

Lectures on Science and
Theology



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Philosophical and Historical
Perspectives

Lecture 3

Physical Cosmology and Christian Theology of Creation

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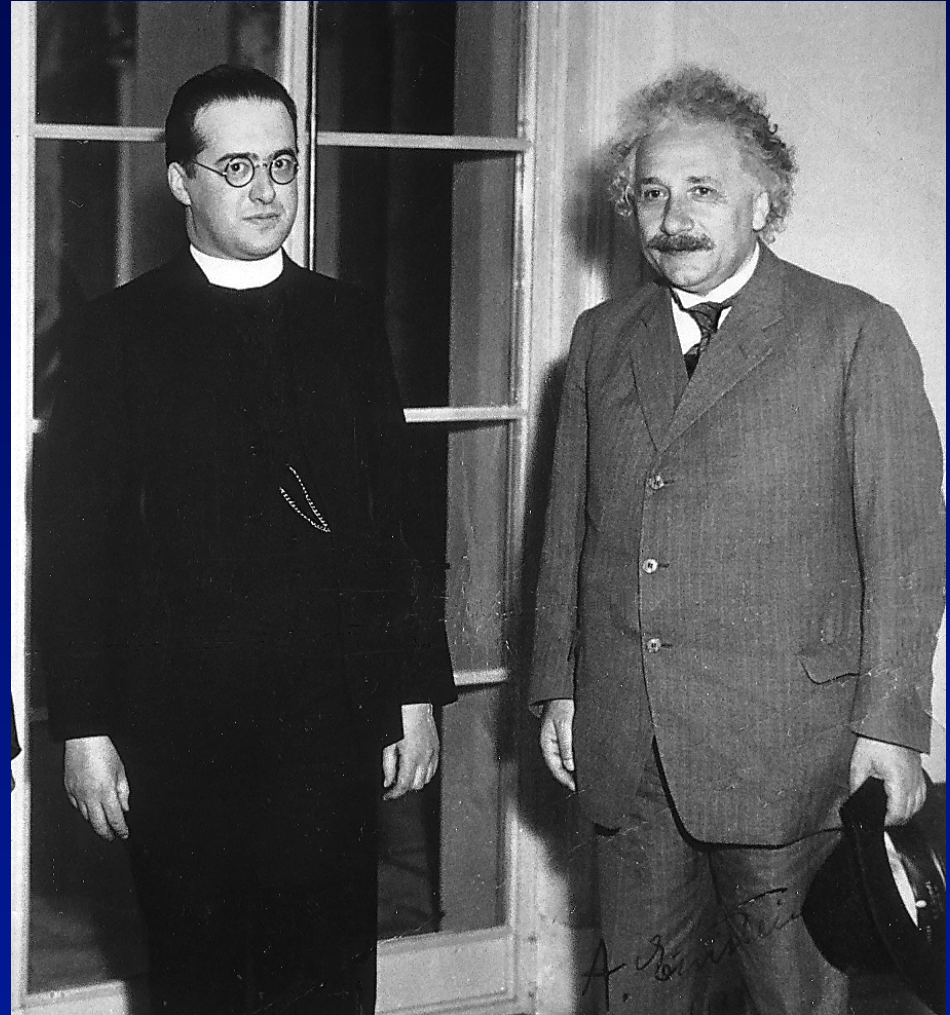


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Summary

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Scientific cosmology and theology of creation:
separation of fields or fruitful interaction?
2. Cosmological models and the debate on the
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nature and theology
4. Conclusions: cosmology, theology and the
human wondering on ultimate questions

Georges Lemaître and
Albert Einstein,
Caltech, 1933



1. Introduction.

**Scientific cosmology and theology of creation:
separation of fields or fruitful interaction?**

■ Why explore the relationship between scientific cosmology and theology of creation?

