On the Origin and Evolution of the Universe: Chaos or Cosmos?

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Abstract

We consider evolution of the Universe based on the standard Big Bang model, quantum models of creation, and recent theory of nonlinear dynamics, including deterministic chaos and fractals. We show that by looking for an order and harmony in the the complex surrounding real world these modern studies give also new insight into the most important philosophical issues exceeding the classical ontological principles, e.g., providing a deeper understanding of an old philosophical question: why does something exist instead of nothing? We postulate that the origin of Universe is based on a simple but nonlinear law. Finally, it is worth noting that in mathematical-natural sciences we ought to look for the sense of the world in the mystery of rationality; the sense of every existence is the justification of the Universe. Finally, we argue that this scientific view provides also sense and hope to a human existence.

Keywords: science, philosophy, reality, truth, reason, religion, sense, life

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Introduction

In the scientific literature evolution the Universe is based on the Big Bang model, which has now become a standard scenario. However, very little is known about the early stages of this evolution, where we should rely on some models, because the required quantum gravity theory is still missing.

On the other hand, creation of the World is usually an important issue of religion (theology of creation). Nevertheless, these two domain of human activity seemed to often be in conflict, some scientists and philosophers have noticed that the aim of science is to explore the Universe created by God; science and natural theology have different methods but the same subject.

Obviously, to bridge these two domains of humane knowledge (science and religion) a proper philosophy is required. Hence, one should return to great philosophers starting from the Greeks asking the questions about the origin of existence of the world, e.g.,

- Aristotle's universe: the world always existed,
  but needed the **eternal** (atemporal) First Mover

- Plato's creation: a Demiurg transformed an initial chaotic stuff
  into the ordered Cosmos

- St. Augustine's Creator (in the fullest sens):
  a **Being** from whom the existence (in time) of all things derives
  (from 'nothingness 'in the past to 'nothingness' in the future)

In this paper, we would like to consider the origin of the Universe in view of the modern science, including quantum models of creation, and recent theory of nonlinear dynamics, deterministic chaos and fractals. We hope that these modern studies give also new insight into the most important philosophical issues exceeding the classical ontological principles, e.g., providing a deeper understanding of an old philosophical question: why does something exist instead of nothing?

Why does something exist instead of nothing?

Gottfried Wilhelm von Leibniz (1646–1716)

Chaos is the score on which reality is written.

Henry Miller (1891-1980)

In the environemnet of Sense the life is worth to live.

Michael Heller (born 1936)

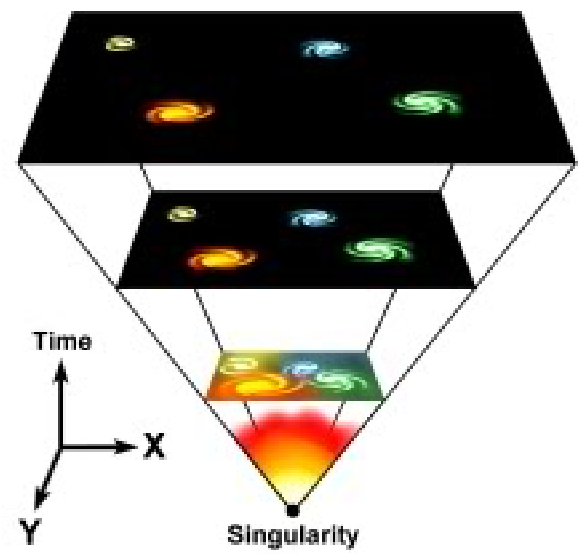
Keywords: science, philosophy, reality, truth, reason, religion, sense, life

Evolution of the Universe

According to the Big Bang model, the Universe expanded from an extremely dense and hot state and continues to expand today.

