The Mystery of the Origin of the Universe

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Abstract

Even though evolution of the universe according to the Big Bang has now become a standard scenario, the origin of its existence is still a Big Mystery. Understanding how did the world begin would require developing a better theory of how space, time, and matter are related. However, the quantum gravity theory is not yet complete and is not able to make accurate predictions about the very earliest moments, when the universe was both extremely dense and extremely small. Nevertheless, based on general relativity and quantum theory some models of the creation of the universe are proposed. One can hence believe that these modern studies give a new insight into the important philosophical issues, providing a deeper understanding of an old philosophical question about reality: why does something exist instead of nothing? We therefore hope that this scientific view would help to give a sense to human existence in the surrounding world.

Keywords: creation, existence, reason, science, reality, sense

Plan of Presentation

1. Universe in Antiquity and Middle Ages
   - Plato and Aristotle
   - St. Augustine and St. Thomas
2. Universe in Modern Science
   - The Big Bang Model
   - Standard Model of Elementary Forces
   - Quantum Models of Creation
   - String Theory
3. Nonlinear Dynamics
   - Deterministic Chaos
   - Fractals
4. Implications for Cosmology and Creation of the Universe
5. Epilogue

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 philosophy and even religion (theology of creation). Nevertheless, these domains of human activity seemed to often be in conflict, some scientists and philosophers (e.g., Michael Heller) 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 theology) 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.,

- Plato's creation: a Demiurg transformed an initial chaotic stuff into the ordered Cosmos
- Aristotle's universe is eternal: the world always existed, but needed the (atemporal?) First Mover or First Cause
- 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)
- Following Aristotle, St. Thomas noticed that God can simultaneously (wholly and perfectly) be in possession of the past, presence, and future (Boethius definition of eternity): **no** contradiction with the biblical concept of creation.

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 environment of Sense the life is worth to live.

Michael Heller (born 1936)

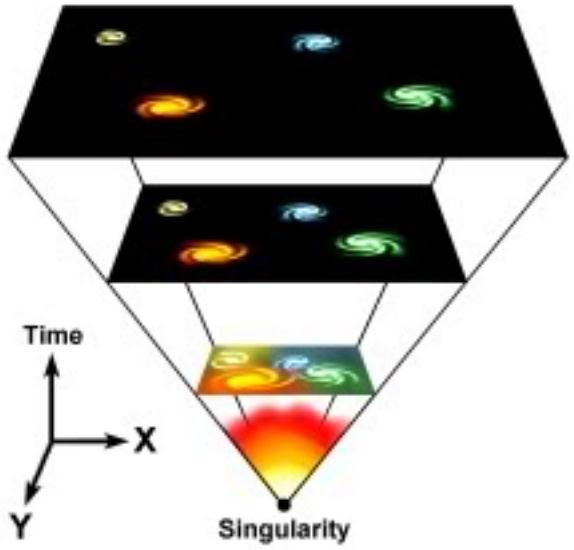
creation, universe, existence, science, theology

