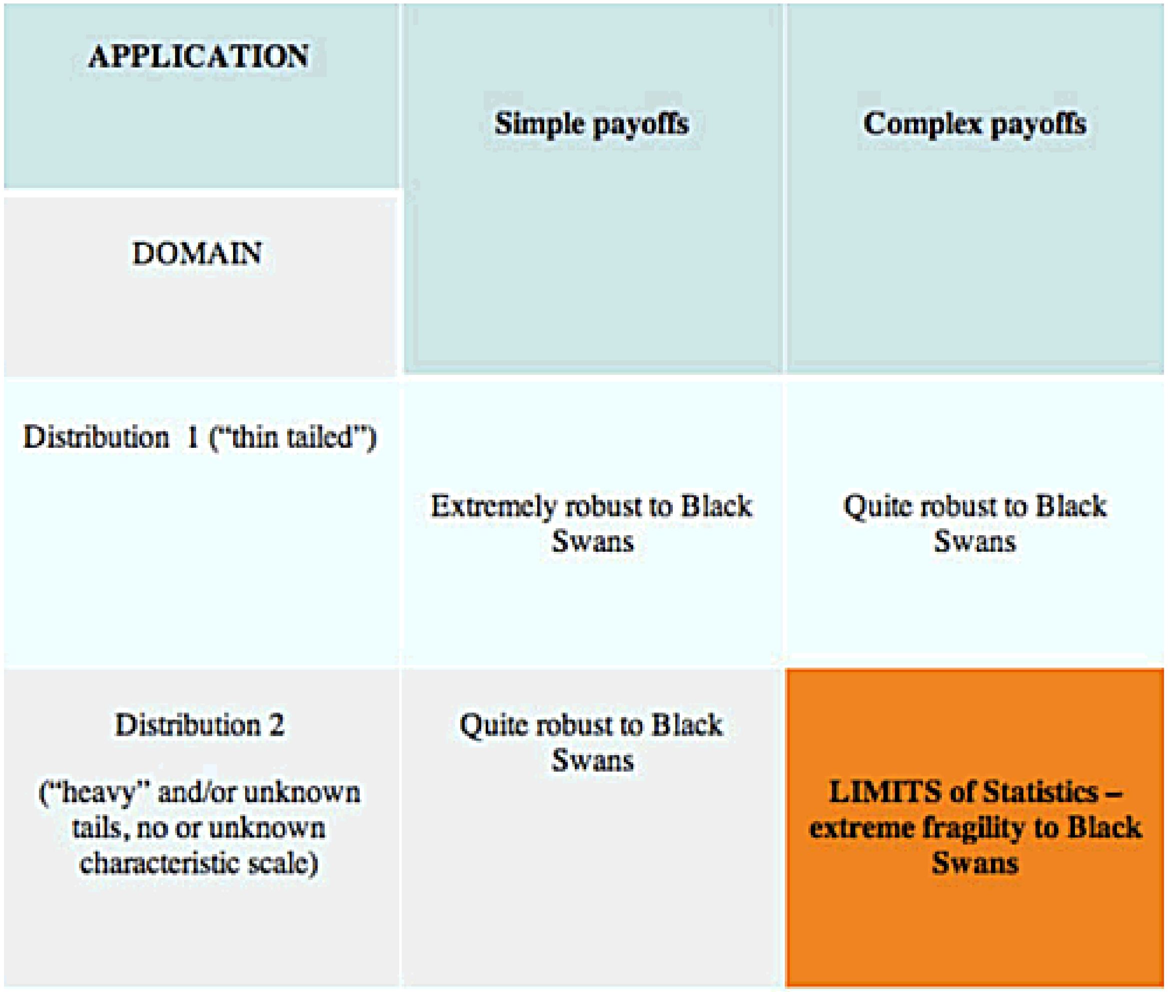
2. Current Approach (09)

Unfortunately, **epistemic uncertainty sources are still treated with the traditional approach of risk analysis**, which provides an acceptable cost/benefit ratio to producer/manufacturer, but in some cases **it may not represent an optimal solution to end user**. In fact, **deep epistemic limitations** reside in some parts of the areas covered in **decision making**.

More generally, **decision theory**, **based on a "fixed universe"** or a model of possible outcomes, **ignores and minimizes** the effect of events that are **"outside model"**. In fact, **contemporary human made systems can be quite fragile** to **unexpected perturbation** because **Statistics can fool you,** unfortunately.

2. Current Approach (10)

Statistics Can Fool You, Unfortunately

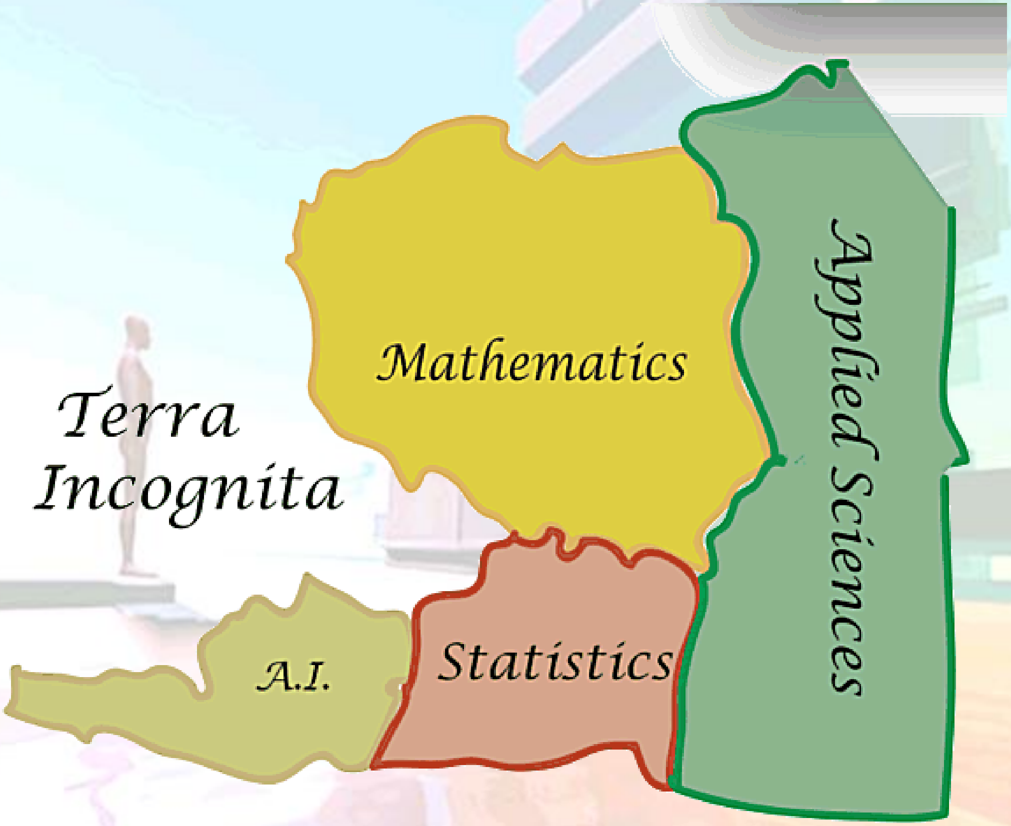


APPLICATION DOMAIN	Simple payoffs	Complex payoffs
Distribution 1 ("thin tailed")	Extremely robust to Black Swans	Quite robust to Black Swans
Distribution 2 ("heavy" and/or unknown tails, no or unknown characteristic scale)	Quite robust to Black Swans	**LIMITS of Statistics – extreme fragility to Black Swans**

(N. Taleb, 2014)

2. Current Approach (11)

Terra Incognita

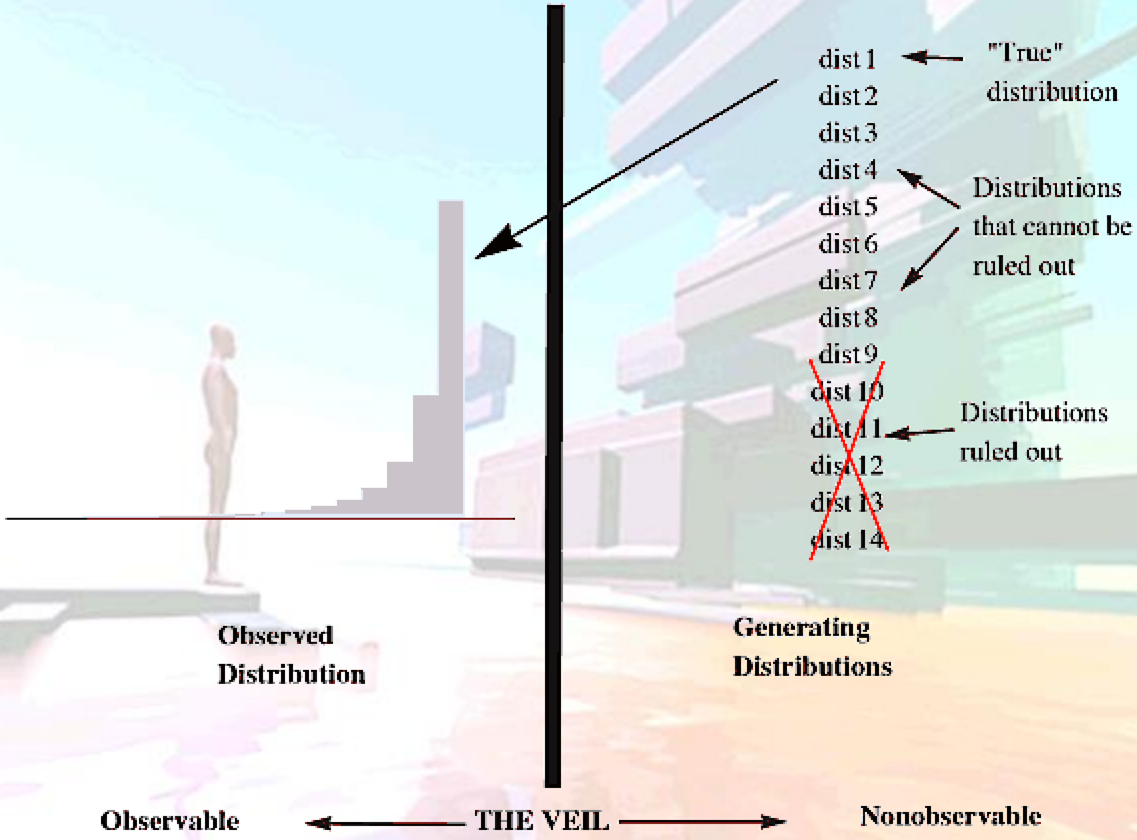


Positioning of **the unknown** that is certainly **out of reach for any type of knowledge**, which includes Bayesian inference.

(Bradley Efron, (2013), Bayes' theorem in the 21st century. Science, 340(6137):1177–1178.)

2. Current Approach (12)

The Probabilistic Veil (Taleb & Pilpel, 2007)



dist 1 ← "True" distribution
dist 2
dist 3
dist 4
dist 5
dist 6
dist 7
dist 8
dist 9
~~dist 10~~
~~dist 11~~
~~dist 12~~
~~dist 13~~
~~dist 14~~

Distributions that cannot be ruled out

Distributions ruled out

Observed Distribution

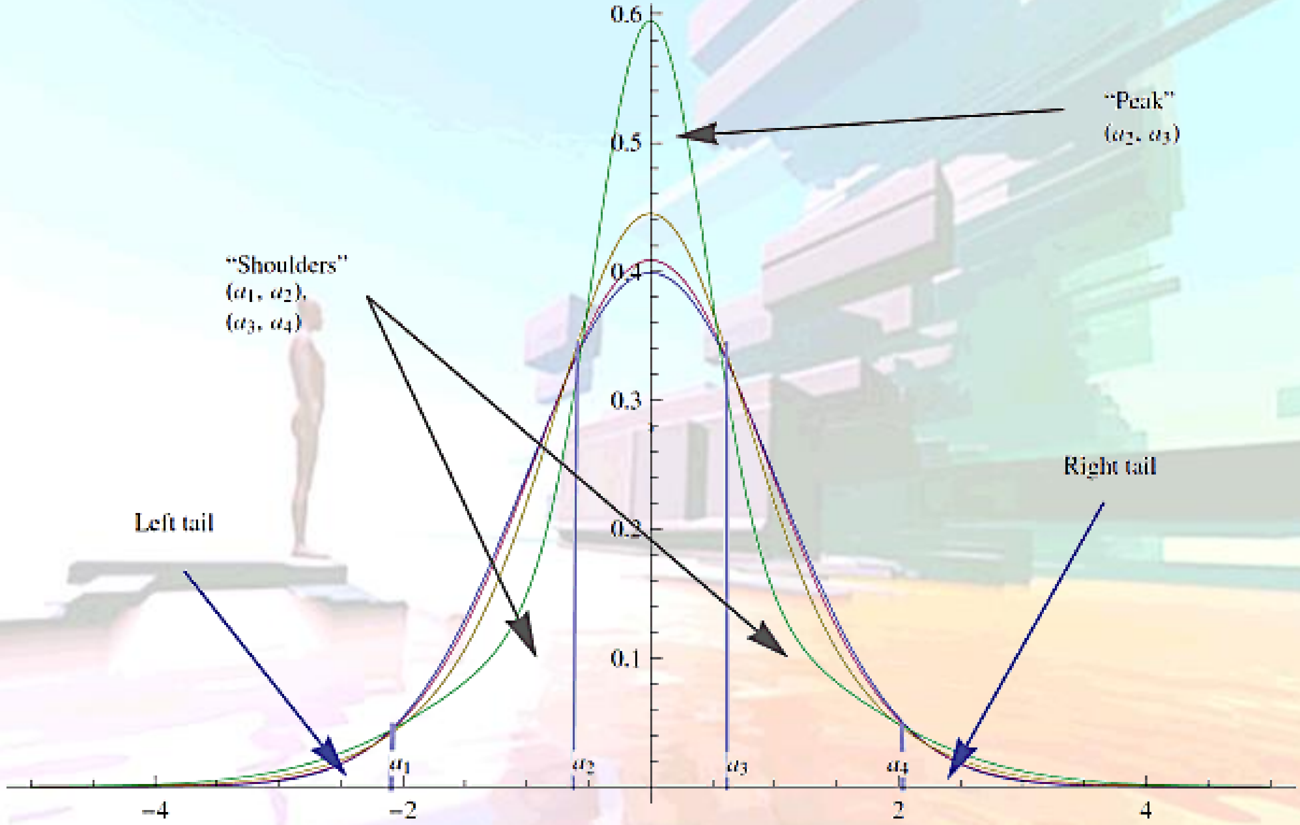
Generating Distributions

Observable ← THE VEIL → Nonobservable

An observer is supplied with data (generated by someone with "perfect statistical information", that is, producing it from a generator of time series). The observer, not knowing the generating process, and basing his information on data and data only, would have to come up with an estimate of the statistical properties (probabilities, mean, variance, value-at-risk, etc.). Clearly, the observer having incomplete information about the generator, and no reliable theory about what the data corresponds to, will always make mistakes, but these mistakes have a certain pattern. This is the central problem of risk management.

2. Current Approach (13)

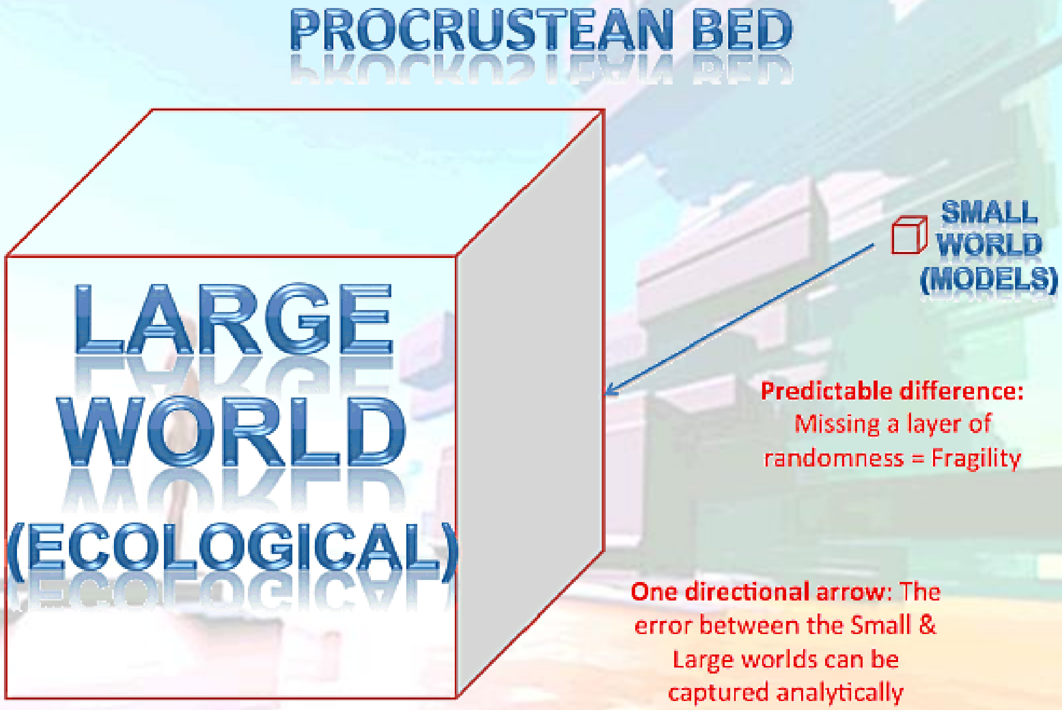
The Body, The Shoulders, and The Tails



Fatter and Fatter Tails through perturbation of σ. Distributions called "bell shape" have a convex-concave-convex shape (or quasi-concave shape). The point is that **events in the tails** of the distributions play the major role **and** their probabilities are not computable, not reliable for any effective use. The implication is that Black Swans do not necessarily come from fat tails; the **main problem** can result **from an incomplete assessment** of tail events.(N.Taleb, 2014)

2. Current Approach (14)

Leonard Savage’s Small World/Large World



PROCRUSTEAN BED

LARGE WORLD (ECOLOGICAL)

SMALL WORLD (MODELS)

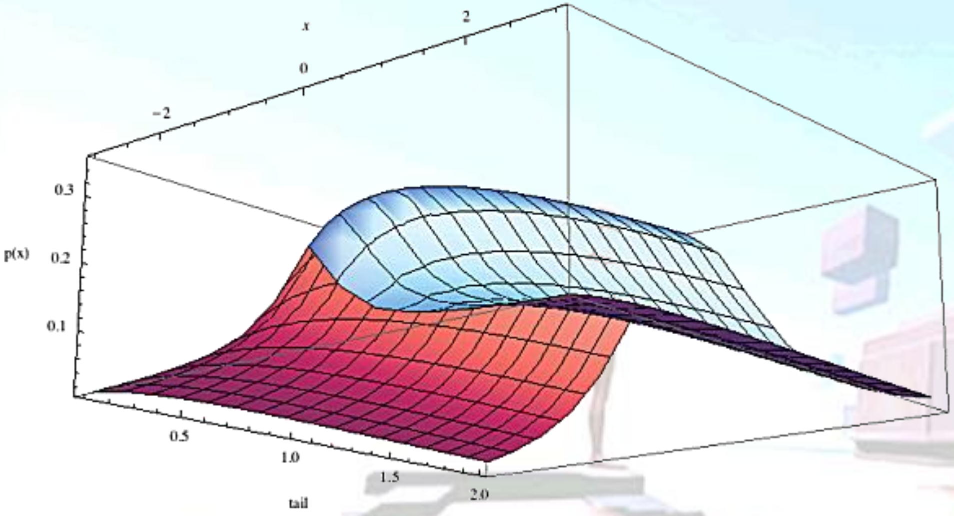
Predictable difference: Missing a layer of randomness = Fragility

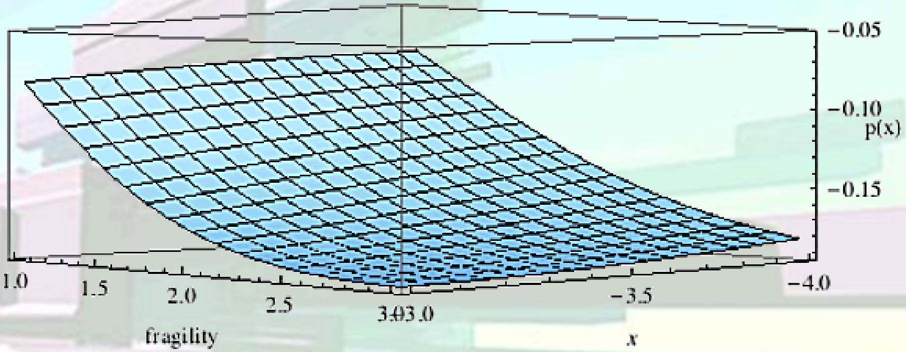
One directional arrow: The error between the Small & Large worlds can be captured analytically

In statistical domains assume Small World ≡ coin tosses and Large World ≡ Real World. Note that **Measure Theory** is not the small world, but **large world**, thanks to the degrees of freedom it confers. **The real world is about incompleteness**: incompleteness of understanding, representation, information, etc., what one does when one does not know what’s going on, or when there is a non-zero chance of not knowing what’s going on. It is based on **focus on the unknown**, not the production of mathematical certainties based on weak assumptions; rather **measure the robustness of the exposure to the unknown**, which can be done mathematically **through metamodel** (a model that examines the effectiveness and reliability of the model), what we call **metaprobability**, even if the meta-approach to the model is not strictly probabilistic. Nevertheless, under the cover of the discipline of **Extreme Value Theory, tail events** are **very opaque computationally**, and **misplaced precision leads to confusion.** (N.Taleb, 2014)

2. Current Approach (15)

Metaprobability, Metadistributions & Fragility



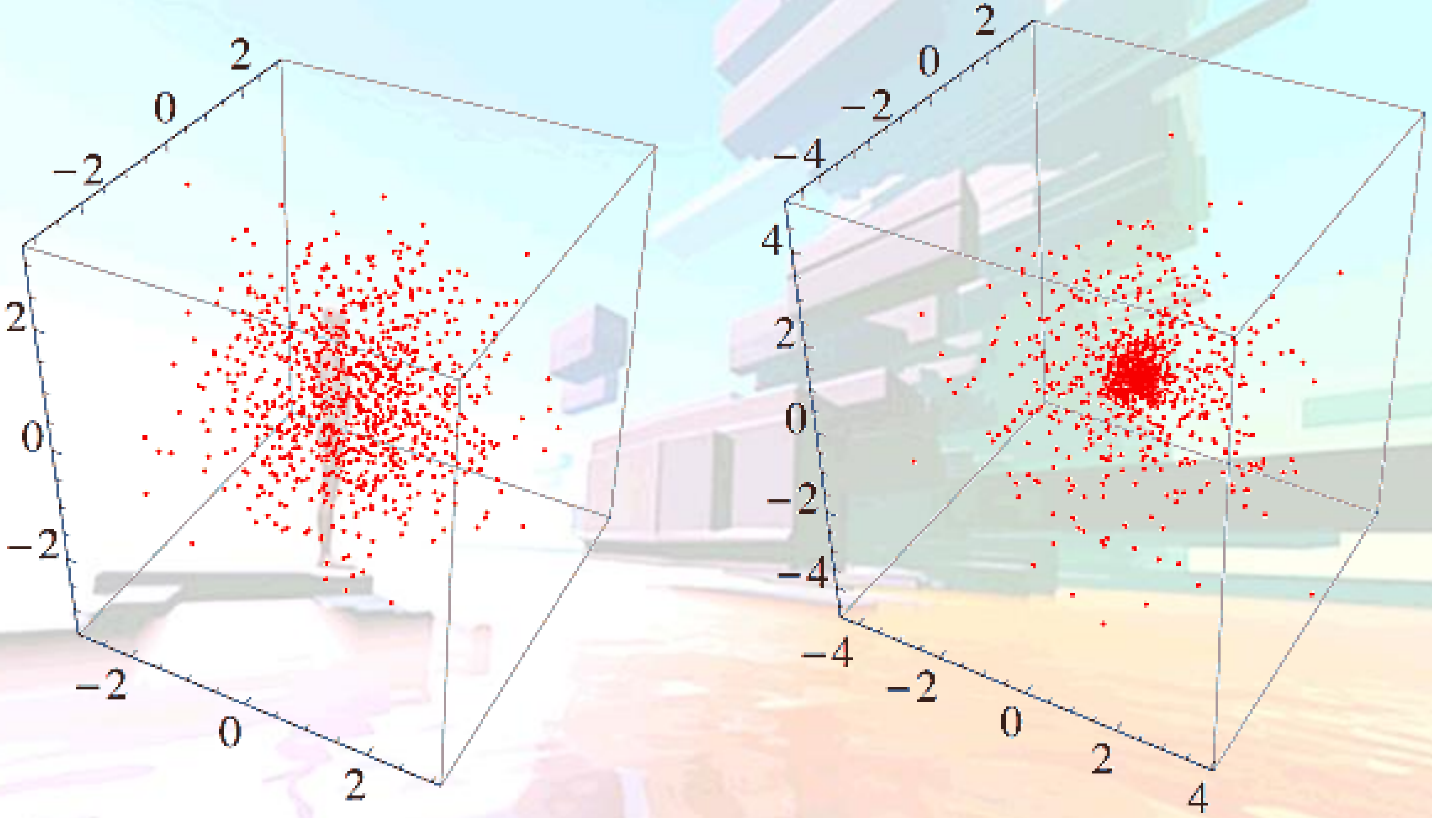


As we consider **the effect of a layer of uncertainty over the probabilities**, we add another dimension to the probability distributions. It results in large effects in the tails, but, visually, these are identified through changes in the "peak" at the center of the distribution. (N.Taleb, 2014)

Then, **Fragility** can be seen in **the slope of the sensitivity of payoff across metadistributions**. (N.Taleb, 2014)

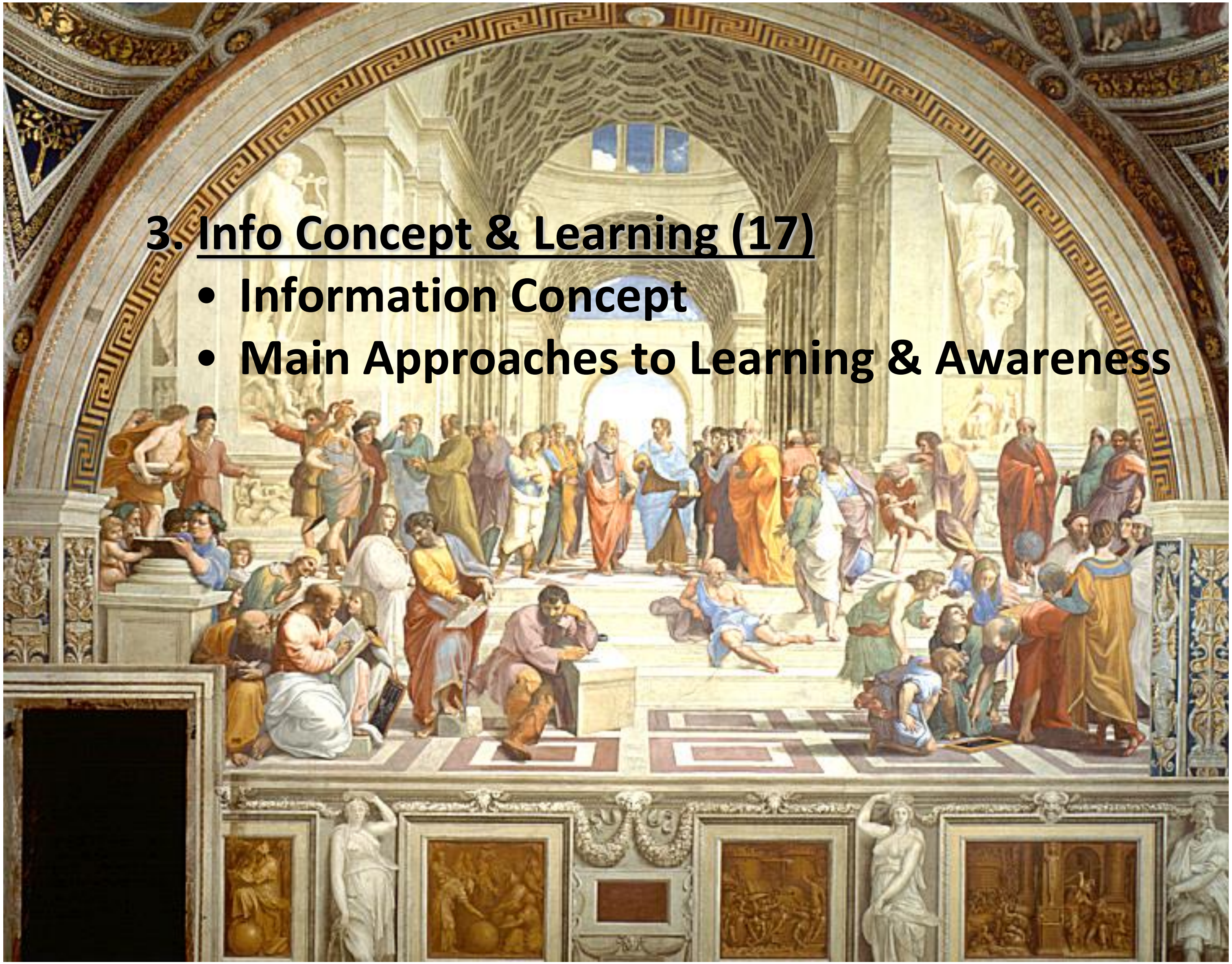
2. Current Approach (16)

Multidimensional Fat Tails Effect



For a 3 dimensional vector, **thin tails (left)** and **fat tails (right)** of the same variance. Instead of a bell curve with higher peak (the "tunnel") we see an increased density of points towards the center. (N.Taleb, 2014)

3. Information & Learning (00)

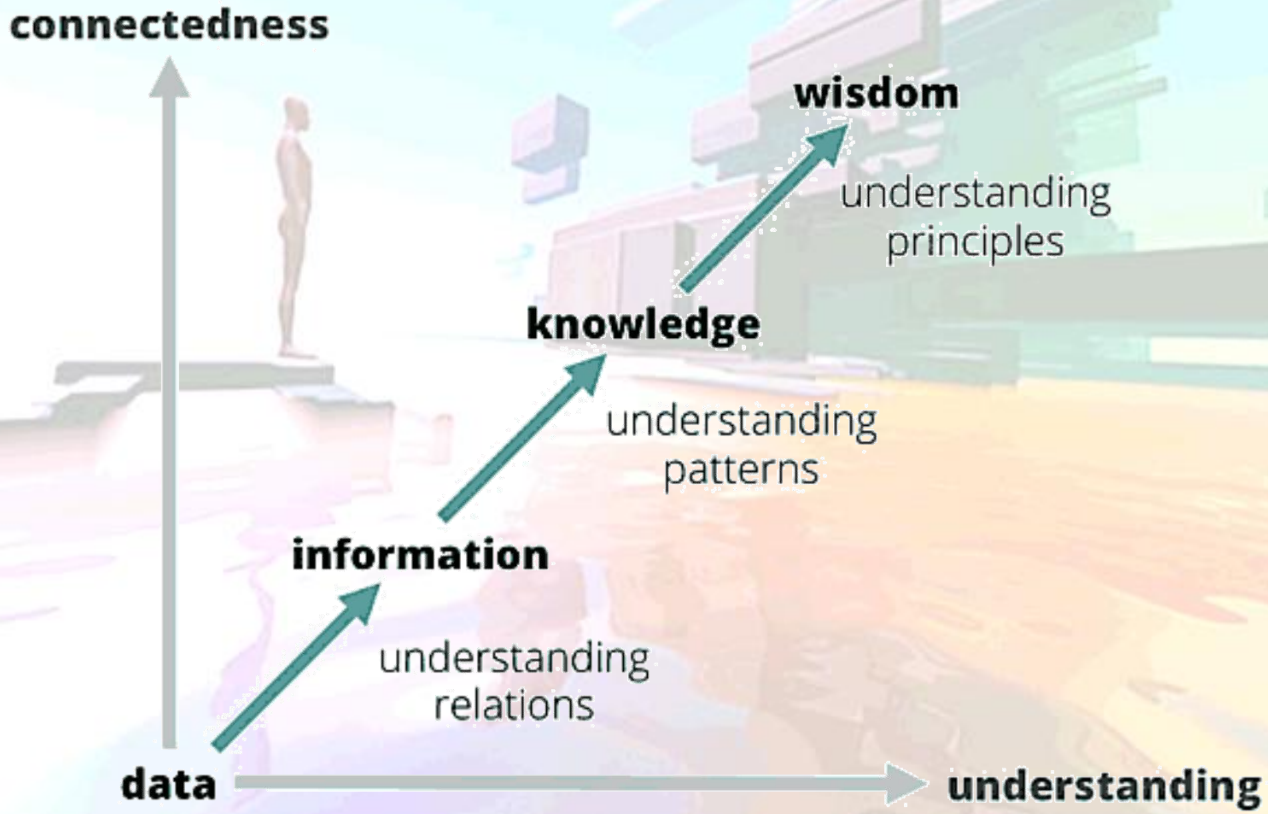


3. Info Concept & Learning (17)

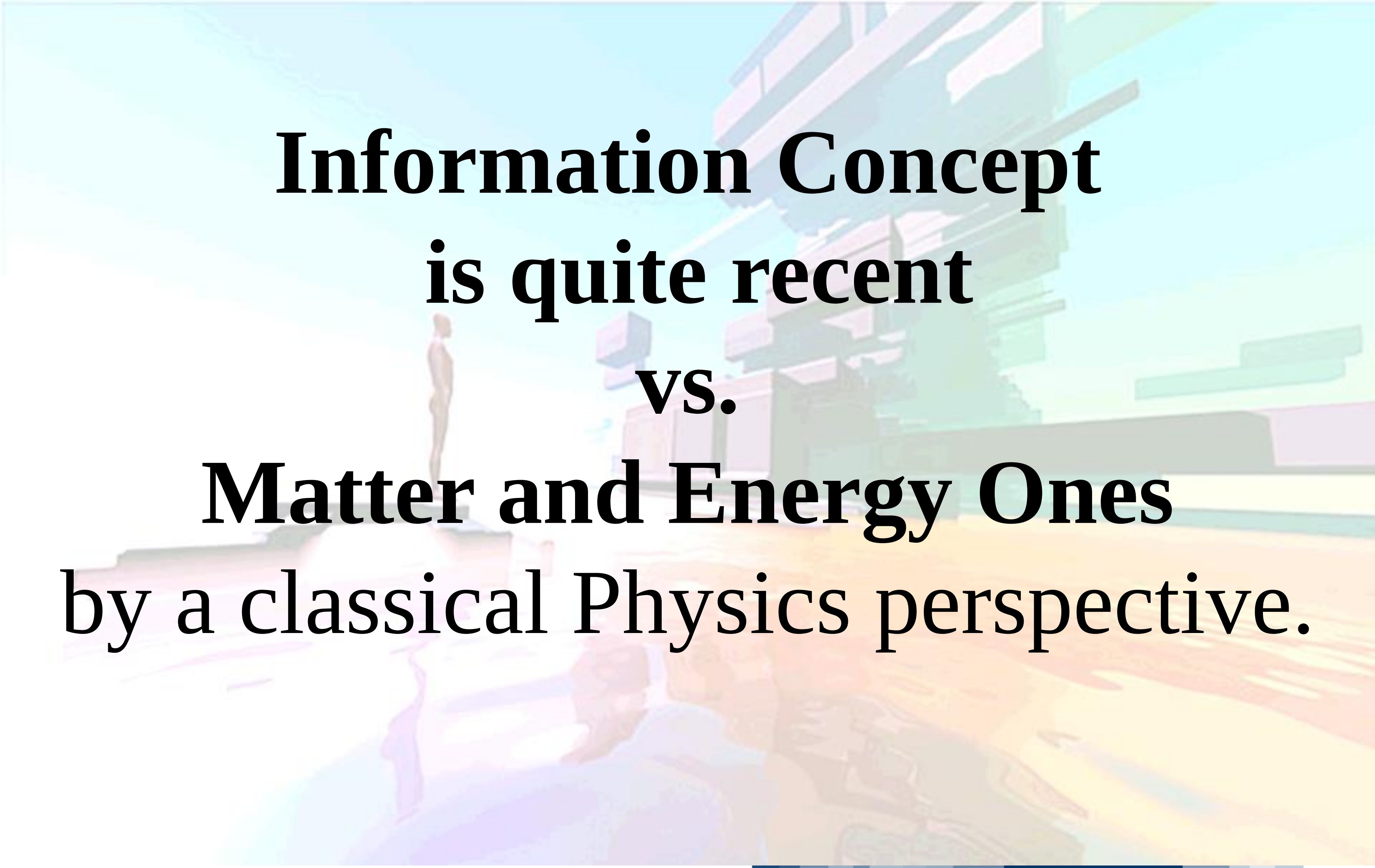
- **Information Concept**
- **Main Approaches to Learning & Awareness**

3. Information & Learning (01)

Information Concept



3. Information & Learning (02)



Information Concept
is quite recent
vs.
Matter and Energy Ones
by a classical Physics perspective.

3. Information & Learning (03)

Information Concept Operative Links

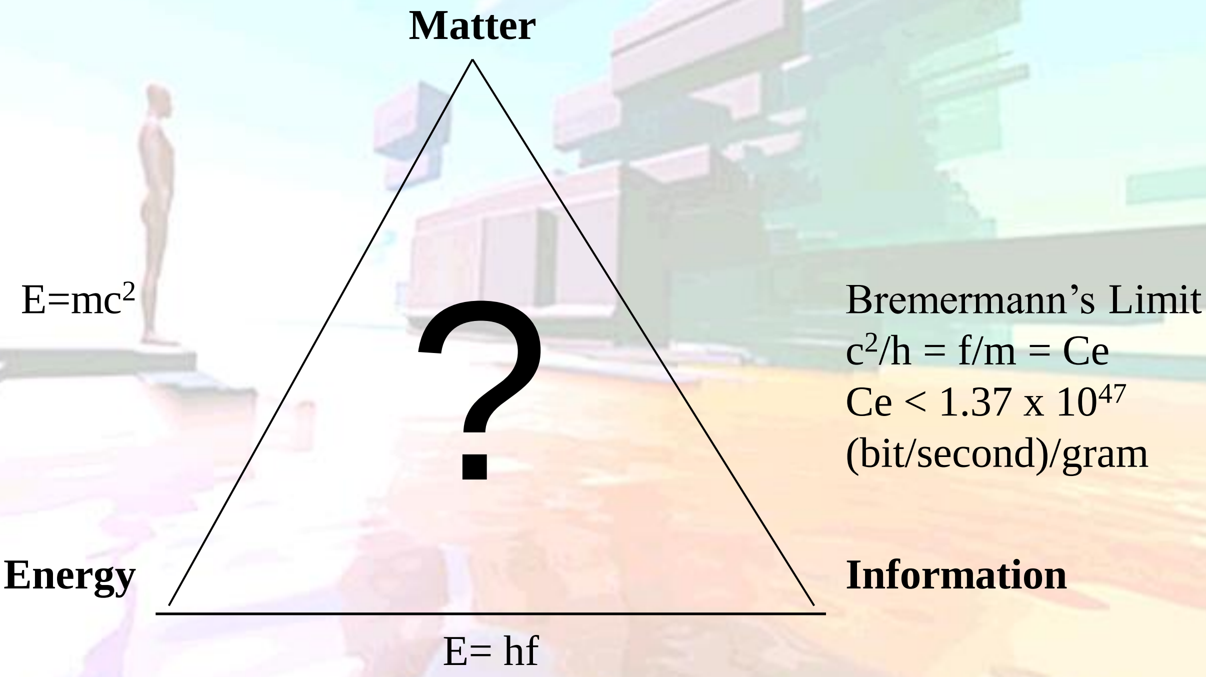
- **Albert Einstein** (1879 –1955) – **Matter and Energy** in **1905**, ($E = mc^2$, light speed c = 299,792,458 m/second).
- **Leó Szilárd** (1898 –1964) – **Energy and Information** in **1929**, (Average value of measurement produced entropy is just exactly as provided by thermodynamic entropy, $S = K \log 2$ → Inexistence of Maxwell’s Demon).
- **Hans-Joachim Bremermann** (1926–1996) – **Matter and Information** in **1962**, ($E = mc^2 = hf$), MOCS (Ce) < **10^{47}** bit/gram/second, (Bremermann Limit → Transcomputational Numbers).