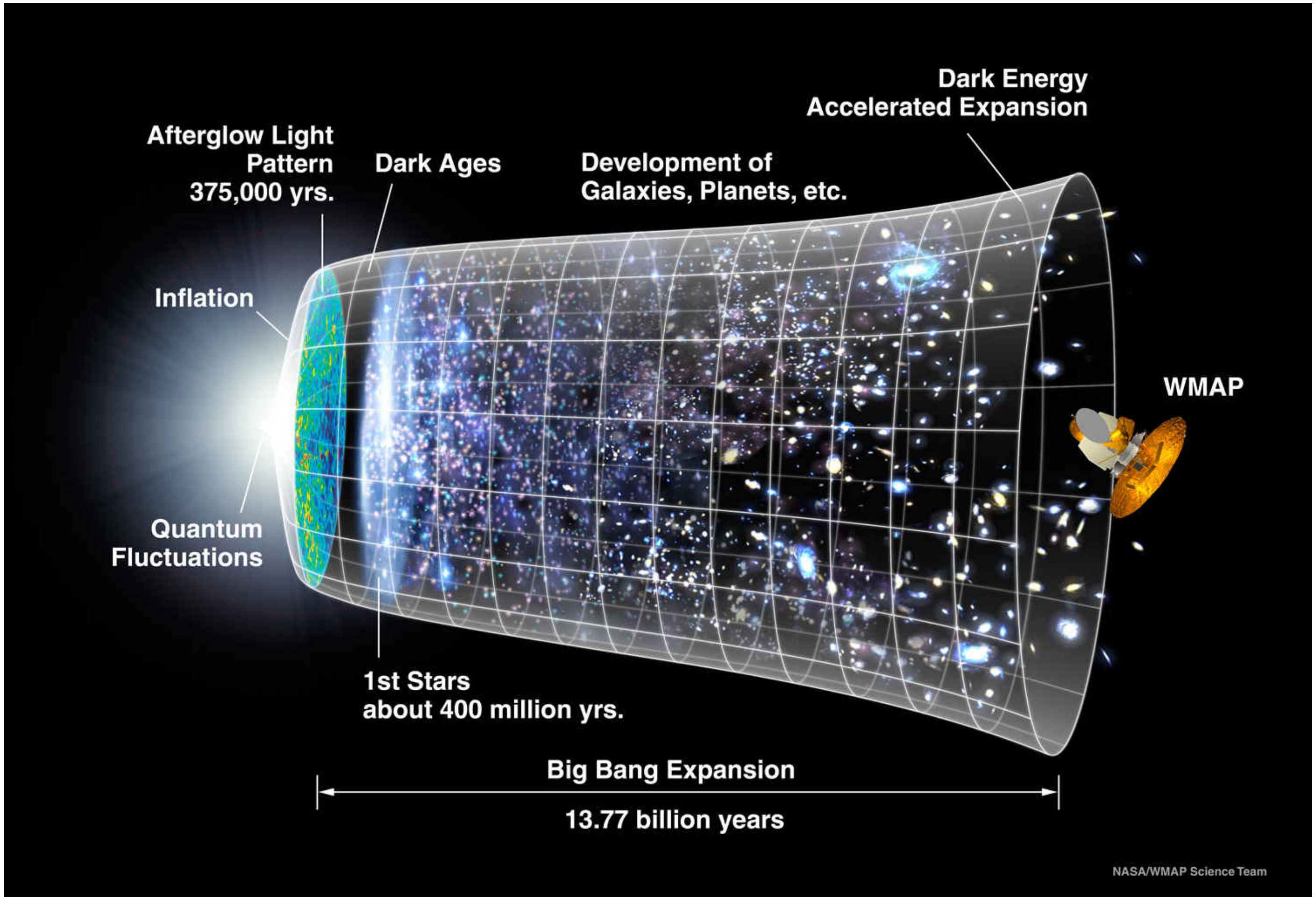
A common analogy explains that space itself is expanding, carrying galaxies with it, like spots on an inflating balloon.

The graphic scheme here is an artist's concept illustrating the expansion of a portion of a flat universe.



Expanding Universe

The Big Bang Model



Schematic of the Evolution of the Universe, Credit: NASA / WMAP Science Team

A representation of the evolution of the universe over 13.77$\pm$0.06 billion years. The far left depicts the earliest moment we can now probe, when a period of "inflation" produced a burst of exponential growth in the universe. (Size is depicted by the vertical extent of the grid in this graphic.)

For the next several billion years, the expansion of the universe gradually slowed down as the matter in the universe pulled on itself via gravity. More recently, the expansion has begun to speed up again as the repulsive effects of **dark energy** have come to dominate the expansion of the universe.

The afterglow light seen by WMAP (Wilkinson Microwave Anisotropy Probe) was emitted about 375,000 years after inflation and has traversed the universe largely unimpeded since then. The conditions of earlier times are imprinted on this light; it also forms a backlight for later developments of the universe.

Where did the universe come from?

(from the Universe Forum, NASA, the Harvard Smithsonian Center for Astrophysics)

No one knows how the first space, time, and matter arose. And scientists are grappling with even deeper questions:

- If there was NOTHING to begin with, then where did the laws of nature come from?
- How did the universe "know" how to proceed?
- And why do the laws of nature produce a universe that is so hospitable to LIFE?

As difficult as these questions are, scientists are attempting to address them with bold new ideas — and new experiments to test those ideas.

