





Conference on Recent Progress  
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# Information as an action

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# The role of Information in Nature



## Objective information in quantum theory

- Atomism of information

  - Ur-theory (C. F. von Weizsäcker)

  - It from bit (J. Wheeler)

  - Protyposis (Th. Görnitz)

- Information alongside energy and matter

  - Active information (D. Bohm)

  - Mindful universe (H. Stapp)



## Objective information in thermodynamics

  - Boltzmann's formulation of the second law

  - Maxwell's demon



## Objective information in Astronomy, biology, etc.



## Roederer's theory of pragmatic information:

- Basically discriminate between biological systems and physical inanimate systems based on the concept of **objective** information.
- Is intended to be a theory of life as well.



## Information is a **dynamic** concept:

It does not reside as an object in CDs, in DNA molecules, in Books and etc, (as it is in the common sense). Information is a fundamental dynamic concept, responsible for a special category of interactions

*Roederer says: "what counts in the end is what information does, not how it looks or sounds, how much it is, or what it is made of"*



## Information as an action



The concept of **interaction** plays a principal role in Roederer's theory:

*"...the presence of one object may alter the state of other objects in some well-defined ways. We call this process an **interaction** – without attempting any formal definition... We just note that in an interaction a correspondence is established between certain properties of one object (its position, speed, form, etc.) and specific changes of the other.*





Roederer classifies all kinds of interactions occurring in nature into two main categories:

- Force-driven interactions occur between inanimate physical bodies **via forces**.
- Information-driven interactions is exclusive to biological systems *"to maintain a long-term state of unstable thermodynamic equilibrium with its surroundings, consistently increase its organization and reproduce, an organism has to rely on information-based interactions **in which form or pattern, not energy, is the controlling factor**".*