Evolution of the Universe in Modern Science

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

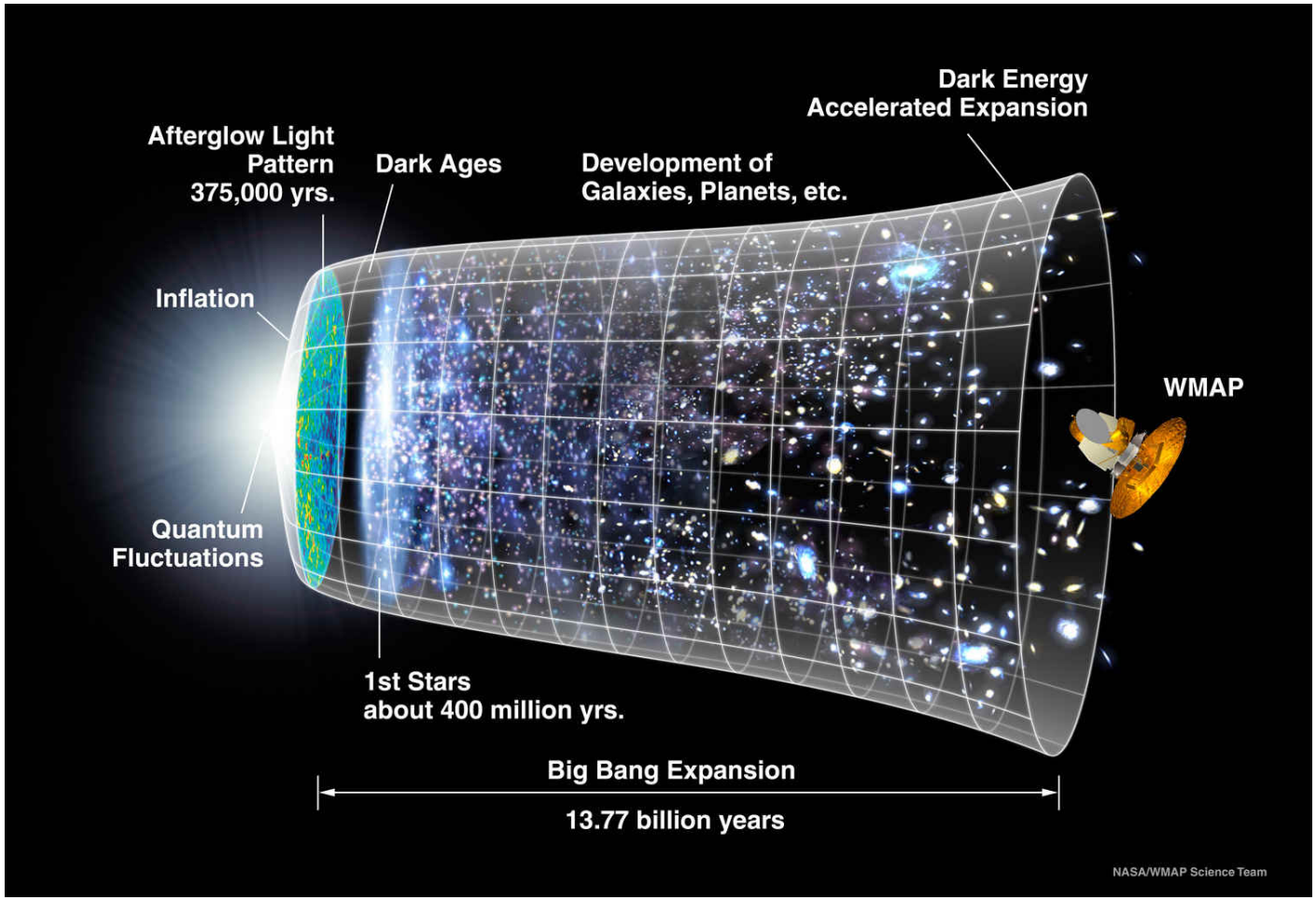
A common analogy explains that space itself is expanding, carrying galaxies with it, like spots on an inflating balloon.

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 ± 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

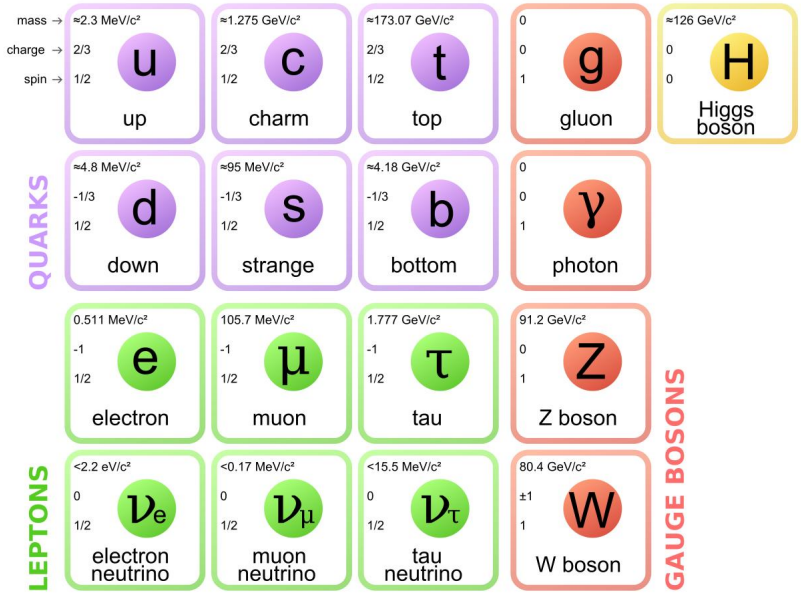
Understanding how the universe began requires developing a better theory of how space, time, and matter are related. In physics, a theory is not a guess or a hypothesis. It is a mathematical model that lets us make predictions about how the world behaves. Einstein's theory of **gravity**, for example,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