In Search of Quantum Gravity

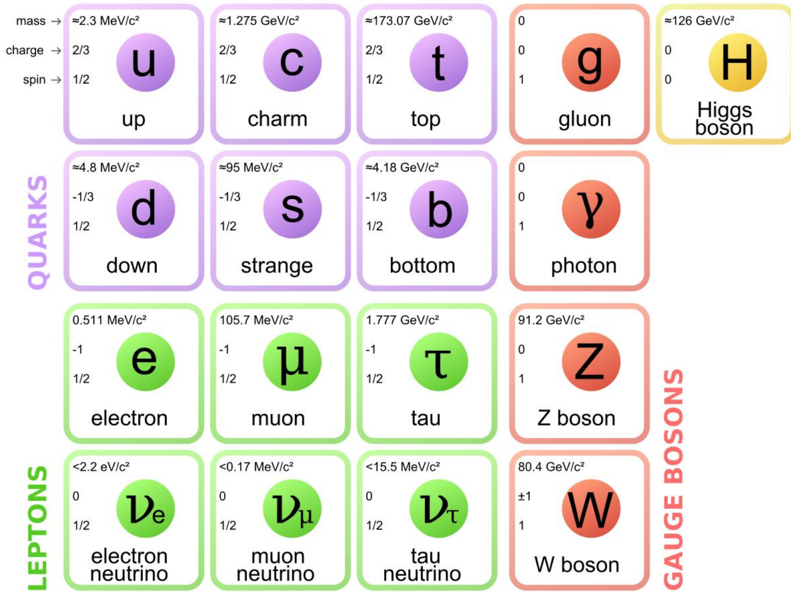
Understanding how the universe began requires developing a better theory of how space, time, and matter are related. In physics, a theory is not a guess or a hypothesis. It is a mathematical model that lets us make predictions about how the world behaves. Einstein's theory of **gravity**, for example, accurately describes how matter responds to gravity in the large-scale world around us.

And our best theory of the tiny sub-atomic realm, called **quantum** theory, makes very accurate predictions about the behavior of matter at tiny scales of distance.

But these two theories are not complete and are not able to make accurate predictions about the very earliest moments when the universe was both extremely dense and extremely small.

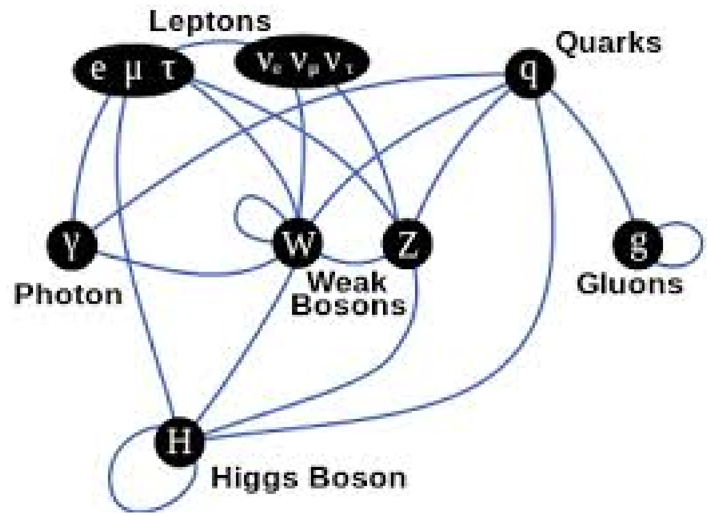
Standard Model of Forces

Elementary Particles



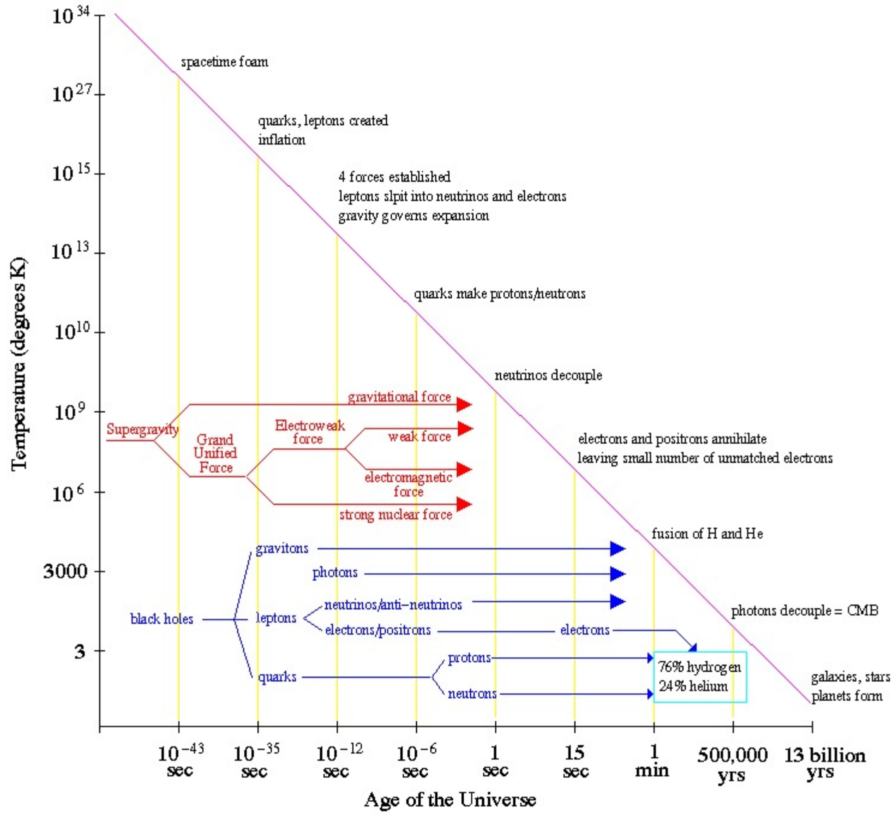
Three generations of particles, with gauge bosons in the fourth column and the Higgs boson in the fifth.