In **2014, Pulkit Grover**, at CMU, coined the term **"Information-Friction"** to describe the energy needed to move information in circuits. The energy required to move information on these circuit wires at transmitter and receiver can be the dominant chunk of total energy.

3. Information & Learning (04)

Natural Energetics Triangular Relationship

(Bio-Quantum Physics of SpaceTime)



Matter

$E=mc^2$

?

Bremermann's Limit
$c^2/h = f/m = Ce$
$Ce < 1.37 \times 10^{47}$
(bit/second)/gram

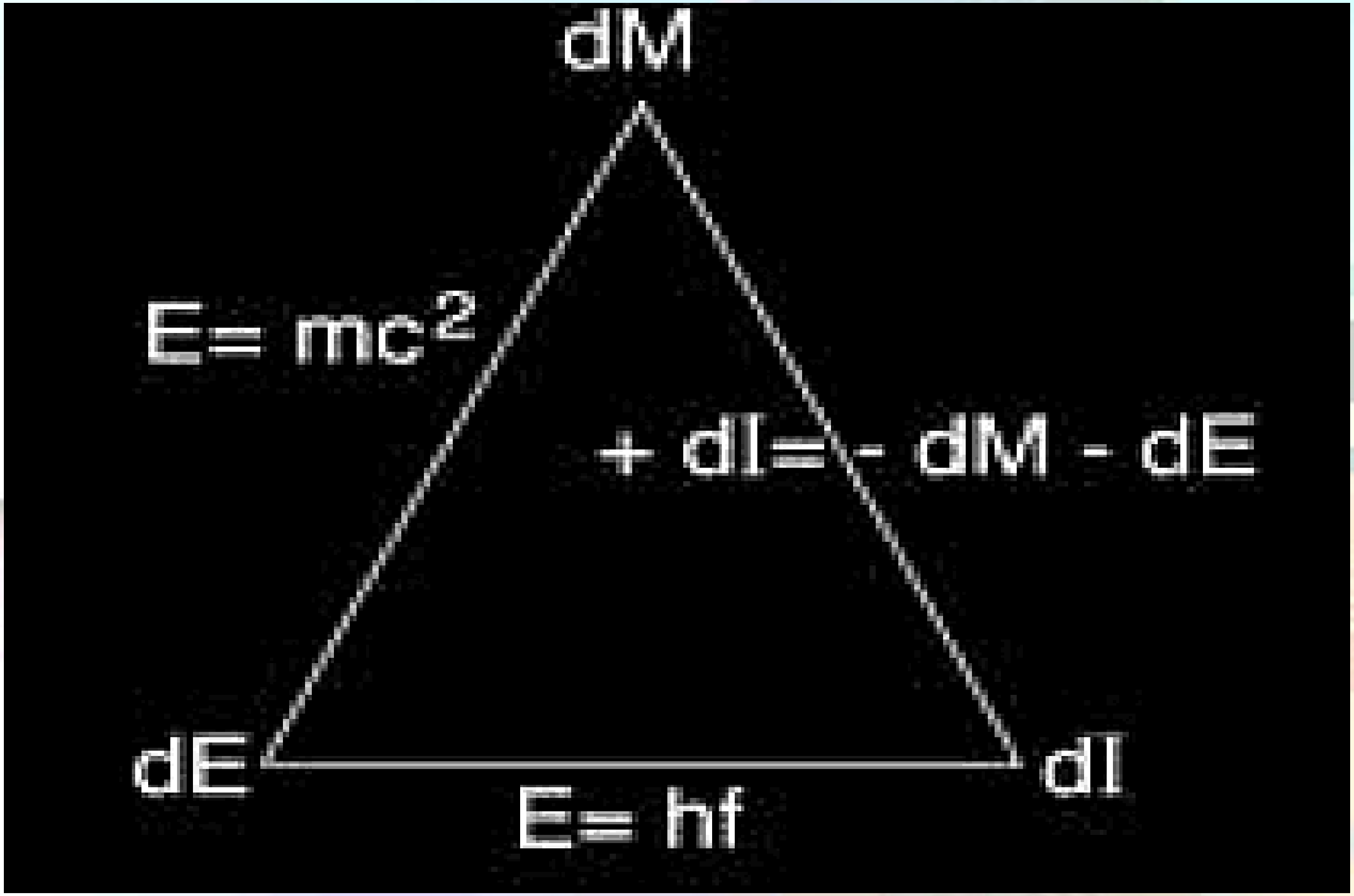
Energy

Information

$E= hf$

3. Information & Learning (05)

Panergetics or Holergetics Core Triangle (Holo-Informed Energetics Triangle)



3. Information & Learning (06)

Information Concept Cybernetics Links

- **Claude Shannon** (1916–2001) – Binary Code Uncertainty Probabilistic Evaluation.
- **Gregory Bateson** (1904–1980) – The Difference that Makes the Difference.
- **Heinz Von Foerster** (1911–2002) – Observer Plays the Key Role.

Shannon entropy (usually denoted by **H(X)**) is **the average unpredictability in a random variable**, which is **equivalent to its information content**. Therefore Shannon entropy is a **stochastic measure of probabilistic information uncertainty**. The concept was introduced by **Claude E. Shannon** in his **1948** paper "A Mathematical Theory of Communication". Shannon entropy provides an absolute limit on the best possible lossless encoding or compression of any communication, assuming that:

the communication can be represented as a sequence of independent and identically distributed random variables.

3. Information & Learning (07)

As the experiences of the 1970s, 1980s and 1990s have shown, **unpredictable changes** can be **very disorienting** at enterprise level.

These major changes, usually discontinuities referred to as **fractures in the environment** rather than trends, will largely determine the **long-term future** of organization. They need to be handled, as **opportunities**, **as positively as possible**.

Chief executives believe that, more than rigor, management discipline, integrity or even vision, **successfully navigating** an increasing complex world **will require creativity**. IBM said that it is needed in all aspects of leadership, including strategic thinking and planning.

But **we need "antifragility" to creatively respond to changes in our environment.** Can we achieve it at system level?

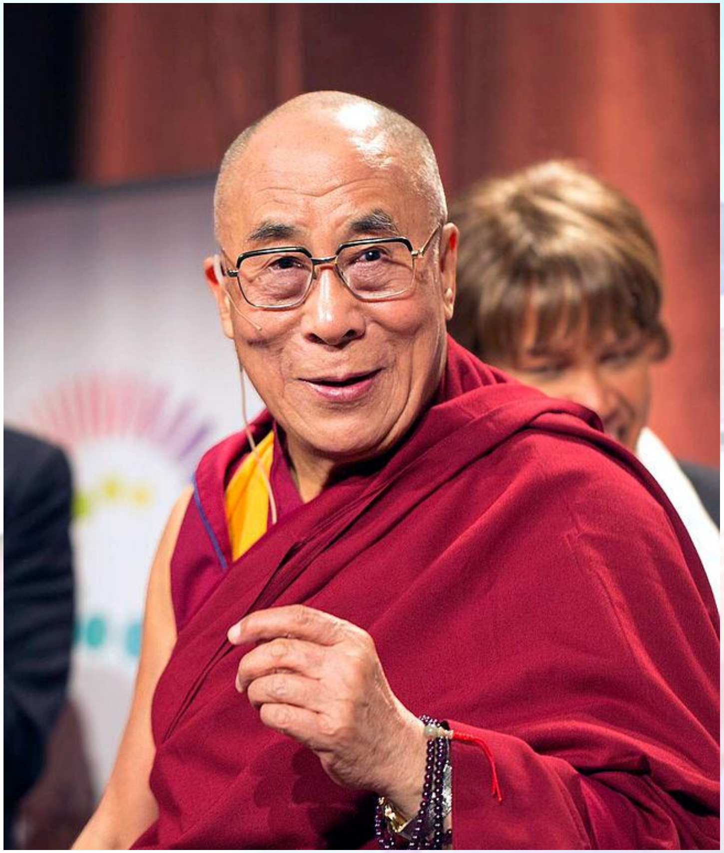
3. Information & Learning (08)

Learning according to Confucius (551 – 479 BCE)

If I hear I forget,
If I see I remember,
If I do I understand.

3. Information & Learning (09)

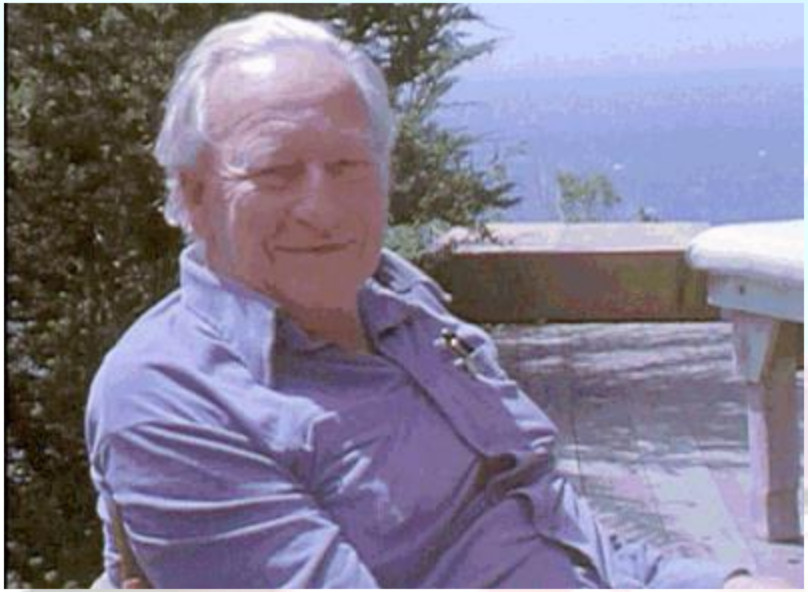
Learning according to Tenzin Gyatso, the 14th Dalai Lama (1935-)



Because we all share this small planet Earth, we have to learn to live in harmony and peace with each other and with Nature. That is not just a dream, but a necessity.

3. Information & Learning (10)

Learning according to Bateson and von Foerster



Quest for the difference that makes the difference, **probing by probing...**

Gregory Bateson (1904 - 1980)

… where the **fundamental role** is played by **Observator viewpoint.**

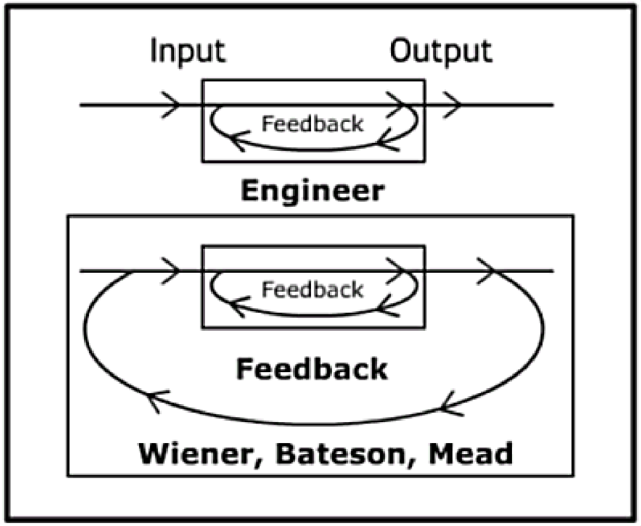
Heinz von Foerster (1911 - 2002)

3. Information & Learning (11)

Bateson: Learning by Widening Your Panorama...

« . . . essentially your ecosystem, your organism-plus-environment, is to be considered as a single circuit. »

Interview with Gregory Bateson and Margaret Mead, Co-Evolution Quarterly, June 1973.



« Never doubt that a small group of thoughtful, committed citizens can change the world; indeed, it's the only thing that ever has. » **Margaret Mead.**

« We are not what we know but what we are willing to learn. » **Mary Catherine Bateson.**

3. Information & Learning (12)

Remembering that "The map is not the territory"

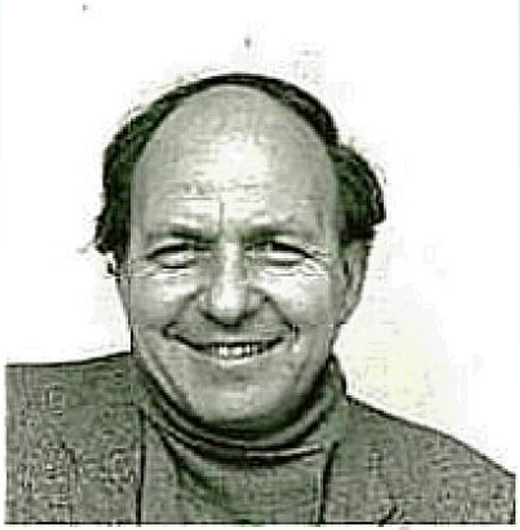
Gregory Bateson (1904-1980), in **"Form, Substance and Difference"**, from **Steps to an Ecology of Mind** (1972), has elucidated the essential impossibility of knowing what the territory is, as **any understanding of it is based on some representation.**

Polish-American scientist and philosopher **Alfred Korzybski** (1879-1950), developer of the "**Theory of General Semantics**", coined the dictum "the map is not the territory", encapsulating his view that **an abstraction derived from something, or a reaction to it, is not the thing itself.**

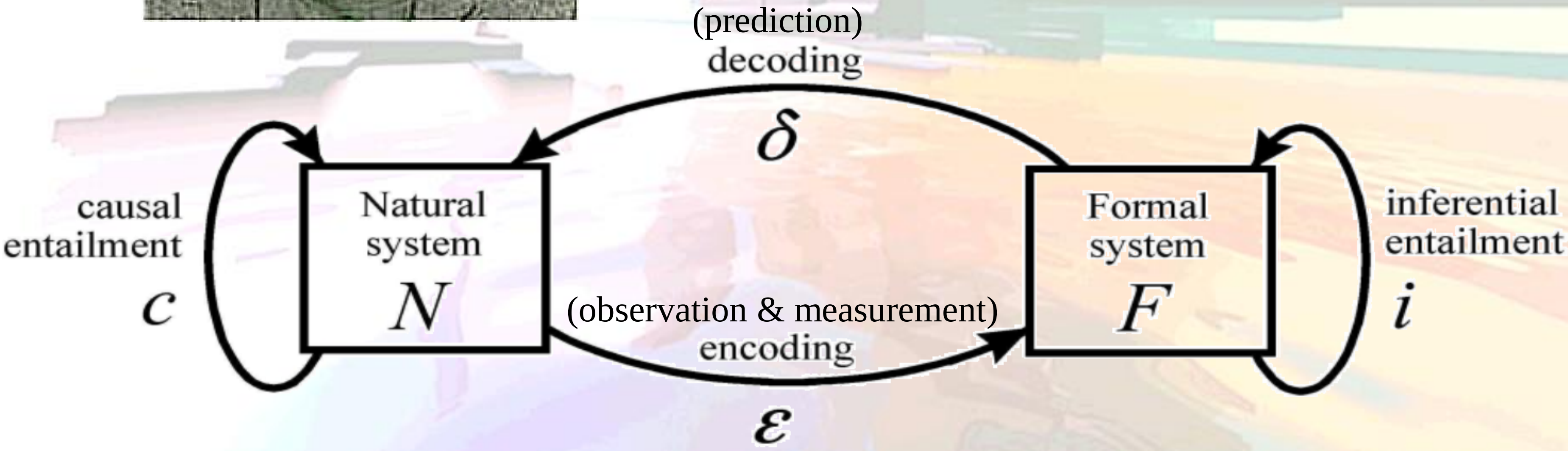
Another basic quandary is the problem of **accuracy**. **Jorge Luis Borges**'s (1899-1986) "**Del rigor en la ciencia**" (1946) describes the tragic uselessness of the perfectly accurate, one-to-one map.

3. Information & Learning (13)

Robert Rosen's System Awareness of Anticipation

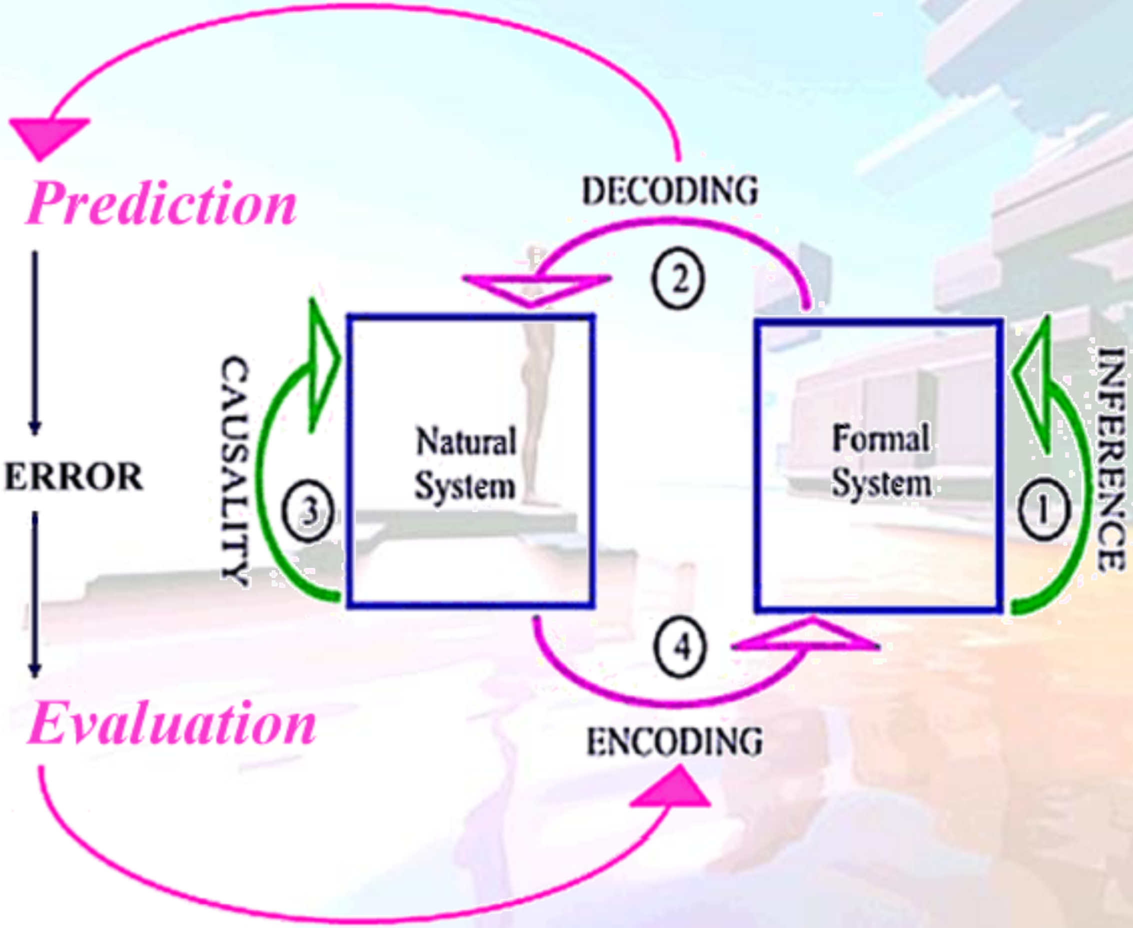


> « …any material realization of the (M,R)-system must have non-computable models. »
>
> **Robert Rosen (1934 - 1998)**



3. Information & Learning (14)

System Anticipation according to Robert Rosen

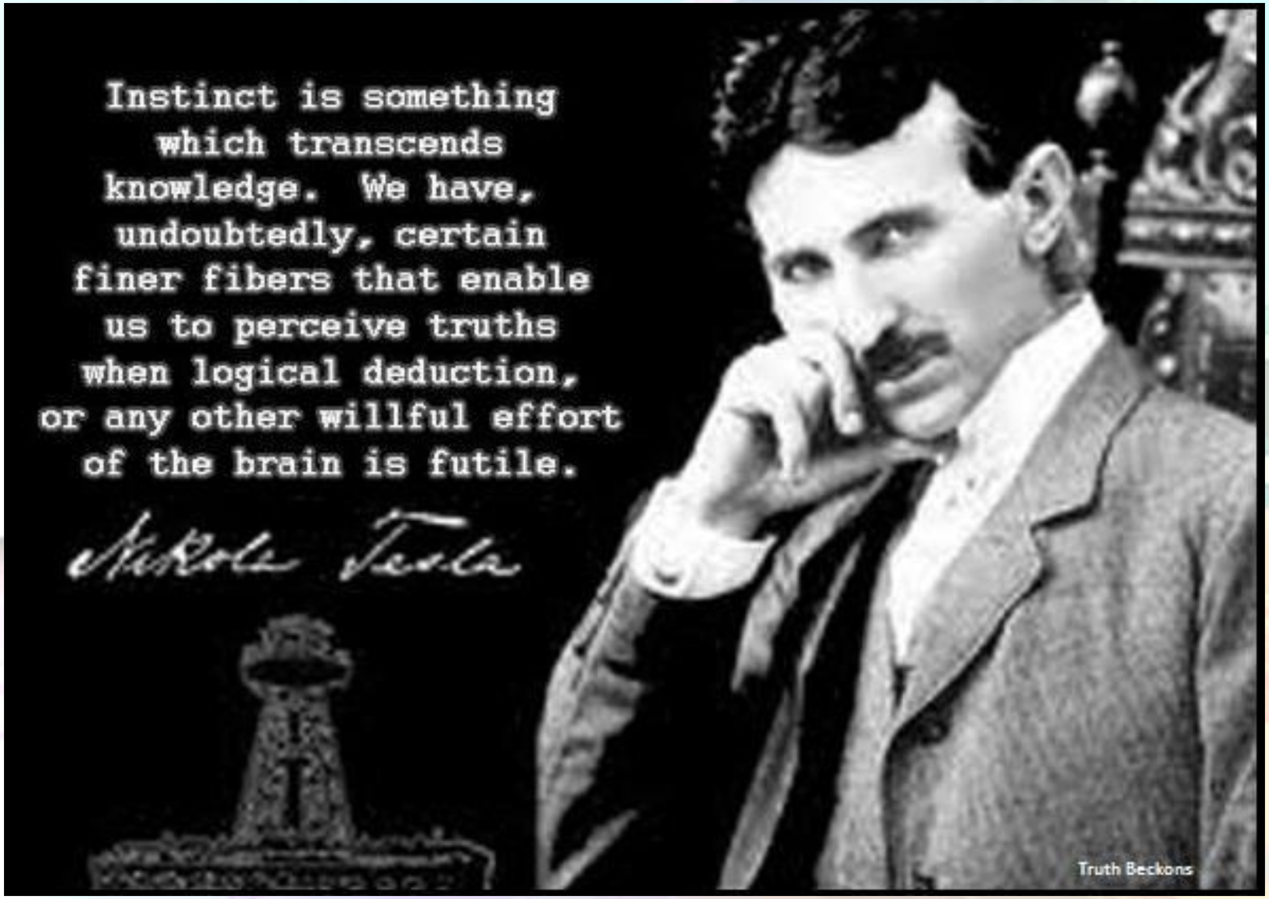


Anticipatory System:
« A system containing **a predictive model of itself** and/or its environment, **which allows it to change state at an instant** in accord with the **model's predictions pertaining to a later instant.** »

(Robert Rosen, 1985)

3. Information & Learning (15)

Remembering The Futurist



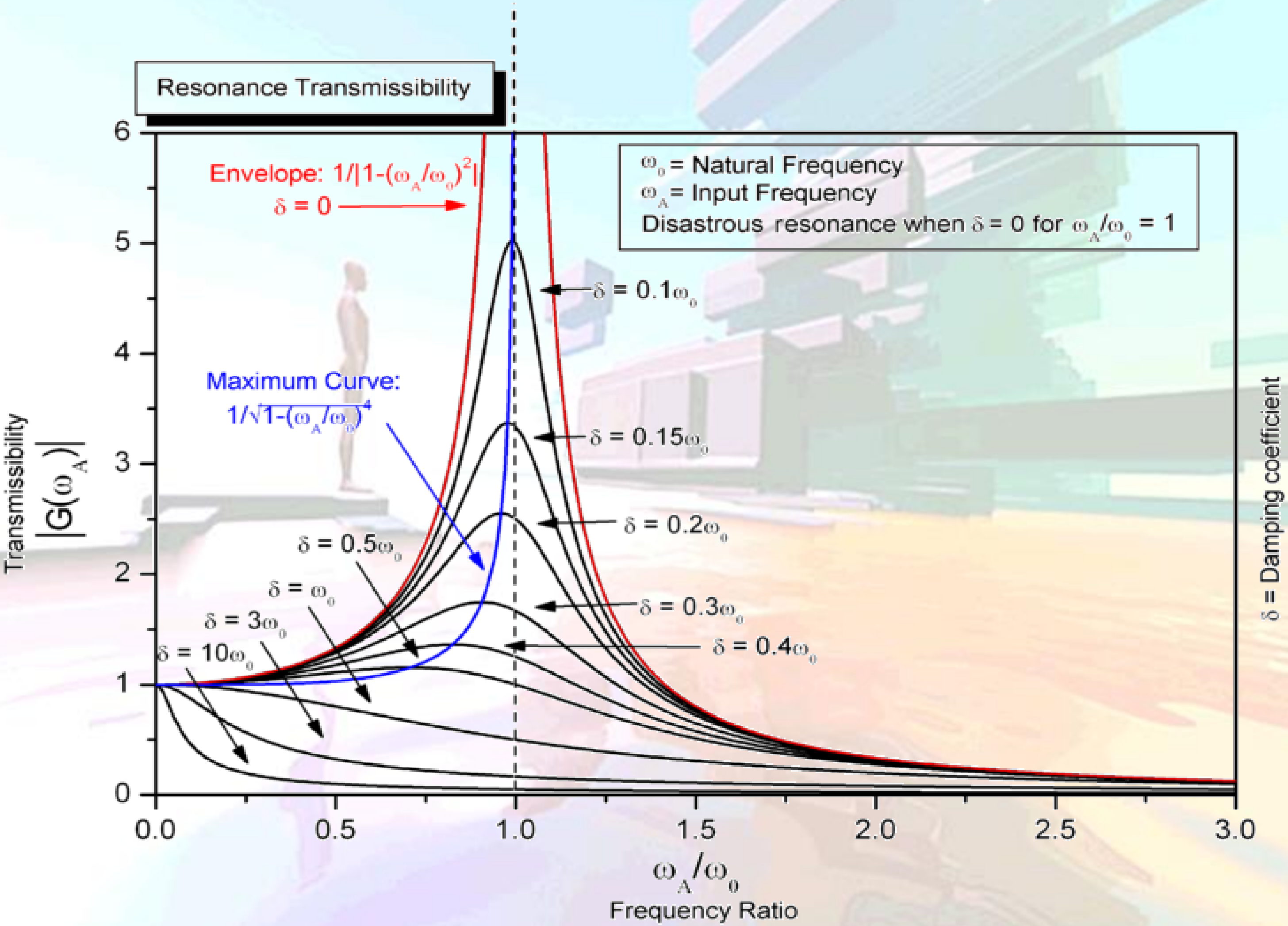
Instinct is something which transcends knowledge. We have, undoubtedly, certain finer fibers that enable us to perceive truths when logical deduction, or any other willful effort of the brain is futile.

Nikola Tesla

Truth Beckons

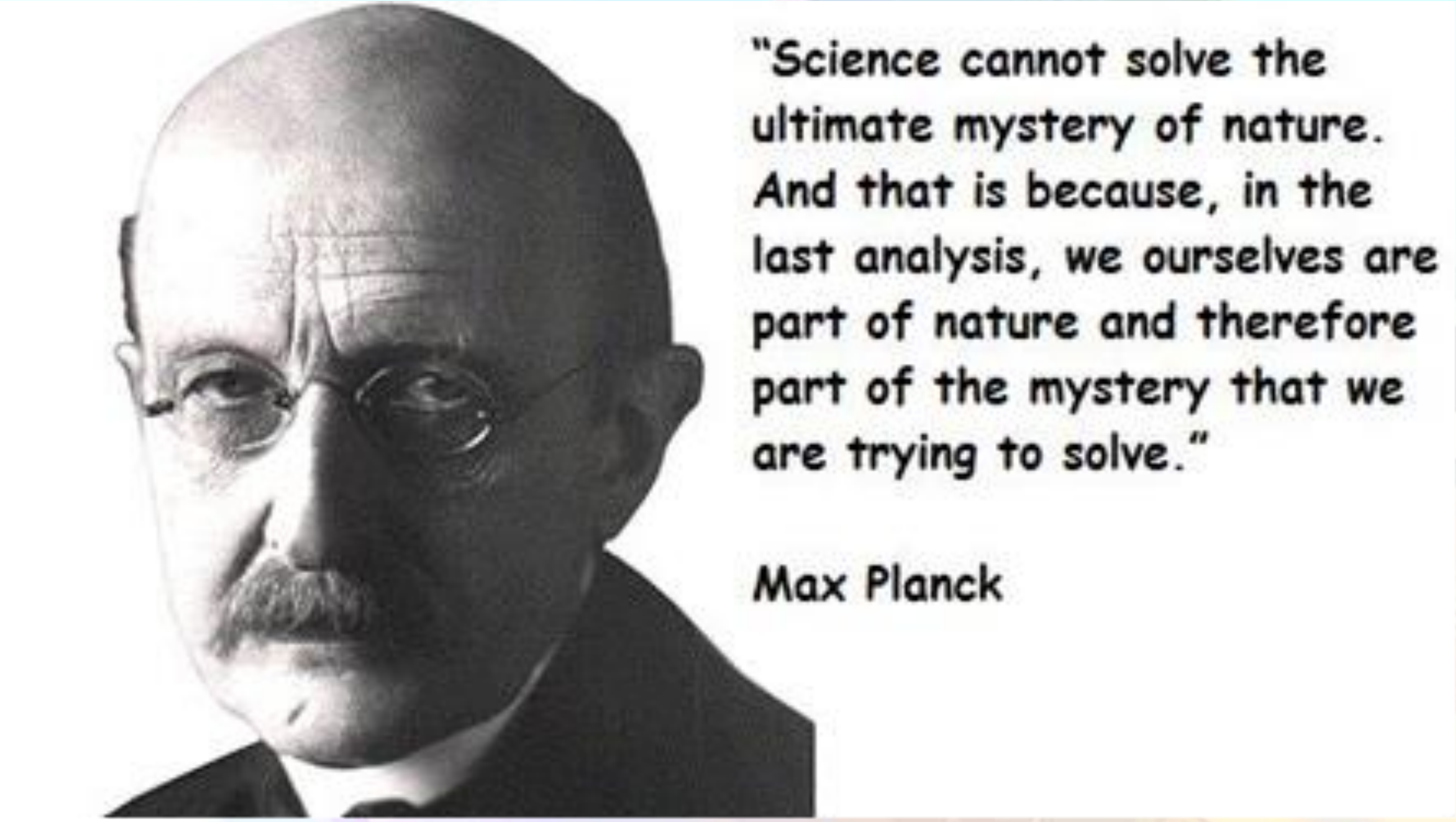
3. Information & Learning (16)

Systemic Resonance Base Reference Diagram



3. Information & Learning (17)

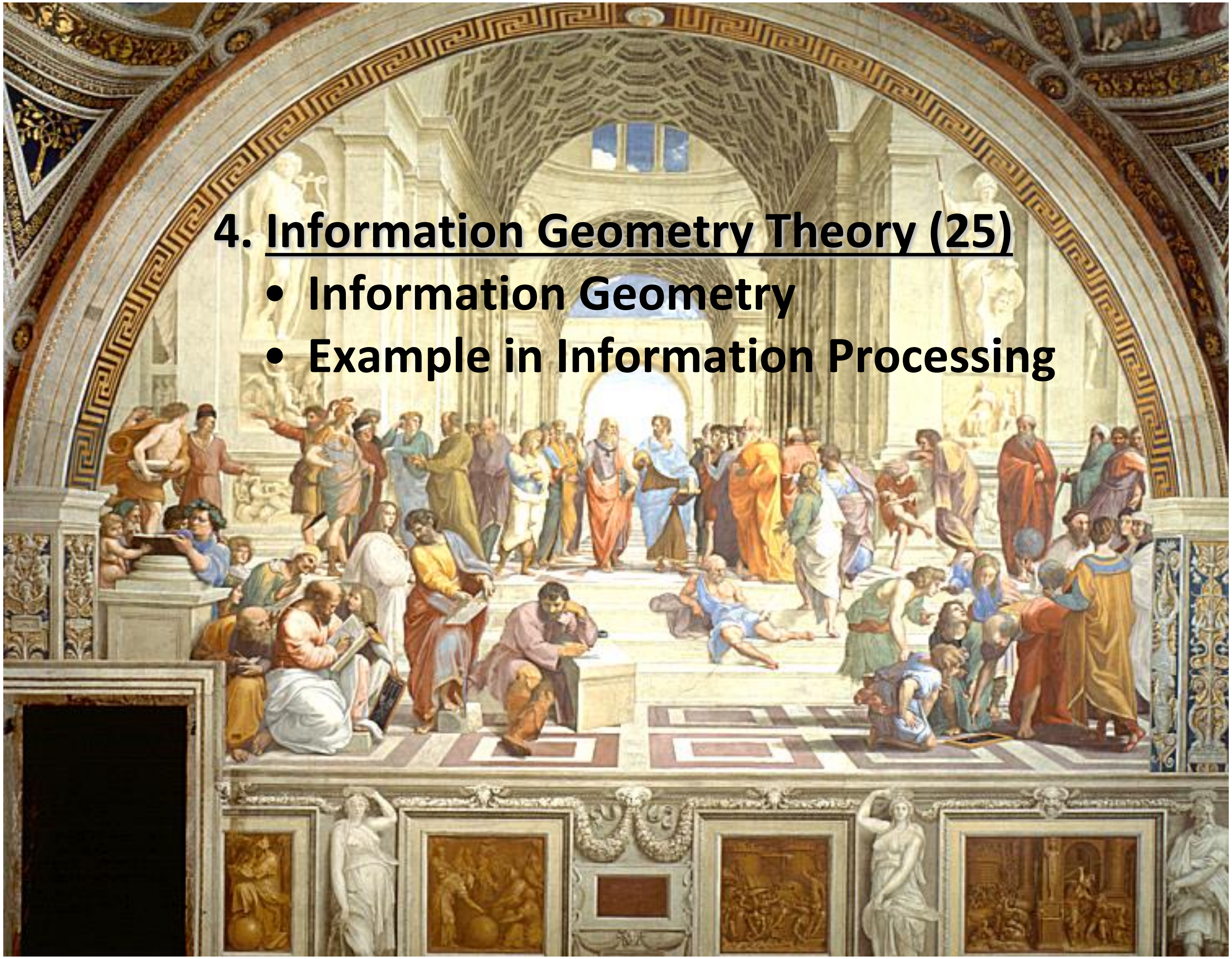
Remembering The Great Pioneer of Quantum Physics



"Science cannot solve the ultimate mystery of nature. And that is because, in the last analysis, we ourselves are part of nature and therefore part of the mystery that we are trying to solve."

Max Planck

4. Information Geometry Theory (00)



4. Information Geometry Theory (25)

- Information Geometry
- Example in Information Processing

4. Information Geometry Theory (01)

Information Geometry

In **1945**, by considering the space of probability distributions, Indian-born mathematician and statistician **Calyampudi Radhakrishna Rao** (1920-) **suggested the differential geometric approach to statistical inference**. He used **Fisher information matrix** in defining the metric, so it was called **Fisher – Rao metric**.

In **1975**, American statistician **Bradley Efron** (1938-) carried the argument a step forward when he **introduced a new affine connection** on the parameter space manifold, and thus shed light on **the role of the embedding curvature** of the statistical model in the relevant space of probability distributions.

So, **Information Geometry** emerged from the study of the geometrical structure of a manifold of probability distributions **under the criterion of invariance**. It defines a **Riemannian metric** uniquely, which is the **Fisher information metric**. Moreover, **a family of dually coupled affine connections** are introduced.

Mathematically, this is a study of a **triple {M, g, T}**, where **M** is a manifold, **g** is a Riemannian metric, and **T** is a third-order symmetric tensor.

4. Information Geometry Theory (02)

Information Geometry

Many important families of probability distributions are **dually flat Riemannian manifolds**. A dually flat manifold possesses a beautiful structure: It has **two mutually coupled flat affine connections** and **two convex functions connected by the Legendre Transformation**. It has a canonical divergence, from which all the geometrical structure is derived. During the last 15 years (1999-2014), it has been applied not only to statistical inferences but also to various fields of information sciences where probability plays an important role.

The Kullback-Leibler divergence **(1951)** (**KL-divergence**) in probability distributions is automatically derived **from the invariant flat nature**. Moreover, the **generalized Pythagorean and geodesic projection theorems hold**.

Conversely, we can define a dually flat Riemannian structure from a convex function. This is derived through the **Legendre Transformation** and **Bregman Divergence (1967) connected with a convex function**.

Therefore, **Information Geometry is applicable to convex analysis**, even when it is not connected with probability distributions. **This widens the applicability of Information Geometry** to convex analysis, machine learning, computer vision, Tsallis entropy, economics, game theory, etc.

4. Information Geometry Theory (03)

Information Geometry

The **Fisher-information matrix** is used to calculate the **covariance matrices** associated with **Maximum-Likelihood Estimator (MLE)**. It can also be used in the formulation of test statistics, such as the **Wald test. MLE gives a unified approach to estimation, which is well-defined in the case of the normal distribution and many other problems. However,** in some complicated problems, **difficulties do occur:** in such problems, MLEs are unsuitable or do not exist.

In the **discrete case**, for **a line array of *N* equally spaced sensors**, the **MLE** spectrum is equal to the average of the reciprocals of the **Maximum Entropy Estimator (MEE)** spectra obtained from one point up to the *N*-point prediction error filter:

$$\frac{1}{MLE(k)} = \frac{1}{N}\sum_{n=1}^{N}\frac{1}{MEE(k,n)}$$

where k = wavenumber = reciprocal wavelength. **The lower resolution of MLE is thus due to the averaging effect of the lowest to the highest resolution MEE spectra**. **MEE analysis** was introduced by **John Parker Burg** in **1967**.

4. Information Geometry Theory (04)

A Practical Example in Image Processing (IP)

In the past, image models ***f*** were thought of having a scalar intensity $t \in \boldsymbol{R}$ at each pixel p (i.e. $f(p) = t$). By IG approach, we can have an univariate Gaussian probability distribution of intensities $n\,(\mu,\ \sigma^2) \in \boldsymbol{N}$, i.e. image f is defined as the function:

$$f:\left\{\begin{array}{c}\Omega \to N \\ p \mapsto n\left(\mu,\sigma^2\right)\end{array}\right\}$$

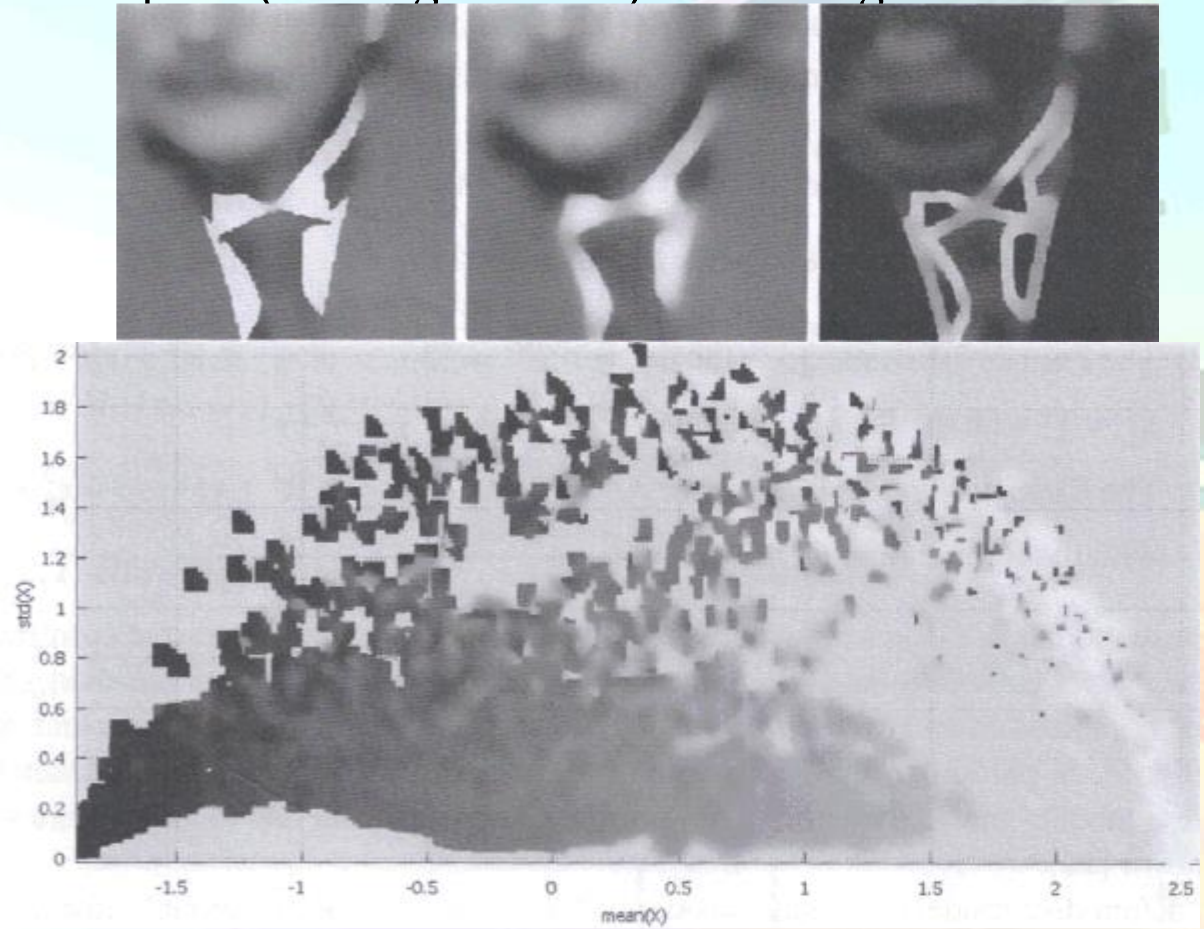
where Ω is the support space of pixels p (e.g. for 2D images $\Omega \subset \boldsymbol{Z}^2$) and ***N*** denotes the family of univariate Gaussian probability distribution functions (**pdf**).