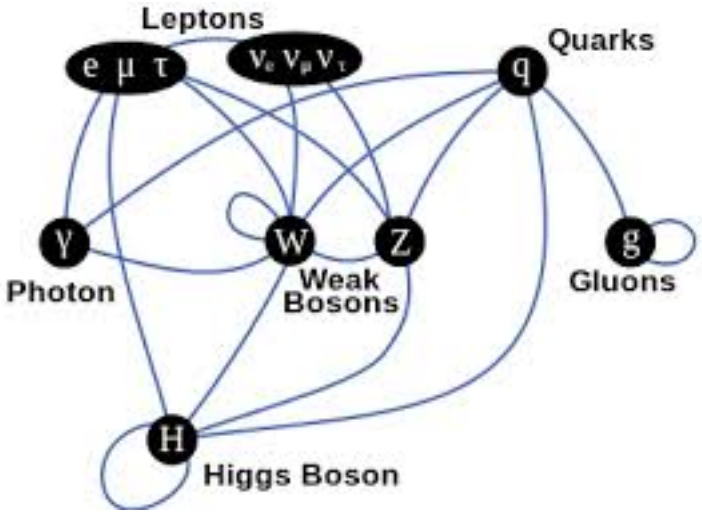
Standard Model of Forces

Elementary Particles



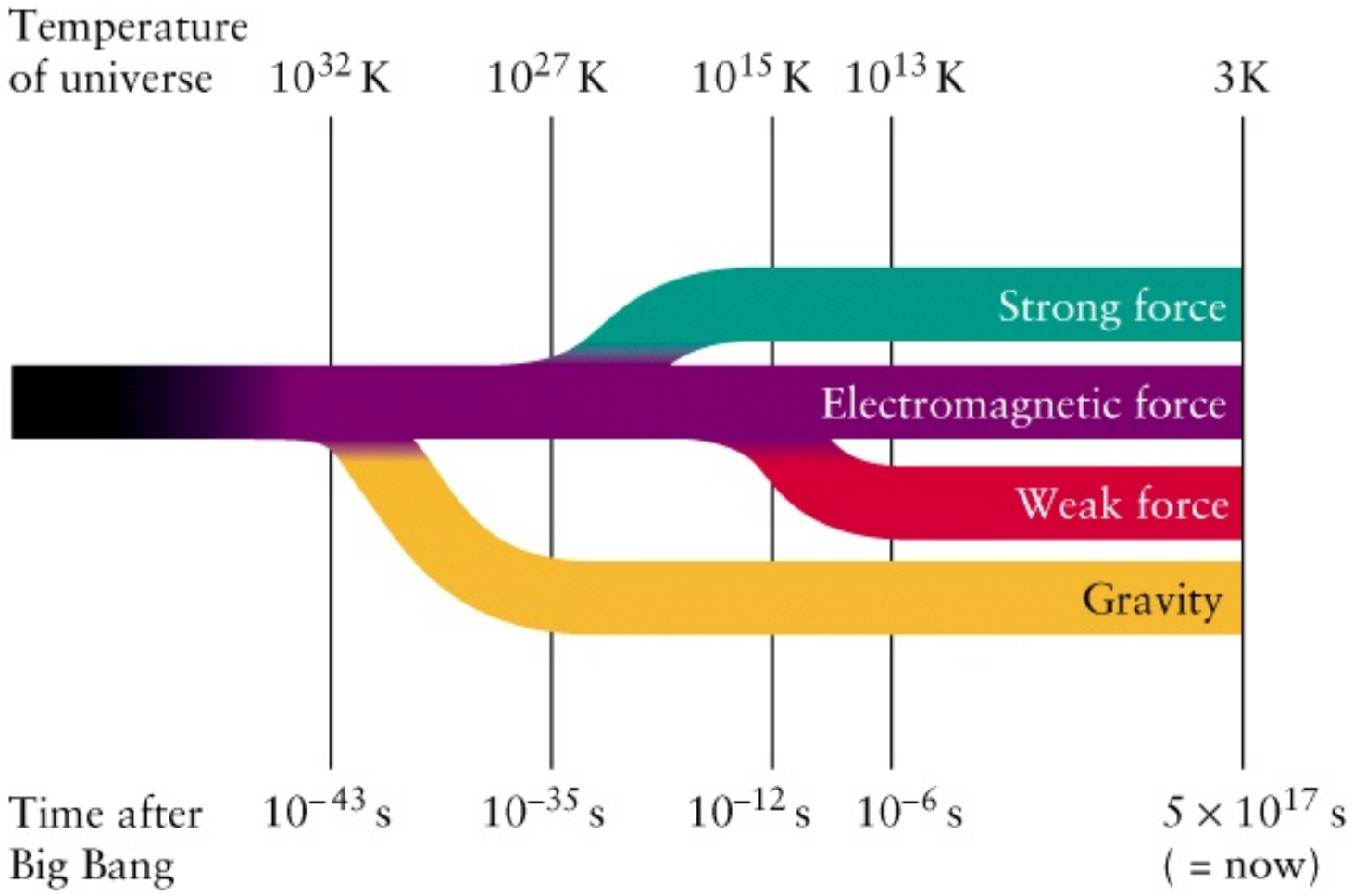
Three generations of particles, with gauge bosons in the fourth column and the Higgs boson in the fifth.

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 & Sasin, 1996)
  beginning is everywhere

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

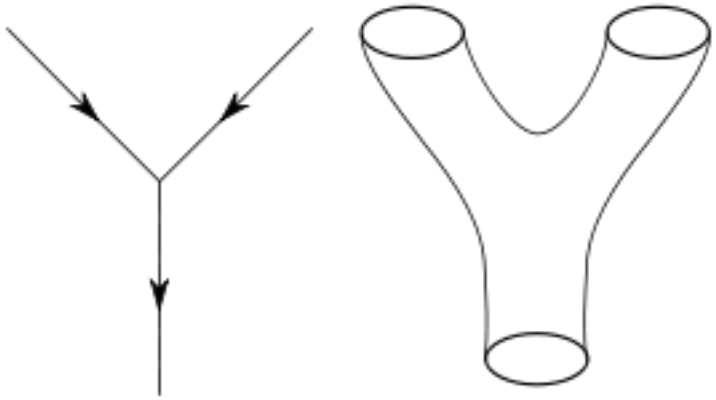
- Cyclic (ekpyrotic) model (Steinhardt & Turok, 2002)
  big bangs and crunches

- 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.

Bibliography

- Hartle J.B., S.W. Hawking, Wave function of the Universe, Physical Review D 28, 2960–2975, 1983.
- Heller M., W. Sasin, Noncommutative structure of singularities in general relativity, Journal of Mathematical Physics 37, 5665–5671, 1996.
- Linde A. D., Chaotic inflation, Physical Letters B, 129, 177–181, 1983; Eternally existing self-reproducing chaotic inflanationary universe, Physical Letters B, 175, 395–400, 1986.
- Steinhardt, P. J., N. Turok, A cyclic model of the Universe, Science 296, 1436–1439, 2002; Cosmic evolution in a cyclic universe, Physica D, 65, 126003, 2002.
- Witten, E., String theory dynamics in various dimensions, Nuclear Physics B, 443, 85–126, 1995.