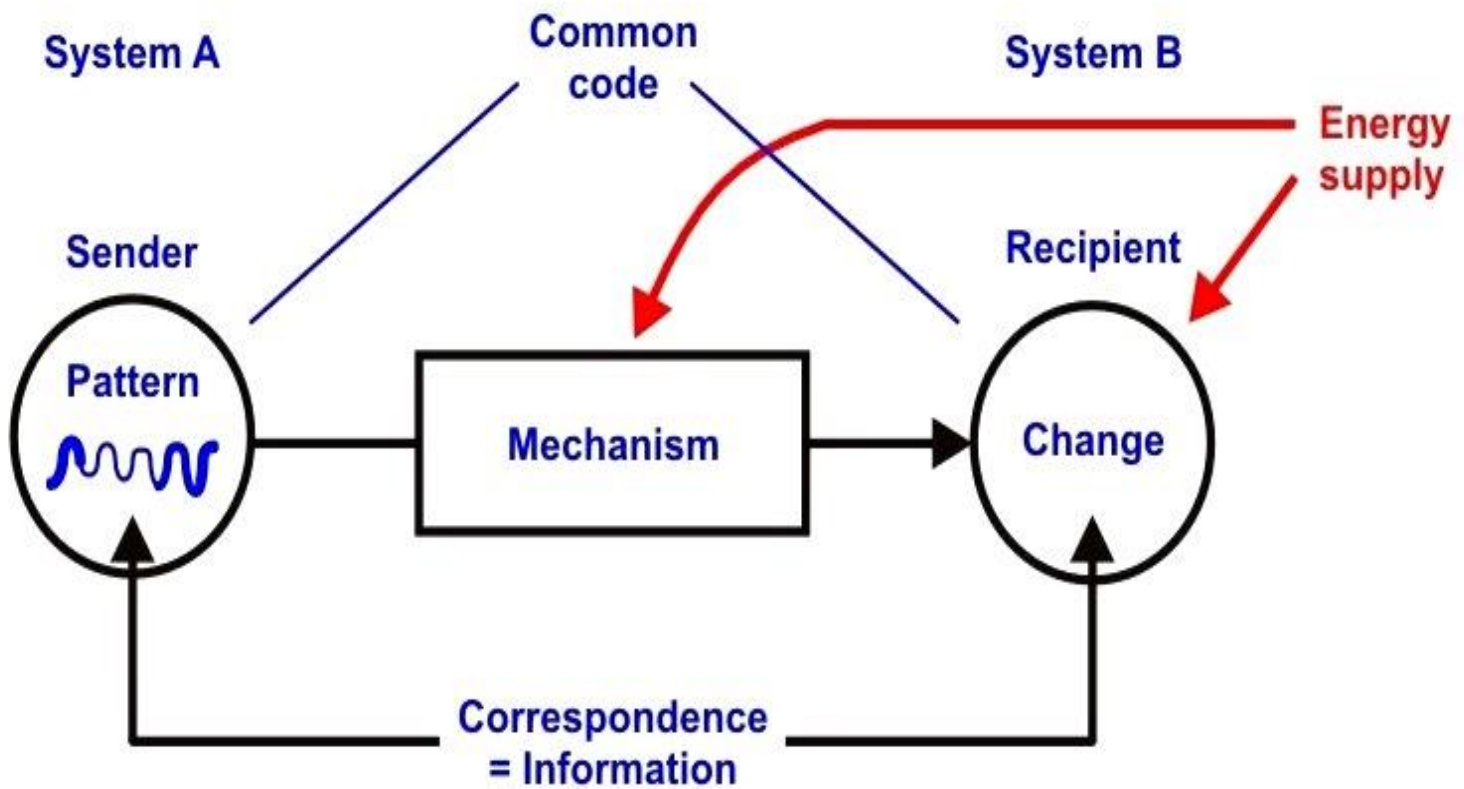
## Force-driven interactions

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- Force-driven interactions occur between two inanimate physical bodies in such a way that “the presence of one modifies the properties of the other (its motion, structure, temperature) in a definite way that depends on the relative configuration of both components of the system”
  - The agent responsible for change of the physical state of the interacting body is mere **energy and force**.
  - Primarily these interactions occur between two elementary particles, so, their interaction is **bidirectional** and **reversible** So, there exists **no true cause and effect** relationship.
  - There are **energy coupling** between two elementary particles.
  - As the system grows in the number of particles and approaches the macroscopic level, these interactions tend to become irreversible and the systems experience a univocal, and a true directed cause and effect interaction and the energy coupling decreases as well.
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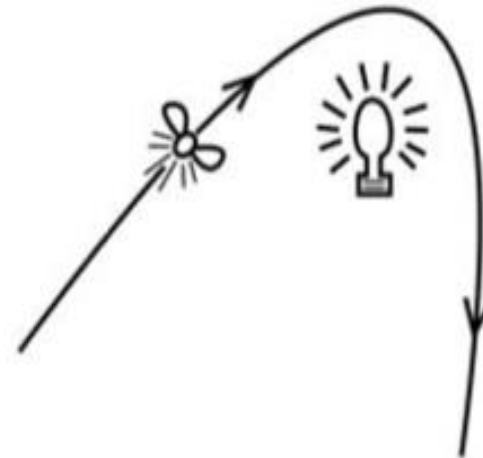
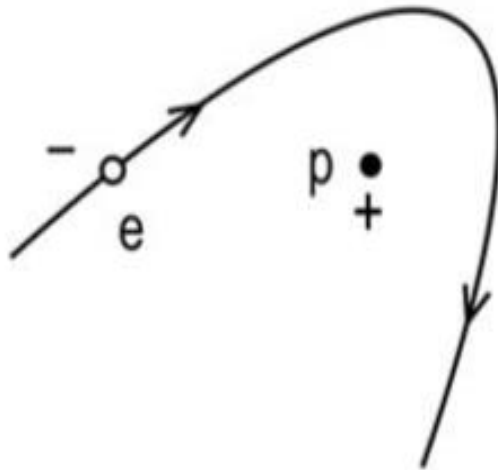


# Information-driven interactions

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- One end of the information-driven interaction (at the recipient) is a **complex** (alive, or constructed by an alive) system and at the other end there is a **pattern**.
  - Mere **shape or pattern** of something – **not its field, forces or energy** – can trigger a specific **change** in a recipient, and do this consistently over and over again.
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- There is purpose and meaning at least at one side of this relation. With purpose and the ability to reset, a one to one correspondence could be established between a pattern at the sender side and a specific change in the recipient will occur.
  - For an information-driven interaction to construct a univocal, there must exist a common code between the pattern A and the recipient B, “so that information can be conveyed and interpreted”. (This is essential because in cases which different input patterns lead to the same output in the recipient, the common code establishes a one to one correspondence between the output and one of the inputs.)
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- When all the above conditions are fulfilled, information appears as an emergent property through the interaction mechanism. This **a true cause and effect relation**.