Interactions



Summary of interactions between particles

Birth and Evolution of the Universe



Great Unification Theory of elementary forces and the evolution of the Universe

Models of Creation of the Universe

- Quantum model (Hartle & Hawking, 1983)
  creation from 'nothing', ex nihilo

- Noncommutative geometry (Heller et al., 1996)
  beginning is everywhere

- String theory (M-theory, Witten, 1995)
  collision of branes

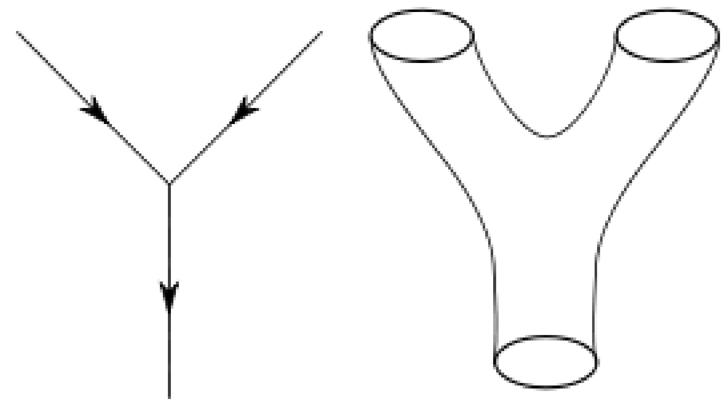
- Cyclic (ekpyrotic) model (Steinhardt & Turok, 2002)
  big bangs and crunches

- Eternal chaotic inflation (Linde, 1986)
  bubble of universes

String Theory

Some of the scholars in physics are working on a new theory of space, time, and matter, called "string theory", that may help us better understand where the universe came from.

String theory is based on new ideas that have not yet been tested. The theory assumes, for example, that the basic particles in nature are not point particles, but are shaped like strings.



Interaction in the subatomic world: world lines of point-like particles in the Standard Model or a world sheet swept up by closed strings in string theory

Predictions of M-theory

The theory requires – and predicts – that space has **more** than the three dimensions in which we move. According to one version of the theory, the particles and forces that make up our world are confined to three dimensions we see — except for gravity, which can "leak" out into the extra dimensions.

This (super)string theory has led to some bizarre new scenarios for the origin of the universe. In one scenario, the Big Bang could have been triggered when our own universe **collided** with a "parallel universe" made of these extra dimensions.

Scenarios like these are very speculative, because the string theory is still in development and remains untested, but they stimulate astronomers to look for new forms of evidence.

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Deterministic Chaos

CHAOS ($\chi\alpha o\varsigma$) is

- NON-PERIODIC long-term behavior
- in a DETERMINISTIC system
- that exhibits SENSITIVITY TO INITIAL CONDITIONS.

We say that a bounded solution $\mathbf{x}(t)$ of a given dynamical system, $\dot{\mathbf{x}} = \mathbf{F}(\mathbf{x})$, is SENSITIVE TO INITIAL CONDITIONS if there is a finite fixed distance $r > 0$ such that for any neighborhood $\|\Delta\mathbf{x}(0)\| < \delta$, where $\delta > 0$, there exists (at least one) other solution $\mathbf{x}(t)$ + $\Delta\mathbf{x}(t)$ for which for some time $t \geq 0$ we have $\|\Delta\mathbf{x}(t)\| \geq r$.

There is a fixed distance r such that no matter how precisely one specify an initial state there is a nearby state (at least one) that gets a distance r away.

Given $\mathbf{x}(\mathbf{t}) = \{x_1(t), \ldots, x_N(t)\}$ any positive finite value of Lyapunov exponents $\lambda_k = \lim_{t\to\infty} \frac{1}{t} \ln \left| \frac{\Delta x_k(t)}{\Delta x_k(0)} \right|$, where $k = 1, \ldots N$, implies chaos.

Deterministic Nonperiodic Flow[1]

EDWARD N. LORENZ

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(Manuscript received 18 November 1962, in revised form 7 January 1963)

ABSTRACT

Finite systems of deterministic ordinary nonlinear differential equations may be designed to represent forced dissipative hydrodynamic flow. Solutions of these equations can be identified with trajectories in phase space. For those systems with bounded solutions, it is found that nonperiodic solutions are ordinarily unstable with respect to small modifications, so that slightly differing initial states can evolve into considerably different states. Systems with bounded solutions are shown to possess bounded numerical solutions.