The idea that we are dealing with two independent, and in some ways incommensurable, fields of study, *would seem* acceptable to many

- ✓ Theology and Sacred Scripture deliver a **spiritual message** that has no necessary relation to the developing of physical facts
- ✓ Science is based on **provisional** and **fallible** results: theology should not bound itself to a specific scientific worldview
- ✓ Theology and science offer **two different and independent readings** of the world, of life, of the human being, capable of coexisting, as far as they do not claim to convey the only truthful account of facts

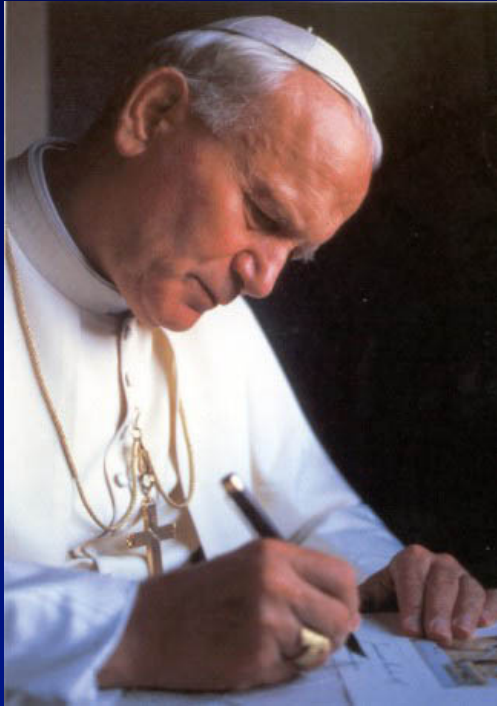
■ However, there are good reasons to take a closer look at these relationships, comparing the views of S & T

✓ Scientific research raises philosophical and sometimes even existential questions to which Christian theology claims to have the answers

✓ Theology can better understand the content of Scripture and God's plan for creation also thanks to the results of science

✓ The universe which is the object of natural sciences is also the one and the same world which God has created through his *Logos*

✓ We search for a unity of knowledge, in which what we know by science must not be contradicted by what we know by listening to the Word of God



“The unity of truth is a fundamental premise of human reasoning, as the principle of non-contradiction makes clear. Revelation renders this unity certain, showing that the God of creation is also the God of salvation history.

It is the one and the same God who establishes and guarantees the intelligibility and reasonableness of the natural order of things upon which scientists confidently depend, and who reveals himself as the Father of our Lord Jesus Christ.”

John Paul II, *Fides et Ratio* (1998), n. 34.



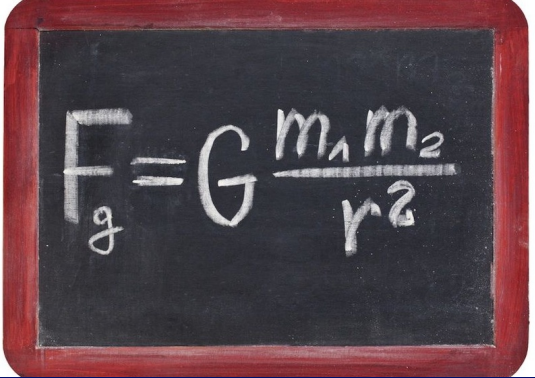
W. Nernst,
A. Einstein,
M. Planck,
R.A. Millikan and
M. von Laue, 1931

2. Cosmological models and the debate on the possible role of a God Creator

Hercules Cluster (Abell 2151), about 200 galaxies, 500 million light-years from the sun



I. Newton's law of universal gravitation


$$F_g = G \frac{m_1 m_2}{r^2}$$

$$R_{\mu\nu} - \frac{1}{2} R g_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}$$

A. Einstein's field equation, relates the geometry of space-time to the distribution of matter within it

R = scalar curvature

$R_{\mu\nu}$ = Ricci curvature tensor

$g_{\mu\nu}$ = metric tensor

Λ = cosmological constant

$T_{\mu\nu}$ = stress energy tensor

G = universal constant of gravitation

c = speed of light in the vacuum

What is a cosmological model?