Deterministic Chaos

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

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

This means that 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.

Alternatively, any positive finite value of Lyapunov exponents implies chaos.

Deterministic Nonperiodic Flow[1]

EDWARD N. LORENZ

Massachusetts Institute of Technology

(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.

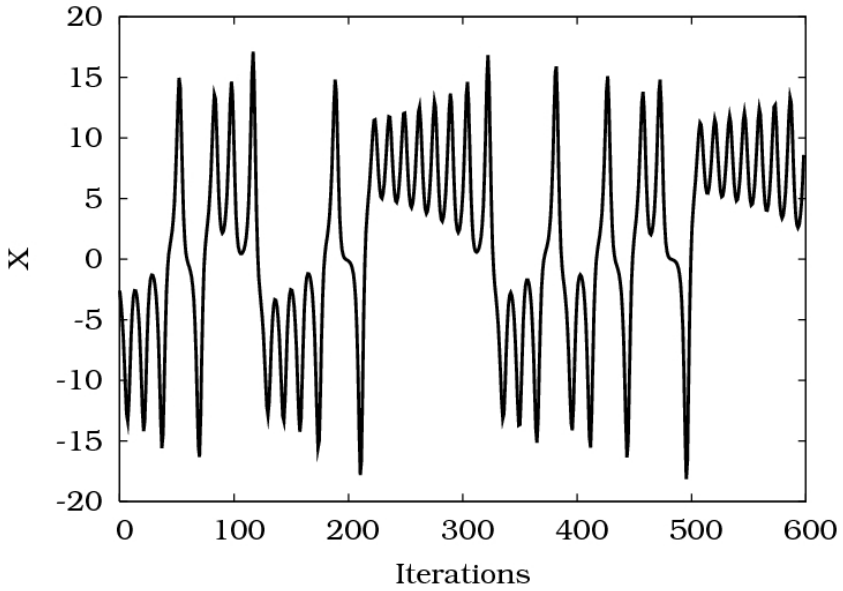
The feasibility of very-long-range weather prediction is examined in the light of these results.

Lorenz Model

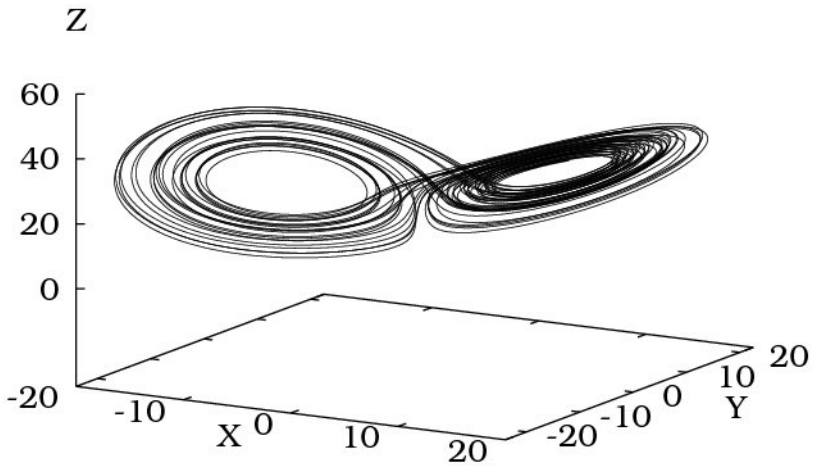
$$\dot{X} = \sigma(Y - X)$$
$$\dot{Y} = -XZ + rX - Y$$
$$\dot{Z} = XY - bZ$$