A simple system representing cellular convection is solved numerically. All of the solutions are found to be unstable, and almost all of them are nonperiodic.

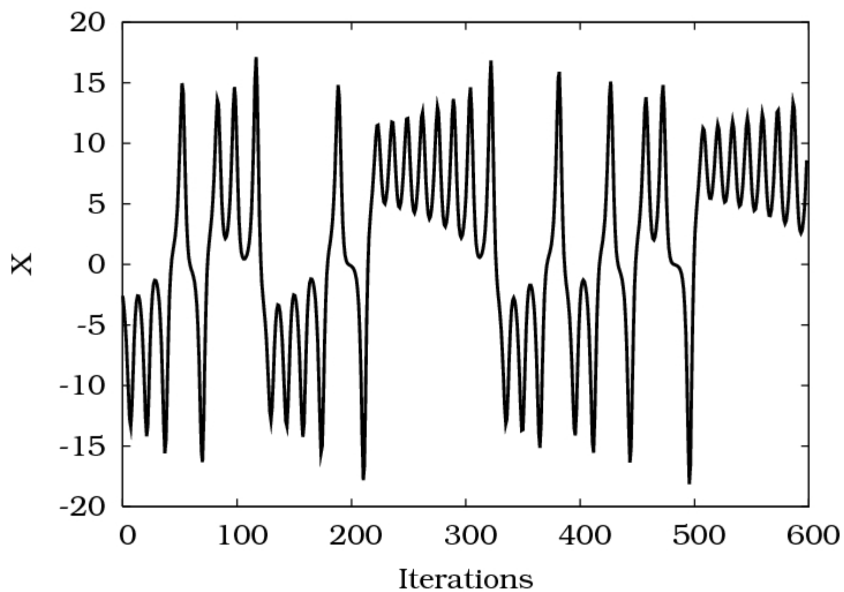
The feasibility of very-long-range weather prediction is examined in the light of these results.

Lorenz Model

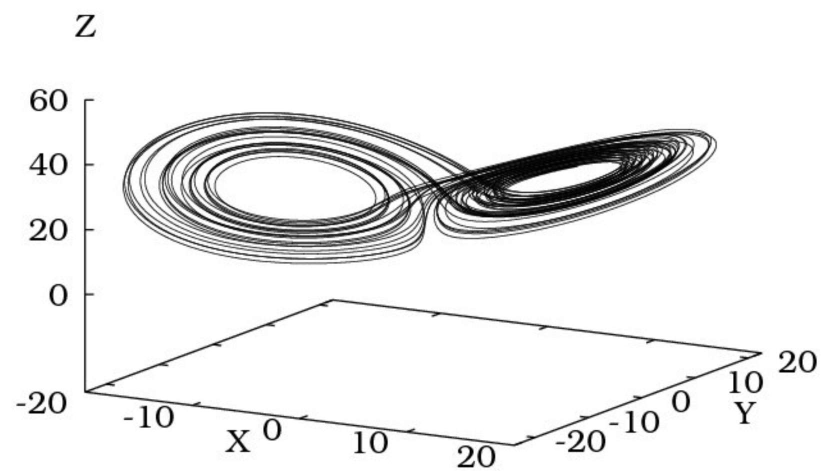
$$\dot{X} = \sigma(Y - X)$$
$$\dot{Y} = -XZ + rX - Y$$
$$\dot{Z} = XY - bZ$$