(J. Angulo, S. Velasco-Forero 2014)

4. Information Geometry Theory (05)

A Practical Example in Image Processing (IP)

On the left, original image. In the center the mean μ of each patch from a structuring element 5x5 pixel square (moving window). On the right their standard deviation σ.



(J. Angulo, S. Velasco-Forero 2014)

4. Information Geometry Theory (06)

A Practical Example in Image Processing (IP)

In IG, the Fisher information metric is a particular Riemannian metric which can be associated to a smooth manifold whose points are probability measures defined on a common probability space. It can be obtained as the infinitesimal form of the Kullback-Leibler divergence (relative entropy). An alternative formulation is obtained by computing the negative of the Hessian of the Shannon entropy.

Therefore, the Fisher information geometry of univariate normal distribution is essentially **the geometry of the Poincaré upper-half plane (PUHP)** with the following change of variables:

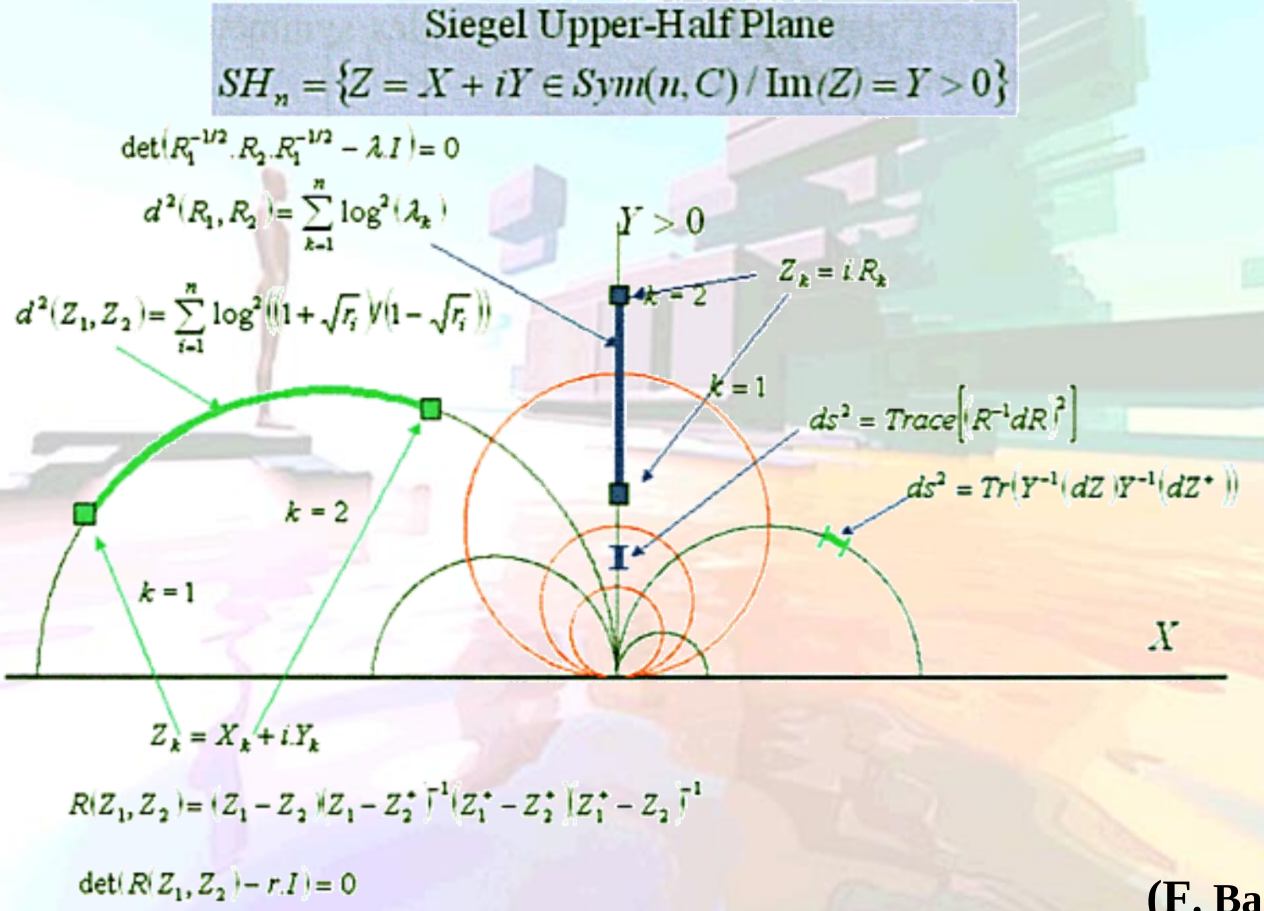
$$x = \mu / \sqrt{2} = \mu^{*}, \qquad y = \sigma .$$

(J. Angulo, S. Velasco-Forero 2014)

4. Information Geometry Theory (07)

Siegel Upper-Half Space

The Poincaré upper-half plane (PUHP) for **2D problems**, and the Siegel upper-half space (SUHS) for **3D problems** (rotational symmetry along Y axis).



(F. Barbaresco, 2014)

4. Information Geometry Theory (08)

A Practical Example in Image Processing (IP)

Mathematical morphology defines nonlinear IP operators based on the computation of **supremum/infimum**-convolution filters (i.e. dilation/erosion operators) in local neighborhoods.

Morphological operators involve that the space of Gaussian distribution ***N*** must be **endowed of a partial ordering** leading to a **complete lattice structure**.

In practice, it means that given a set of Gaussian pdfs, we need to be able to define a Gaussian pdf which corresponds to the infimum of the image patch-set and another one to the supremum.

A possible way to deal with the partial ordering problem of ***N*** is based on considering that **the univariate Gaussian pdfs are points in a Riemannian manifold (hyperbolic space)**, according to the IG approach.

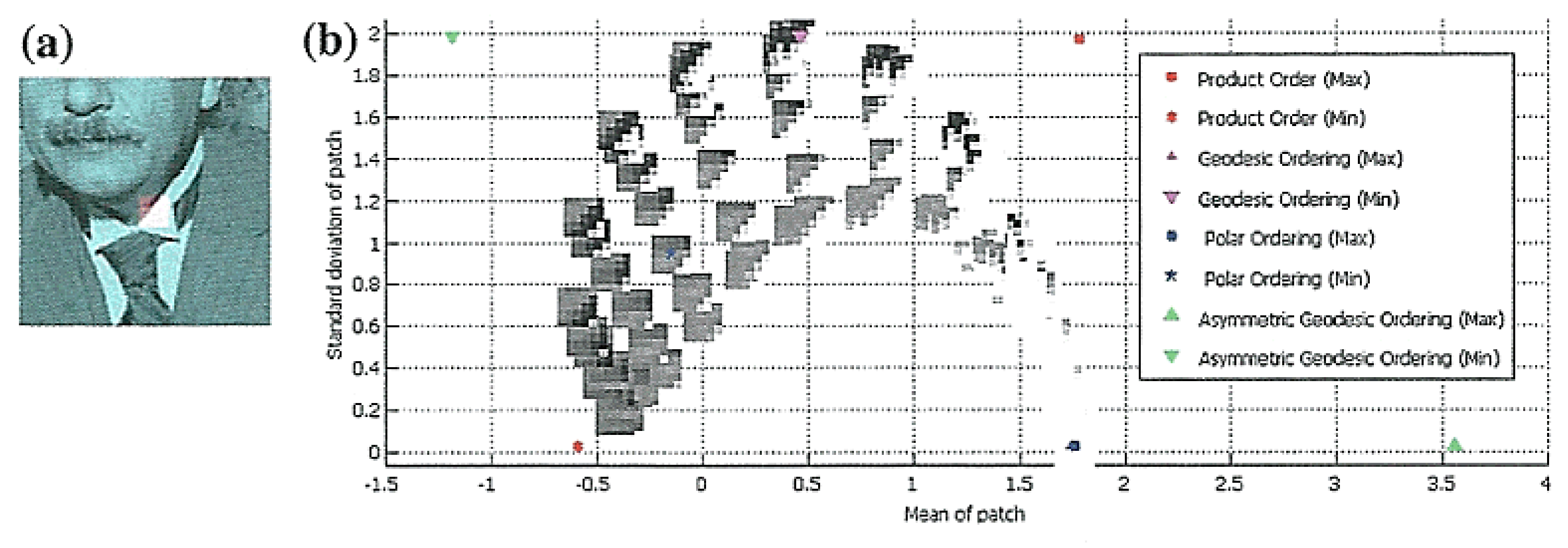
The notion of **ordering invariance** in the PUHP **with respect to** simple transitive group T of **the group of motions** was considered in the Soviet literature by **A.K. Guts** in the 70s, according to the following transformation:

$$z = x + iy \mapsto z' = (\lambda x + \alpha) + i\lambda y .$$

(J. Angulo, S. Velasco-Forero 2014)

4. Information Geometry Theory (09)

A Practical Example in Image Processing (IP)

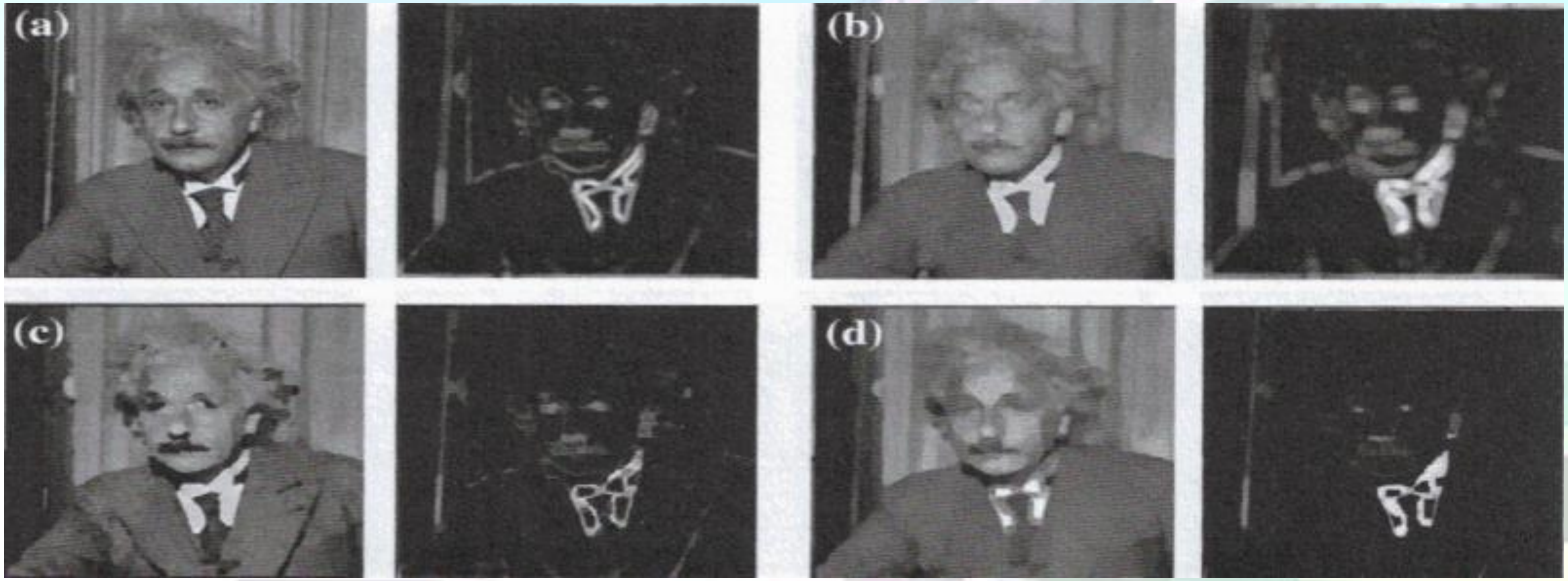


Supremum and infimum of a set of 25 patches parameterized by their mean and standard deviation: **(a)** in *pink* the region where the overlapped patches are taken; **(b)** embedding into the space $\boldsymbol{H}^2$ of the coordinates $(\mu^*/,\sigma)$ and corresponding sup and inf for the different ordering strategies.

(J. Angulo, S. Velasco-Forero 2014)

4. Information Geometry Theory (10)

A Practical Example in Image Processing (IP)



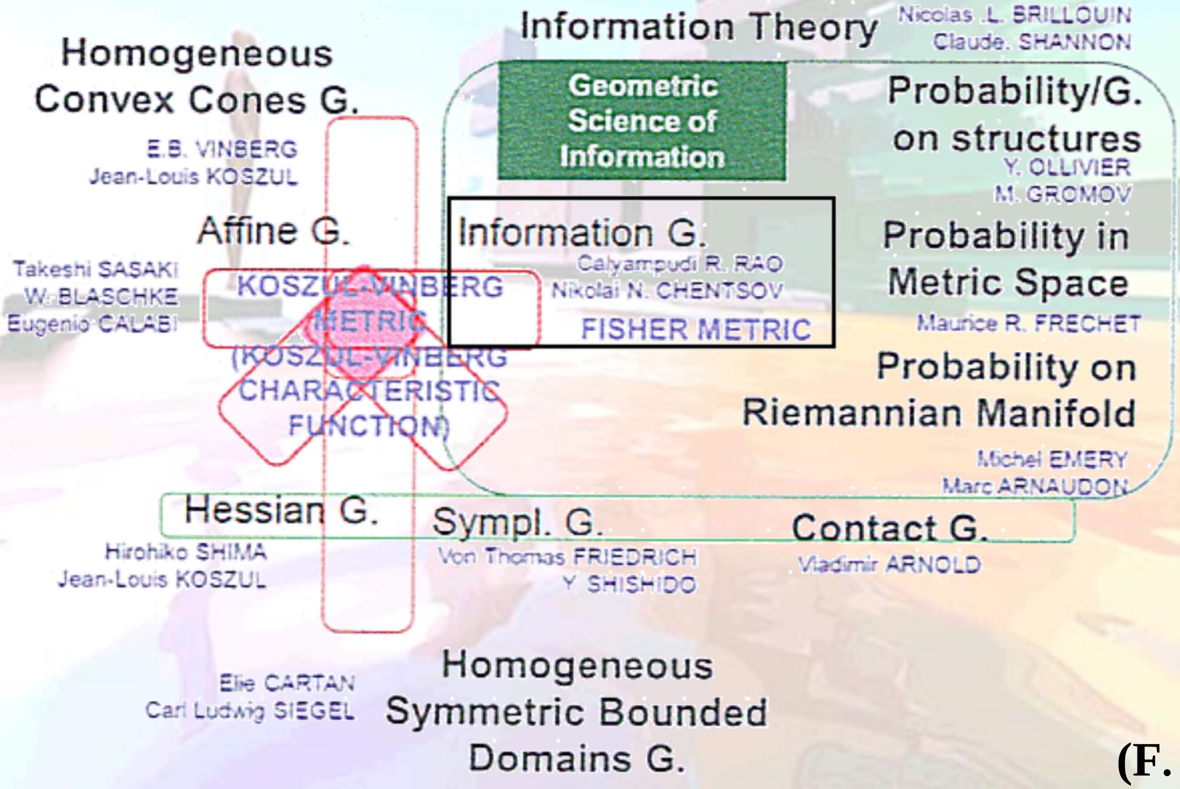
Comparison of dilation of Gaussian distribution-valued image: **(a)** original image, showing both the real and the imaginary components; **(b)** upper half-plane product ordering (equivalent to standard processing); **(c)** upper half-plane polar ordering; **(d)** upper half-plane polar ordering with parameter $\alpha=0.01$. Again the structuring element is a square of 5x5 pixels.

(J. Angulo, S. Velasco-Forero 2014)

4. Information Geometry Theory (11)

Current Landscape of Geometric Science of Information

Hessian (J.L. Koszul), Homogeneous Convex Cones (E. Vinberg), Homogeneous Symmetric Bounded Domains (E. Cartan, C.L. Siegel), Symplectic (T. von Friedrich, J.M. Souriau), Affine (T. Sasaki, E. Calabi), Information (C. Rao, N. Chentsov). Through Legendre Duality, Contact (V. Arnold) is considered as the odd-dimensional twin of symplectic geometry and could be used to understand Legendre mapping in information geometry.



Information Theory
Nicolas .L. BRILLOUIN
Claude. SHANNON

Homogeneous Convex Cones G.
E.B. VINBERG
Jean-Louis KOSZUL

Geometric Science of Information

Probability/G. on structures
Y. OLLIVIER
M. GROMOV

Affine G.
Takeshi SASAKI
W. BLASCHKE
Eugenio CALABI

Information G.
Calyampudi R. RAO
Nikolai N. CHENTSOV
FISHER METRIC

KOSZUL-VINBERG METRIC

(KOSZUL-VINBERG CHARACTERISTIC FUNCTION)

Probability in Metric Space
Maurice R. FRECHET

Probability on Riemannian Manifold
Michel EMERY
Marc ARNAUDON

Hessian G.
Hirohiko SHIMA
Jean-Louis KOSZUL

Sympl. G.
Von Thomas FRIEDRICH
Y. SHISHIDO

Contact G.
Vladimir ARNOLD

Homogeneous Symmetric Bounded Domains G.
Elie CARTAN
Carl Ludwig SIEGEL

(F. Barbaresco, 2014)

4. Information Geometry Theory (12)

Information Concept Modeling in Math
has been approached by
Two Large Theoretical and Operative Areas
interlinked by
Irriducible Complementarity.

Continuous Probabilistic Approach (Stochastic Measure)
Well Developed and Applied in all Scientific Areas.
(Calculus + Stochastic Analysis).

Discrete Deterministic Approach (Combinatorically Based)
Less Developed and Applied in a few quite specific Scientific Areas.
(Combinatorial Calculus + Algebraic Analysis).

4. Information Geometry Theory (13)

Major Problem with Shannon’s Approach

- In **2004**, University of Michigan physicist **Mark Newman**, along with biologist **Michael Lachmann** and computer scientist **Cristopher Moore**, applied Shannon’s approach to electromagnetic transmission.
- Specifically, they show that if electromagnetic radiation is used as a transmission medium, **the most information-efficient encoding format** for a given message is **indistinguishable from blackbody radiation**.
- So, paradoxically if you don't know the code used for the message **you can't tell the difference between an information-rich message and a random jumble of letters** (noise as **“unstructured information”** concept).

4. Information Geometry Theory (14)

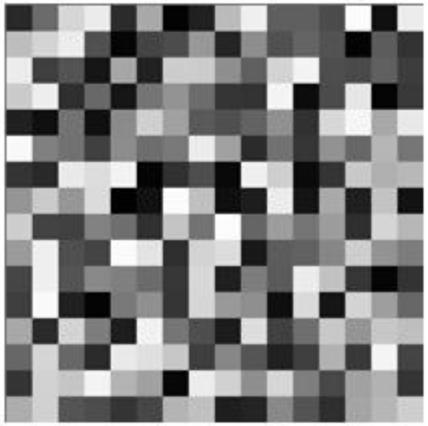
As a matter of fact, the **classical instrumentation noise discrimination problem** is still faced by the single domain channel transfer function concept (Shannon’s noisy channel), starting from **classic Shannon’s information theory** concept, and then applying traditional perturbation computational model **under either additive or multiplicative perturbation hypothesis**.

In general, **H(x)**, called **"Shannon entropy,"** is the average unpredictability in a random variable, which is equivalent to its information content. The concept was introduced by Claude E. Shannon in his **1948** paper "A Mathematical Theory of Communication."

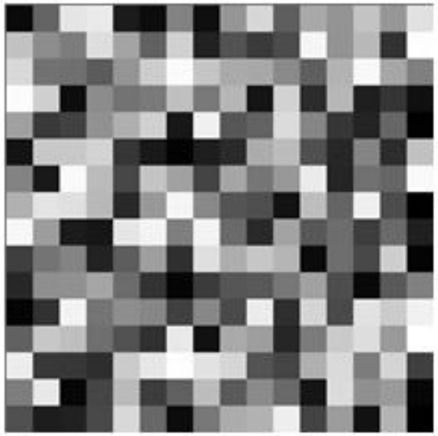
Shannon’s entropy provides an **absolute limit on the best possible lossless encoding or compression** of any communication, assuming that the communication may be represented as **a sequence of independent and identically distributed random variables**.

4. Information Geometry Theory (15)

First Example:
(16 by 16 pixel, 256-shades of gray image)



$H_1(X)$ = 0.893995, in single precision arithmetic,
$H_2(X)$ = 0.893995239236685, in double precision arithmetic
$H_3(X)$ =
0.893995239236684877496472491876528813219927312274
6343439319551627, with 64-digit precision arithmetic.



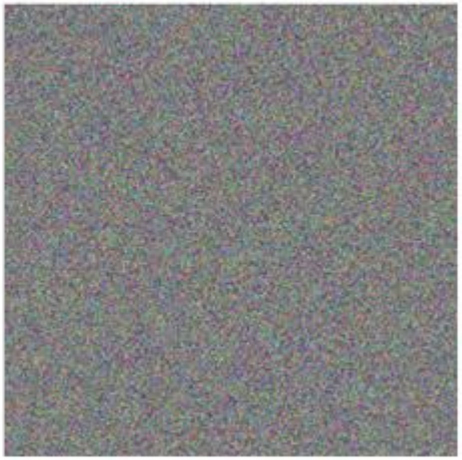
$H_1(X)$ = 1.000000, in single precision arithmetic,
$H_2(X)$ = 1.000000000000000, in double precision arithmetic
$H_3(X)$ =
1.000000000000000000000000000000000000000000000000
0000000000000, with 64-digit precision arithmetic.

(R.A. Fiorini, 2014)

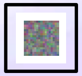
4. Information Geometry Theory (16)

Second Example: Image Lossless Compression Test (4,096 by 4,096 pixel, 16,777,216 true color image)

$H_1(X)$ = 0.999292, in single precision arithmetic,
$H_2(X)$ = 0.999292377044885, in double precision arithmetic
$H_3(X)$ = 0.9992923770448853118692398478371254320637916484441241727700678337, with 64-digit precision arithmetic.



$H_1(X)$ = 1.000000, in single precision arithmetic,
$H_2(X)$ = 0.99999999993863, in double precision arithmetic
$H_3(X)$ = 0.99999999993862998327578214706655513480906038553944271528197718 84, with 64-digit precision arithmetic.



(R.A. Fiorini, 2014)

4. Information Geometry Theory (17)

ICIAP 2013

International Conference on Image Analysis and Processing 2013
September 11-13, 2013, Naples, Italy
Reviews For Paper
Paper ID 286
Title **LOSSLESS IMAGE COMPRESSION AND REGENERATION BY COMBINATORIAL MODULAR OPTIMIZATION**

The paper should introduce a combinatorial modular optimization for compressing lossless image, but essentially it is a not clear (and not concise) review of the main solution strategies for mathematical optimization problems.

Section 3 should illustrate the details of the proposed approach, but it is mainly focussed on the explanation of the well known Shannon theorem. Moreover, it is not clear which are the main drawbacks of existing methods that should be overcome by using their approach.

The experimental results presented in figure 2 are not clear: two apparently identical gray images.

4. Information Geometry Theory (18)

Third Example:

(Nobuyuki Kayahara’s Spinning Dancer, 2003)

This image cannot currently be displayed.

4. Information Geometry Theory (19)

Computational Information Contemporary Double-Bind

Our computational information contemporary classic systemic tools (developed under the positivist reductionist paradigm) are totally unable to capture and to tell the difference between an information-rich message (optimally encoded message) and a random jumble of signs that we call "noise" (they are quite fragile).

It is a distressing dilemma in computational communication…
(and in the overall contemporary scientific community too; just at the origin of human being knowledge extraction and building process from our environment, where we are immersed within.)

How does it come we scientists (statisticians) are still in business without having worked out a definitive solution to the problem of the logical relationship between experience and knowledge? **(Piercesare Secchi, 2013)**

4. Information Geometry Theory (20)

Computational Information Contemporary Double-Bind

**We need to extend our systemic tools
to solve this double-bind dilemma.**

HOW

**We must discover a creative solution
in our contemporary systemic paradigm
OR
undergo to yet a new paradigm change!**

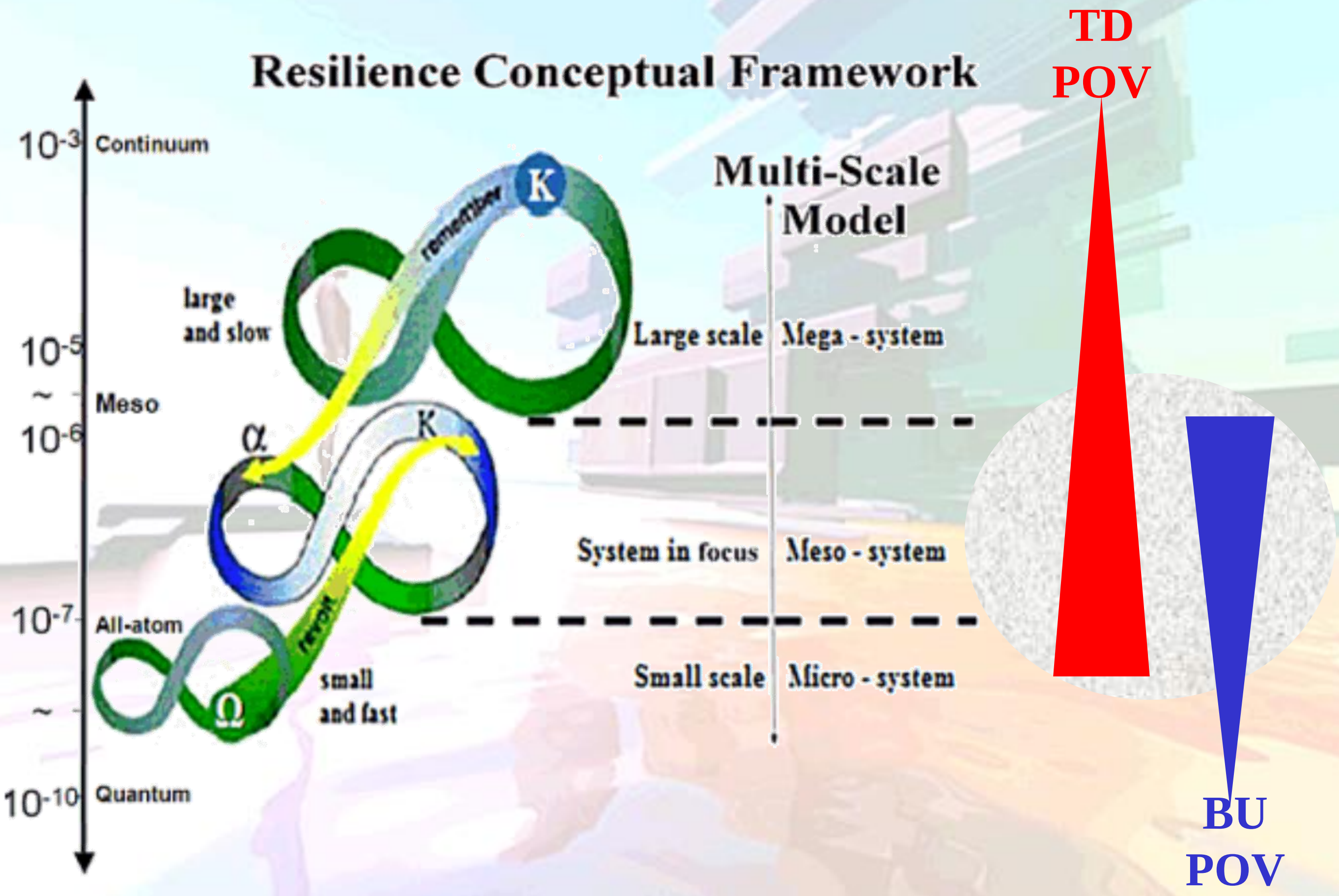
4. Information Geometry Theory (21)

Major Problem with Combinatorial Approach

- In **1951**, Cybernetician **Ross W. Ashby** (1903 –1972) has shown that a few symbolic computational strategies are practically unachievable (**“combinatorial explosion”** concept).
- E.g. A **20 by 20 LED grid** (you can turn them on and off) is associated to 2^{400} different patterns, i.e. $2^{400} > 10^{100}$ different combinations.
- A **brute force approach strategy** to find a specific pattern **is going to fail**: an “Earth-sized computer”, computing since our contemporary estimated Universe creation, (according to our best measurement of **the age of our universe**, as of **22 March 2013** (13.798 ± 0.037 billion years ($4.354 \pm 0.012 \times 10^{17}$ seconds) within the Lambda-CDM concordance model), would be unable to achieve the desired result (to find our desired pattern).

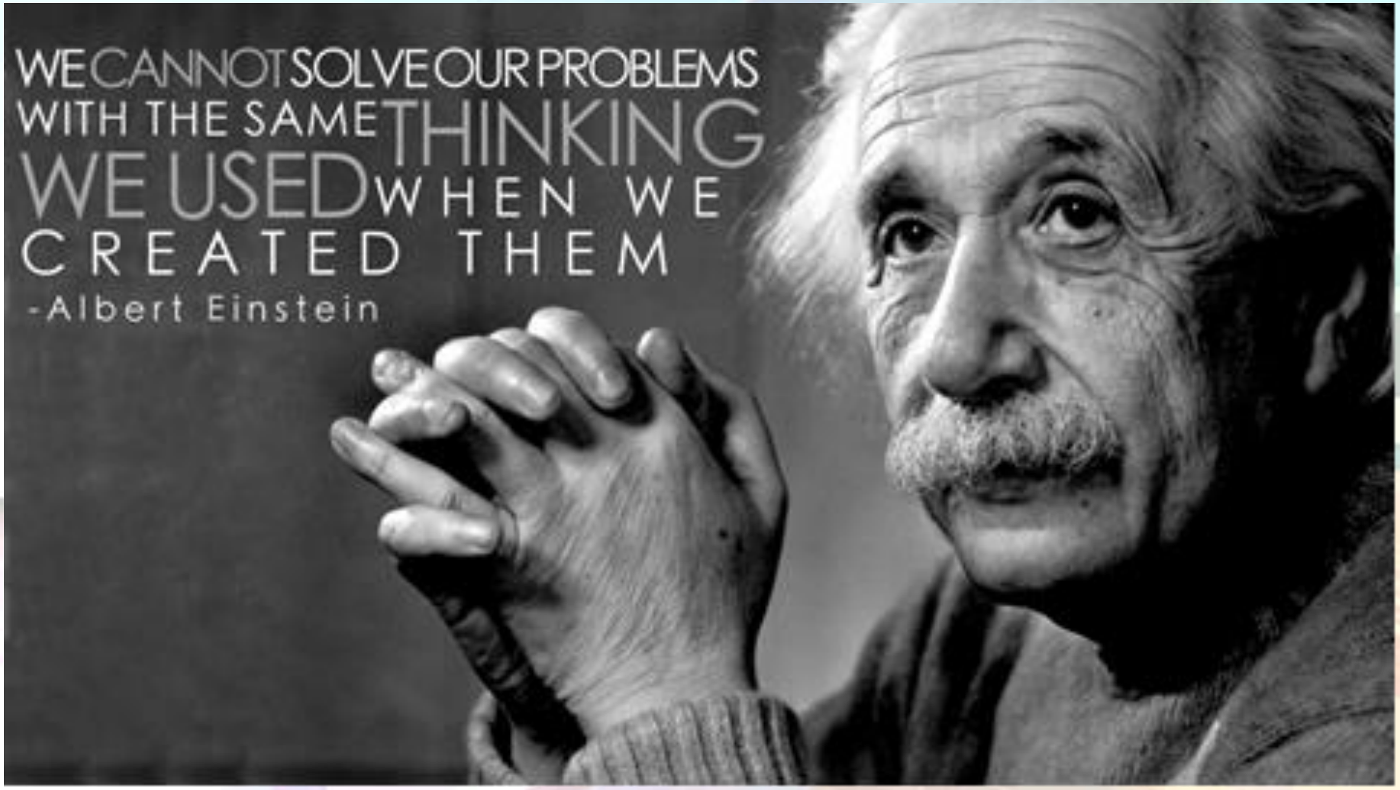
4. Information Geometry Theory (22)

The Root of the Problem for Multi-Scale System Modeling



4. Information Geometry Theory (23)

Remembering The Relativity’s Father



4. Information Geometry Theory (24)

The central idea is that **an assessment of system fragility** (and control of such fragility) **is more useful**, and **more reliable**, **than probability risk management** and **data-based methods** of risk detection.

Fragility can be defined as **an accelerating sensitivity to a harmful stressor**: this response plots as a **concave curve** and mathematically culminates in **more harm than benefit** from the disorder cluster (uncertainty, incomplete knowledge, etc.)

Antifragility is the opposite, producing a **convex response** that leads to **more benefit than arm**. All we need is to be able **to assess whether the system is accelerating towards arm or benefit**.

We do not need to know the history and statistics of the system to measure its fragility or antifragility, or to be able to predict rare and random (**black swan**) events.

4. Information Geometry Theory (25)

Ontological Uncertainty

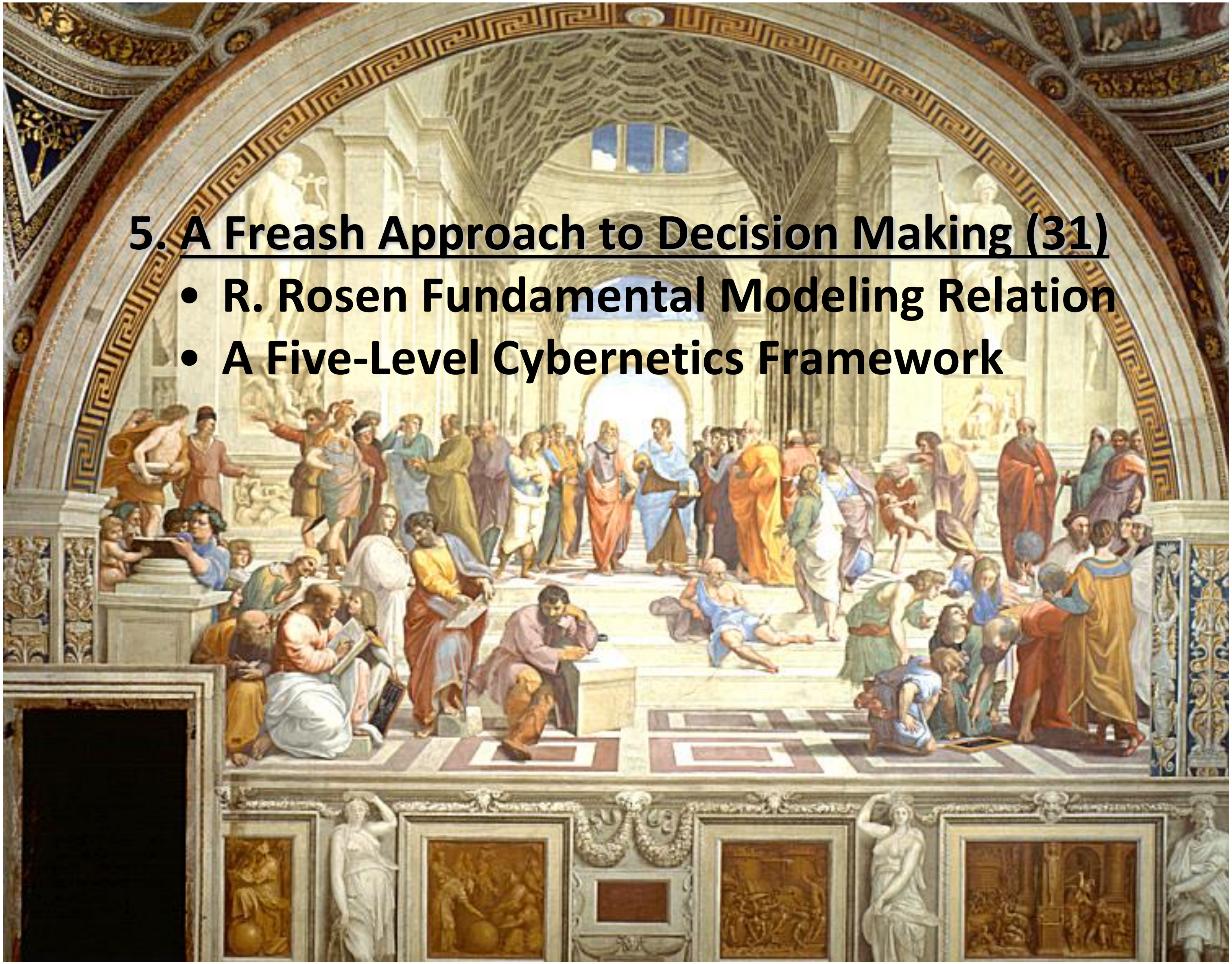
Global complex socio-economic-ecological systems, formed by a large number of parts at different scales of more or less hierarchical systems, produce **emergent patterns** and **unintended consequences at various scales**.

A key feature of such complex interactions is that **outcomes are inherently uncertain** and **big data cannot reduce this uncertainty**.

In **2005**, **Lane and Maxfield** coined the term **"ontological uncertainty"** to refer to situations where human agents must make decisions in a context where not only the **future trajectory of an entity is uncertain** but also **its future interactions** with other entities and those with each other.

It can also be called **radical uncertainty** and is the type recognised by **Keynes** in his well-known remarks in the **General Theory**.