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

Time series for X



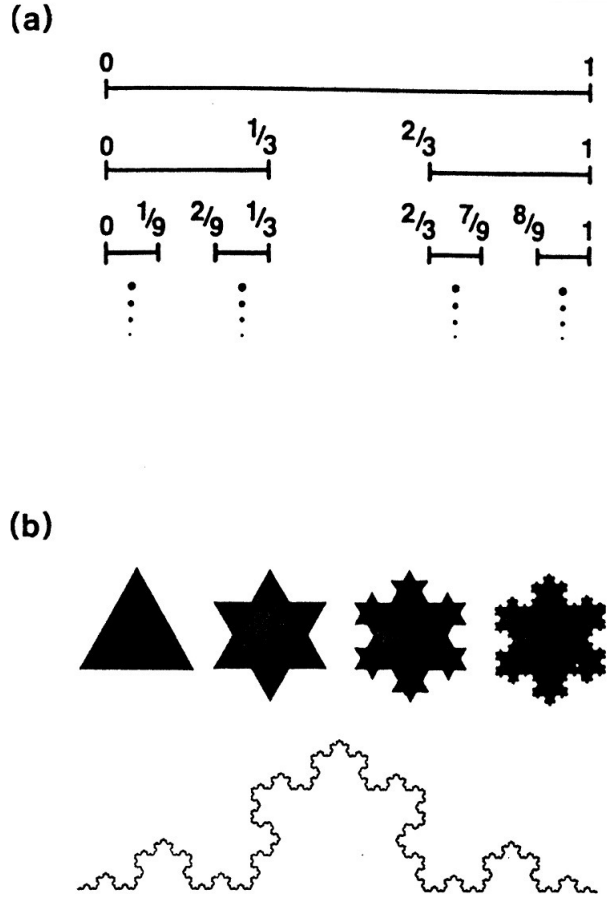
Strange Attractor



Fractals and the World

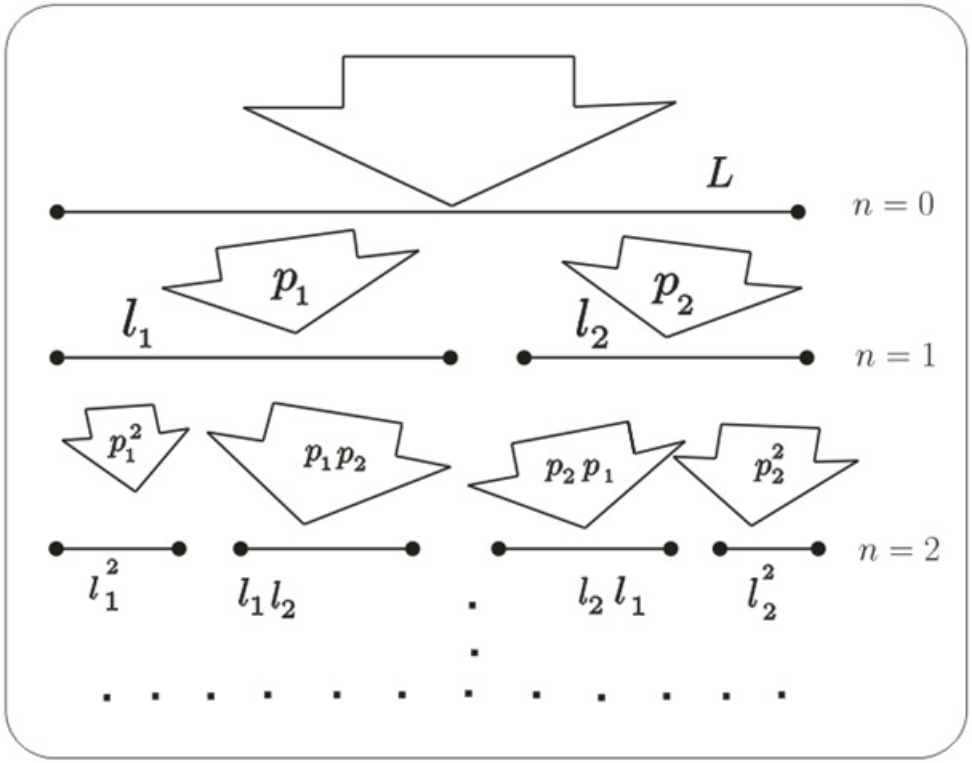
A **fractal** is a rough or fragmented geometrical object that can be subdivided in parts, each of which is (at least approximately) a reduced-size copy of the whole. Fractals are generally *self-similar* and independent of scale (fractal dimension).