Parameters:
$r = 28$, $\sigma = 10$, $b = 8/3$

Time series for X



Strange Attractor



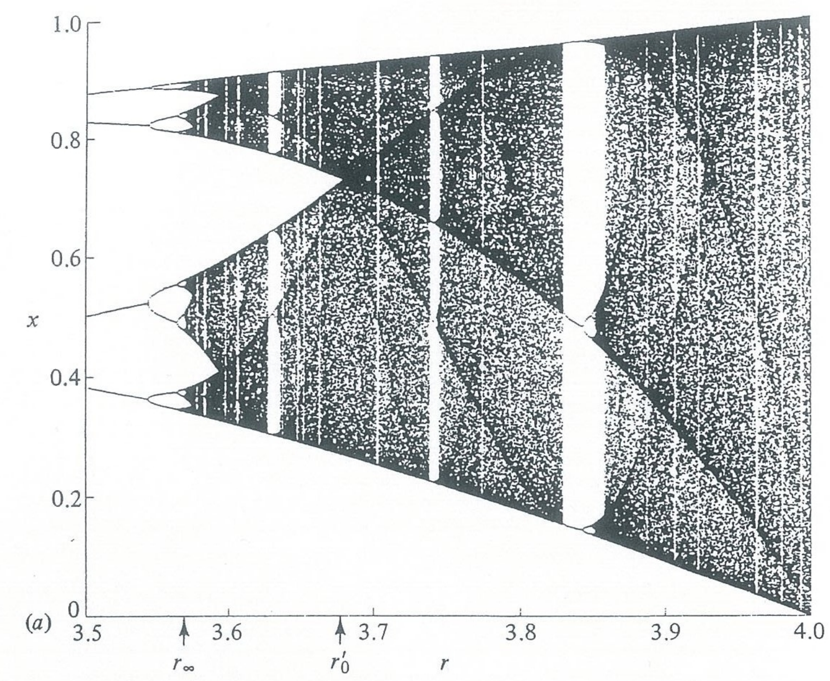
Bifurcations

Bifurcation diagram of the variable x ($0 \le x_n \le 1.0$) for the logistic map

$$x_{n+1} = f(x_n)$$

where $f(x) = rx(1-x)$, $n = 0, 1, \ldots, \infty$, depending on the control parameter $0 \le r \le 4.0$ that exhibits period doubling route to chaos.

Period doubling starts at $r = 3.0$ (period 2^2 is born at $r = 1 + \sqrt{2} \approx 3.449$) and successive bifurcations (for periods 2^k) come faster and faster, converging to $r_\infty \approx 3.57$, where long-term behavior becomes nonperiodic (period 2^∞). But suddenly, for $r > r_\infty$, at a critical value $r_c = 1 + 2\sqrt{2} \approx 3.8284$ period 3 (periodic window) is born (*tangent* bifurcation, type I **intermittent** chaos for $r \lesssim r_c$). Hence both chaos and order (nonperiodic and periodic solutions) are intertwined.