5. A Freash Approach to Decision Making (00)



5. A Freash Approach to Decision Making (31)

- R. Rosen Fundamental Modeling Relation
- A Five-Level Cybernetics Framework

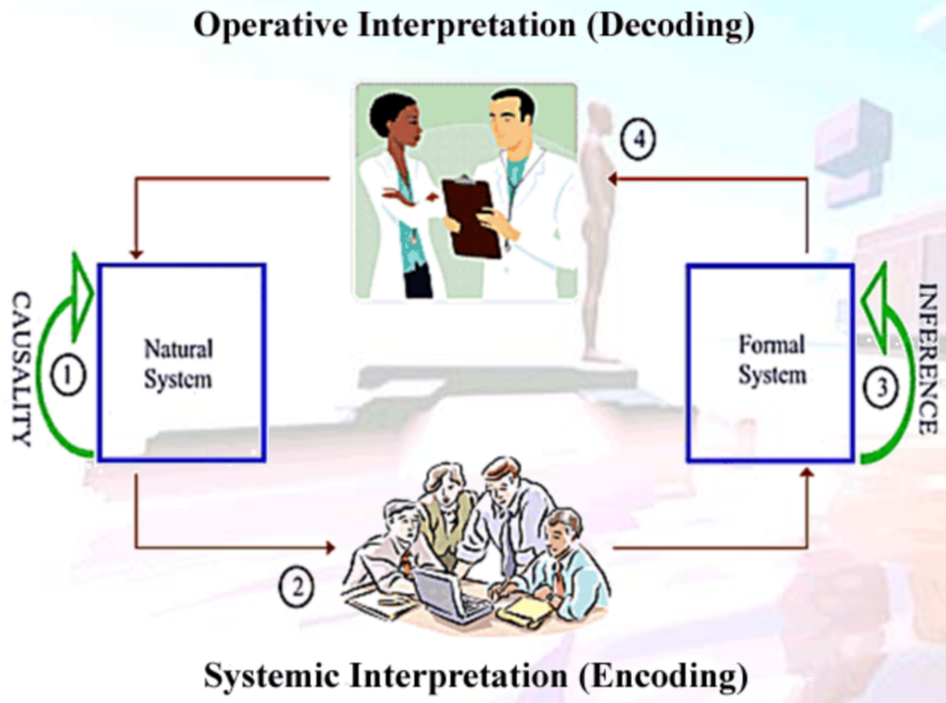
5. A Freash Approach to Decision Making (01)

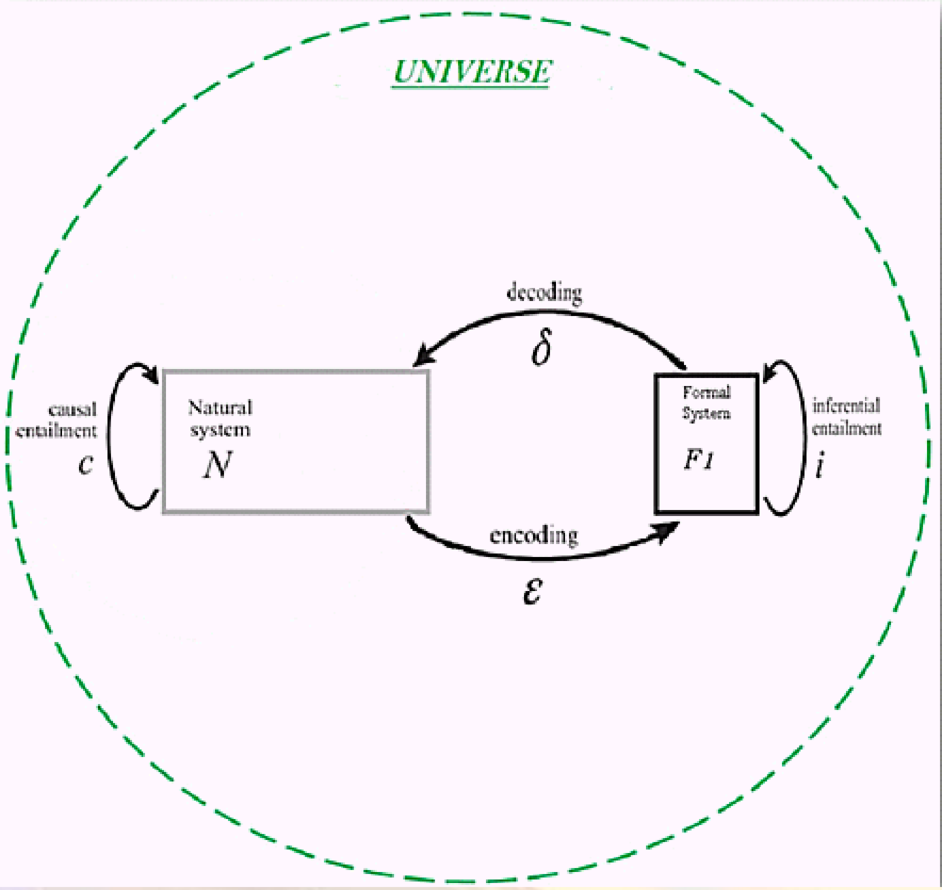
Two Large Systemic Research Areas to Living System Theory

- **Formal Approach (What is Life?):**
  Erwin Rudolf Josef Alexander Schrödinger (1887 – 1961)
  Norbert Wiener (1894 – 1964)
  Ludwig von Bertalanffy (1901 – 1972)
  James Grier Miller (1916 – 2002)
  . . .
- **Substantial Approach (Why Life?):**
  Vladimir Ivanovič Vernadskij (1863 – 1945)
  Nicolas Rashevsky (1899 – 1972)
  Robert Rosen (1934 – 1998)(Rosen, 1985)
  . . .

5. A Freash Approach to Decision Making (02)

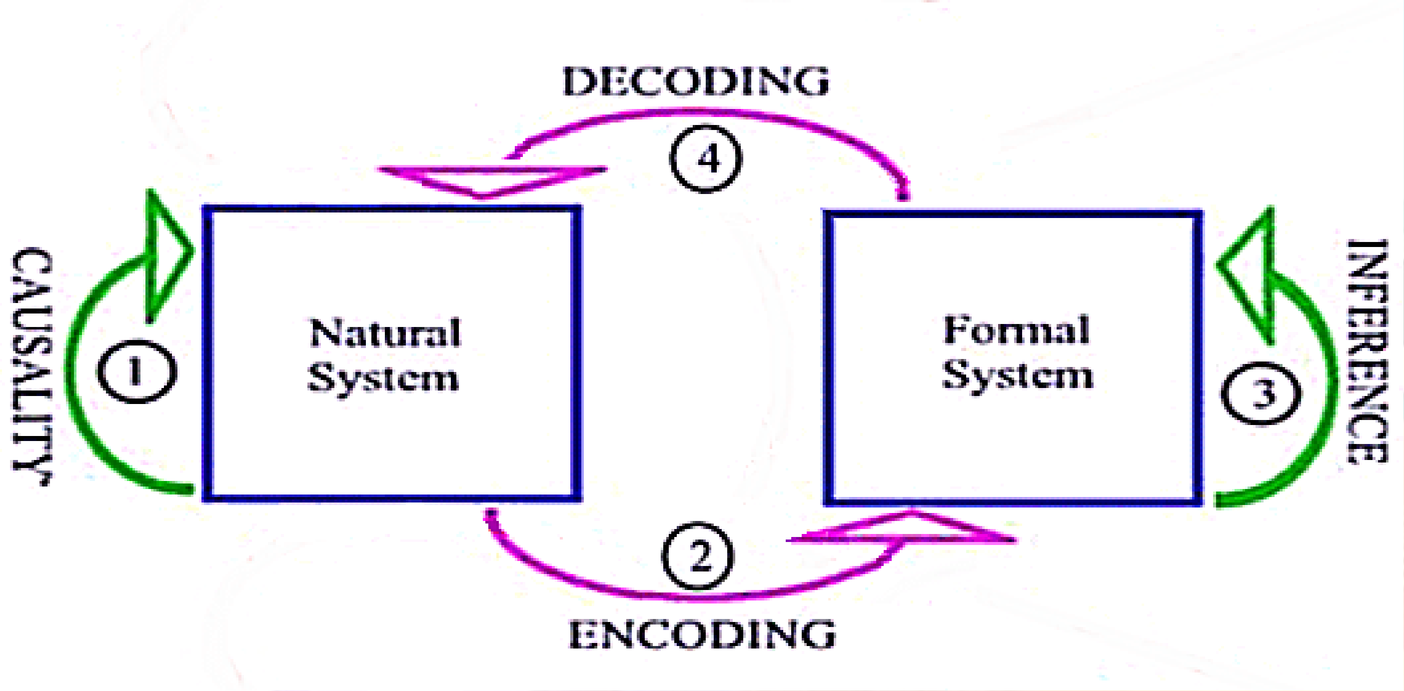
R. Rosen Fundamental Modeling Relation





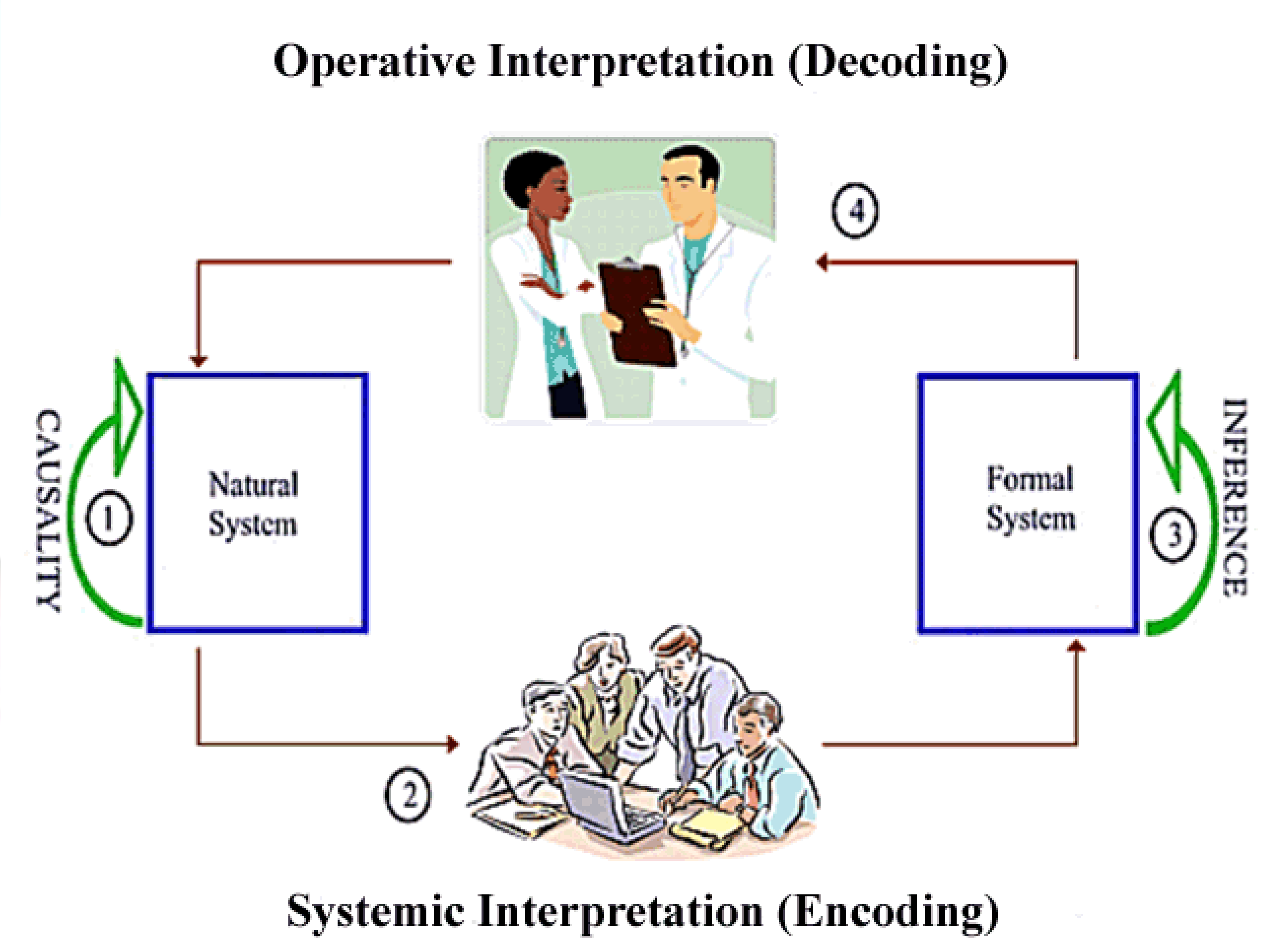
5. A Freash Approach to Decision Making (03)

R. Rosen Fundamental Modeling Relation



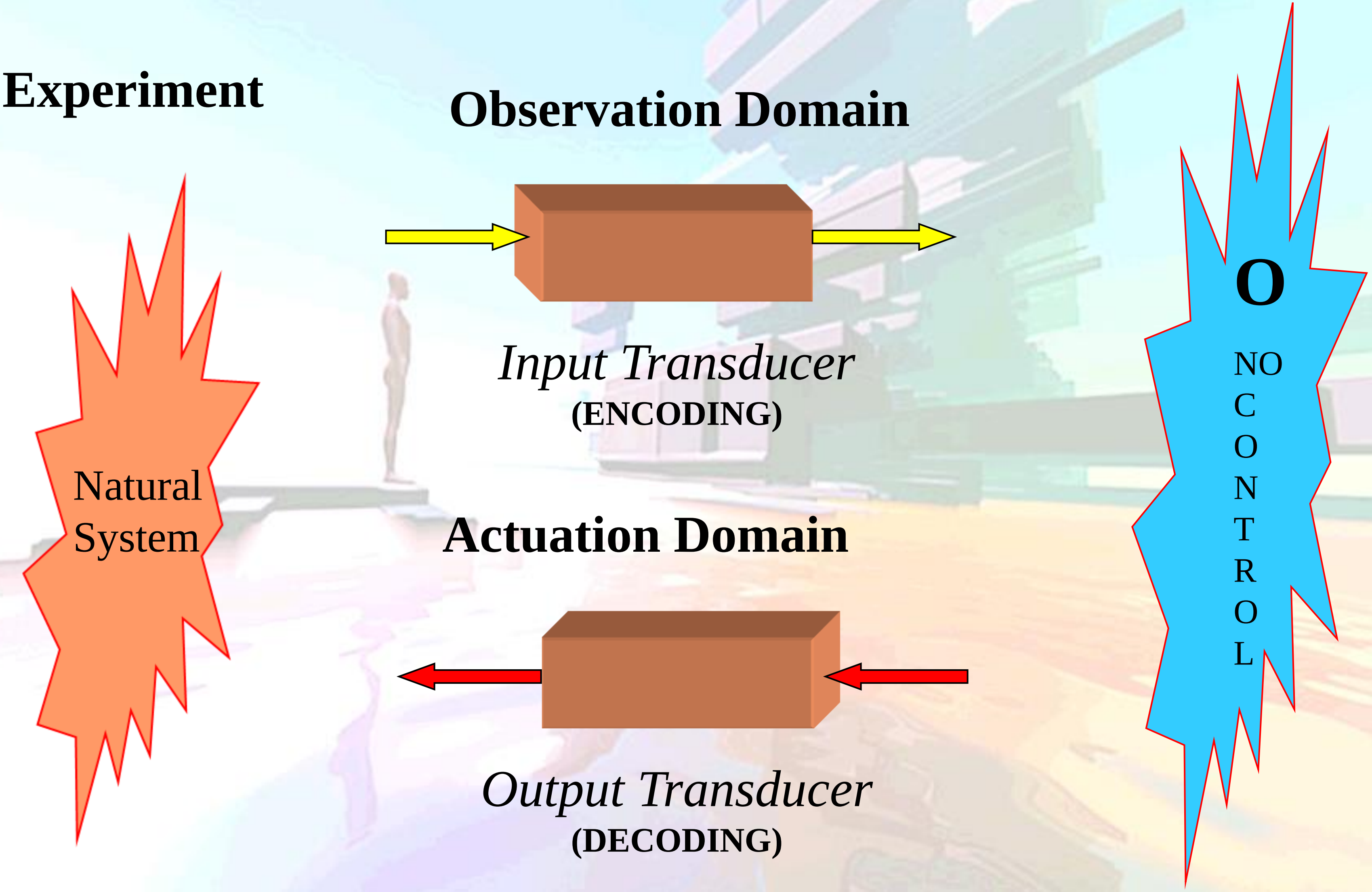
5. A Freash Approach to Decision Making (04)

Basic Operative Reference Scenario



5. A Freash Approach to Decision Making (05)

Basic Operative Reference Scenario



Experiment

Observation Domain

Input Transducer

(ENCODING)

Natural System

Actuation Domain

Output Transducer

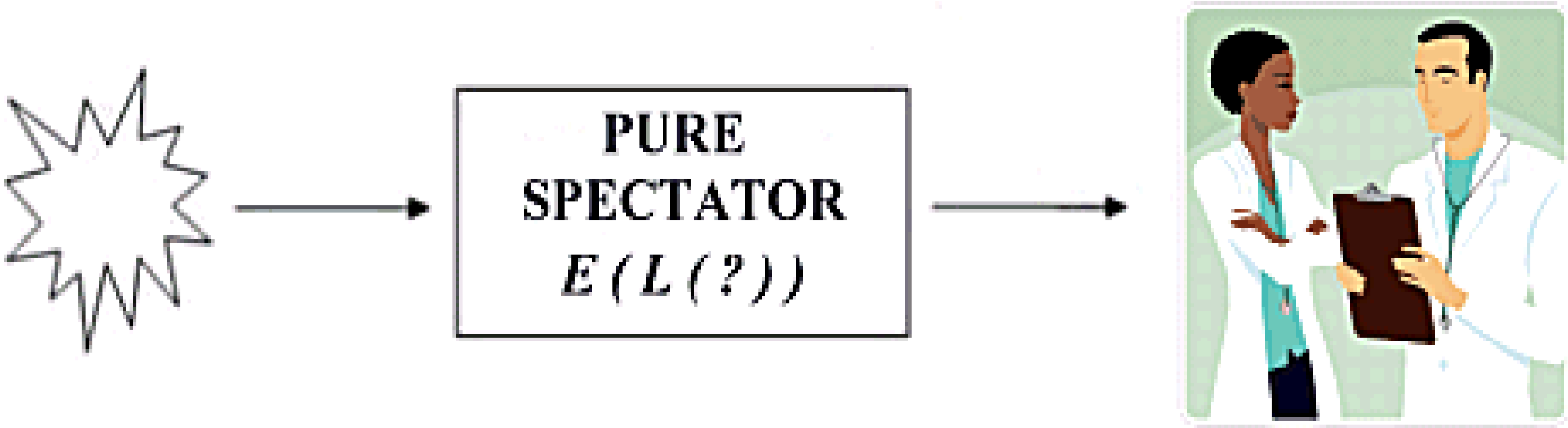
(DECODING)

O

NO CONTROL

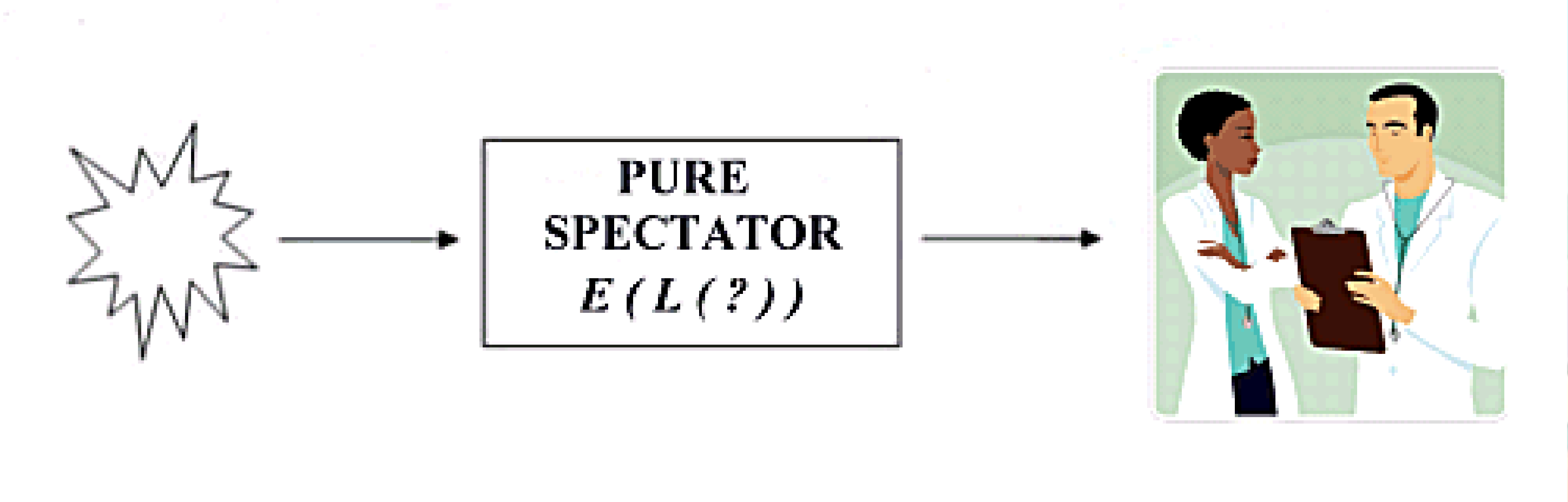
5. A Freash Approach to Decision Making (06)

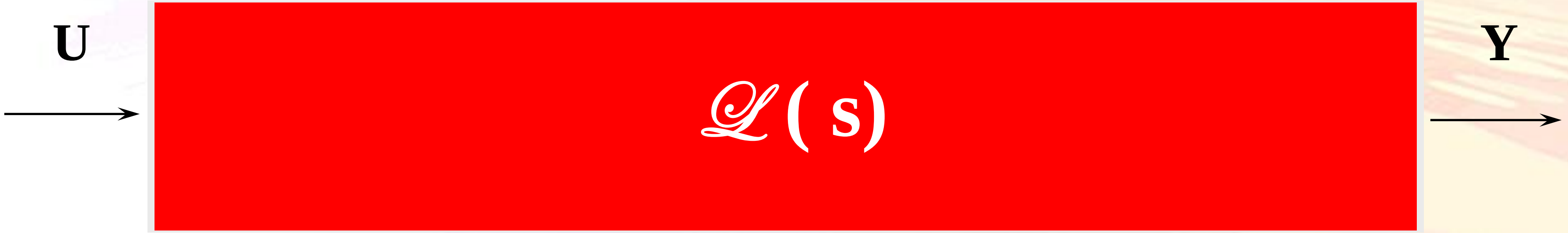
PURE SPECTATOR
Experimental Uncontrolled Observation



5. A Freash Approach to Decision Making (07)

Classic Single Domain Channel Transfer Function Approach (Shannon Information Channel)





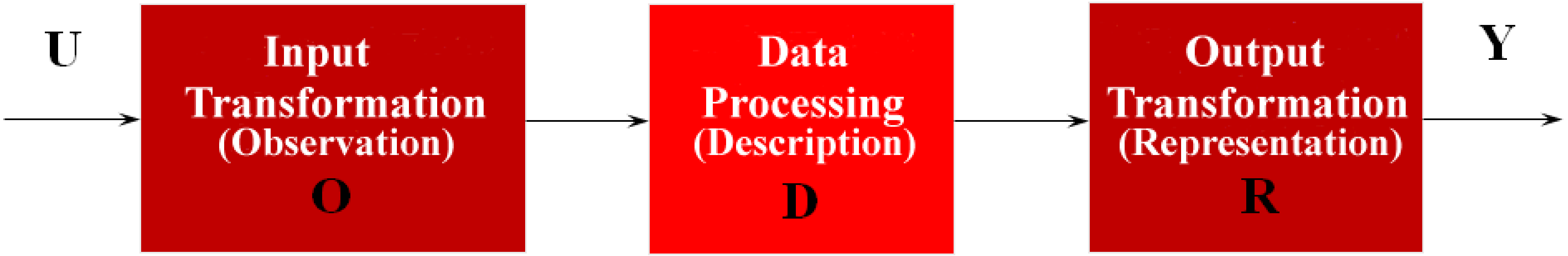
U

$\mathscr{L}(s)$

Y

5. A Freash Approach to Decision Making (08)

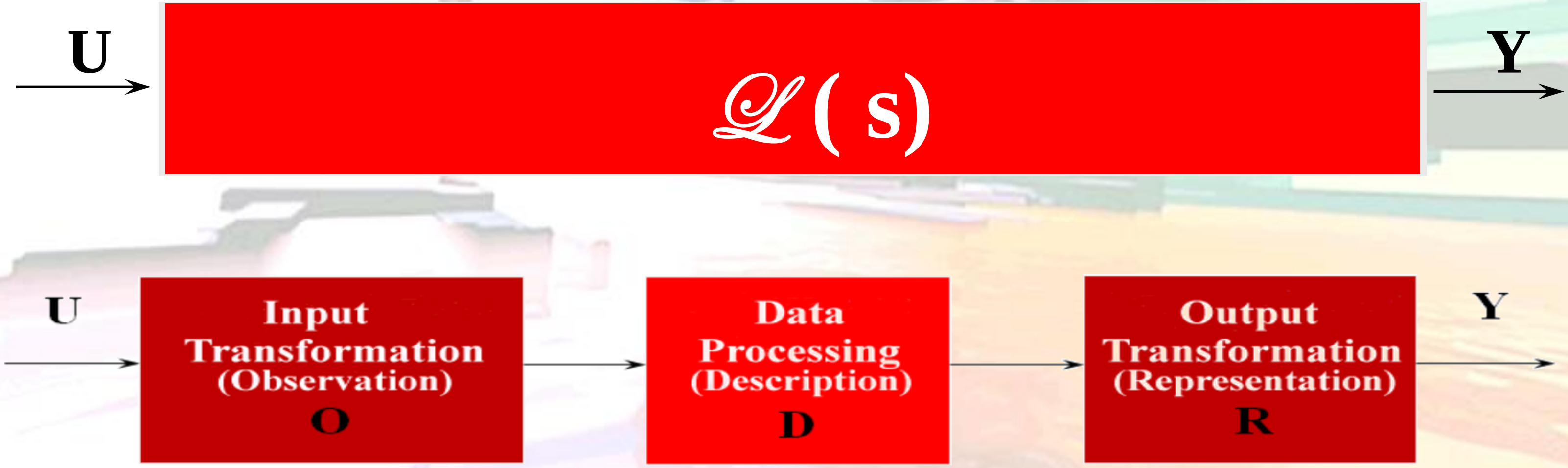
From **Shannon Information Channel** to **ODR Model**



$$\mathscr{L}(s) = O \cdot D \cdot R$$

5. A Freash Approach to Decision Making (09)

In the past six decades, trend in Systems Theory research has shifted from classical **single information channel transfer function** to the decomposition of classical single channel transfer function into **ODR functional sub-domain transfer function** approach (**O**bservation, **D**escription and **R**epresentation subdomains) to fit theoretical system design consideration to practical implementation needs much better.

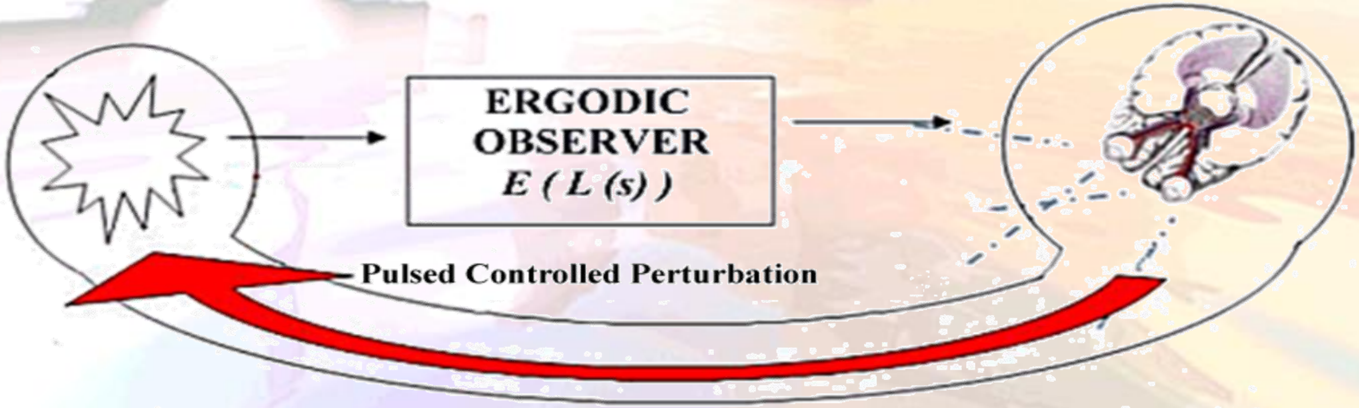


$$\mathscr{L}(\,s) = O \cdot D \cdot R$$

5. A Freash Approach to Decision Making (10)

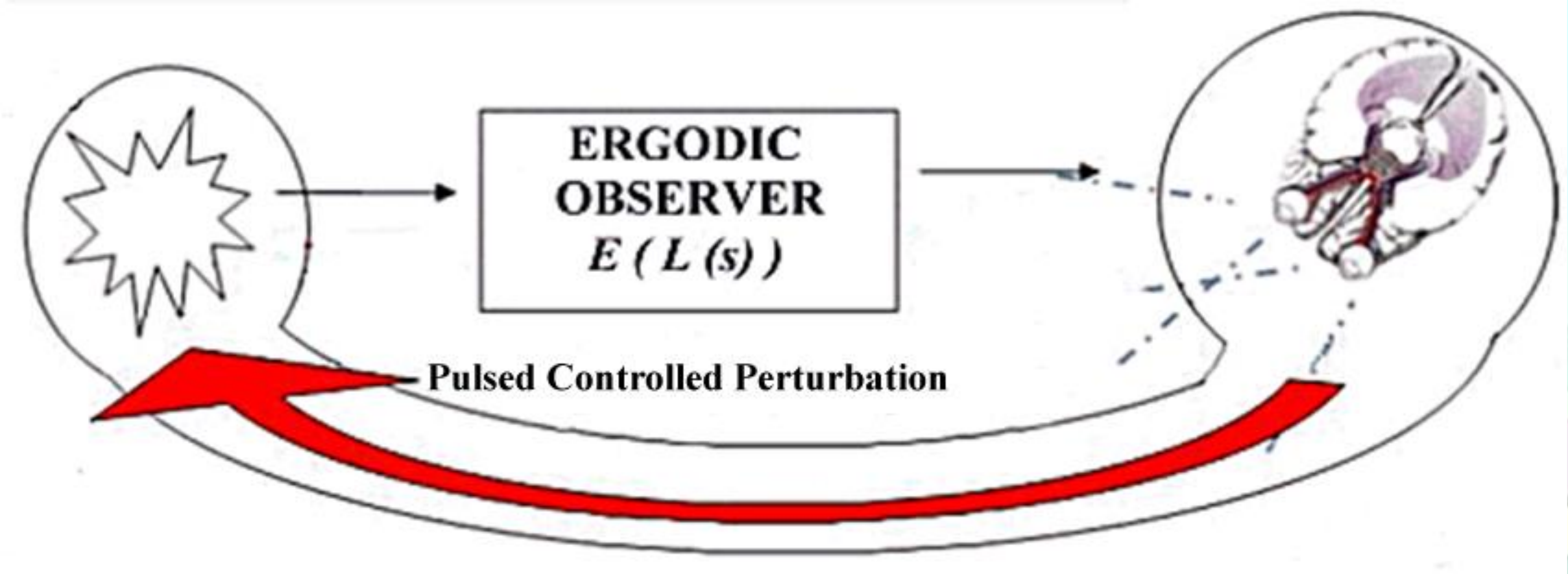
A deeper awareness about information acquisition and generation limitations by classical experimental observation process has been grown. In order to overcome part of those limitations, the pulsed **“Controlled Perturbative Approach" (CPA)** was developed in advanced research areas.

$$\mathscr{L}(s) = O \cdot D \cdot R$$



5. A Freash Approach to Decision Making (11)

ERGODIC OBSERVER

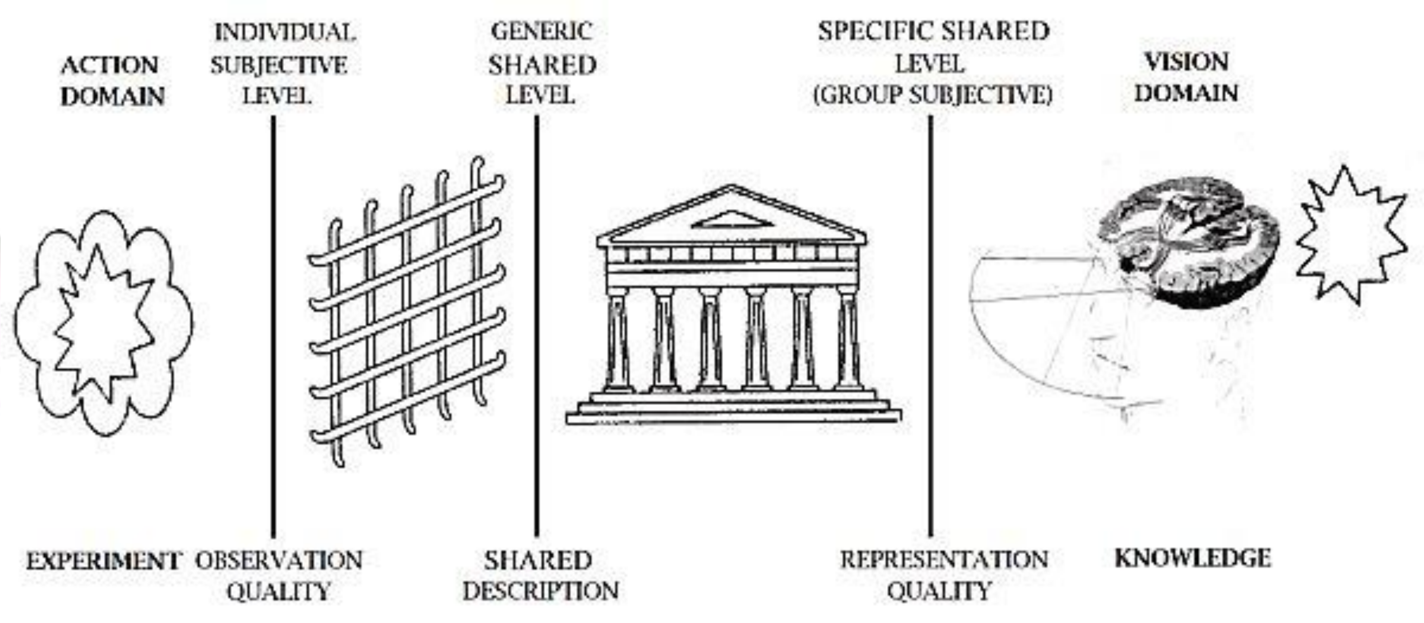


The pulsed ”**Controlled Perturbative Approach**” (**CPA**) was conceived in advanced experimental research areas, in the 1970s. One of its practical implementation was the laser ”**Pump&Probe**” (**P&P**) technique. CPA and P&P techniques have been applied to disciplines like P&P **spectroscopy in biology**, P&P **biomedical imaging**, P&P **molecular dynamics**, P&P **Optical Coherence Tomography** (OCT), etc.

5. A Freash Approach to Decision Making (12)

CICT new awareness

According to new "Computational Information Conservation Theory" (CICT) point of view, all computational information usually lost in the classic computational domain approach can be captured and recovered by corresponding **ODR complementary co-domains**, step-by-step. Then co-domain information can be used to correct any computed result, achieving computational information conservation.