A physico-matematical differential equation able to represent

- the distribution of matter-energy within a space-time geometry
- the structure in space and evolution in time of the physical universe

including the origin and the final scenarios of space-time and matter (if they are part of the model)

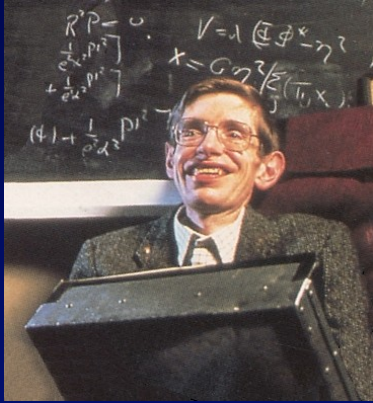


The question on the *origin* of the universe in cosmology and the debate about the possible role of an intelligent Creator..

The debate arises in the context of the so-called problems of *incompleteness*, logical or ontological, i.e. in the epistemological context of the *problem of foundations*. Actually, this debate

- ✓ is wrongly centered on the problem of a temporal beginning ($t = 0$)
- ✓ or on the "choice" of the boundary conditions of the equations describing the physical-mathematical evolution in time of the cosmic models
- ✓ stems from contemporary cosmology's desire to conceptualize the physical universe as a whole

☞ The reference to a Creator is introduced in the context of the "logic of the first move," endorsing the image of a "God of the gap"



Stephen Hawking
(1942-2018)

“If the universe had a beginning, we might suppose that it had a creator. But if the universe is completely self-contained, with no boundary or edge, it would have no beginning and no end: it would simply exist. But then, what room would there be for a creator?”

Many people don't like the idea that time had a beginning, probably because that notion smacks a bit of divine intervention.”

(A Brief History of Time, 1988)

“Many scientists are puzzled when it comes to the initial conditions of the universe, because they perceive that this borders on metaphysics and religion.”

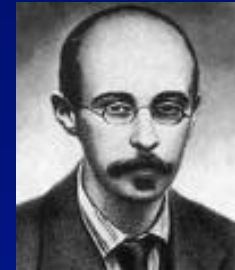
(The Edge of Spacetime, in P. Davies (ed.), "The New Physics," Cambridge 1989)

The debate thus develops about the meaning to associate to a (possible) "initial singularity", $t \rightarrow 0$.

For the purposes of our discussion, we examine 3 main "families" (A, B, C) of cosmological models

A) **Cosmological models** for a matter dominated, expanding universe, which predict (or expect) the existence of an initial gravitational singularity in the origin of space-time (usually known as *Big Bang models*)

- **standard models**, i.e., Friedmann-Lemaître solutions to Einstein's field equations employing a Robertson Walker geometry (FLRW models)



A. Friedmann
(1888-1925)



G. Lemaître (1894-1966)

B) Cosmological models that remove (or do not depend on) the existence of an initial singularity

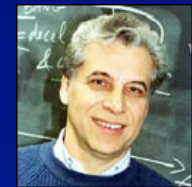
- steady-state or quasi-stationary models
- cyclic universe models
- models in which introduce a geometric transformation that removes the dependence on time, thus generating a *self-contained* universe
- models describing the origin of matter-energy as a quantum fluctuation from the *nothingness* of empty space
- models employing the framework of super-string theory and try to describe a "pre-Big Bang" era, where classical space-time emerges from a timeless "*foam*"



Fred Hoyle
(1915-2001)