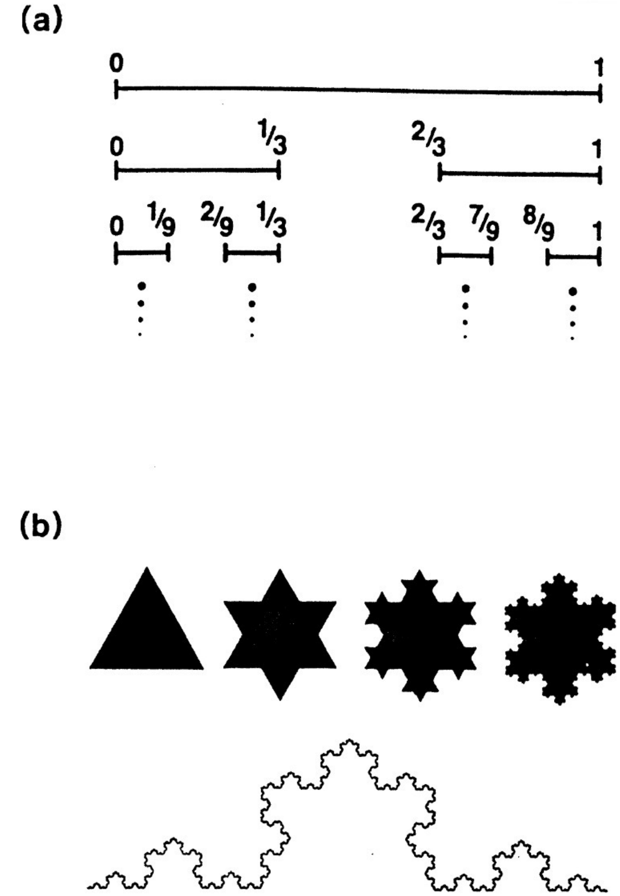


Bifurcation for the logistic map

Fractals and Multifractals

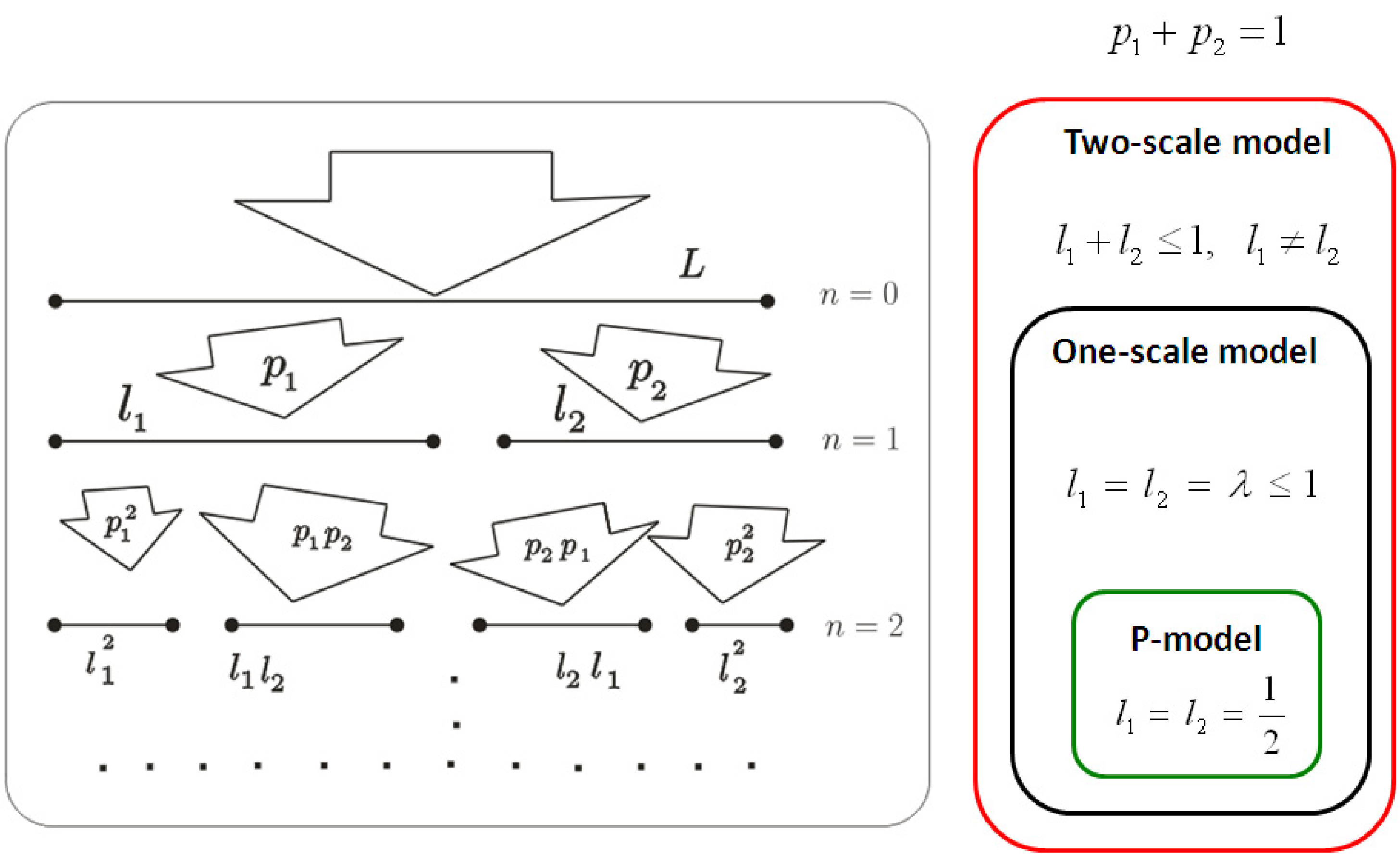
A **fractal** is a rough or fragmented geometrical object that can be subdivided in parts, each of which is (at least approximately) a reduced-size copy of the whole. Fractals are generally *self-similar* and independent of scale (fractal dimension).

A **multifractal** is a set of intertwined fractals. Self-similarity of multifractals is scale dependent (spectrum of dimensions). A deviation from a strict self-similarity is also called INTERMITTENCY.



(a) Cantor set and (b) Koch triangle

Multifractal Models for Turbulence



A generalized two-scale weighted Cantor set model for turbulence (Macek, 2007, 2012).

Implications

- **Nonlinear** systems exhibit complex phenomena, including bifurcation, intermittency, and chaos.

- Fractals can describe complex shapes in the real word.

- Strange chaotic attractors have fractal structure and are sensitive to initial conditions.

- Within the complex dynamics of the fluctuating intermittent parameters of turbulent media there is a detectable, hidden ORDER described by a generalized Cantor set that exhibits a multifractal structure.

- Based on that scientific experience here we argue that a simple but possibly a **nonlinear law**, within theory of chaos and (multi-)fractals, can describe a hidden ORDER for creation of Cosmos, at the Planck epoch, when space (at scale of 10^{-35} m) and time (10^{-43} s) were originated.

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Science and Religion

Following seminal works of the recent Templeton Prize winners Bernard d'Espagnat (2009) and Michał Heller (2008), we consider the consequences of science and religion for the **sense** of human life in the surrounding universe (Espagnat, 1983; Heller, 1996, 2010).

Naturally, we are aware of essential differences between science and religion. While the natural sciences try to explain the world in terms of laws by using a language of mathematical structures avoiding supernatural causes, religion aims to express the Divine Reality by using human language. Even though the methods of science and religion are different, studies on quantum reality suggest that one can mutually help each other to approach the unique Truth (Espagnat, 1983).

In our view this certainly requires **new** philosophical **concepts** based on metaphysics exceeding the classical ontological principles (Macek, 2000). Moreover, in our experience science is continuously renewing our thoughts about God and the sense of human life (Macek, 2009, 2010).

Philosophy of Science

In particular, Heller has proposed an integrated view of science and philosophy and has even constructed a program toward such an INTERDISCIPLINARY knowledge (Heller, 1996).