5. A Freash Approach to Decision Making (13)

U

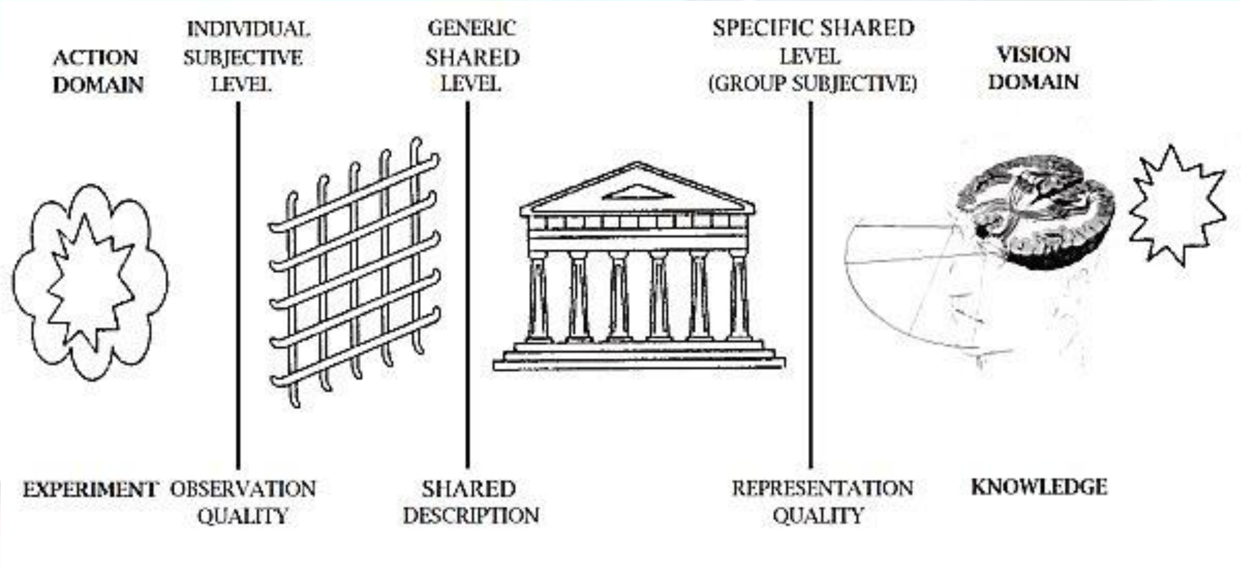
Input Transformation (Observation) O

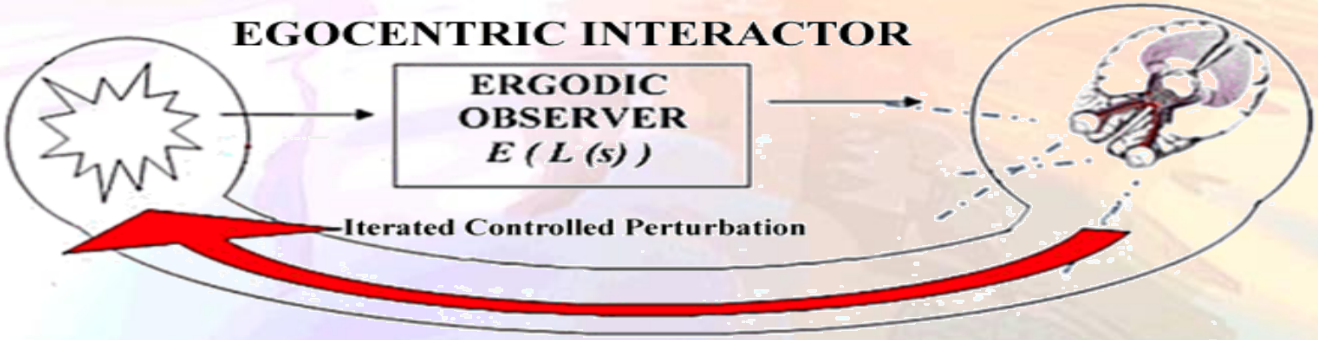
Data Processing (Description) D

Output Transformation (Representation) R

Y

$$\mathscr{L}(s) = \mathbf{O} \cdot \mathbf{D} \cdot \mathbf{R}$$





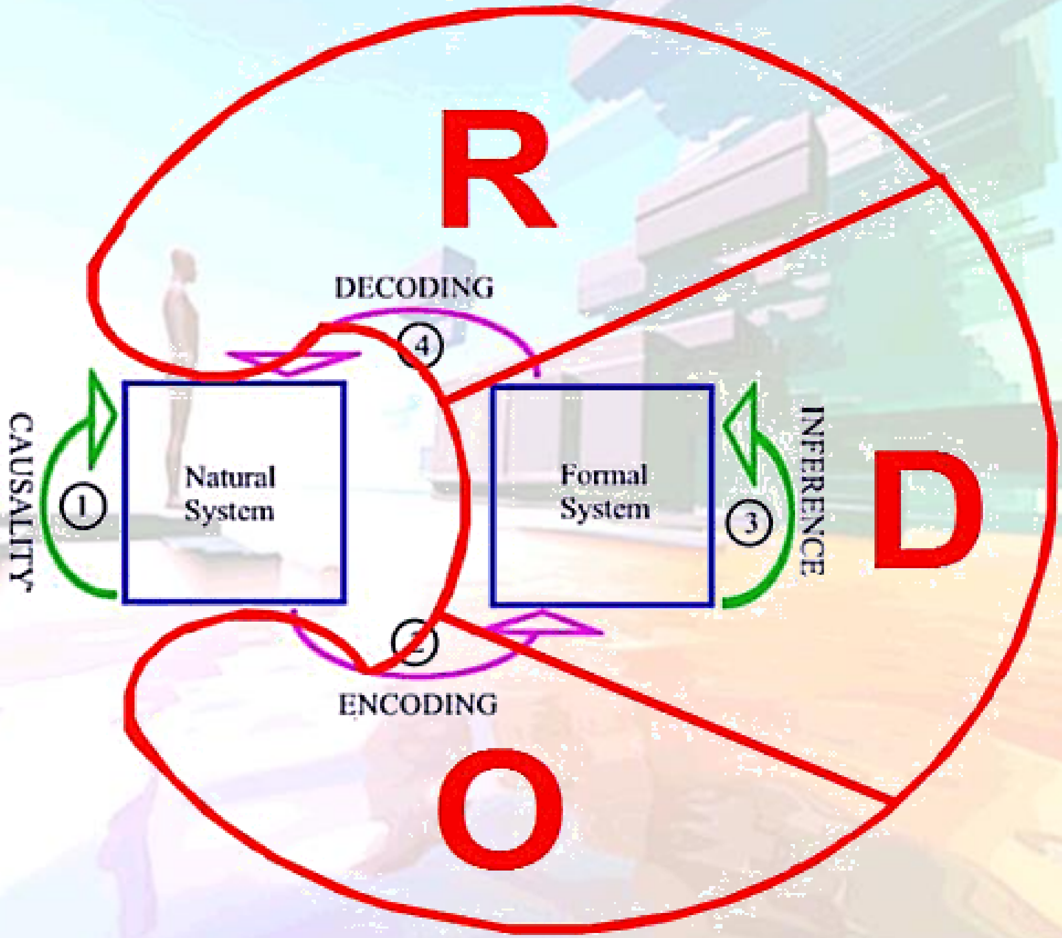
EGOCENTRIC INTERACTOR

ERGODIC OBSERVER
E (L (s))

Iterated Controlled Perturbation

5. A Freash Approach to Decision Making (14)

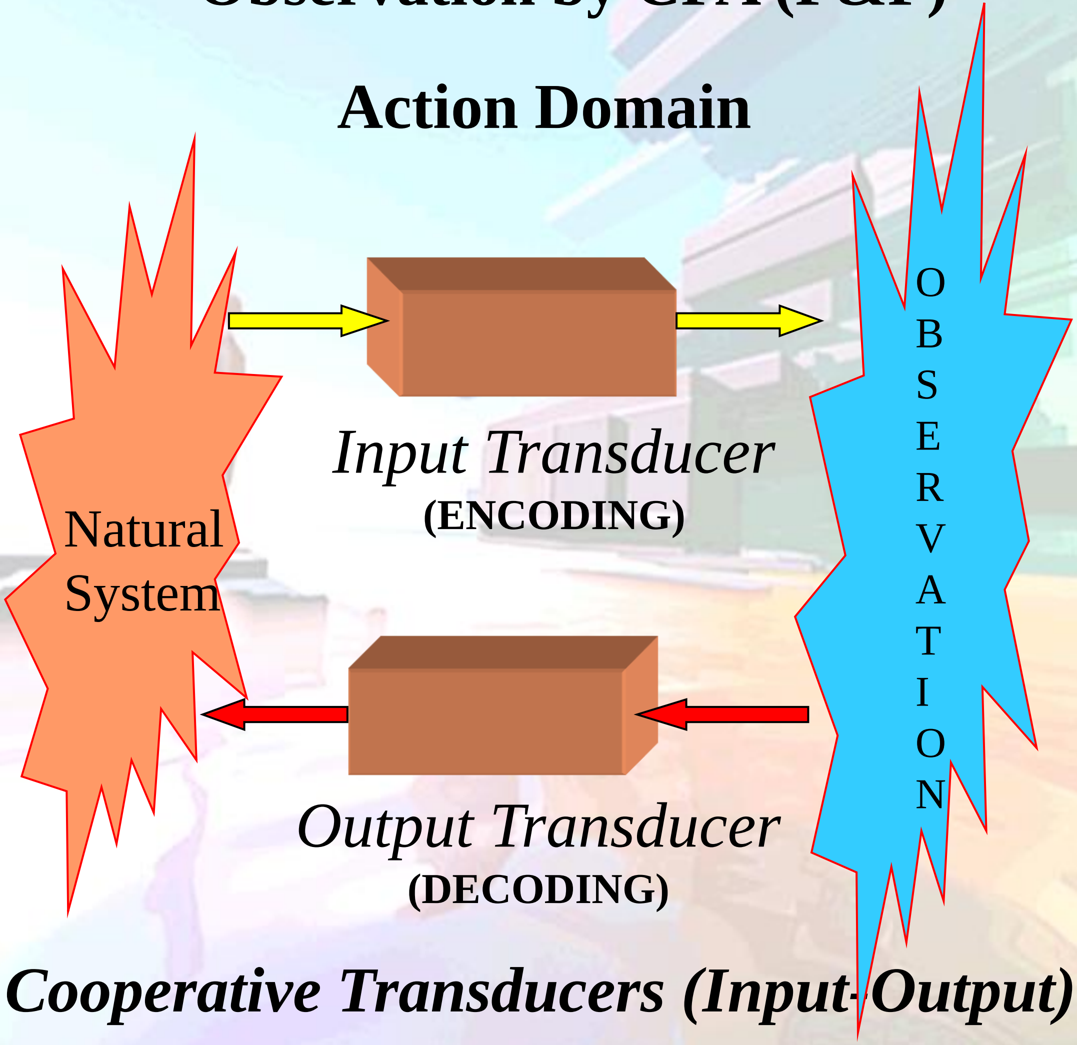
From **Rosen Modeling Relation** to **ODR Model**



5. A Freash Approach to Decision Making (15)

ERGODIC OBSERVER
Observation by CPA (P&P)

Action Domain



Natural System

Input Transducer
(ENCODING)

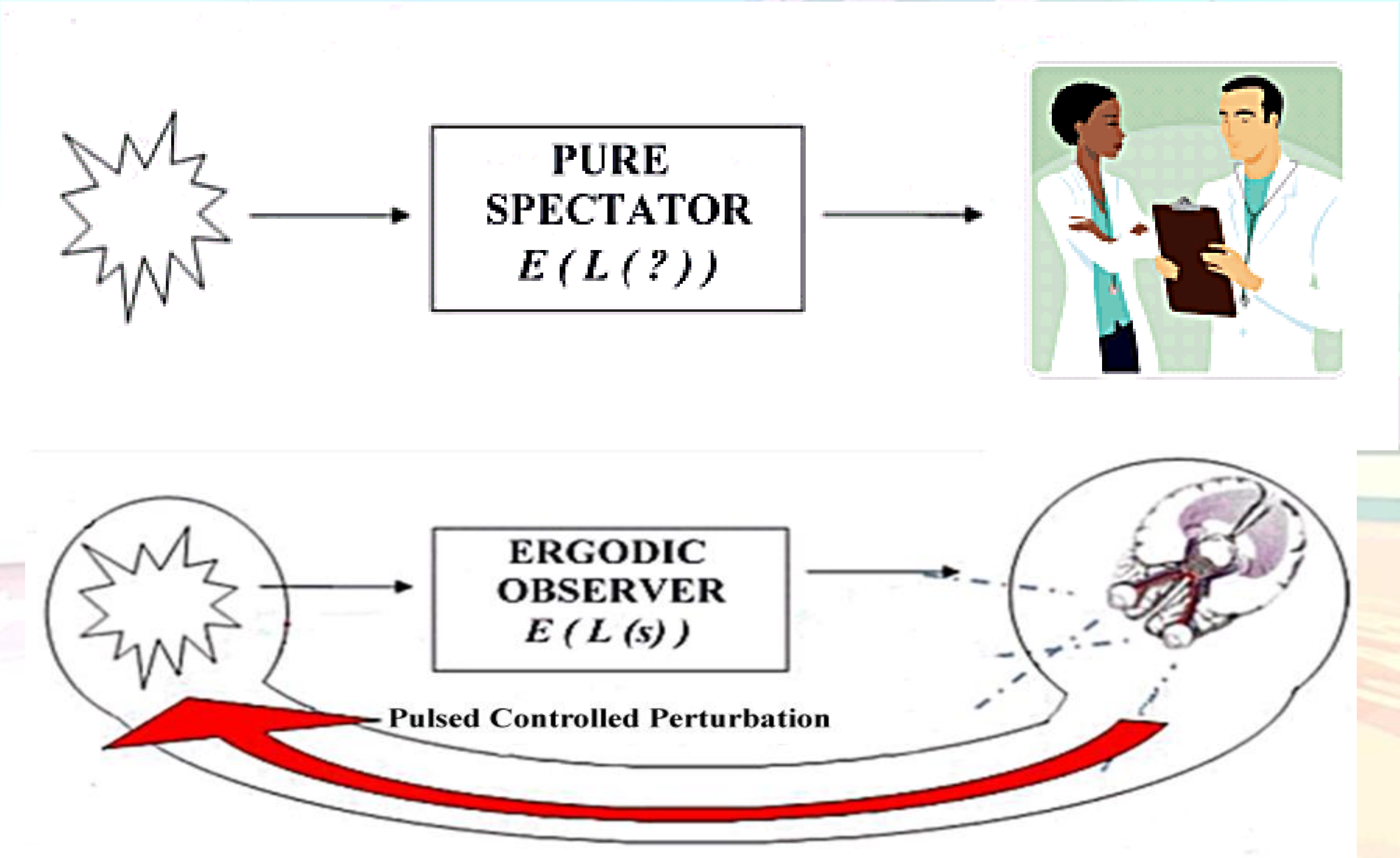
Output Transducer
(DECODING)

OBSERVATION

Cooperative Transducers (Input-Output)

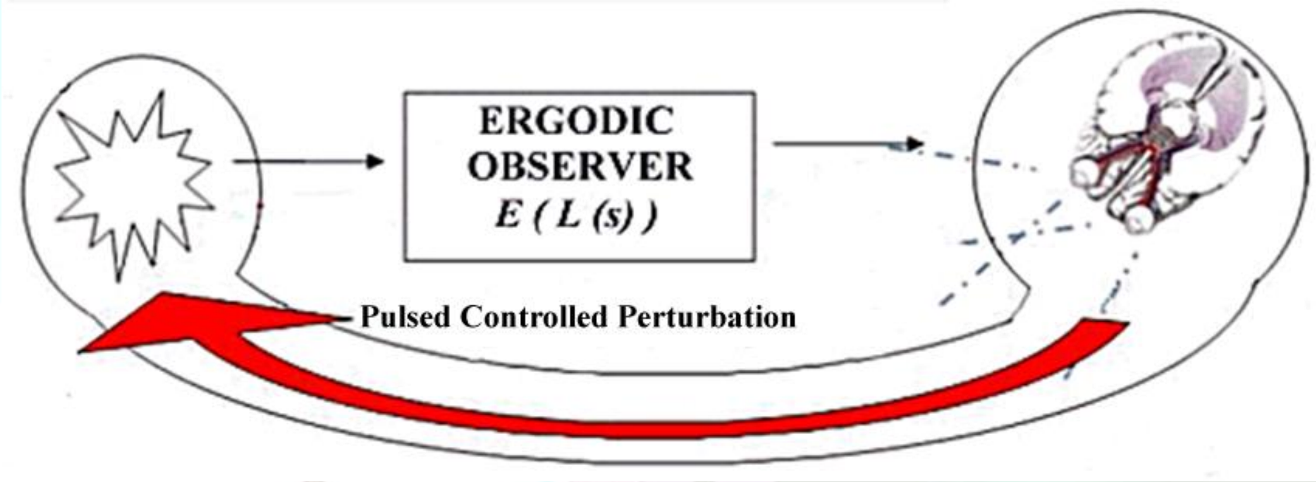
5. A Freash Approach to Decision Making (16)

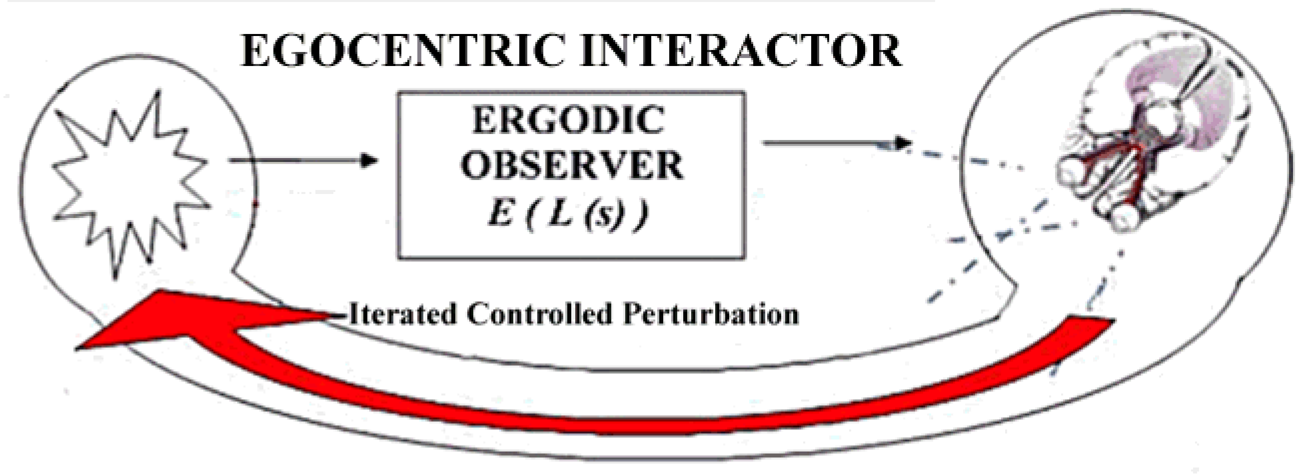
From **PURE SPECTATOR** to **ERGODIC OBSERVER**



5. A Freash Approach to Decision Making (17)

From **ERGODIC OBSERVER** to **EGOCENTRIC INTERACTOR**



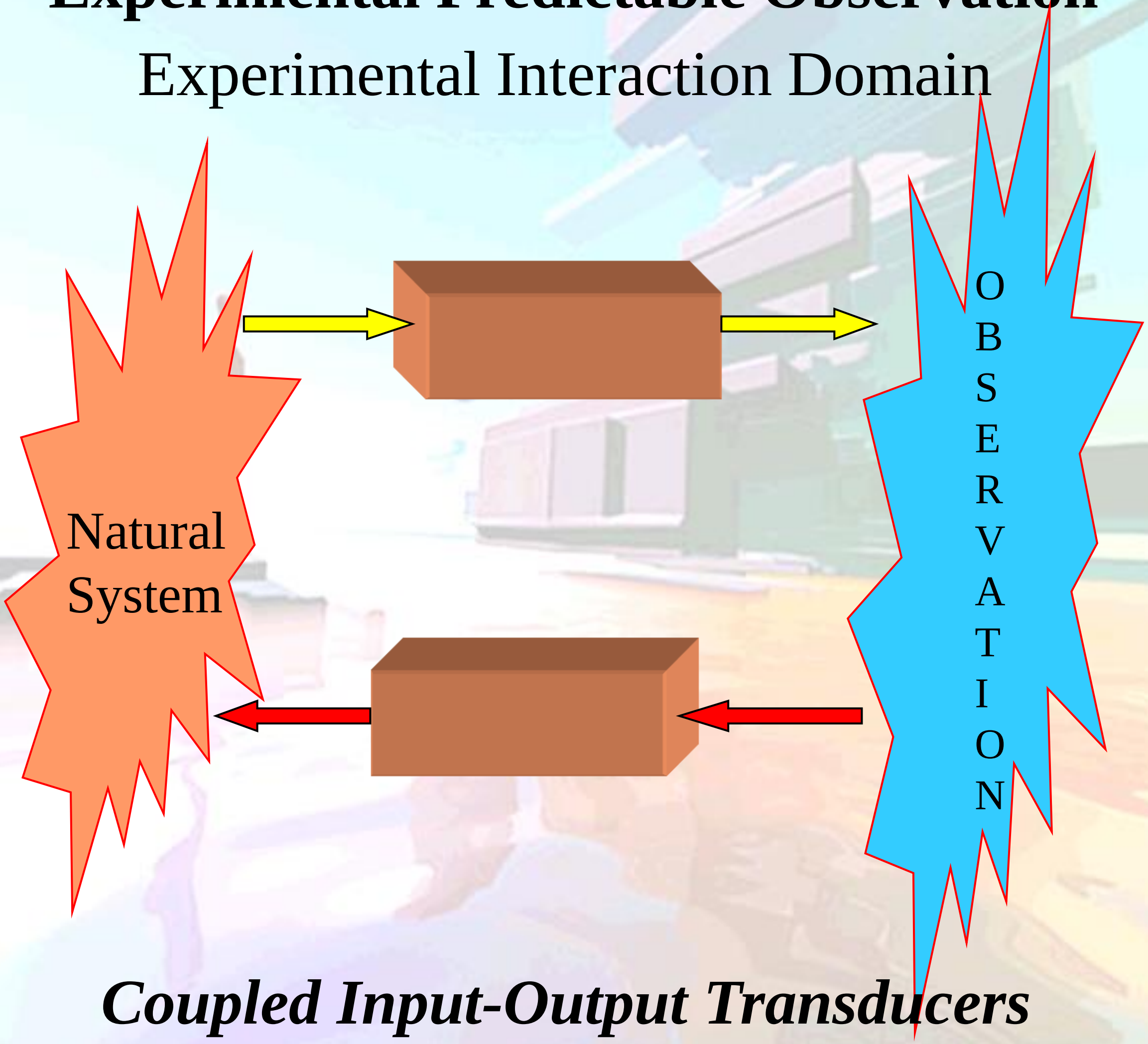


5. A Freash Approach to Decision Making (18)

EGOCENTRIC INTERACTOR

Experimental Predictable Observation

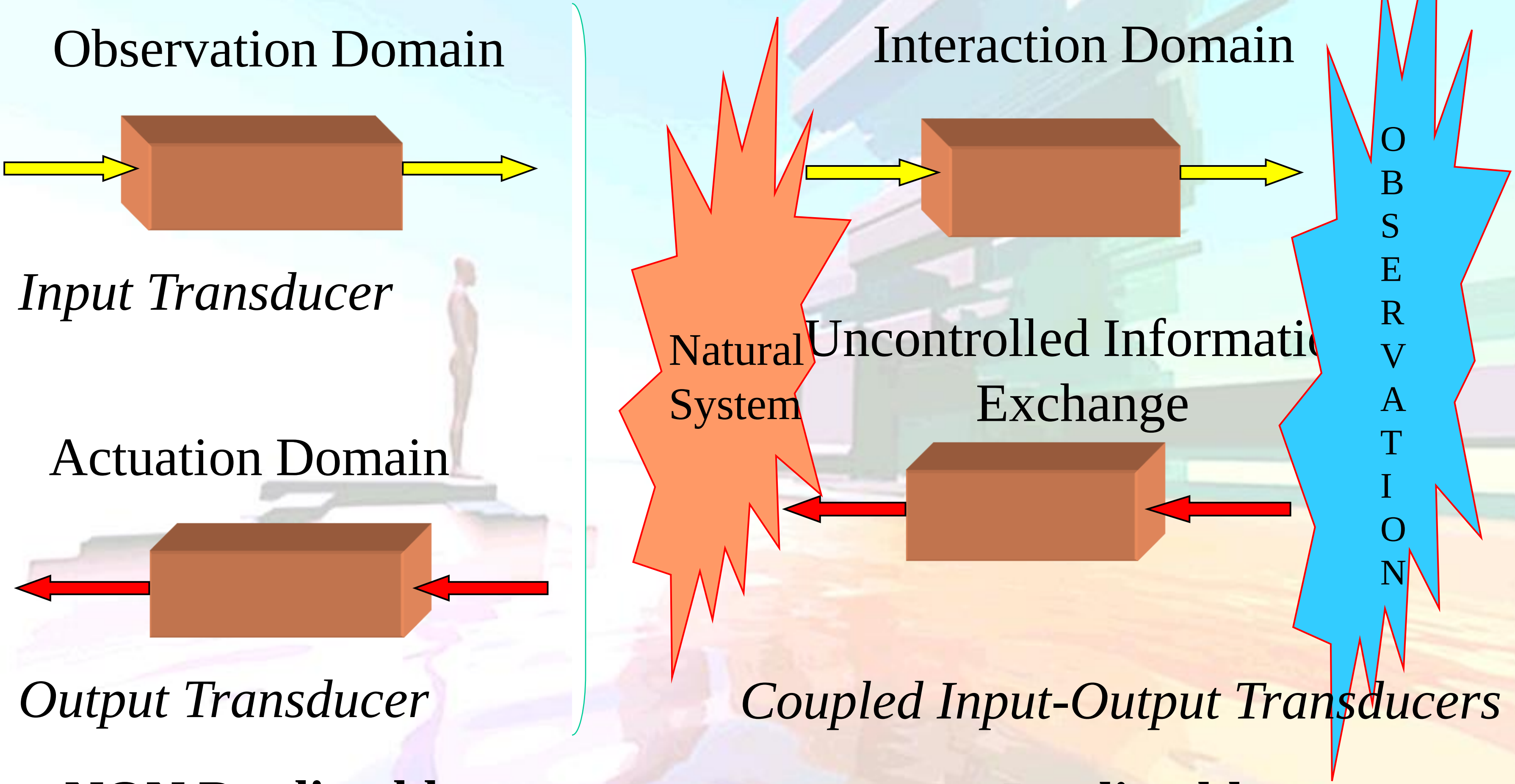
Experimental Interaction Domain



Coupled Input-Output Transducers

5. A Freash Approach to Decision Making (19)

PURE SPECTATOR vs. EGOCENTRIC INTERACTOR



Observation Domain

Input Transducer

Actuation Domain

Output Transducer

Interaction Domain

Natural System

Uncontrolled Informati
Exchange

O B S E R V A T I O N

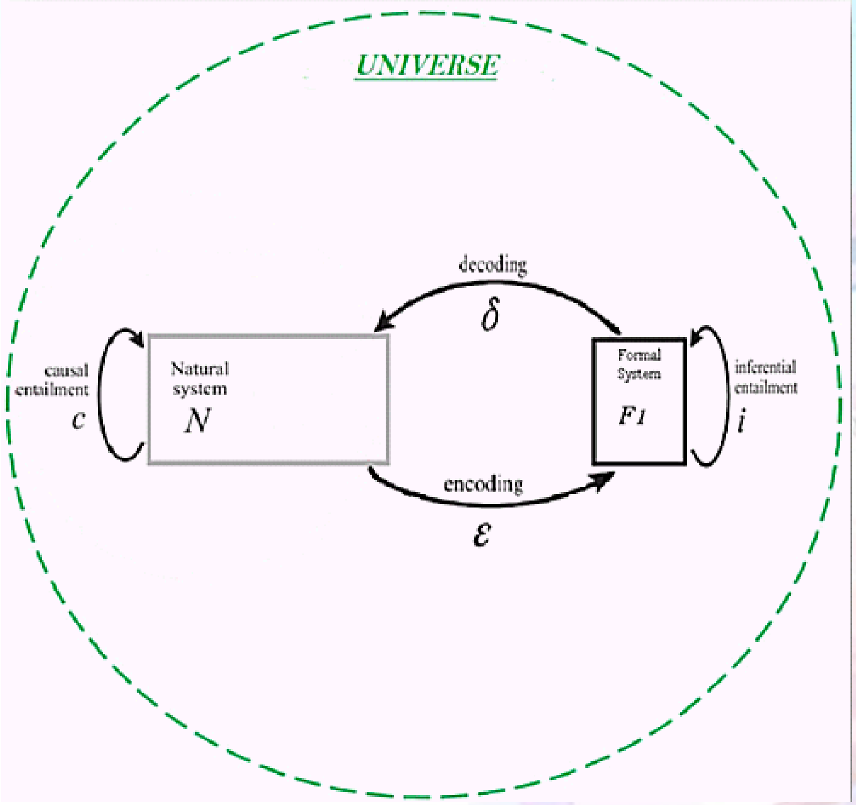
Coupled Input-Output Transducers

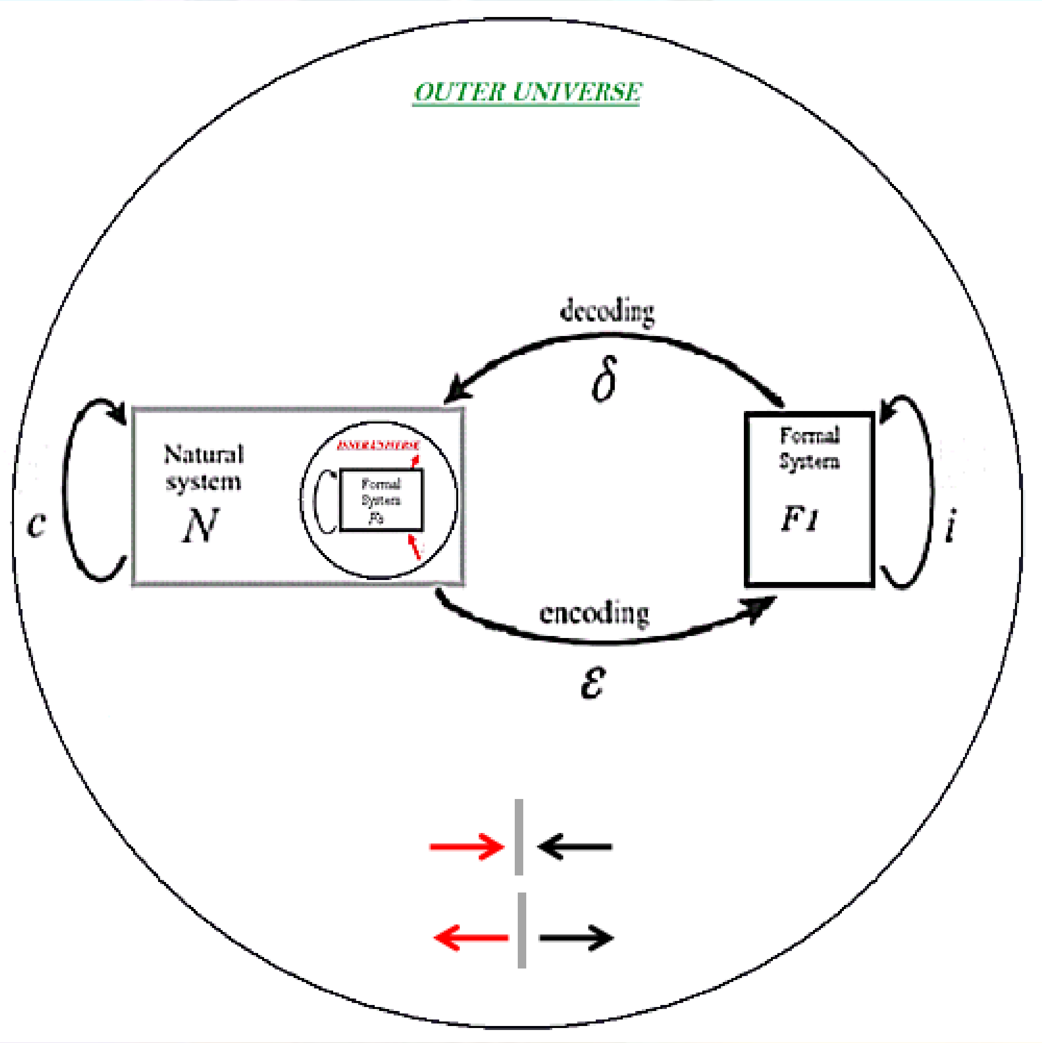
NON Predictable OBSERVATION

Predictable OBSERVATION

5. A Freash Approach to Decision Making (20)

R. Rosen Fundamental Modeling Relation (Reflexive/Reflective)





5. A Freash Approach to Decision Making (21)

R. Rosen Fundamental Modeling Relation (Reflexive/Reflective)

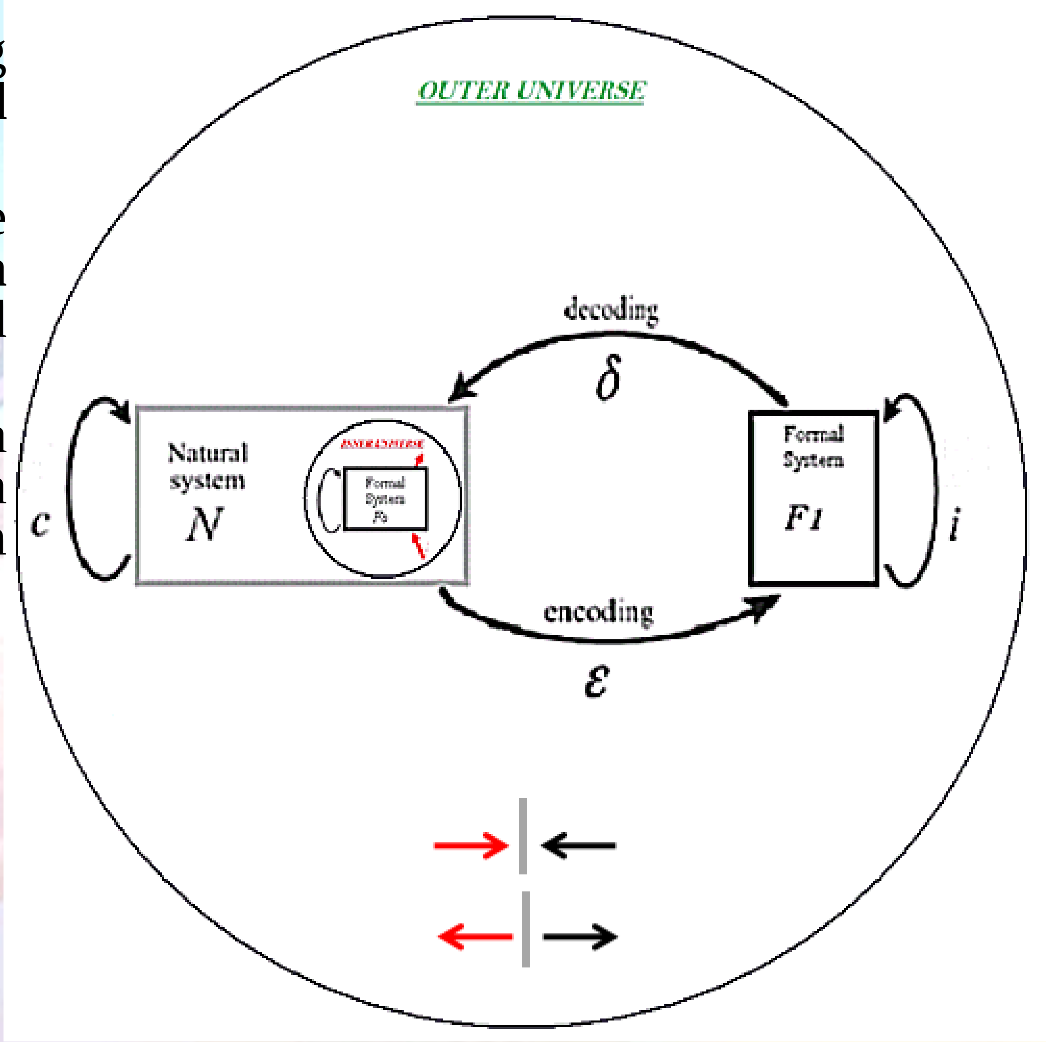
R. Rosen Fundamental Modeling Relation with **explicit Reflexive and Reflective Representations**.

Immediately, Reflexive and Reflective Representations create **two base system scaling symmetries**: convergent and divergent scaling symmetries.

They allow for the correspondence of a **Inner Universe** representation to an **Outer Universe** representation, both linked by the **Kelvin Transform**.

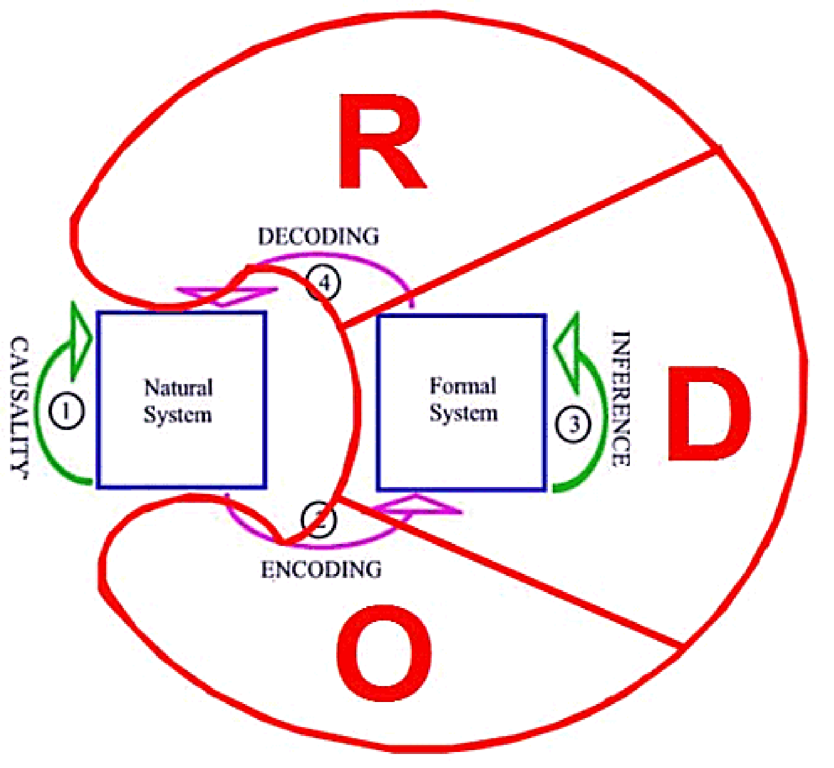
Convergent Scaling: →|←

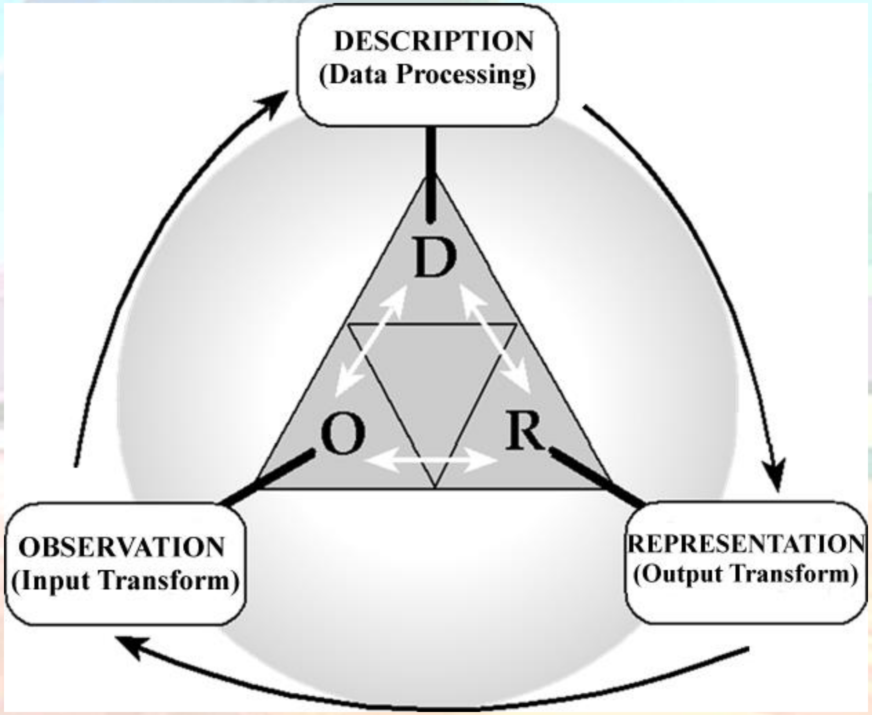
Divergent Scaling: ←|→



5. A Freash Approach to Decision Making (22)

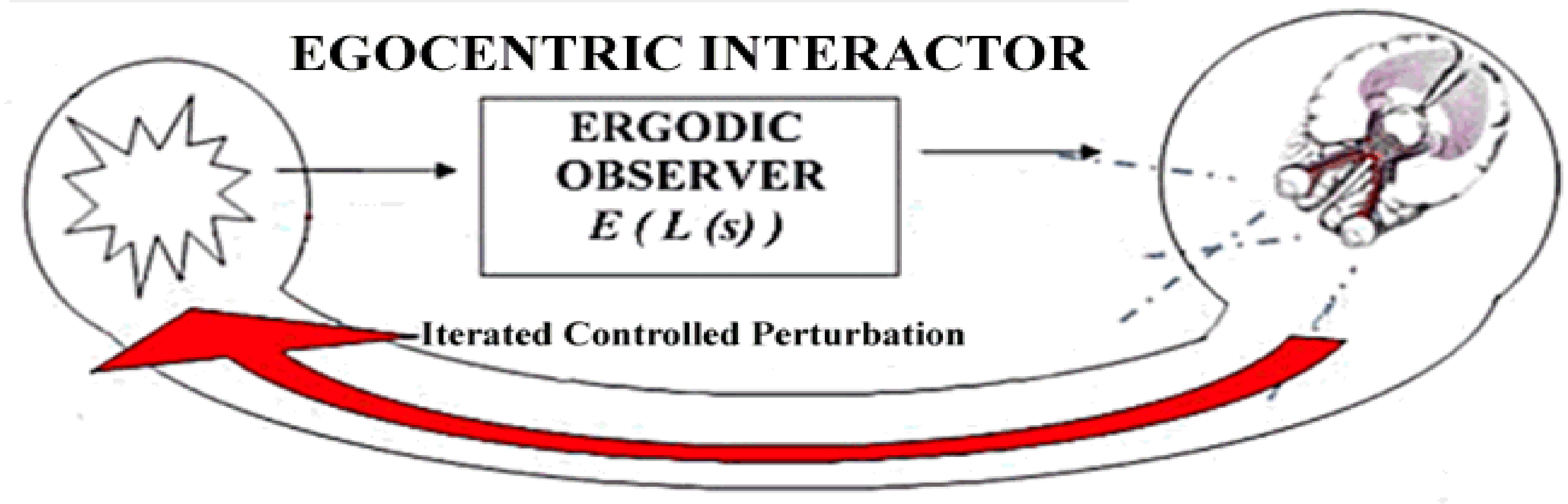
From Rosen Modeling Relation to ODR Recursive Model