S. Hawking
(1942-2018)



G. Veneziano
(1942-)

C) *Multiverse* models originating in inflation scenarios

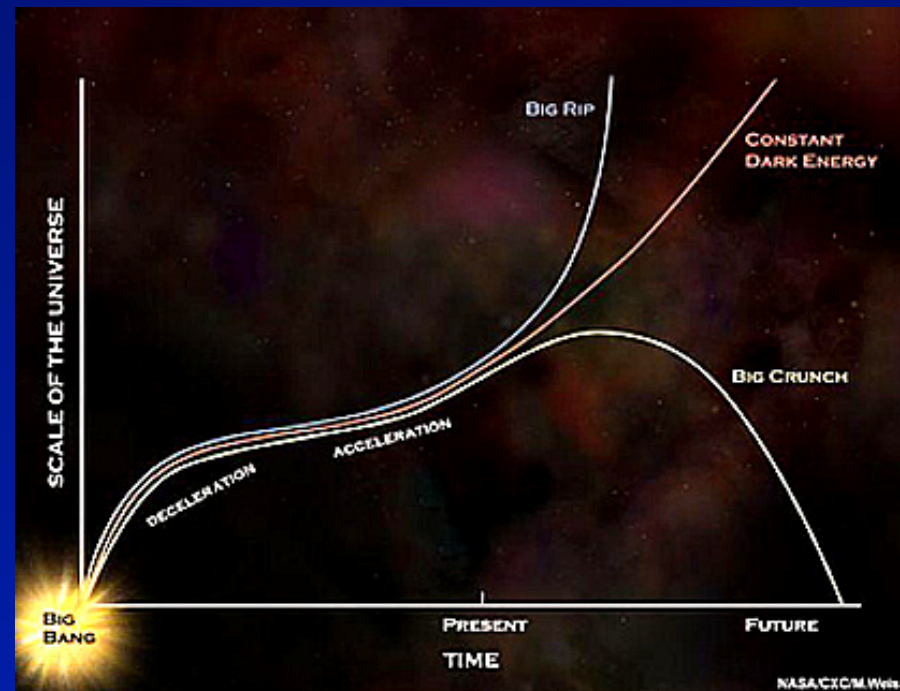
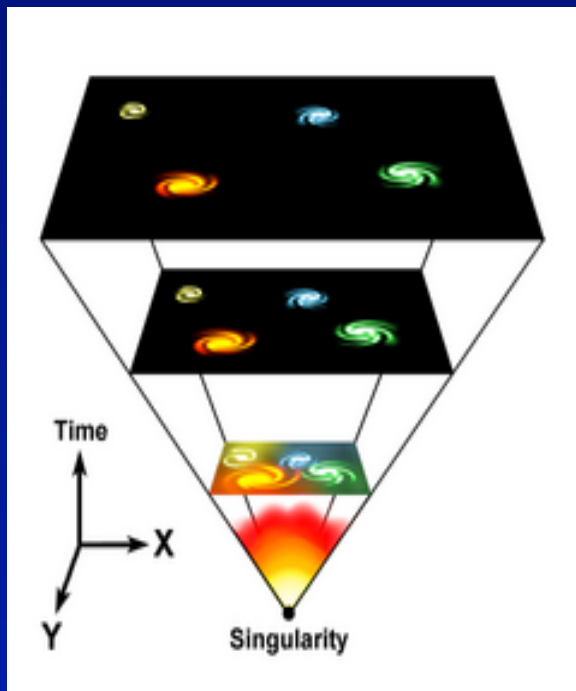
- universe consists in many causally independent space-time regions, without a single space-time origin



A. Guth (1947-)

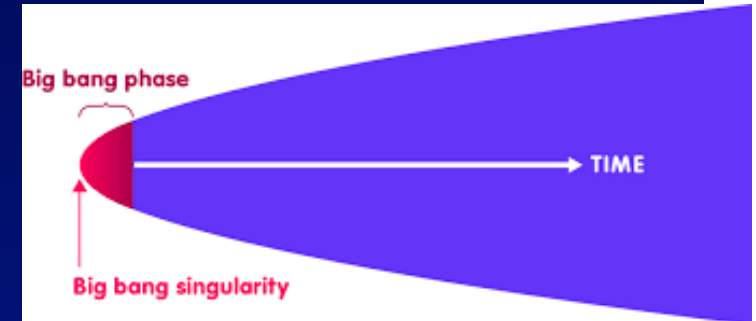
A) *Big Bang* cosmological models with an initial space-time gravitational singularity

The gravitational singularities do not correspond to the physical-mathematical definition of an origin of time: the point $t = 0$ does not belong to the domain of definition of the equations, and therefore for $t \rightarrow 0$ there is a divergence of the significant physical parameters T , ρ , etc.