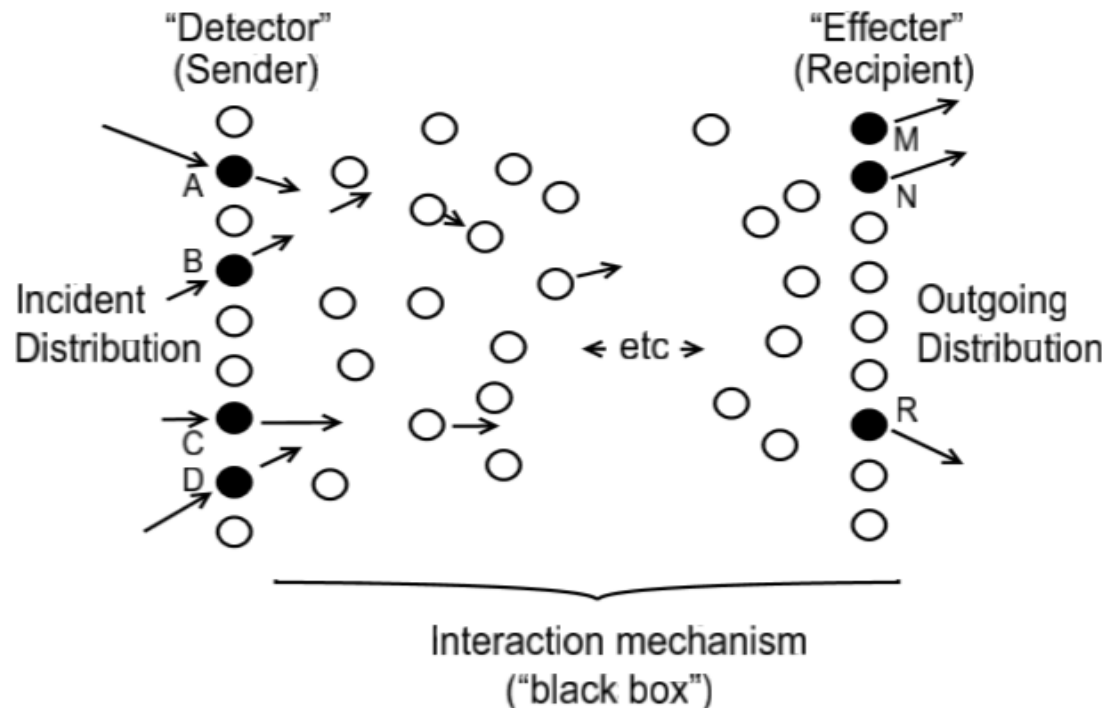




# The origin of information

The first “grand moment” in the evolution of life occurred when carbon-based molecules of sufficiently high complexity appeared for which the information expressed in their structural patterns began to take a highly selective control of their interaction with the surrounding medium.

A mechanical illustration:






# Critical analysis of Roederer's pragmatic theory of information

- The classification of interactions in this theory is not comprehensive.

There are phenomena in physics which are not force-driven.



Roederer believes that the thermodynamic irreversibility, black holes in astronomy, decoherence in quantum mechanics all are force driven and any information-based interpretation is not acceptable and should be regarded as [information for us](#).

Even if we don't aim to use information as an agent responsible for the odd effects in the above theories or as an interpretative aid, we do not yet have clear explanation of the related phenomena based on forces-driven interactions.



# Critical analysis of Roederer's pragmatic theory of information

Example:


Joule expansion of an ideal gas occurs without internal energy change (no work no energy exchange). This is a directed, irreversible process which is described based on the entropy increase.



What entropy is? There is no explanation based on bidirectional force-based interactions and energy exchange for the second law of thermodynamics.

(Roederer believes that what is responsible for the behavior is simply Newton's laws. Entropy is a concept invented by humans that helps describe quantitatively many (especially irreversible) processes in statistical mechanics.)

However, we know that irreversibility in the macroscopic level has not a fair explanation based on the first law of thermodynamics.