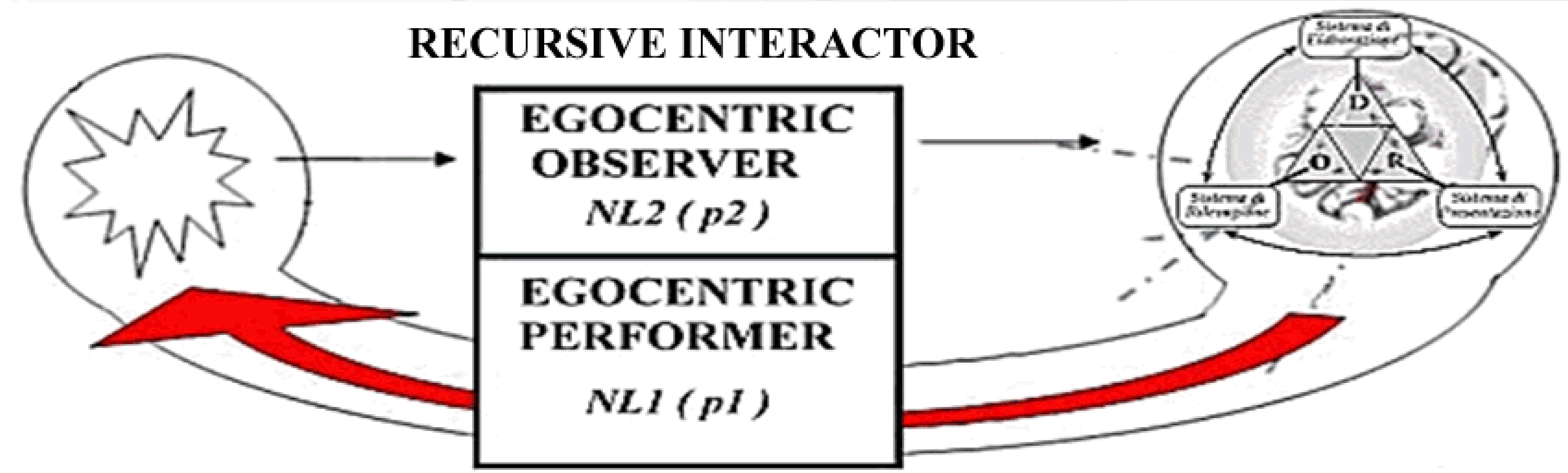




5. A Freash Approach to Decision Making (23)

From EGOCENTRIC to RECURSIVE INTERACTOR

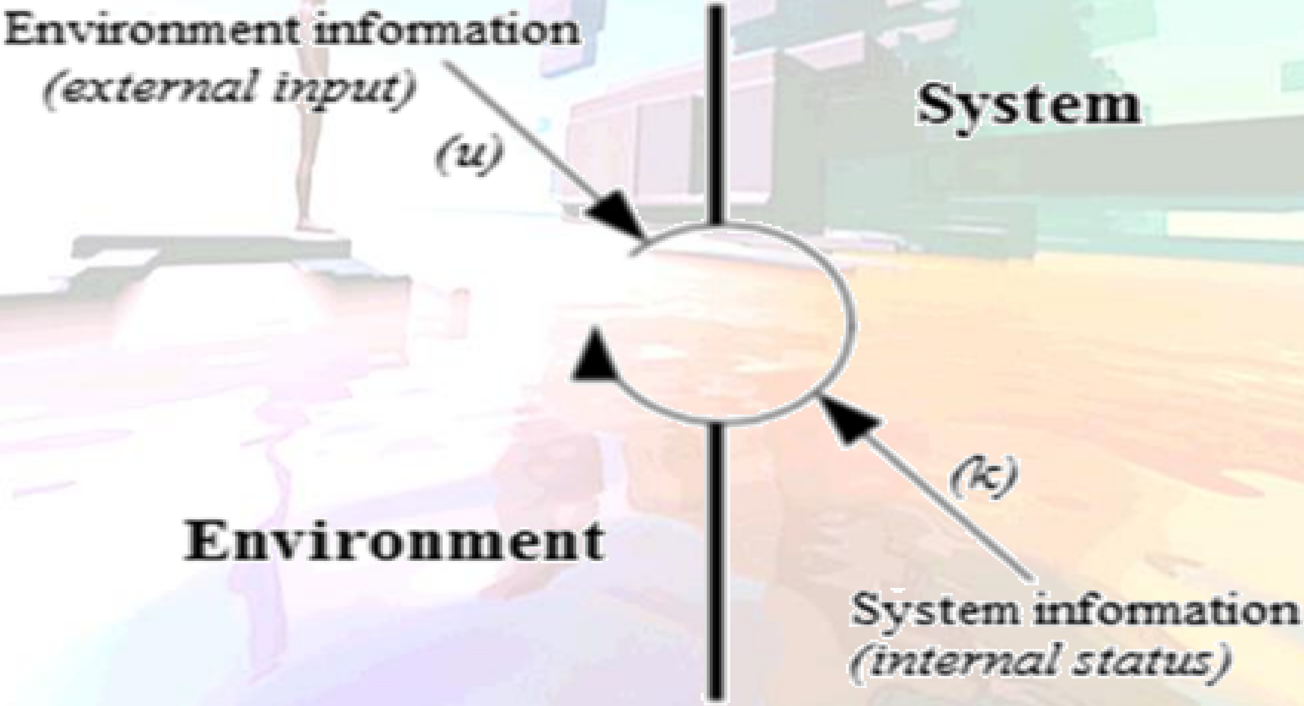




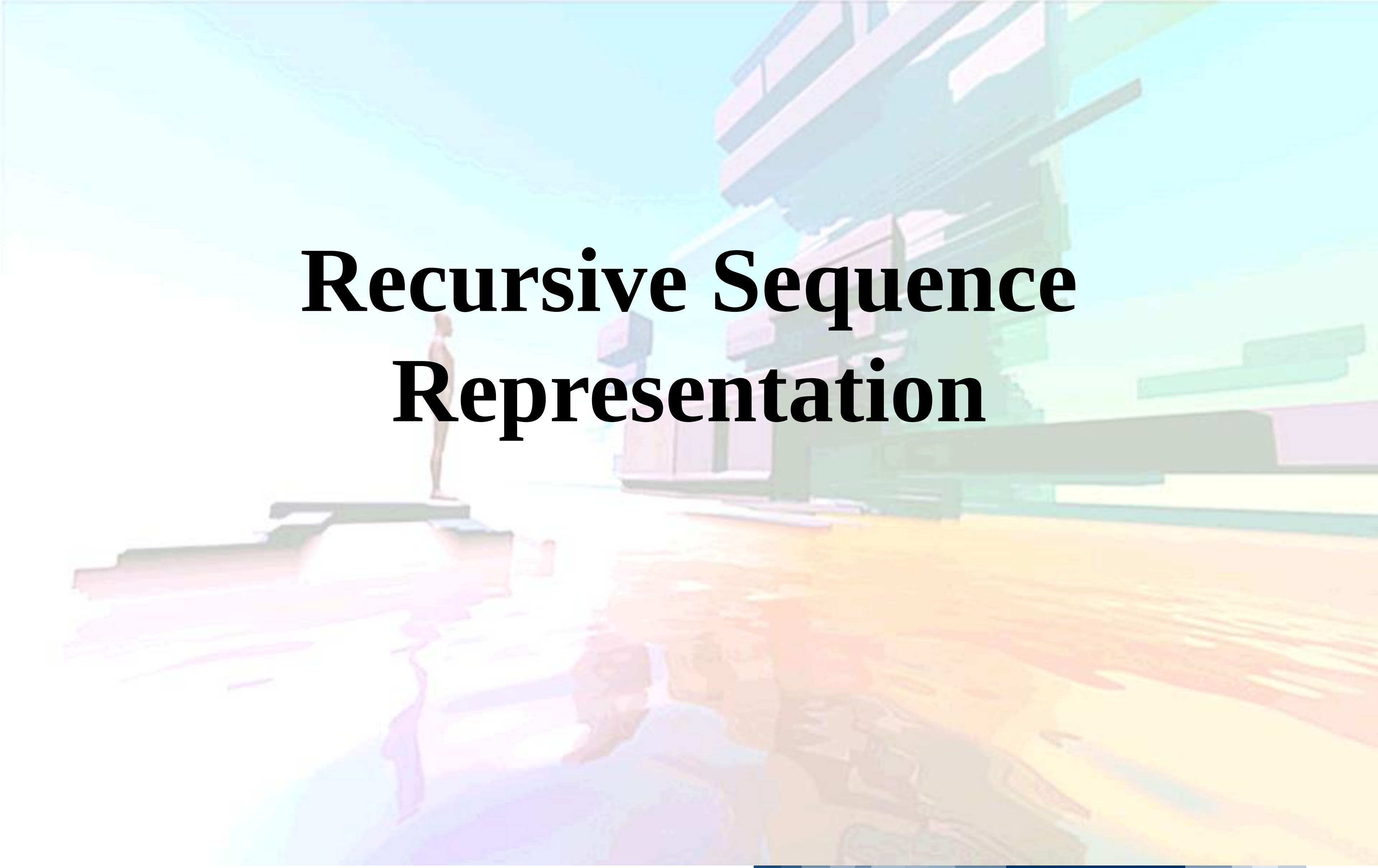
5. A Freash Approach to Decision Making (24)

System Input Information Aggregation

Our main idea is **binding known information to the unknown one.** Then, System Interaction by Recursive Sequencing allows for aggregating **Environment External Input (*u*)** with **Internal System Control Status (*k*).**



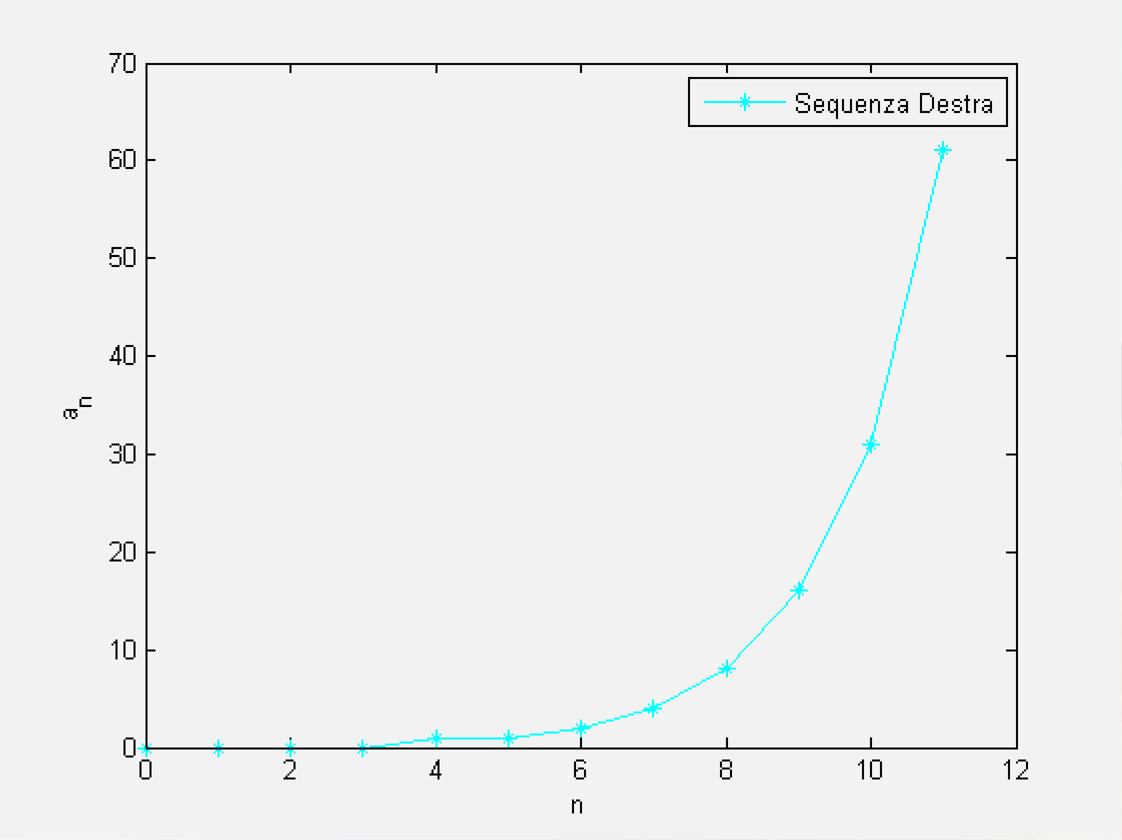
5. A Freash Approach to Decision Making (25)



Recursive Sequence Representation

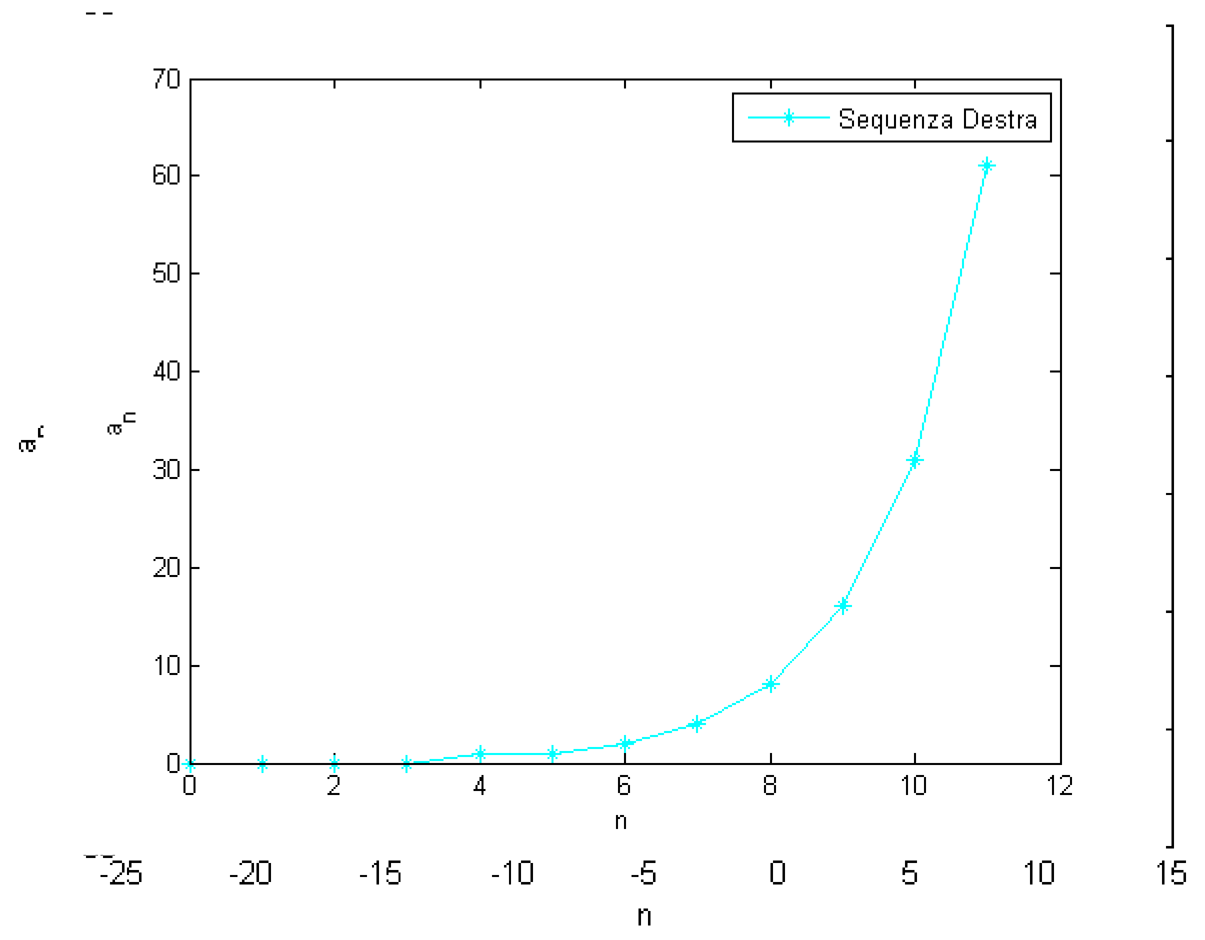
5. A Freash Approach to Decision Making (26)

As a recursive sequence simple example, let us take into consideration the result of a fifth order **LTR** recurrence relation (for n = 0, 1, 2, …, ∞) as a dynamical system trajectory, depicted in the following figure:



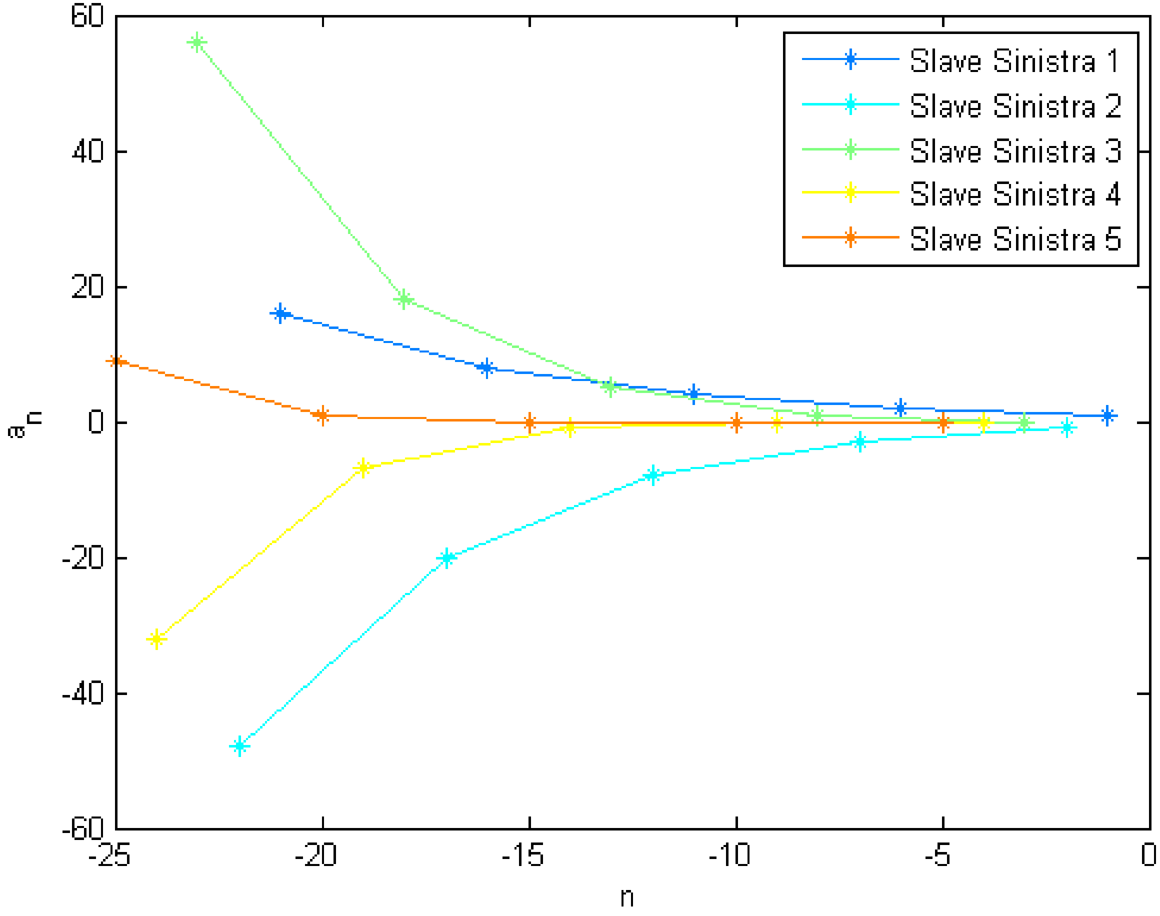
5. A Freash Approach to Decision Making (27)

Now, **according to CICT**, it is possible to get a **unique RTL function extension**, as reported below, offering a divergent oscillating function, apparently difficult to get any immediate interpretation.

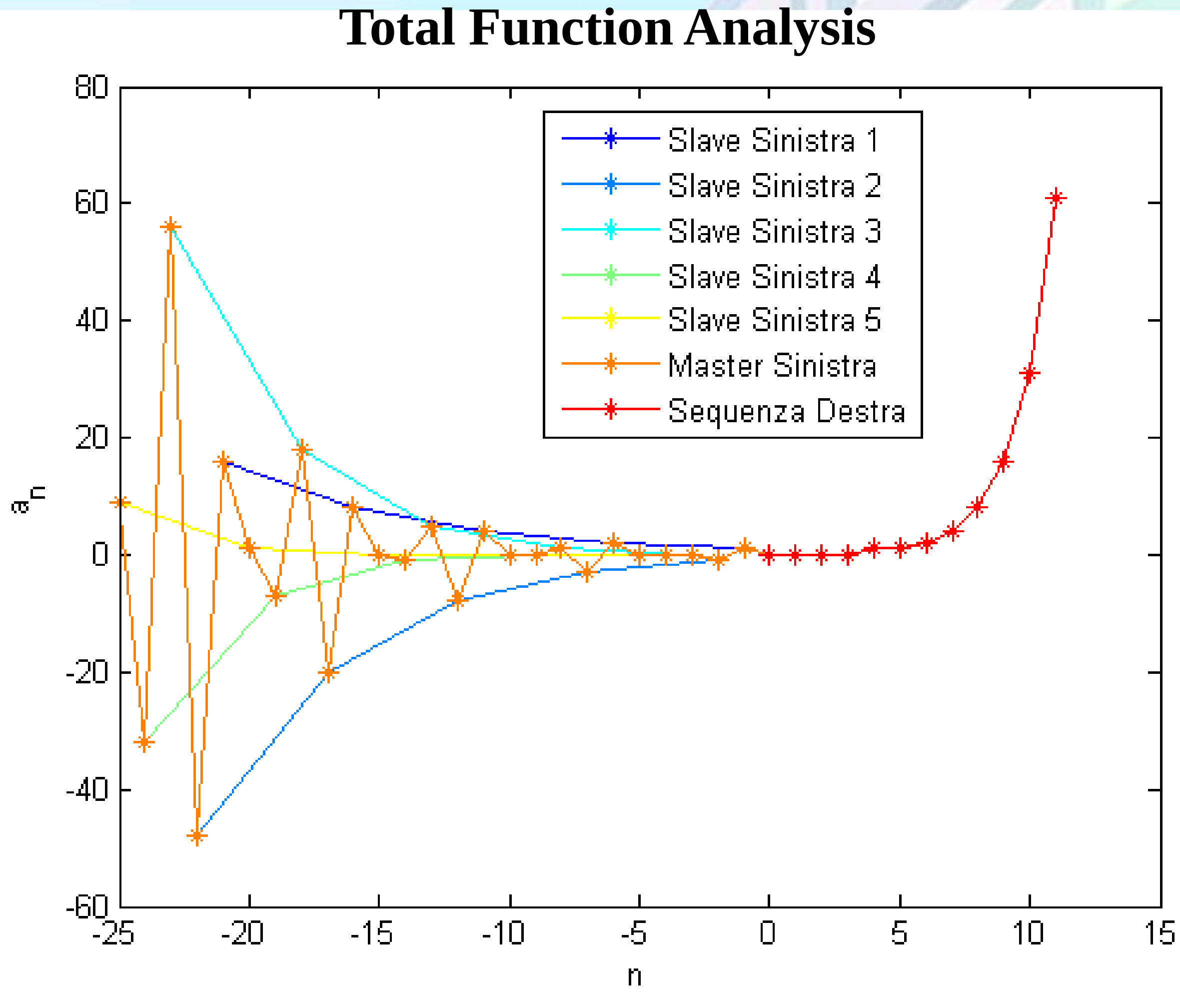


5. A Freash Approach to Decision Making (28)

As a matter of fact, the divergent oscillating function is the apparently uncoherent overall result of five concealed coherently arranged exponential subprocesses.



5. A Freash Approach to Decision Making (29)



So, even previously assumed simple function should be more carefully studied by a system dynamics point of view.

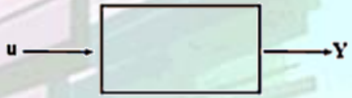
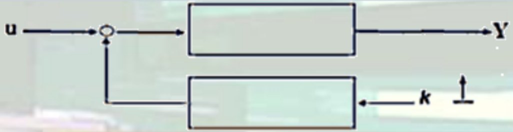
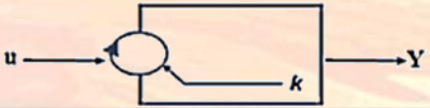
5. A Freash Approach to Decision Making (30)

A Five-Level Cybernetics Framework

- **ZERO (Clausius):** Ideal, closed system, **totally isolated open-loop system**.
- **ONE (Wiener):** "**Self-steering**" is assumed to be **isolated from the act of observation** and negative feedback functions as part of a mechanical process to maintain homeostasis.
- **TWO (von Foerster):** The process of "self-steering" is now understood **to be affected by observer/s**, but the related mathematical modeling is insufficiently complex to encourage new values emerge. Nevertheless, it is understood that **Positive and Negative Feedback can lead to morphogenesis intuitively**.
- **THREE (Bateson):** The process is understood as an interaction that can affect/be affected by **many observers**, but it does not address what this means for the "social" response-ability of the single participant observer. Articulated values emerge.
- **FOUR (Rosen):** Multiple realities emerge by the freedom of choice of the **creative observer** that determines the outcome for both the system and the observer. This puts demands on the self-awareness of the observer, and response-ability for/in action.

5. A Freash Approach to Decision Making (31)

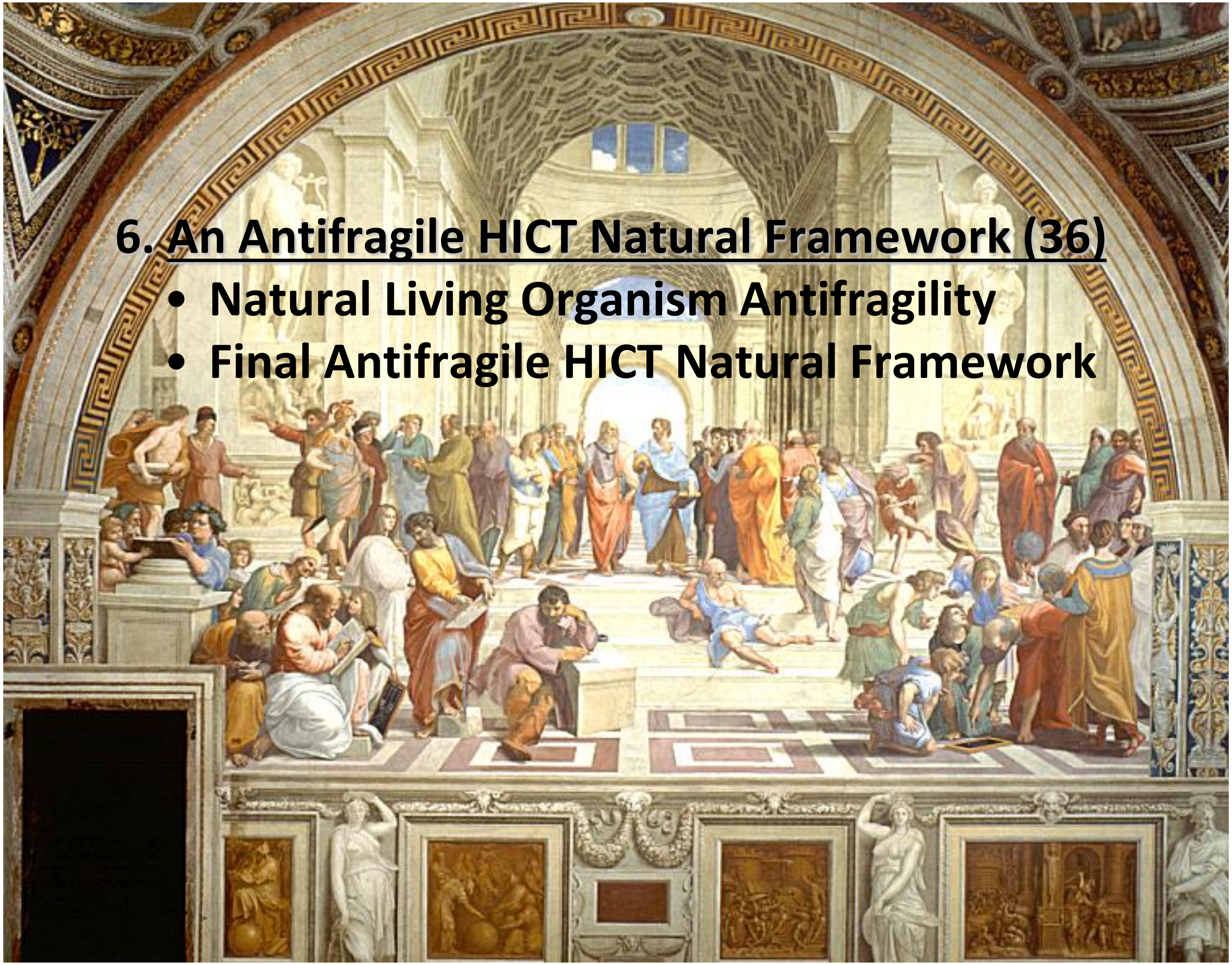
Our final post-Bertalanffy Systemics Healthcare Framework

BIOMEDICAL CYBERNETIC ORDER	INTERACTION STYLE	GRAPHIC SYMBOL
Zero	Pure Spectator	
First	Ergodic Observer	
Second	Pulsed Egocentric Interactor	
Third	Iterated Egocentric Interactor	
Fourth	Recursive Interactor	

This **new awareness** can guide any quantum leap to more convenient future **post-human cybernetics approaches** in science and technology.

(R.A. Fiorini, 2011)

6. An Antifragile HICT Natural Framework (00)



6. An Antifragile HICT Natural Framework (36)

- Natural Living Organism Antifragility
- Final Antifragile HICT Natural Framework

6. An Antifragile HICT Natural Framework (01)

Natural Living Organism Antifragility

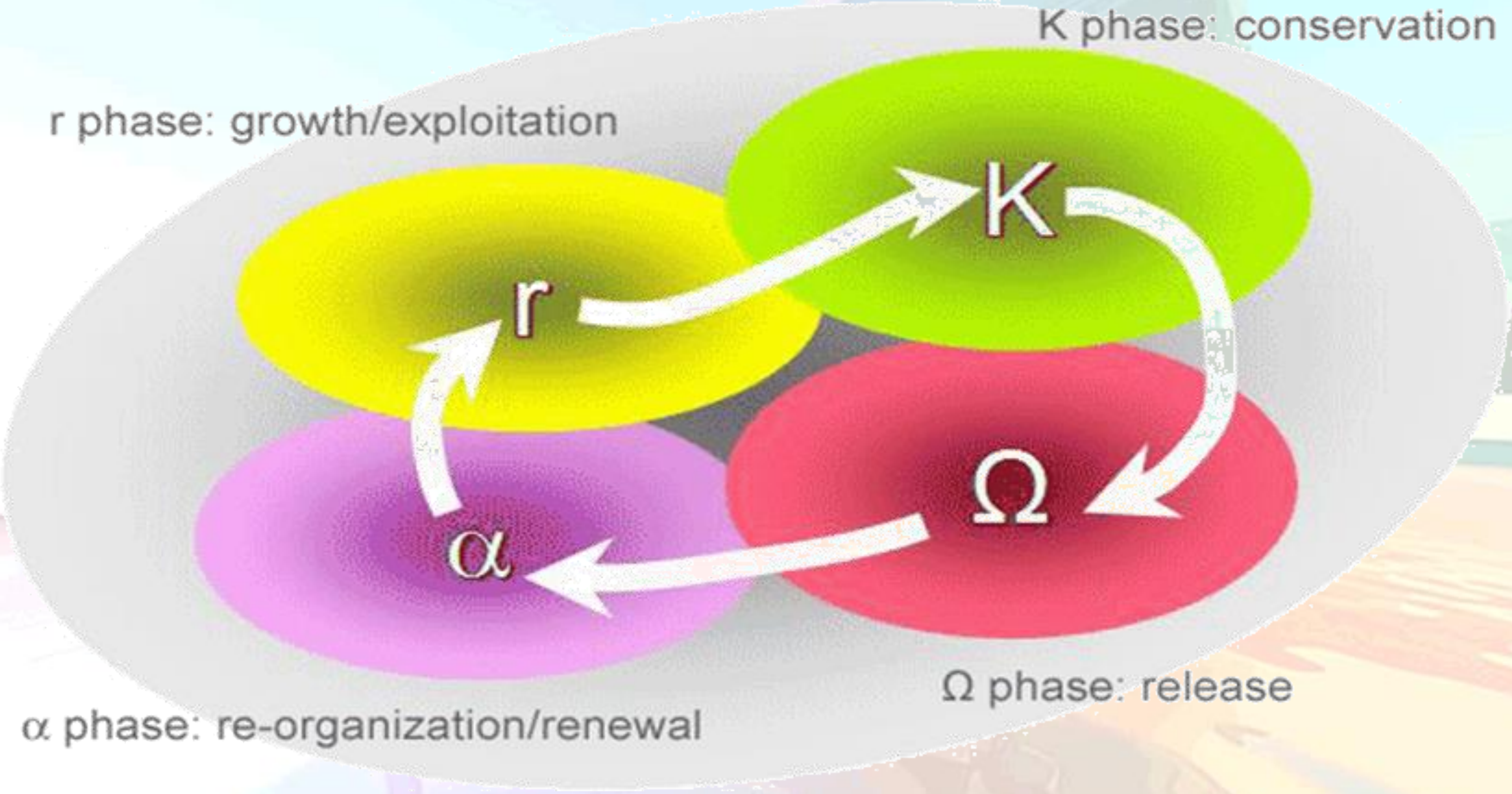
Canadian ecologist **Crawford Stanley (Buzz) Holling** (1930-) has introduced important ideas in the application of ecology and evolution, including **resilience**, **adaptive management**, **the adaptive cycle,** and **panarchy**.

Panarchy is a conceptual term first coined by the Belgian philosopher, economist, and botanist **Paul Emile de Puydt** (1810–1891) in **1860**, referring to **a specific form of governance** (Panarchy) that would encompass (pan-) all others.(de Puydt, 1860) Here, "**Panarchy**" refers to the framework for conceptualizing **the type of coupled human-environment systems** described in **Gunderson & Holling** (2002) and more briefly, with some changes, in **Walker et al.** (2006). This framework may be divided into two parts, as "the resilience conceptual framework" and "the adaptive cycle metaphor."(Gotts, 2007)

6. An Antifragile HICT Natural Framework (02)

Environment Interface According to The Adaptive Cycle Metaphor

Holling and Gotts (2002, 2007)

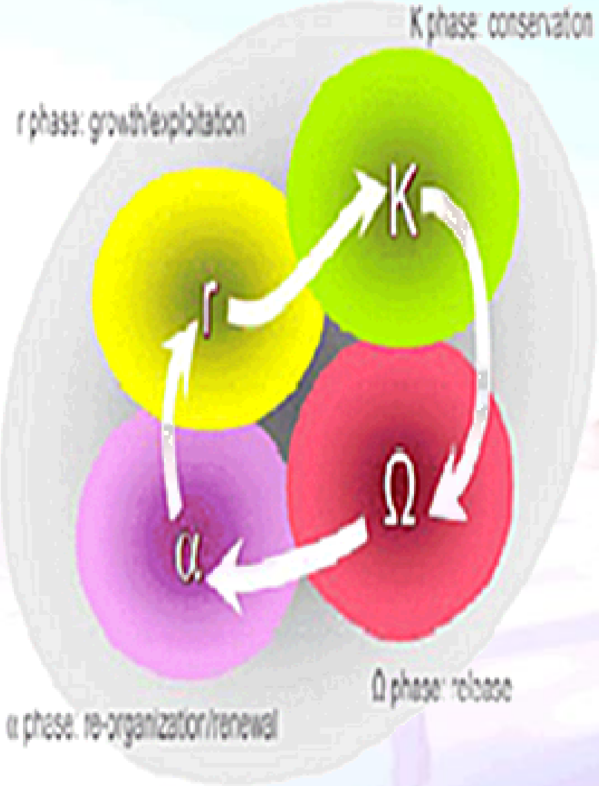


6. An Antifragile HICT Natural Framework (03)

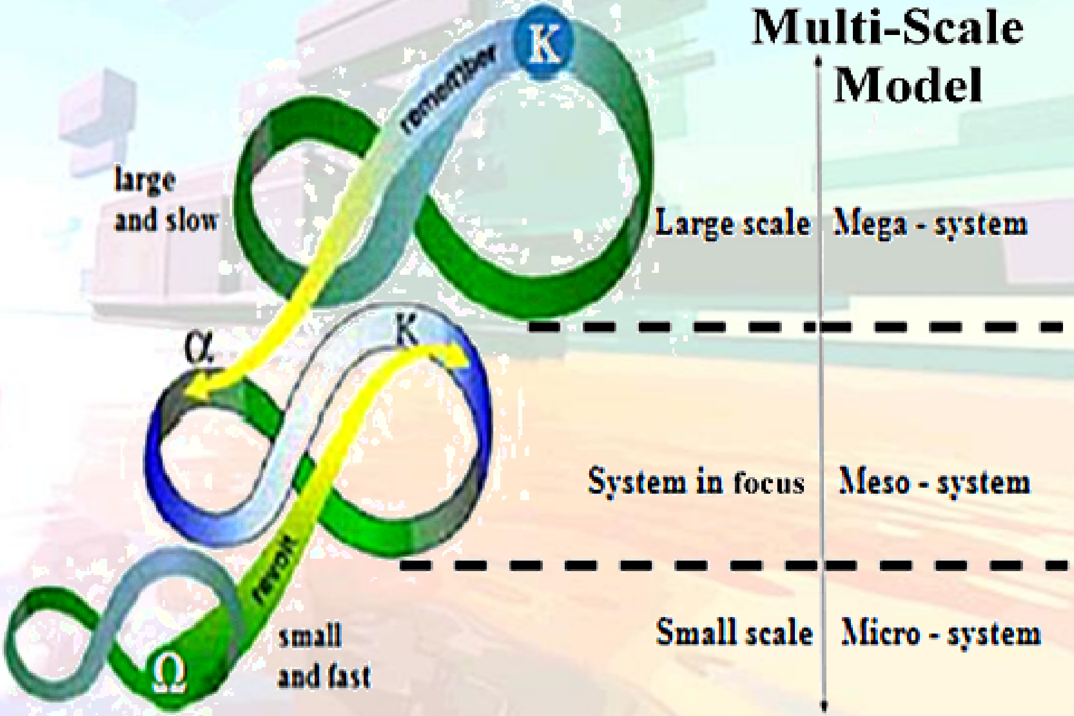
System Resilience from Multi-Scale Modeling

Gunderson & Holling and Walker (2002, 2006)