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



$$p_1 + p_2 = 1$$

Two-scale model

$$l_1 + l_2 \le 1, \quad l_1 \ne l_2$$

One-scale model

$$l_1 = l_2 = \lambda \le 1$$

P-model

$$l_1 = l_2 = \frac{1}{2}$$

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

Implications

- **Nonlinear** systems exhibit complex phenomena, including chaos, where the effect is not proportional to the cause. This should influence the classical Aristotelian concept of the First Cause.
- Fractals resulting from simple mathematical rules can describe complex shapes in the real word.
- Strange chaotic attractors have fractal structure and are sensitive to initial conditions. Therefore, this should also be taken into consideration for the ultimate explanations of the Universe.
- Within the complex dynamics of the fluctuating intermittent parameters of turbulent media there is a detectable, hidden ORDER described by a Cantor set that exhibits a fractal structure.
- Based on that scientific experience here we also argue that a simple but possibly a **nonlinear law**, within theory of chaos and 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 (Macek, 2016).

Bibliography

- Lorenz, E. N., Deterministic Nonperiodic Flow, *Journal of the Atmospheric Sciences*, 20, 130–141, 1963.
- Macek, W. M., On Being and Non-being in Science, Philosophy, and Theology, in *Interpretations of Reality: a Dialogue among Theology and Sciences*, P. Coda, R. Presilla (eds.), *Quaderni Sefir*, 1, Pontifical Lateran University, Rome, Italy, pp. 119–132, 2000.
- Macek, W. M., Multifractality and Intermittency in the Solar Wind, *Nonlinear Processes in Geophysics*, 14, 695–700, 2007.
- Macek, W. M., Szczepaniak, A., Generalized Two-Scale Weighted Cantor Set Model for Solar Wind Turbulence, *Geophysical Research Letters*, 35, L02108, 2008.
- Macek, W. M., Multifractal Turbulence in the Heliosphere, in *Exploring the Solar Wind* edited by M. Lazar, Intech, ISBN 978-953-51-0399-4, 2012.
- Macek, W. M., Strumik, M., Hyperchaotic Intermittent Convection in a Magnetized Viscous Fluid, *Physical Review Letters*, 112, 074502, 2014.
- Macek, W. M., Wawrzaszek, A., Burlaga, L. F., Multifractal Structures Detected by Voyager 1 at the Heliospheric Boundaries, *Astrophysical Journal Letters*, 793: L30, 2014.
- W. M. Macek, On the Origin and the Existence of the World, in *Studies in Science and Theology XV*, D. Evers, M. Fuller, A. Runehov, K.-W. Saether (eds.), Yearbook of the European Society for the Study of Science and Theology 2015/2016, pp. 69–81, 2016.
- Mandelbrot, B. B., *The Fractal Geometry of Nature*, Freeman, New York, 1982.
- Stewart, I., *Does God Play Dice? The New Mathematics of Chaos*, Blackwell Publishers, 1990.
- Strogatz, S. H., *Nonlinear Dynamics and Chaos*, Addison-Wesley, Reading, 1994.

Conclusions

- We therefore hope that the modern studies together with the original thought of Aristotle should give us a new insight into the most important philosophical issues exceeding the classical ontological principles (Macek, 2000), providing a deeper understanding of the old philosophical question formulated by Leibniz (1714): *Why does something exist instead of nothing?*

- We also argue that if we do not like to continue philosophical studies in separation from science, then classic philosophy should open its thought to the most important ideas and achievements of the modern 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 to the mathematical natural sciences that would admit a better understanding sense of man in his relation to the Universe and the Reality.

  Thank you!

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

Wiesław M. Macek is Ordinary Professor at the Faculty of Mathematics and Natural Sciences of the Cardinal Stefan Wyszyński University in Warsaw, Poland, and at the Space Research Centre of the Polish Academy of Sciences, also received Ph.D. in theology. He was a member of Plasma Wave Science team on the Voyager mission to Neptune in 1989. His recent research interests focus on nonlinear dynamics and fractal structure of the solar wind, and include philosophy and theology in the context of contemporary science.