The philosophy and resulting theology of Heller certainly is a proclamation of **rationalism**. Focusing on God and the created universe, he continuously underlines that not only science but also faith should be rational and is arguing that theology and science both have a common objective: understanding man and the world created by God.

In this way, Heller has even put forward a proposal for a new theological discipline: a theology of science, which should look at sciences from the theological point of view and from the moral perspective (Macek, 2010, 2011).

The Universe and Sense

For Heller the whole universe is the unique Word of God that gives **sense** to man, history, and the world (Heller, 2010). Reason that was at the beginning penetrates every being; existence results from rationality of Divine Thought. Naturally, he is convinced that faith should not be in separation from science. For Heller science as a whole is a *locus theologicus*.

Certainly, as every being also the universe requires some justification of existence. We ought to look for the sense of the world in the mystery of rationality; the sense given by God to every existing being is the **justification** of the universe.

That is why we can experience that really

something **does** exist instead of nothing (cf. G. W. Leibniz).

- We should note a certain relation of the universe to **thought**. Surprisingly enough, nevertheless human thinking is limited to a very short time, now it allows us to recover the whole cosmic history, which began about 14 billions years ago. Moreover, the human values can be realized in the context of the universe, which is an incarnation of a sensible thought.

- We are deeply immersed in the universe, since a life has appeared during the evolution of the Solar System (3.8 billions years ago) followed by a first **brain** awareness event, i.e., when the first man was born.

- Moreover, the human individuals are able to act following their own **will** and thoughts, including feelings that are very characteristic for our life. Therefore, any choice of sense is a demand of **rationality**, because the rejection of the sense should be considered as a betrayal of the human reason. In this way, when asking about the sense, we are also asking about God, who is continuously providing the sense to the whole universe.

- In scientific studies of the dynamical systems one of the most intriguing problems is the question of **reversibility**, or strictly speaking the problem of the time arrow, which is related to the statistical law of thermodynamical entropy.

  This means that the present moment is always separated from the future and naturally from the past; consequently the world is historical. Basically, we all know that it is not possible to go back into the past. In particular, our biological clock is a special case of a thermodynamic clock. Unfortunately, when the entropy achieves its maximum every complex organism will die. Therefore, the **death** is not only a private tragic event, but it could be regarded as a participation in the cosmic structure.

- It is now clear that there should be **no** contradiction between
  - evolution and creation
    (in favor of evolutionary creationism),
  - determinism and indeterminism
    (in view of deterministic chaos theory and quantum mechanics).

  Obviously, a spiritual and moral evolution of every man depend on himself. Therefore, following critical **rationalism** of Popper, Heller has also noticed that decision of being rational in a human life is a moral choice. Rationality then becomes morality of thinking.

The Sense of Life

- Because every human being is naturally a part of the universe, the question of the sense of man is strictly **related** to the sense of the universe. It would rather be unlikely the existence of a senseless human life in a sensitive Universe; this could be logically inconsistent.

  Naturally, in order to achieve a happiness in our personal life, it is not enough to enjoy the present moment (as suggested by J. M. Bocheński): the universe should rather have a **global** sense, which is not limited to a given moment (Heller, 2010).

  Admittedly, we should learn ourselves how to live each present moment in our life. On the other hand, however, because the appearance of awareness was a critical moment of the human history, we can continuously ask ourself about our own future and the final **objective**.

- It would seem that from the scientific point of view coping with **death** is always hopeless.

  But one should note that the entropy is surely a stochastic quantity as is also the irreversibility of time. Therefore, we know from science that the experience of passing away resulting from one-directional time arrow can only be attributed to complex bodies and this does not necessarily apply for simple (not complex) systems.

  Death is a consequence of complexity; something that is not complex does not exists in any time flow and hence cannot die. Unexpectedly, nonlinear contemporary science based of fractals and deterministic chaos teaches us that the systems that looks complicated could result from a simple (but nonlinear) law (Macek, 2000).

  Anyway, in a human dramatic eschatological perspective, when expecting our own biological death, one can look for hope in rationality of God, which is the source of all natural or supernatural laws. We see that the scientific observations could shed a light on a religious belief that the death is the transition from time to eternity.

Conclusions

- We believe that the modern concept of the theology of science can certainly BRIDGE SCIENCE AND RELIGION, which gives **sense** of life (Macek, 2010, 2011).

- We also argue that if we do not like to continue theological studies in separation from science, then classic theology should open its thought to the most important ideas and achievements of the mathematical natural **sciences**.

Epilogue

- We argue that the scientific theories of **nonlinear** dynamics, *chaos* and *fractals* help us to understand the origin of the Universe.
- We hope that the philosophy of science should open philosophy and theology to the mathematical natural sciences that would admit a better understanding sense of man in his relation to the Universe and the transcendent Reality.

Thank you!

Adopted from *Bible moralisée* (1220–1230) by Mandelbrot (1982)

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