Adaptive Cycle Metaphor



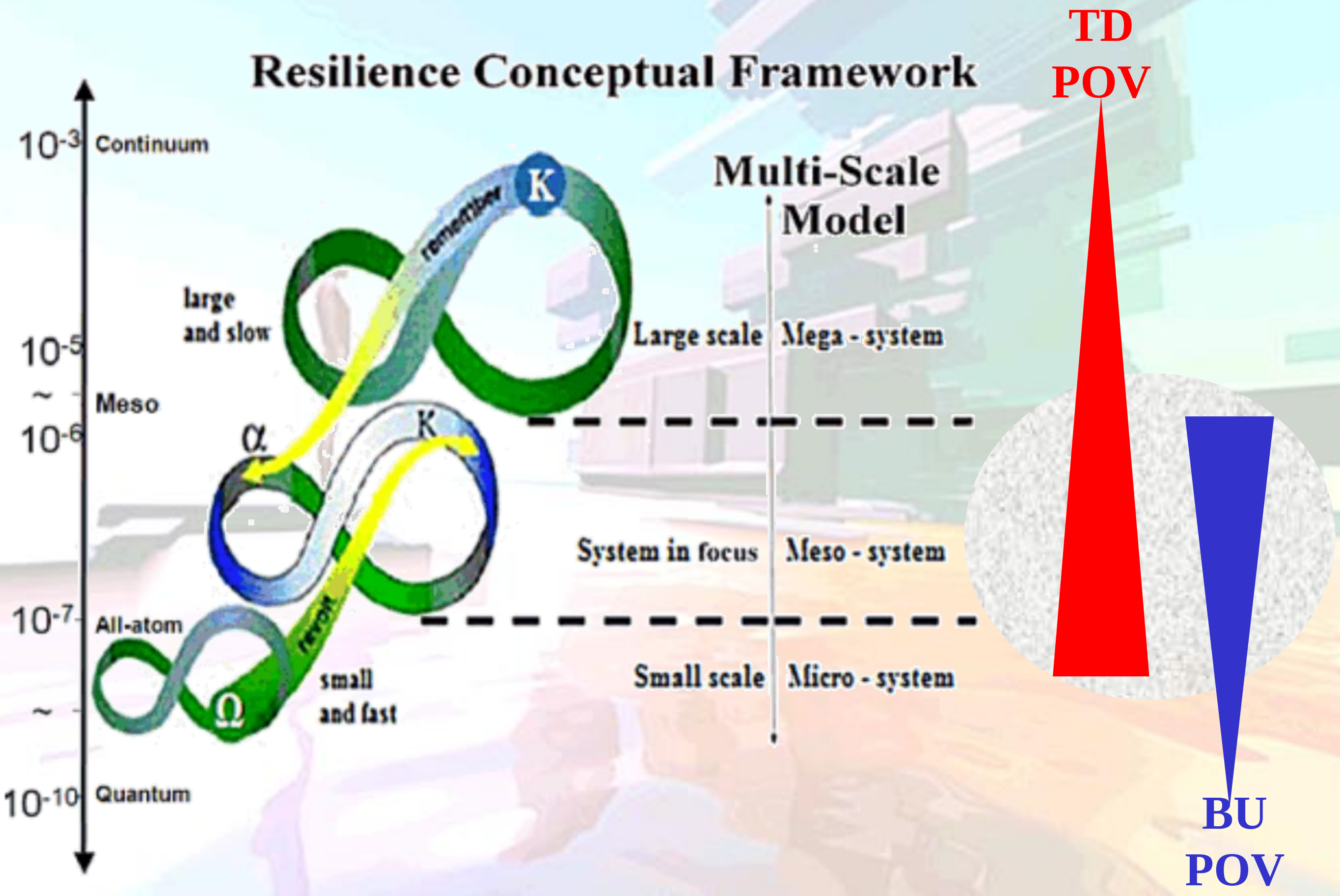
Resilience Conceptual Framework



6. An Antifragile HICT Natural Framework (04)

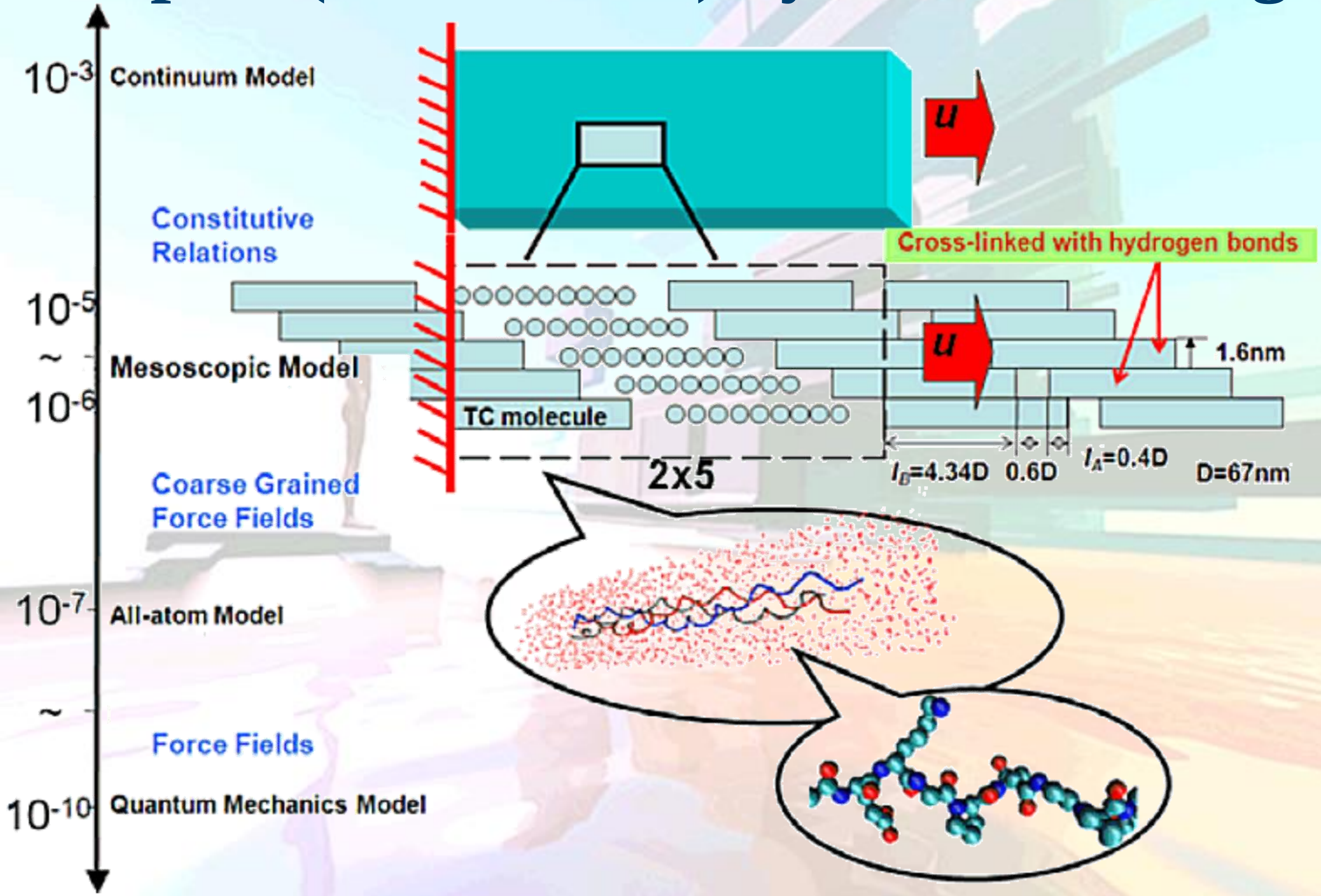
System Resilience from Multi-Scale Modeling

Gunderson & Holling and Walker (2002, 2006)



6. An Antifragile HICT Natural Framework (05)

Complex (Multi-Scale) System Modeling



(R.A. Fiorini, 2015)

6. An Antifragile HICT Natural Framework (06)

Ontological Uncertainty Management (OUM)

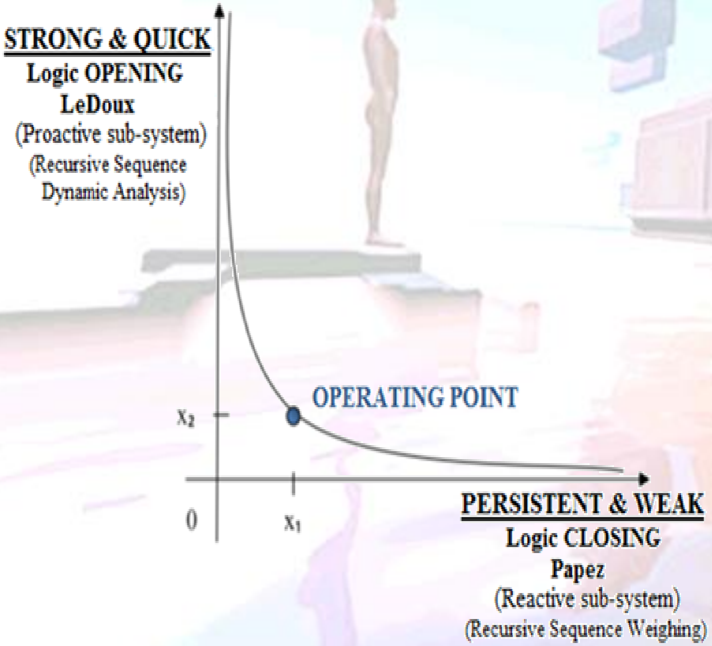
Epistemic and **aleatory (natural) uncertainties** are fixed **neither in space nor in time**. What is aleatory uncertainty in one model can be epistemic uncertainty in another model, at least in part. And what appears to be aleatory uncertainty at the present time may be cast, at least in part, into epistemic uncertainty at a later date.

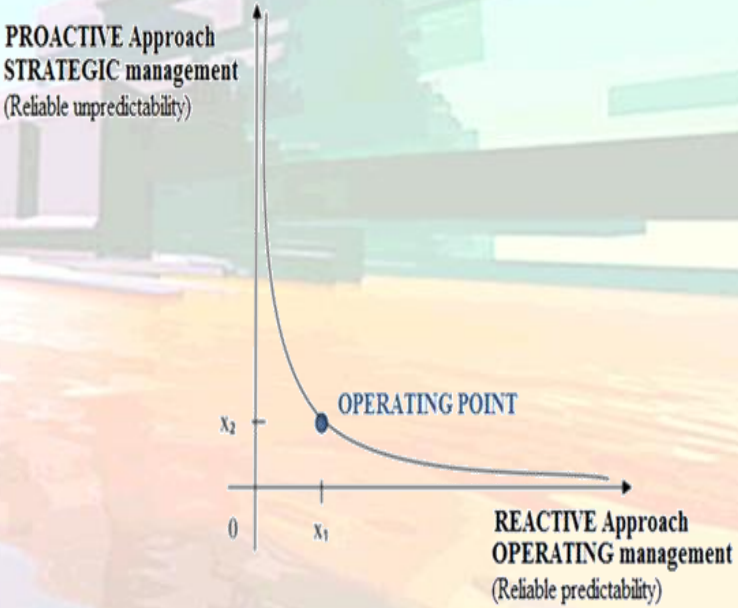
It is much better to think about them as **an irreducible complementary ideal asymptotic dichotomy** only.

6. An Antifragile HICT Natural Framework (07)

Ontological Uncertainty Management (OUM)

Operating Point can emerge as a **new Trans-disciplinary Reality Level**, based on **an irreducible complementary ideal asymptotic dichotomy:** Two Complementary Irreducible Coupled Computational Subsystems.





6. An Antifragile HICT Natural Framework (08)

Operating Point can emerge as a **new Trans-disciplinary Reality Level**, based on **an irreducible complementary ideal asymptotic dichotomy:** Two Complementary Irreducible Coupled Management Subsystems.

For **OPERATING Management (REACTIVE Approach) Subsystem**, we can choose from different alternatives offered by literature, like Deming's PDCA Cycle,(Taiichi Ohno, 2012) Discovery-Driven Planning,(Gunther McGrath & MacMillan, 1995), etc…

For **STRATEGIC Management (Proactive Approach) Subsystem,** we can choose from different alternatives offered by literature, like Boyd OODA Cycle,(Boyd, 1987; Osinga, 2006) Theory-Focused Planning,(Govindarajan & Trimble, 2004), etc…

To get a specific example for this presentation, as **OPERATING Management (REACTIVE Approach) Subsystem**, we choose **Deming PDCA Cycle**, and as **STRATEGIC Management (Proactive Approach) Subsystem,** we use **Boyd's OODA Cycle.**

6. An Antifragile HICT Natural Framework (09)

HICT Natural Framework System Example

Environment Interface Planning:

Holling's Cycle (r – K – Omega - Alpha).

Operational Management Planning:

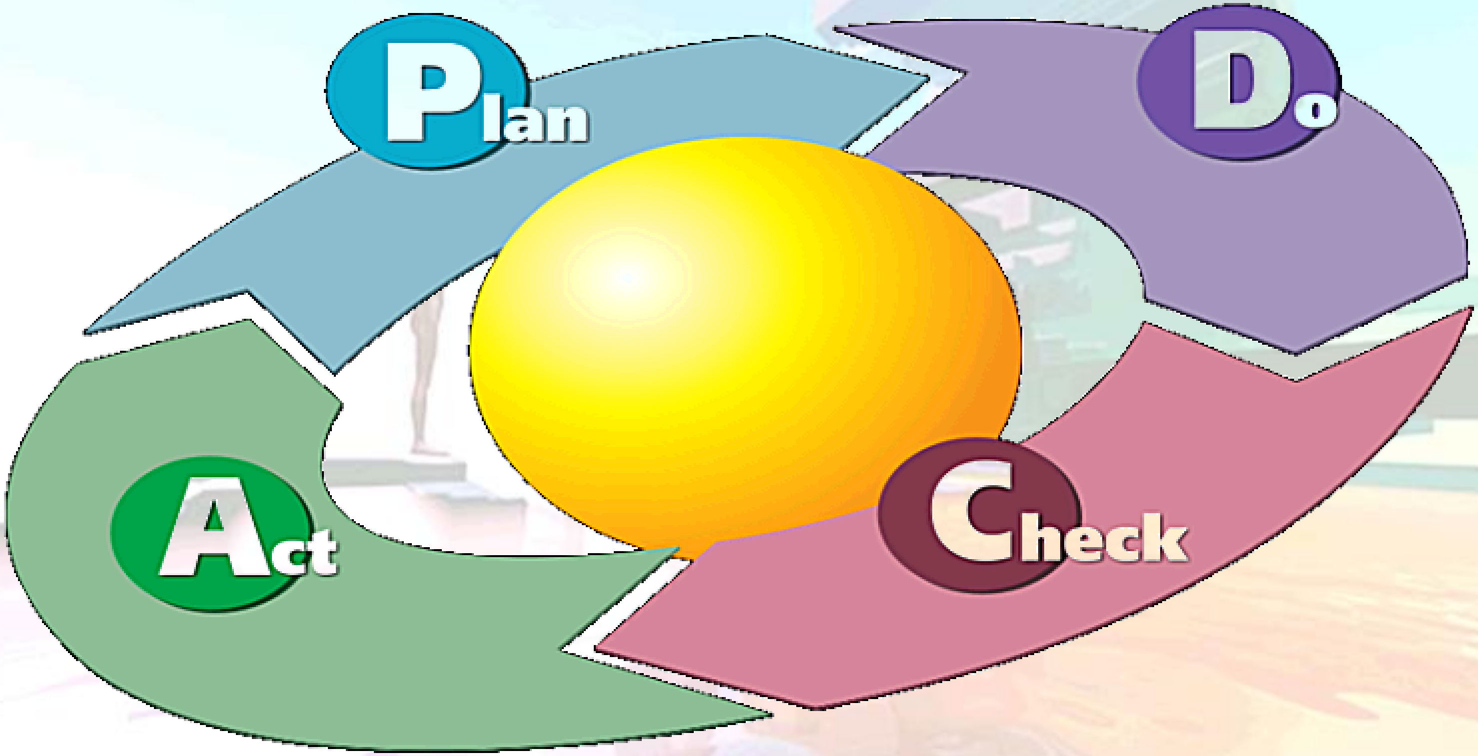
Deming's Cycle (P – D – C - A).

Strategic Management Planning:

Boyd's Cycle (O – O – D - A).

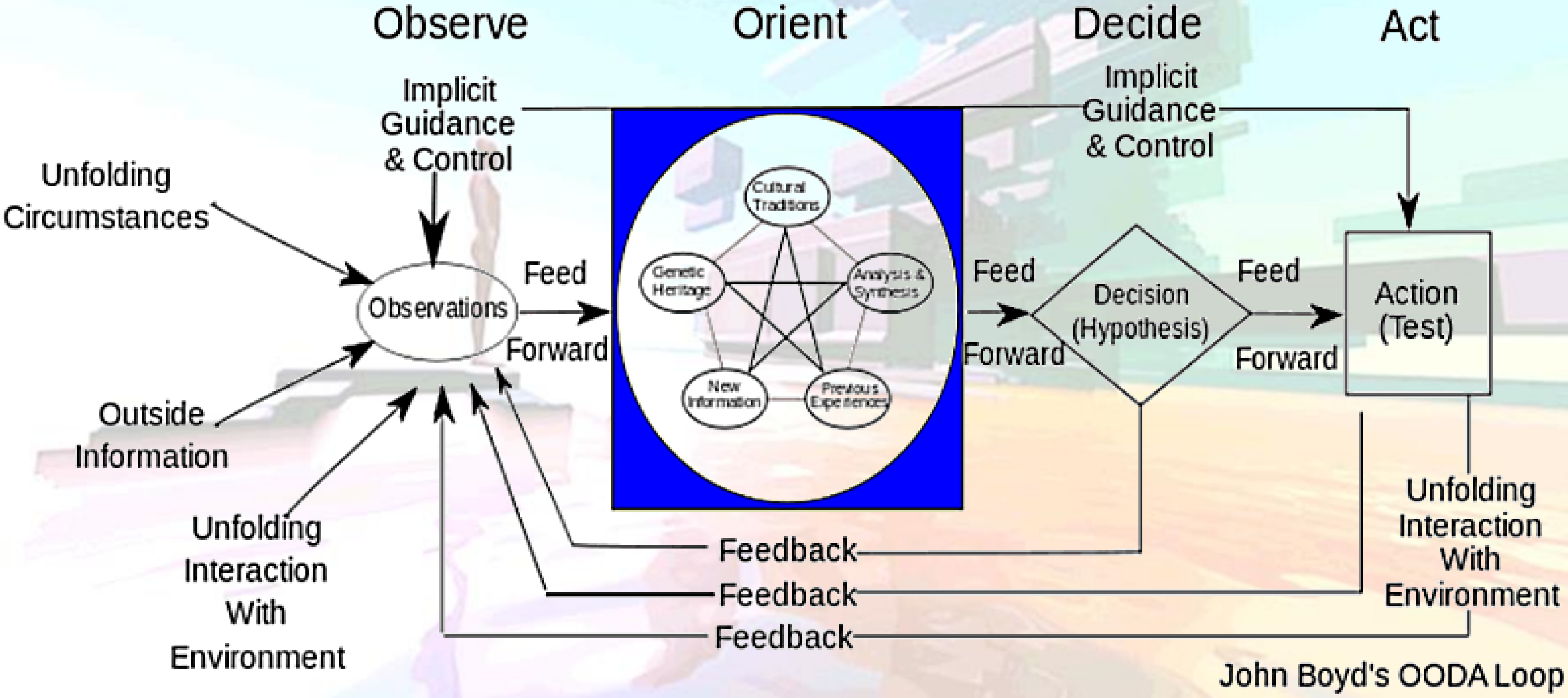
6. An Antifragile HICT Natural Framework (10)

Operational Management Planning (Deming's Cycle)



6. An Antifragile HICT Natural Framework (11)

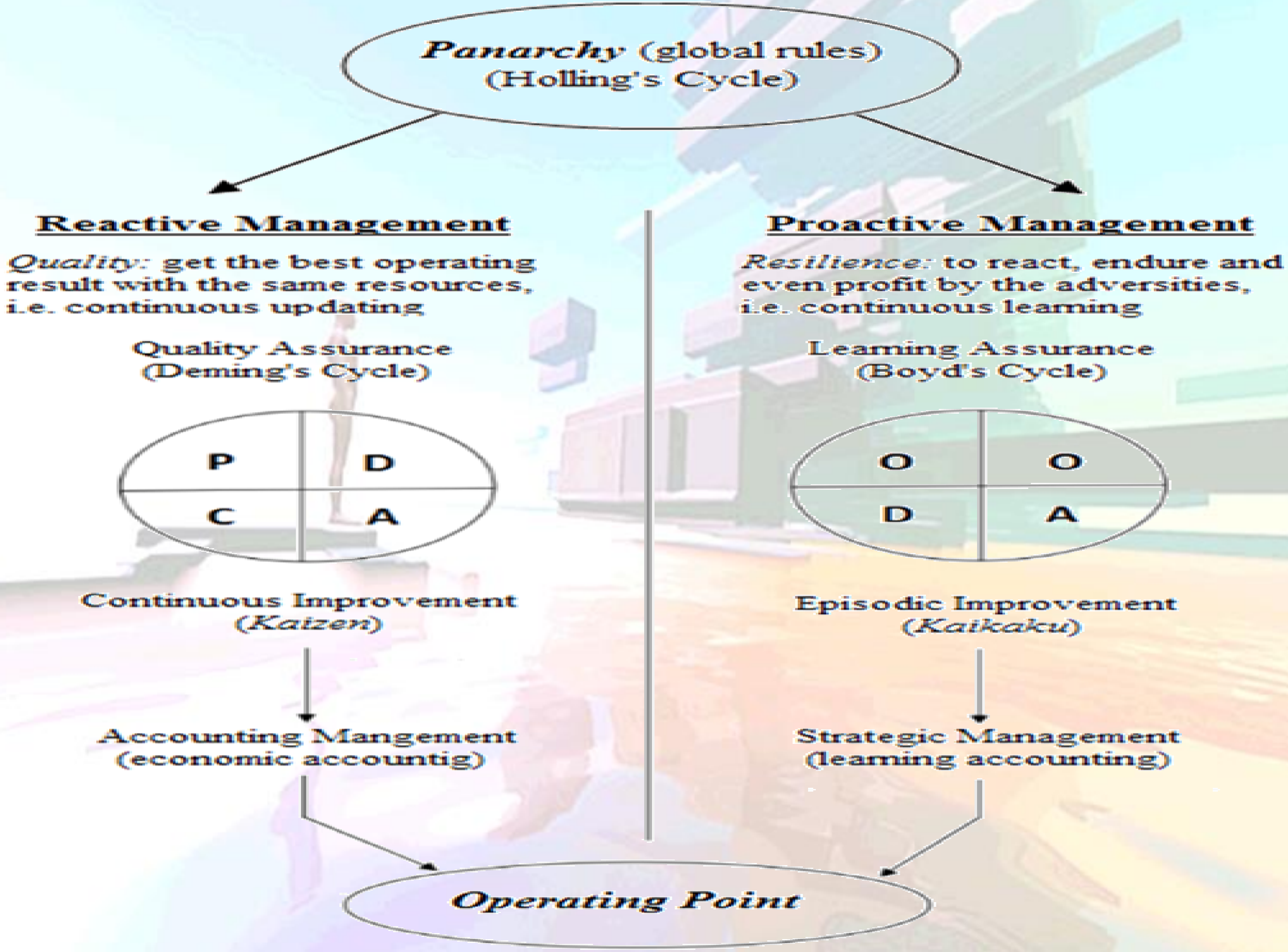
Strategic Management Planning (Boyd's Cycle)



John Boyd's OODA Loop

6. An Antifragile HICT Natural Framework (12)

Final Antifragile HICT Natural Framework



Panarchy (global rules)
(Holling's Cycle)

Reactive Management

Quality: get the best operating result with the same resources, i.e. continuous updating

Quality Assurance
(Deming's Cycle)

P D
C A

Continuous Improvement
(*Kaizen*)

Accounting Mangement
(economic accountig)

Proactive Management

Resilience: to react, endure and even profit by the adversities, i.e. continuous learning

Learning Assurance
(Boyd's Cycle)

O O
D A

Episodic Improvement
(*Kaikaku*)

Strategic Management
(learning accounting)

Operating Point

6. An Antifragile HICT Natural Framework (13)

The final result is **CICT new awareness of a hyperbolic framework of coded heterogeneous hyperbolic structures**, underlying the familiar Euclidean surface representation system.

CICT emerged from the study of the geometrical structure of a discrete manifold of ordered hyperbolic substructures, coded by formal power series, **under the criterion of evolutive structural invariance at arbitrary precision**.

It defines an **arbitrary-scaling discrete Riemannian manifold uniquely**, under HG metric, that, **for arbitrary finite point accuracy *L* going to infinity** (exact solution theoretically), **is homeomorphic to traditional IG Riemannian manifold**.

In other words, **HG can describe a projective relativistic geometry directly hardwired into elementary arithmetic long division remainder sequences**, offering many competitive computational advantages over traditional Euclidean approach.

6. An Antifragile HICT Natural Framework (14)

It turns out that, while free generator exponentially growing sequences can be divergent or convergent, **their closures can be defined in terms of polynomials**.

In this way, even simple traditional scalar moduli can emerge out as an approximation from sequences of phased generators.

CICT can help to reach a unified vision to many current mathematical, physics and biophysics problems and **to find their optimized solutions** quite easily. Expected impacts are multifarious and quite articulated at different system scale.

One of the first practical result was that usual elementary arithmetic long division remainder sequences can be even interpreted as combinatorially optimized coding sequences for hyperbolic geometric structures, as point on a discrete Riemannian manifold, under HG metric, **indistinguishable from traditional random noise sources by classical Shannon entropy, and contemporary most advanced instrumentation**.

6. An Antifragile HICT Natural Framework (15)

Formal Power Series Representation

6. An Antifragile HICT Natural Framework (16)

The **CICT fundamental relationship** that ties together numeric body information of divergent and convergent monotonic power series in any base (in this case decimal, with no loss of generality), with ***D* ending by digit 9**, is given by the following CICT fundamental LTR-RTL correspondence equation:

$$\frac{1}{D} = \sum_{k=0}^{\infty} \frac{1}{10^W}\left(\frac{\overline{D}}{10^W}\right)^k \Rightarrow \ldots \Leftarrow Div\left(\frac{1}{D}\right) = \sum_{k=0}^{\infty}(D+1)^k \qquad \text{Eq.(7)}$$

where $\overline{D}$ is the additive 10^W complement of D, i.e. $\overline{D} = (10^W - D)$, W is the word representation precision length of the denominator D and "Div" means "Divergence of".

Further generalizations related to ***D* ending by digit 1 or 3 or 7 are straightforward**.

Increasing the level of representation accuracy, the total number of allowed convergent paths to 1/*D*, as monotonic power series (as allowed conservative paths), increases accordingly and can be counted exactly, till maximum machine word length and beyond: like **discrete quantum paths denser and denser to one another, towards a never ending "blending quantum continuum,"** by a Top-Down system perspective.

6. An Antifragile HICT Natural Framework (17)

Our knowledge of RFD Q_L and corresponding RFD R_L can allow reversing LTR numeric power convergent sequence to its corresponding RTL numeric power divergent sequence uniquely.

Reversing a convergent sequence into a divergent one and vice-versa is the fundamental property to reach information conservation, i.e. information reversibility.

Eventually, **OECS have strong connection even to classic DFT algorithmic structure for discrete data**, Number-Theoretic Transform (NTT), Laplace and Mellin Transforms.

Coherent precision correspondence leads to transparency, ordering, reversibility, kosmos, simplicity, clarity, and **to algorithmic quantum incomputability on real macroscopic machines**.

6. An Antifragile HICT Natural Framework (18)

Rational representations are able to capture two different type of information at the same time, **modulus** (usual quotient information) and associated **outer phase or intrinsic cycle information** which an **inner phase** can be computed from.

So, **rational information** can be better thought to be **isomorphic to vector information** rather than to usual scalar one, at least.

CICT results have been presented in term of classical power series to show the **close relationships to classical and modern control theory** approaches for **causal continuous-time and discrete-time linear systems.**

Traditional rational number system ***Q*** properties allow **to compute evolutive irreducible co-domain** for every computational operative domain used.

Then, all computational information usually lost by using traditional computational approach can be captured and recovered by a corresponding complementary co-domain, step-by-step. Then **co-domain information can be used to correct any computed result, achieving computational information conservation.**

6. An Antifragile HICT Natural Framework (19)

CICT emerged from the study of the geometrical structure of a discrete manifold of ordered hyperbolic substructures, coded by formal power series, **under the criterion of evolutive structural invariance at arbitrary precision**.

It defines an **arbitrary-scaling discrete Riemannian manifold uniquely**, under HG metric, that, **for arbitrary finite point accuracy level *L* going to infinity** (exact solution theoretically), **is homeomorphic to traditional Information Geometry Riemannian manifold**.

In other words, **HG can describe a projective relativistic geometry directly hardwired into elementary arithmetic long division remainder sequences**, offering many competitive computational advantages over traditional Euclidean approach.

6. An Antifragile HICT Natural Framework (20)

New Vision on Rational Number System

Elementary Arithmetic long **Division** minority components (**Remainders**, R), for long time, **concealed relational knowledge** to their dominant result (**Quotient**, Q), not only can always allow **quotient regeneration** from their remainder information **to any arbitrary precision**, but even to achieve **information conservation** and **coding minimization,** by combinatorial **OECS** (Optimized Exponential Cyclic Sequences), for dynamical systems.

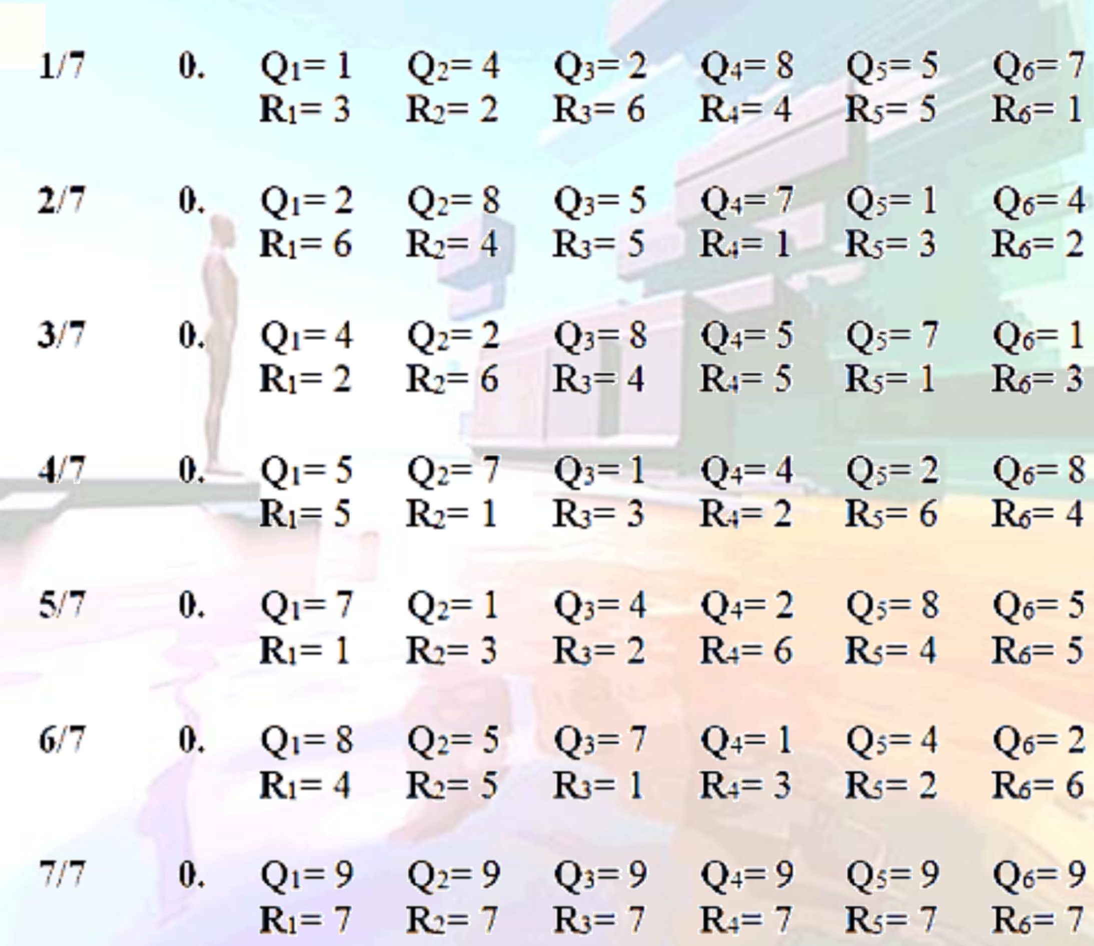
Then traditional ***Q*** **Arithmetic** can be even regarded as a highly sophisticated **open logic**, **powerful and flexible LTR and RTL formal numeric language of languages**, with self-defining consistent word and rule, **starting from elementary generator and relation**.

This **new awareness** can guide the development of successful more convenient algorithm, application and powerful computational system.

(Fiorini & Laguteta, 2013)

6. An Antifragile HICT Natural Framework (21)

SN (Solid Number) Family Group (First Order) Remainder OECS Recursion



1/7	0.	$Q_1= 1$ $R_1= 3$	$Q_2= 4$ $R_2= 2$	$Q_3= 2$ $R_3= 6$	$Q_4= 8$ $R_4= 4$	$Q_5= 5$ $R_5= 5$	$Q_6= 7$ $R_6= 1$
2/7	0.	$Q_1= 2$ $R_1= 6$	$Q_2= 8$ $R_2= 4$	$Q_3= 5$ $R_3= 5$	$Q_4= 7$ $R_4= 1$	$Q_5= 1$ $R_5= 3$	$Q_6= 4$ $R_6= 2$
3/7	0.	$Q_1= 4$ $R_1= 2$	$Q_2= 2$ $R_2= 6$	$Q_3= 8$ $R_3= 4$	$Q_4= 5$ $R_4= 5$	$Q_5= 7$ $R_5= 1$	$Q_6= 1$ $R_6= 3$
4/7	0.	$Q_1= 5$ $R_1= 5$	$Q_2= 7$ $R_2= 1$	$Q_3= 1$ $R_3= 3$	$Q_4= 4$ $R_4= 2$	$Q_5= 2$ $R_5= 6$	$Q_6= 8$ $R_6= 4$
5/7	0.	$Q_1= 7$ $R_1= 1$	$Q_2= 1$ $R_2= 3$	$Q_3= 4$ $R_3= 2$	$Q_4= 2$ $R_4= 6$	$Q_5= 8$ $R_5= 4$	$Q_6= 5$ $R_6= 5$
6/7	0.	$Q_1= 8$ $R_1= 4$	$Q_2= 5$ $R_2= 5$	$Q_3= 7$ $R_3= 1$	$Q_4= 1$ $R_4= 3$	$Q_5= 4$ $R_5= 2$	$Q_6= 2$ $R_6= 6$
7/7	0.	$Q_1= 9$ $R_1= 7$	$Q_2= 9$ $R_2= 7$	$Q_3= 9$ $R_3= 7$	$Q_4= 9$ $R_4= 7$	$Q_5= 9$ $R_5= 7$	$Q_6= 9$ $R_6= 7$

6. An Antifragile HICT Natural Framework (22)

CICT SN (Solid Number) Encoding
True Color Image Example (512 by 768 pixel)

6. An Antifragile HICT Natural Framework (23)

Solid Number (SN) Family Group (first order)
OECS Modular Trajectory Rescaling

(Precision = 10^{-2})

Geometric Series Representation	Compact Representation
$$\frac{1}{07} = \sum_{k=0}^{\infty} \frac{1}{10^2}\left(\frac{93}{10^2}\right)^k ,$$	01(93)
$$\frac{1}{07} = \sum_{k=0}^{\infty} \frac{2}{10^2}\left(\frac{86}{10^2}\right)^k ,$$	02(86)
$$\frac{1}{07} = \sum_{k=0}^{\infty} \frac{3}{10^2}\left(\frac{79}{10^2}\right)^k ,$$	03(79)
$\vdots$	
$$\frac{1}{07} = \sum_{k=0}^{\infty} \frac{14}{10^2}\left(\frac{02}{10^2}\right)^k .$$	14(02)

6. An Antifragile HICT Natural Framework (24)

The Discrete Continuum of Egyptian Fractions

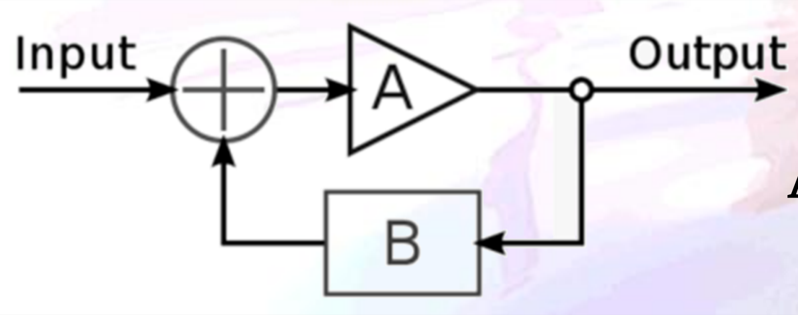
1/(N-1) ← 1/N → 1/(N+1)

Upscale Contiguity Operator

$$\sum_{k=1}^{\infty}\left(\frac{1}{N}\right)^{k}=\frac{1}{N-1}\ ,\ k=1,2,3,\ldots\in N$$

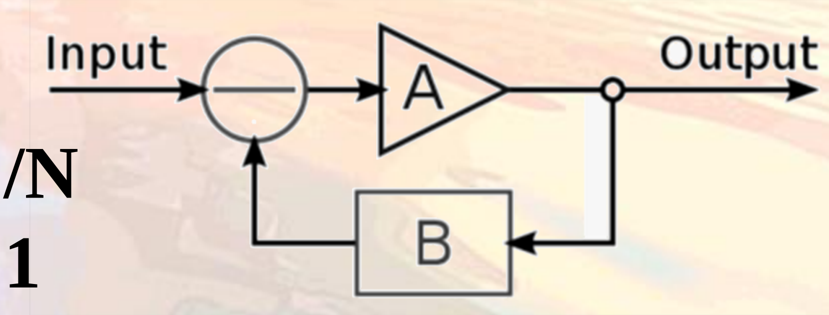
Downscale Contiguity Operator

$$\sum_{k=0}^{\infty}(-1)^{k}\left(\frac{1}{N}\right)^{(k+1)}=\frac{1}{N+1}\ ,\ k=0,1,2,3,\ldots\in N$$



A = 1/N

B = 1



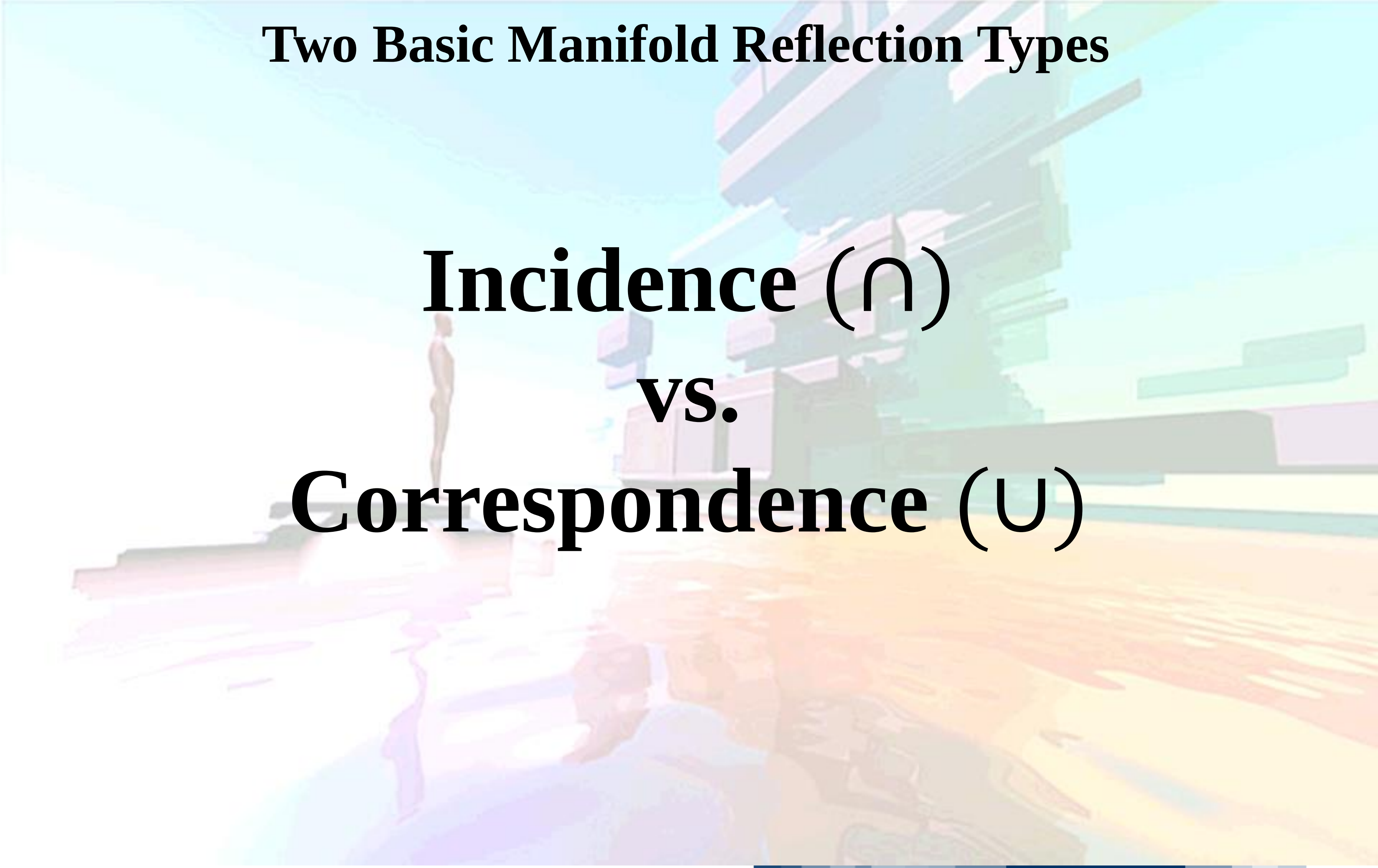
6. An Antifragile HICT Natural Framework (25)

OECS Word Space Example (Precision = 10^{-2})

1/03	1/04	1/05	1/06	1/07	1/08	1/09	1/10	1/11	1/12	1/13	1/14	1/15	1/16	1/17	1/18	1/19	1/20
37 (11)	29 (16)	24 (20)	20 (20)	18 (26)	16 (28)	15 (35)	14 (40)	13 (43)	12 (44)	11 (43)	11 (54)	10 (50)	10 (60)	09 (53)	09 (62)	09 (71)	09 (80)
36 (08)	28 (12)	23 (15)	19 (14)	17 (19)	15 (20)	14 (26)	13 (30)	12 (32)	11 (32)	10 (30)	10 (40)	09 (35)	09 (44)	08 (36)	08 (44)	08 (52)	08 (60)
35 (05)	27 (08)	22 (10)	18 (08)	16 (12)	14 (12)	13 (17)	12 (20)	11 (21)	10 (20)	09 (17)	09 (26)	08 (20)	08 (28)	07 (19)	07 (26)	07 (33)	07 (40)
34 (02)	26 (04)	21 (05)	17 (02)	15 (05)	13 (04)	12 (08)	11 (10)	10 (10)	09 (08)	08 (04)	08 (12)	07 (05)	07 (12)	06 (02)	06 (08)	06 (14)	06 (20)
33 (01)	25 (00)	20 (00)	16 (04)	14 (02)	12 (04)	11 (01)	10 (00)	09 (01)	08 (04)	07 (09)	07 (02)	06 (10)	06 (04)	05 (15)	05 (10)	05 (05)	05 (00)
32 (04)	24 (04)	19 (05)	15 (10)	13 (09)	11 (12)	10 (10)	09 (10)	08 (12)	07 (16)	06 (22)	06 (16)	05 (25)	05 (20)	04 (32)	04 (28)	04 (24)	04 (20)
31 (07)	23 (08)	18 (10)	14 (16)	12 (16)	10 (20)	09 (19)	08 (20)	07 (23)	06 (28)	05 (35)	05 (30)	04 (40)	04 (36)	03 (49)	03 (46)	03 (43)	03 (40)
30 (10)	22 (12)	17 (15)	13 (22)	11 (23)	09 (28)	08 (28)	07 (30)	06 (34)	05 (40)	04 (48)	04 (44)	03 (55)	03 (52)	02 (66)	02 (64)	02 (62)	02 (60)
29 (13)	21 (16)	16 (20)	12 (28)	10 (30)	08 (36)	07 (37)	06 (40)	05 (45)	04 (52)	03 (61)	03 (58)	02 (70)	02 (68)	01 (83)	01 (82)	01 (81)	01 (80)

6. An Antifragile HICT Natural Framework (26)

Two Basic Manifold Reflection Types



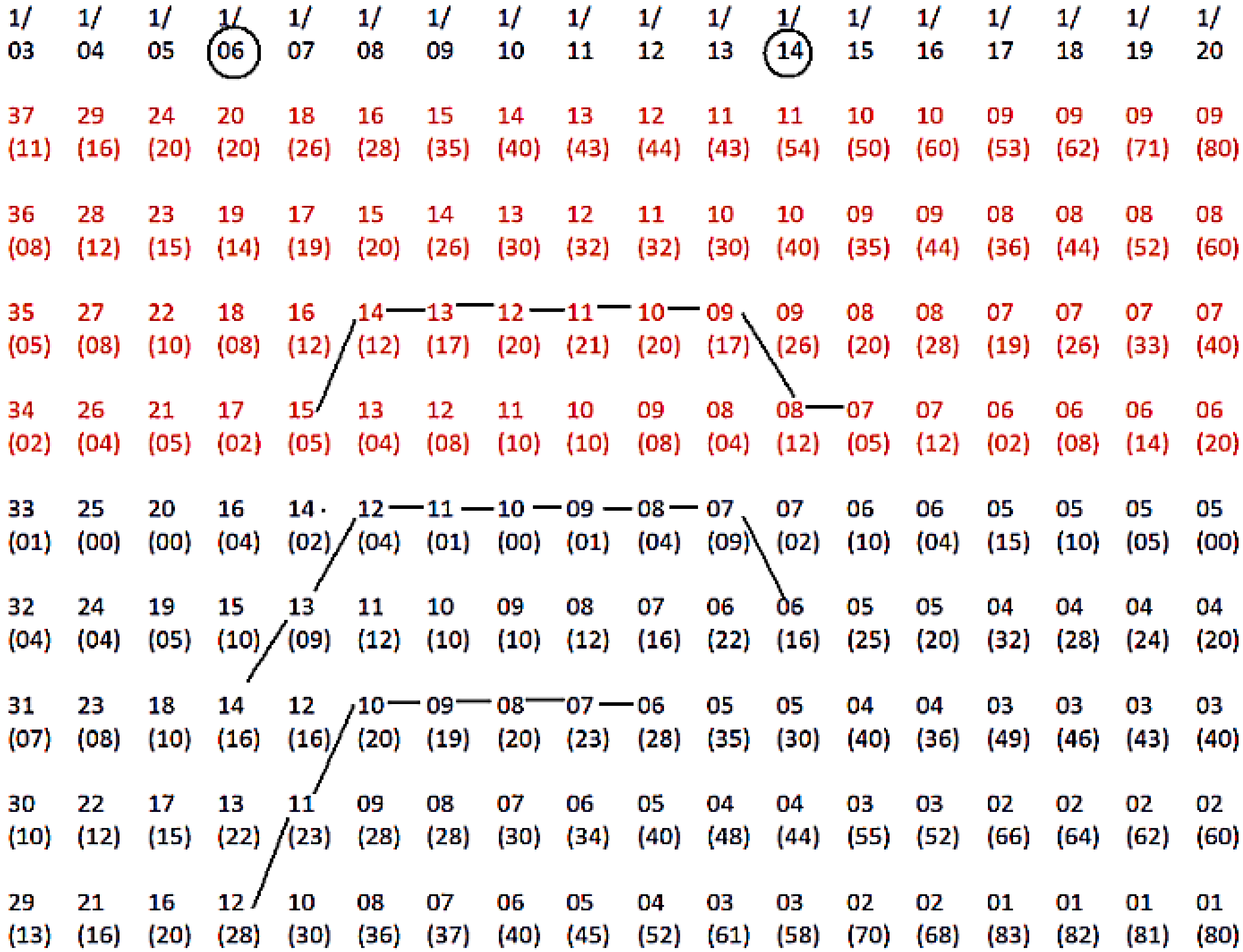
Incidence (∩)

vs.