He believes that entropy is a human invention, but he explains the appearance of information based on the increase of complexity and irreversibility in the billiard ball illustration. This illustration of emergence of irreversibility based on the reversible mechanics of balls motion suffers from the same weakness that H-theorem does in this respect.





# Critical analysis of Roederer's pragmatic theory of information


Example:

In quantum mechanics also there are process which are not force-driven.



Force is not responsible for quantum correlations

Statistical nature of quantum mechanics is in contradiction with the deterministic nature of force-driven interactions.



So, the classification of interactions in Roederer's theory ignores a significant part of physical problems and phenomena.



# Critical analysis of Roederer's pragmatic theory of information

The theory lacks a proper definition for some of its principal concepts like complexity and energy coupling.

## Complexity



In this journey of matter beginning from the big bang and continuing in the present to future, there is a time that c-based macromolecules exceeded a certain limit of complexity and built prebiotic molecules and cells. This is the limit at which information-driven interactions emerged as a basic category of interactions in the evolution process. This is the limiting point which life appears as an emergent property in the universe, as Roederer proposes.




This is true that living beings are more complex than inanimate bodies is true, but complexity by itself doesn't provide convincing explanation for them to attain all those properties associated with life.





# Critical analysis of Roederer's pragmatic theory of information

There are cases in which all the above requirements for information exist but there is no information-based change. So life is a concept **prior** to and **irreducible** to information which is not explainable based on increase of complexity. (a dead man in a duel)




Complexity increase doesn't explain **how purpose, meaning**, the ability to reset to the initial conditions and all other properties associated with life appeared through the evolution of the biomolecules.

## Purpose and meaning

How purpose and meaning should be defined in the biomolecular level of informational actions?

Does a gene when produces a special protein, knows what a property is it going to generate at the phenotype level?




Therefore, the rigorous definition of information in Roederer's theory seems to be applicable to conscious living beings. Yet in this realm it suffers from serious problems.



# Critical analysis of Roederer's pragmatic theory of information


## One to one correspondence

One to one correspondence between the pattern and the change in an informational action is not a necessary condition.



One to one correspondence gives the informational action a deterministic property that is different than what our common sense experiences. Living beings are not deterministic systems.

In processes like creative thinking, random decisions, and even in evolution there are points at which such a one to one correspondence breaks down. This intermediate point at which a new correspondence establishes should be regarded as an informational action or not?



In organic chemistry there are molecular reactions which are very spatio-selective and the feasibility of these reactions is very dependent on the orbital orientation. There is one to one correspondence between the reaction and the pattern of the organic molecules. So what makes the former reactions biological in this pragmatic theory?





# Critical analysis of Roederer's pragmatic theory of information

According to the one to one correspondence defined in this theory, pragmatic information cannot be quantified. We disagree with this claim. Because not all actions specially human decisions are rigorously programed or follow a purpose. In full and empty game we make random decisions that is associated with an amount of information.



## How to discriminate information from knowledge?

Roederer tries to include thinking process in human brain in the informational action category, by asserting that "*in information-processing chain can be triggered from "inside" the system rather than by signals from the environment*". However, this brings about additional problems like: what is the difference between knowledge and information in Roederer's theory? or how can we distinguish creative thoughts from thoughts relying on memory recall?




## Selected References


- Roederer, J. G. (2005). "Information and its Role in Nature". (Heidelberg, New York: Springer-Verlag).
- Roederer, J.G. (2003) "On the concept of information and its role in nature" Entropy 5: 1-31.
- Roederer, J. G. (2012) "Toward an information-based interpretation of quantum mechanics and the quantum-classical transition" arXiv: 1108.0999v2 (quantph).
- Roederer, J.G. (2004) "When and where did information first appear in the Universe?" In New Avenues in Bioinformatics J. Seckbach et al., eds. Kluwer Acad. Publ., Dordrecht.
- Roederer, J.G., "Bad Habits in Quantum Mechanics, Quantum Informatics for Cognitive, Social, and Semantic Processes: Papers from the AAAI Fall Symposium (FS-10-08)



Thank you for your time and consideration



This is a piece,  
too fair to be a child of chance,  
and not of care!



No atoms casually together hurl'd,  
could e'er produce so beautiful a world!



“John Dryden”