Correspondence (∪)

6. An Antifragile HICT Natural Framework (27)

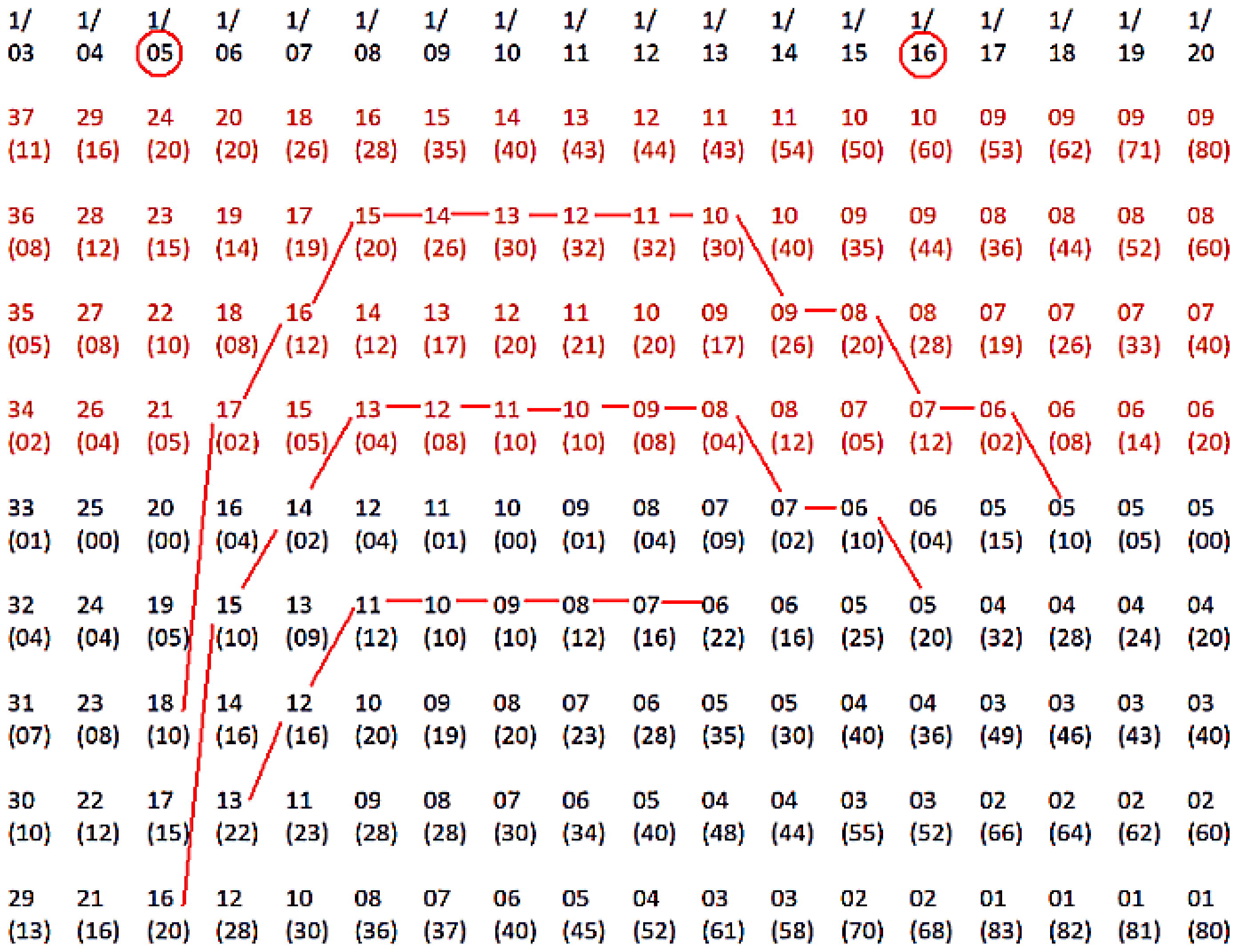
Incidence (∩)



1/03	1/04	1/05	1/06	1/07	1/08	1/09	1/10	1/11	1/12	1/13	1/14	1/15	1/16	1/17	1/18	1/19	1/20
37 (11)	29 (16)	24 (20)	20 (20)	18 (26)	16 (28)	15 (35)	14 (40)	13 (43)	12 (44)	11 (43)	11 (54)	10 (50)	10 (60)	09 (53)	09 (62)	09 (71)	09 (80)
36 (08)	28 (12)	23 (15)	19 (14)	17 (19)	15 (20)	14 (26)	13 (30)	12 (32)	11 (32)	10 (30)	10 (40)	09 (35)	09 (44)	08 (36)	08 (44)	08 (52)	08 (60)
35 (05)	27 (08)	22 (10)	18 (08)	16 (12)	14 (12)	13 (17)	12 (20)	11 (21)	10 (20)	09 (17)	09 (26)	08 (20)	08 (28)	07 (19)	07 (26)	07 (33)	07 (40)
34 (02)	26 (04)	21 (05)	17 (02)	15 (05)	13 (04)	12 (08)	11 (10)	10 (10)	09 (08)	08 (04)	08 (12)	07 (05)	07 (12)	06 (02)	06 (08)	06 (14)	06 (20)
33 (01)	25 (00)	20 (00)	16 (04)	14 (02)	12 (04)	11 (01)	10 (00)	09 (01)	08 (04)	07 (09)	07 (02)	06 (10)	06 (04)	05 (15)	05 (10)	05 (05)	05 (00)
32 (04)	24 (04)	19 (05)	15 (10)	13 (09)	11 (12)	10 (10)	09 (10)	08 (12)	07 (16)	06 (22)	06 (16)	05 (25)	05 (20)	04 (32)	04 (28)	04 (24)	04 (20)
31 (07)	23 (08)	18 (10)	14 (16)	12 (16)	10 (20)	09 (19)	08 (20)	07 (23)	06 (28)	05 (35)	05 (30)	04 (40)	04 (36)	03 (49)	03 (46)	03 (43)	03 (40)
30 (10)	22 (12)	17 (15)	13 (22)	11 (23)	09 (28)	08 (28)	07 (30)	06 (34)	05 (40)	04 (48)	04 (44)	03 (55)	03 (52)	02 (66)	02 (64)	02 (62)	02 (60)
29 (13)	21 (16)	16 (20)	12 (28)	10 (30)	08 (36)	07 (37)	06 (40)	05 (45)	04 (52)	03 (61)	03 (58)	02 (70)	02 (68)	01 (83)	01 (82)	01 (81)	01 (80)

6. An Antifragile HICT Natural Framework (28)

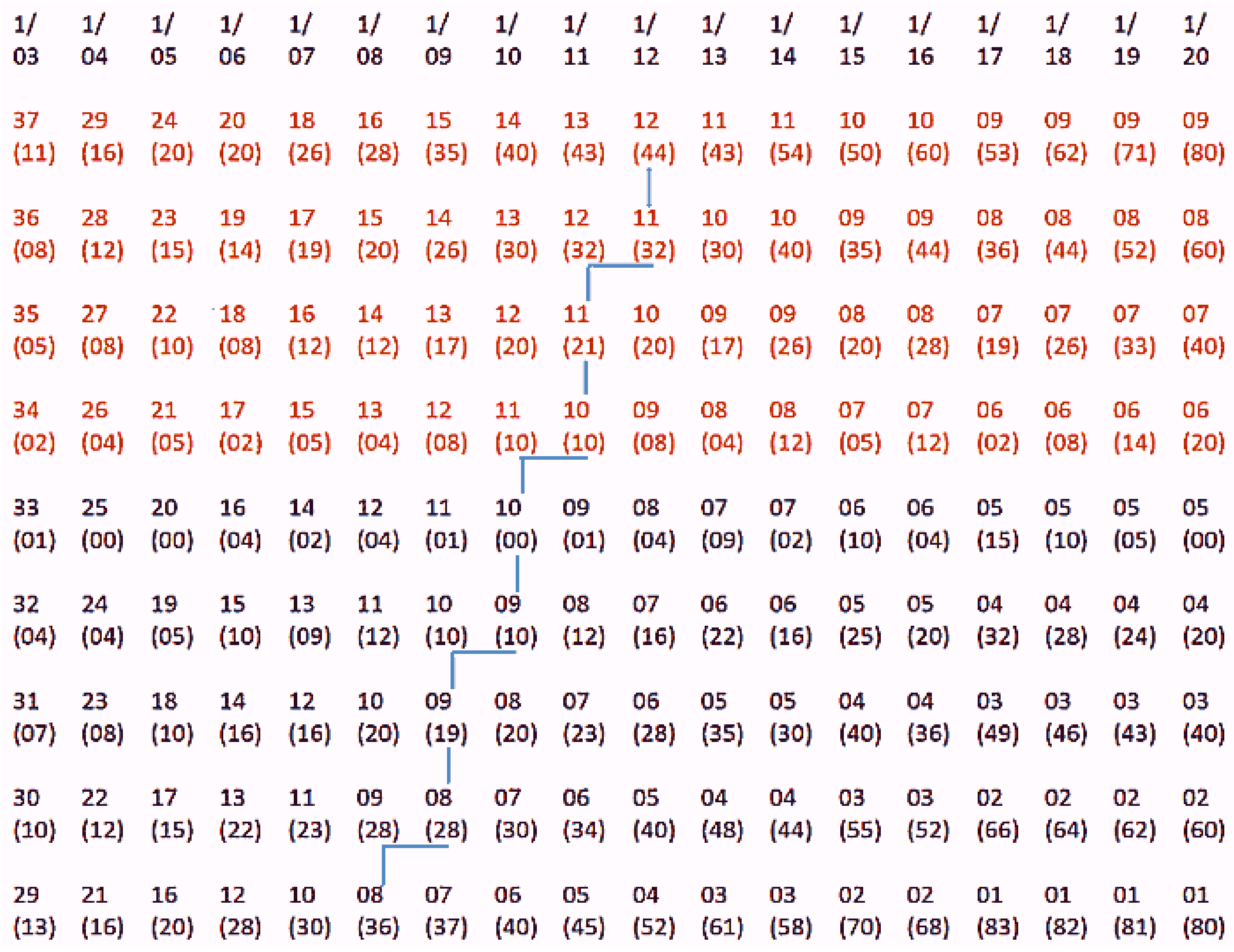
Correspondence (∪)



1/03	1/04	1/05	1/06	1/07	1/08	1/09	1/10	1/11	1/12	1/13	1/14	1/15	1/16	1/17	1/18	1/19	1/20
37 (11)	29 (16)	24 (20)	20 (20)	18 (26)	16 (28)	15 (35)	14 (40)	13 (43)	12 (44)	11 (43)	11 (54)	10 (50)	10 (60)	09 (53)	09 (62)	09 (71)	09 (80)
36 (08)	28 (12)	23 (15)	19 (14)	17 (19)	15 (20)	14 (26)	13 (30)	12 (32)	11 (32)	10 (30)	10 (40)	09 (35)	09 (44)	08 (36)	08 (44)	08 (52)	08 (60)
35 (05)	27 (08)	22 (10)	18 (08)	16 (12)	14 (12)	13 (17)	12 (20)	11 (21)	10 (20)	09 (17)	09 (26)	08 (20)	08 (28)	07 (19)	07 (26)	07 (33)	07 (40)
34 (02)	26 (04)	21 (05)	17 (02)	15 (05)	13 (04)	12 (08)	11 (10)	10 (10)	09 (08)	08 (04)	08 (12)	07 (05)	07 (12)	06 (02)	06 (08)	06 (14)	06 (20)
33 (01)	25 (00)	20 (00)	16 (04)	14 (02)	12 (04)	11 (01)	10 (00)	09 (01)	08 (04)	07 (09)	07 (02)	06 (10)	06 (04)	05 (15)	05 (10)	05 (05)	05 (00)
32 (04)	24 (04)	19 (05)	15 (10)	13 (09)	11 (12)	10 (10)	09 (10)	08 (12)	07 (16)	06 (22)	06 (16)	05 (25)	05 (20)	04 (32)	04 (28)	04 (24)	04 (20)
31 (07)	23 (08)	18 (10)	14 (16)	12 (16)	10 (20)	09 (19)	08 (20)	07 (23)	06 (28)	05 (35)	05 (30)	04 (40)	04 (36)	03 (49)	03 (46)	03 (43)	03 (40)
30 (10)	22 (12)	17 (15)	13 (22)	11 (23)	09 (28)	08 (28)	07 (30)	06 (34)	05 (40)	04 (48)	04 (44)	03 (55)	03 (52)	02 (66)	02 (64)	02 (62)	02 (60)
29 (13)	21 (16)	16 (20)	12 (28)	10 (30)	08 (36)	07 (37)	06 (40)	05 (45)	04 (52)	03 (61)	03 (58)	02 (70)	02 (68)	01 (83)	01 (82)	01 (81)	01 (80)

6. An Antifragile HICT Natural Framework (29)

Incidence-Correspondence Alternation



1/03	1/04	1/05	1/06	1/07	1/08	1/09	1/10	1/11	1/12	1/13	1/14	1/15	1/16	1/17	1/18	1/19	1/20
37 (11)	29 (16)	24 (20)	20 (20)	18 (26)	16 (28)	15 (35)	14 (40)	13 (43)	12 (44)	11 (43)	11 (54)	10 (50)	10 (60)	09 (53)	09 (62)	09 (71)	09 (80)
36 (08)	28 (12)	23 (15)	19 (14)	17 (19)	15 (20)	14 (26)	13 (30)	12 (32)	11 (32)	10 (30)	10 (40)	09 (35)	09 (44)	08 (36)	08 (44)	08 (52)	08 (60)
35 (05)	27 (08)	22 (10)	18 (08)	16 (12)	14 (12)	13 (17)	12 (20)	11 (21)	10 (20)	09 (17)	09 (26)	08 (20)	08 (28)	07 (19)	07 (26)	07 (33)	07 (40)
34 (02)	26 (04)	21 (05)	17 (02)	15 (05)	13 (04)	12 (08)	11 (10)	10 (10)	09 (08)	08 (04)	08 (12)	07 (05)	07 (12)	06 (02)	06 (08)	06 (14)	06 (20)
33 (01)	25 (00)	20 (00)	16 (04)	14 (02)	12 (04)	11 (01)	10 (00)	09 (01)	08 (04)	07 (09)	07 (02)	06 (10)	06 (04)	05 (15)	05 (10)	05 (05)	05 (00)
32 (04)	24 (04)	19 (05)	15 (10)	13 (09)	11 (12)	10 (10)	09 (10)	08 (12)	07 (16)	06 (22)	06 (16)	05 (25)	05 (20)	04 (32)	04 (28)	04 (24)	04 (20)
31 (07)	23 (08)	18 (10)	14 (16)	12 (16)	10 (20)	09 (19)	08 (20)	07 (23)	06 (28)	05 (35)	05 (30)	04 (40)	04 (36)	03 (49)	03 (46)	03 (43)	03 (40)
30 (10)	22 (12)	17 (15)	13 (22)	11 (23)	09 (28)	08 (28)	07 (30)	06 (34)	05 (40)	04 (48)	04 (44)	03 (55)	03 (52)	02 (66)	02 (64)	02 (62)	02 (60)
29 (13)	21 (16)	16 (20)	12 (28)	10 (30)	08 (36)	07 (37)	06 (40)	05 (45)	04 (52)	03 (61)	03 (58)	02 (70)	02 (68)	01 (83)	01 (82)	01 (81)	01 (80)

6. An Antifragile HICT Natural Framework (30)

Fundamental CICT OECS Properties

We got rich new knowledge about fundamental number concepts and properties by **Optimized Exponential Cyclic Sequences** (OECS):

a) Symbolic vs. **OpeRational** Number Representation;
b) Prime vs. **SN Family Group Order** properties;
c) Arbitrary Precision **Exact Rational Number Representation**;
d) Incidence vs. **Correspondence** in **OECS Word Space**;
e) OECS phased generators **Fixed Point** vs. **Pairing** properties;
f) etc… etc…

More specifically, **OECS Family Group of any order** can play a fundamental role by capturing and optimally encoding deterministic information to be lossless recovered at any arbitrary precision.

Combinatorially **OECS** are totally indistinguishable from computer generated pseudo-random sequences or traditional "system noise" to an external Observer.

6. An Antifragile HICT Natural Framework (31)

Half-Plane Space vs. OECS Space

Two Irreducible Complementary Operative Spaces

Half-Plane Space

- Inert matter best operational representation compromise.
- A Representation Space endowed with full Flexibility (mapping complexity to simplicity to give space to Imagination).
- Simplified system dynamics framework (Newtonian Approach).
- To model any geometrical space and monitor system dynamics behavior only.
- A Spectator can become a system innatural perturbation.

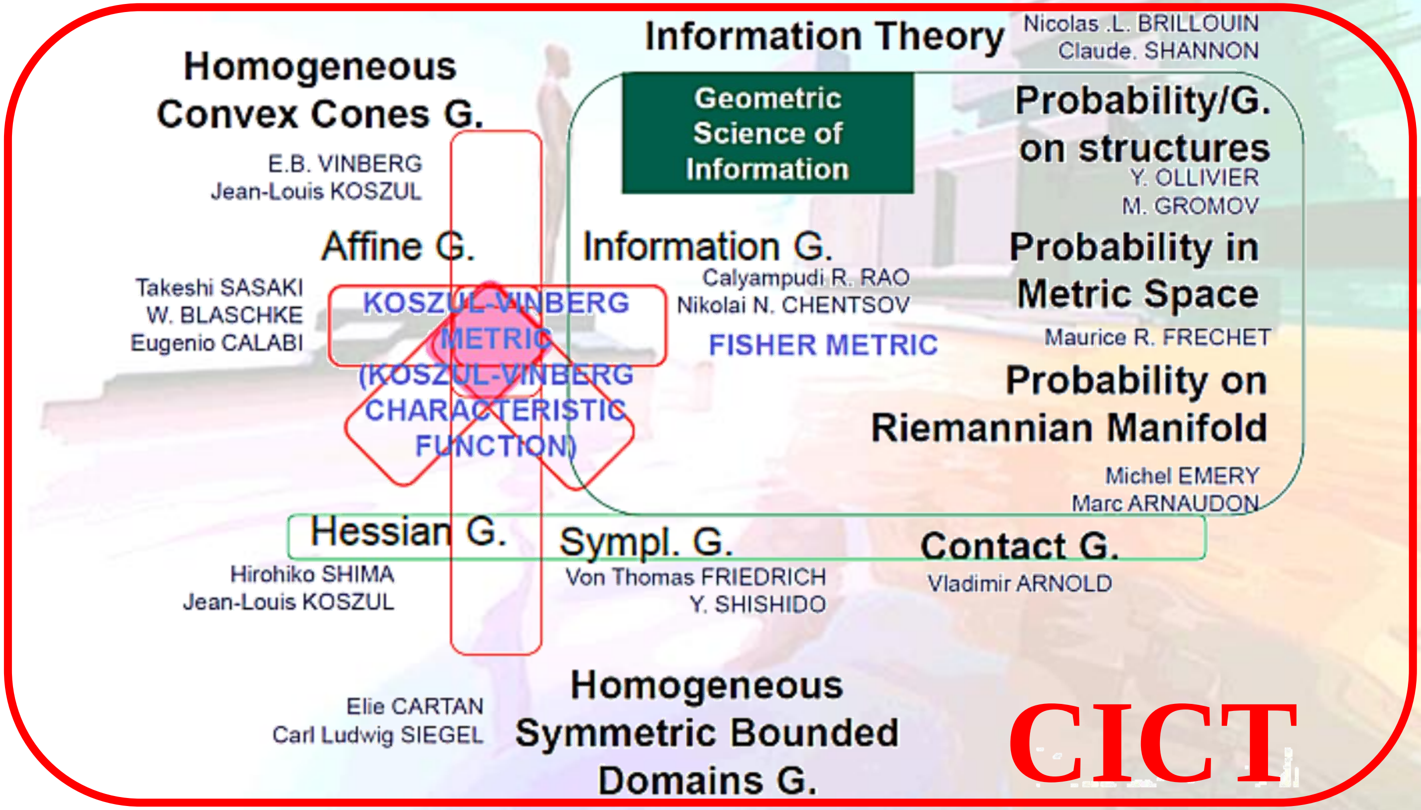
OECS Space

- Livig matter best representation operational compromise.
- An Outer Representation Space one-to-one linked to its Inner Representation Space.
- Natural system dynamics framework (Quantum Physics Approach).
- To model projective relativistic geometry and to anticipate emergent system dynamics.
- An Observer can become a system natural co-artifex.

6. An Antifragile HICT Natural Framework (32)

Current Landscape of Geometric Science of Information

Hessian (J.L. Koszul), Homogeneous Convex Cones (E. Vinberg), Homogeneous Symmetric Bounded Domains (E. Cartan, C.L. Siegel), Symplectic (T. von Friedrich, J.M. Souriau), Affine (T. Sasaki, E. Calabi), Information (C. Rao, N. Chentsov). Through Legendre Duality, Contact (V. Arnold) is considered as the odd-dimensional twin of symplectic geometry and could be used to understand Legendre mapping in information geometry.



Information Theory

Nicolas .L. BRILLOUIN
Claude. SHANNON

Homogeneous Convex Cones G.

E.B. VINBERG
Jean-Louis KOSZUL

Geometric Science of Information

Probability/G. on structures

Y. OLLIVIER
M. GROMOV

Affine G.

Takeshi SASAKI
W. BLASCHKE
Eugenio CALABI

Information G.

Calyampudi R. RAO
Nikolai N. CHENTSOV

Probability in Metric Space

Maurice R. FRECHET

KOSZUL-VINBERG METRIC
(KOSZUL-VINBERG CHARACTERISTIC FUNCTION)

FISHER METRIC

Probability on Riemannian Manifold

Michel EMERY
Marc ARNAUDON

Hessian G.

Hirohiko SHIMA
Jean-Louis KOSZUL

Sympl. G.

Von Thomas FRIEDRICH
Y. SHISHIDO

Contact G.

Vladimir ARNOLD

Homogeneous Symmetric Bounded Domains G.

Elie CARTAN
Carl Ludwig SIEGEL

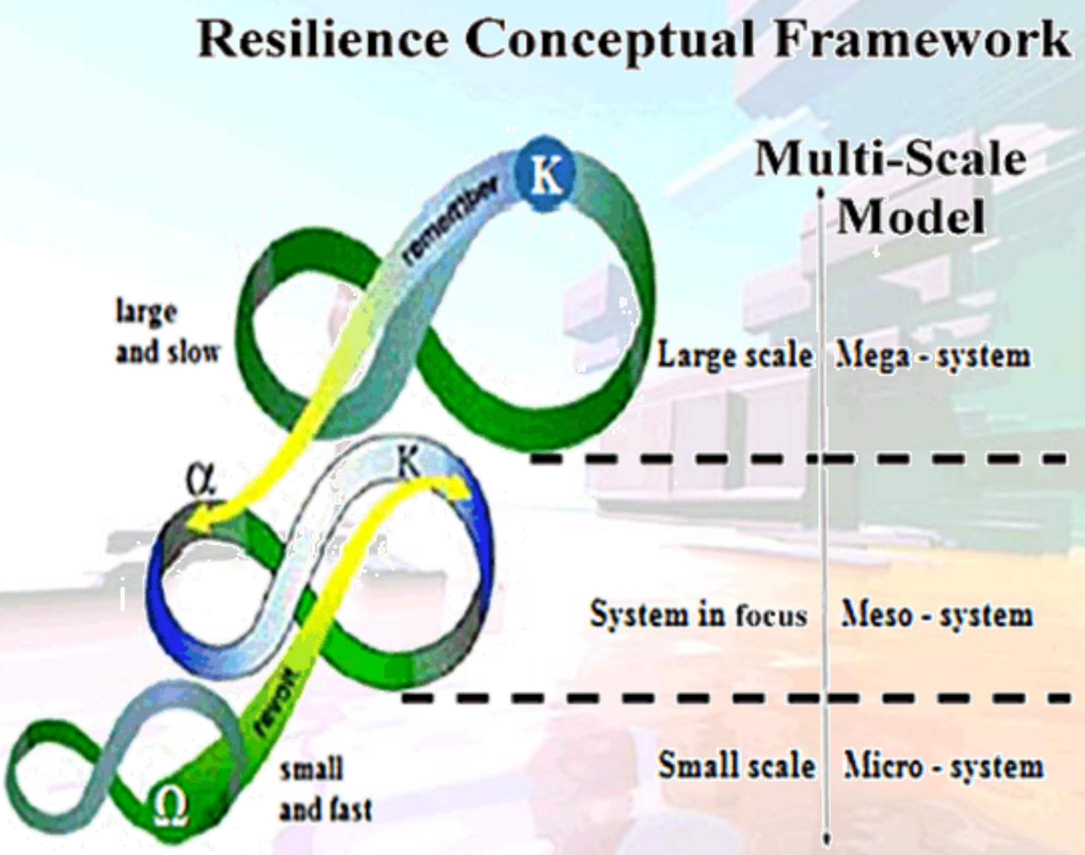
CICT

(F. Barbaresco, 2014)

(R.A. Fiorini, 2014)

6. An Antifragile HICT Natural Framework (33)

CICT Solution to the Problem for Multi-Scale System Modeling

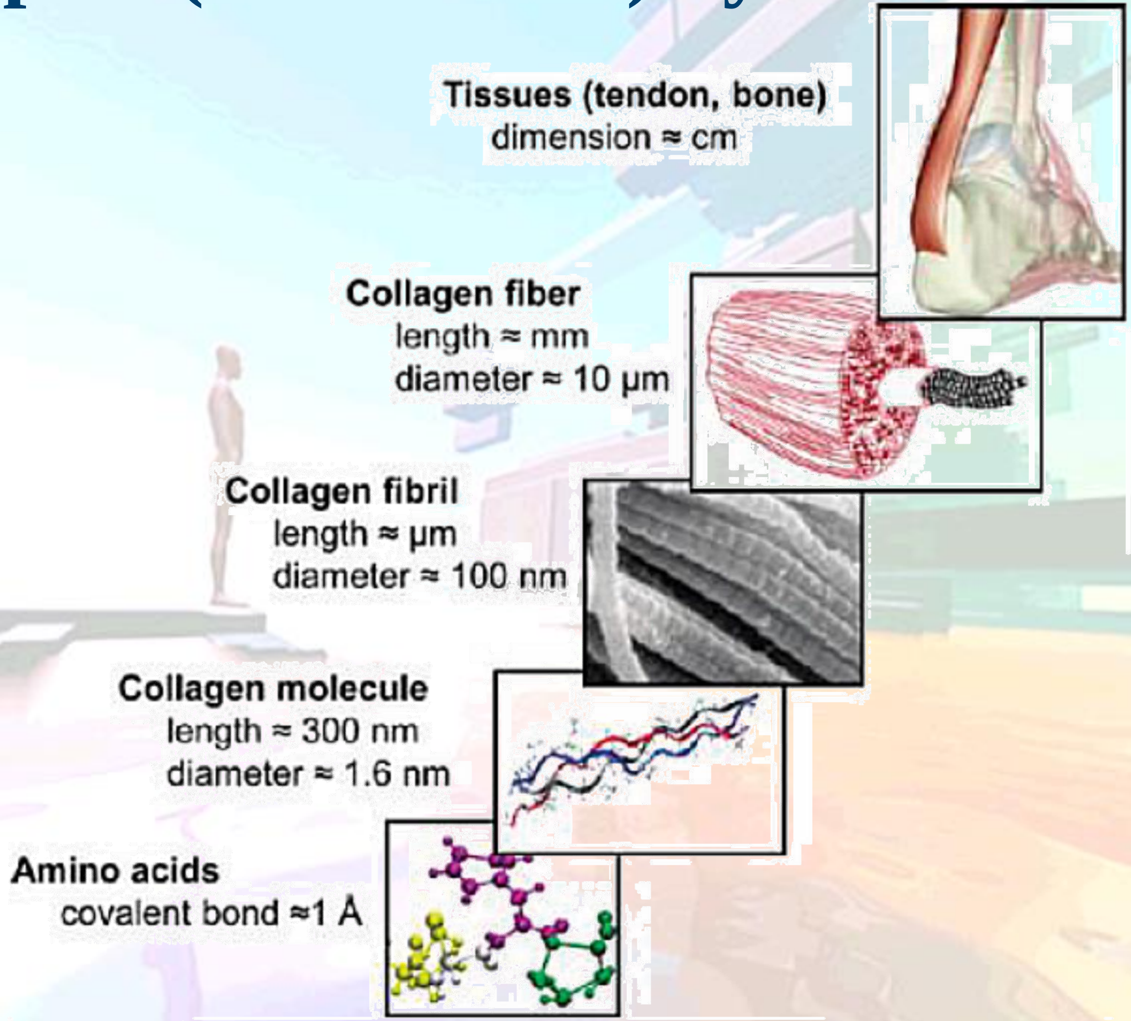


TD
POV

BU
POV

6. An Antifragile HICT Natural Framework (34)

Complex (Multi-Scale) System Modeling



(R.A. Fiorini, 2015)

6. An Antifragile HICT Natural Framework (35)

Specifically, **CICT has shown that classical Shannon entropy computation is completely unable to reliably discriminate so called computational "random noise" (RN) from any combinatorically optimized encoded message by OECS, now called "deterministic noise" (DN).**

CICT can help us to develop strategies **to gather much more reliable experimental information from single experimentation** and to conserve overall system information.

The latest **CICT** claim is that the **external world** real system physical manifestation properties and related human perception are **HG representation based**, while Euclidean approximated locally. Furthermore, the fundamental play of human information observation interaction with an **"external-internal world representation"** is related by the different manifestation and representation properties of **a unique fundamental computational information structuring principle: the Kelvin Transform** (KT).

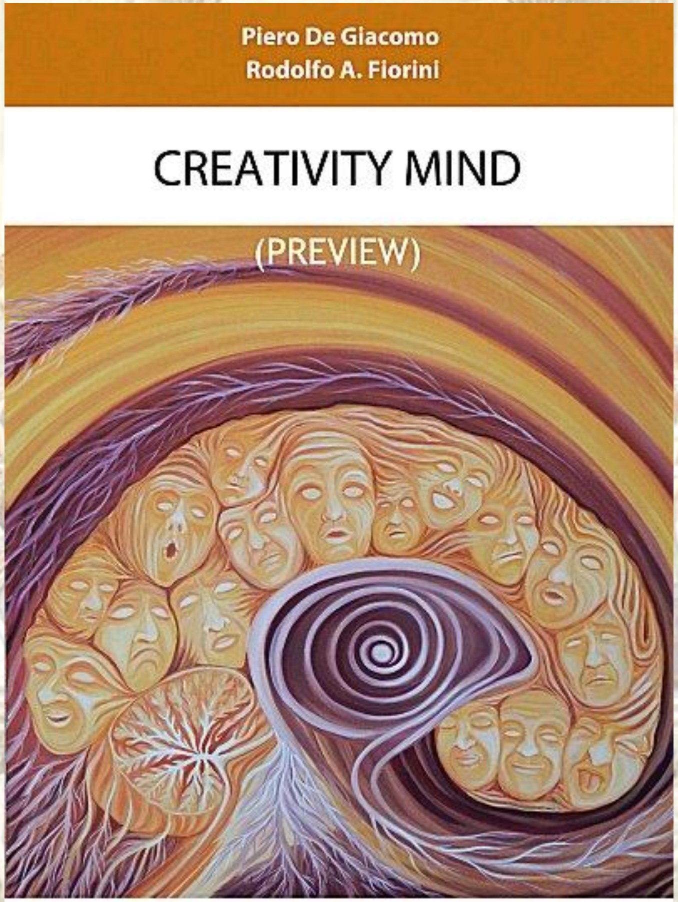
6. An Antifragile HICT Natural Framework (36)

With **no coherent inner phase information**, we get **system decoherence**, **entropy generation** and **information dissipation**.

In fact, misplaced precision leads to information opacity, fuzziness, irreversibility, chaos, complexity and confusion.

Announcement

If you like to know more



Piero De Giacomo
Rodolfo A. Fiorini

CREATIVITY MIND

(PREVIEW)

7. Summary & Conclusions (00)

7. **Summary and Conclusions (07)**
- Quick Recap
- Main References

7. Summary & Conclusions (01)

CICT Natural Framework

To cope with **ontological uncertainty** effectively, we need **OUM approach at system level.** We need a starting subsystem with **LC** to initialize a recursive process of continuous self-organization and self-logic learning refinement, based on **LA**, till a desired condition is reached.

This is a convenient and effective method for grasping system natural logic dynamics behaviour, as function of specific unpredictable perturbance, unknown at system design level.

Therefore, a symbolic support, to capture all the relevant system interaction symmetries and asymmetries, is needed .

Advanced systemics knowledge can be used to achieve resilience and antifragile systemic result, for more reliable clinical psychiatry and psychology application.

7. Summary & Conclusions (02)

CICT Natural Framework

We have seen that the correct AMS modeling of a coherent system must involve two kinds of interaction:

1- an interaction similar to that considered by **Classical Physics**, where objects interact by exchanging energy. These exchanges are connected with the appearance of forces measured by their magnitude (modulus) only, in an assumed continuum manifold that may be approached and studied by traditional stochastic and probabilistic tools offered by the large arena of the Geometric Science of Information (GSI).

Since energy cannot travel faster than light, this interaction obeys the **principle of causality (Science 1.0 approach)**. The missing part of this worldview is usually called "system noise", "background radiation", etc... on cosmic scale by human being;

7. Summary & Conclusions (03)

CICT Natural Framework

2- an interaction where a **common phase** arises among different objects because of their coupling to the quantum fluctuations and hence to an e.m. potential. In this case there is no propagation of matter and/or energy taking place, and the components of the system "talk" to each other through the modulations of the phase field travelling at the phase velocity, which has no upper limit and can be larger than c, the speed of light **(Science 2.0 approach)**.

CICT new awareness of a discrete HG (hyperbolic geometry) subspace **(reciprocal space)** of coded heterogeneous hyperbolic structures, underlying the familiar ***Q*** Euclidean **(direct space)** surface representation, shows that any natural number n in ***N*** has associated a specific, non-arbitrary phase relationship that we have to take into account to full conserve overall system information content by computation in Euclidean space. This awareness opens the way to system AMS information conservation by the CICT PG approach.

7. Summary & Conclusions (04)

CICT Natural Framework

Increasing the level of representation accuracy, the total number of allowed convergent paths to 1/D, as allowed conservative paths, increases accordingly and can be counted exactly, and so on, till maximum machine word length and beyond: like discrete quantum paths denser and denser to one another, towards a never ending "blending quantum continuum," by a TD perspective.

While differentiable trajectories found in standard mathematical physics are automatically scale invariant, it is the main insight of the CICT theory that also certain non-differentiable paths (resultant paths, emerging from lower scales combined quantum trajectories, which explicitly depend on the scale and accuracy of the observer) can be scale invariant.

CICT considers information not only on the **statistical manifold** of model states but also on the **combinatorial manifold** of low-level discrete, phased generators and empirical measures of noise sources, **related to experimental high-level overall perturbation**.

CICT approach can offer a powerful, effective and convenient "**Science 2.0**" universal framework to develop innovative application and beyond, towards a more sustainable economy and wellbeing, in a global competition scenario.

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