☞ To speak of the existence of this singularity *as a theological creation event* makes no sense, because:

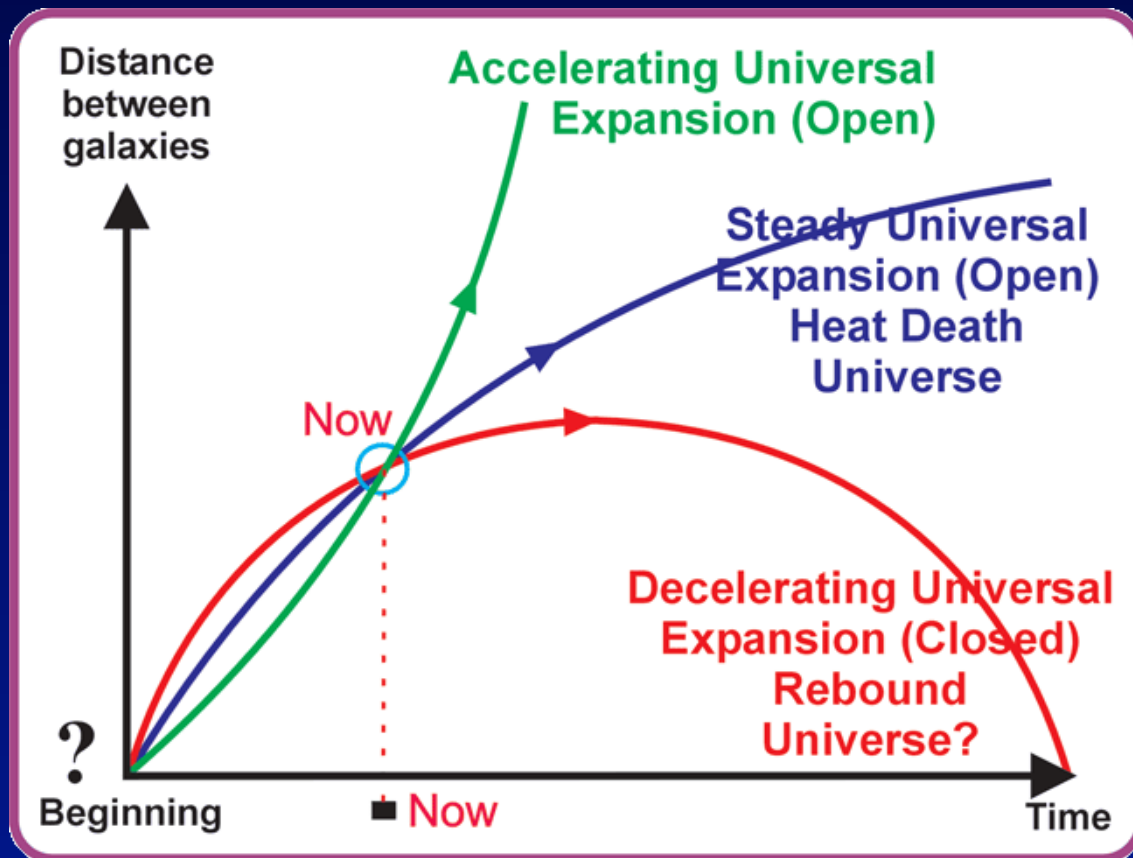
✓ We do not possess a physics adequate for describing the conditions of matter-energy and space-time within the Planck era, for sizes less than 10^{-33} cm and times less than 10^{-43} sec



✓ Since the mass density determining the space-time geometry also determines the rate at which time flows, approaching a finite single-point could take an infinite time

✓ From a theological view-point, the dependence of a created universe on a Creator is not satisfactorily represented by a time-beginning: creation is not a single-time event

☞ When gravitational singularities are erroneously clothed with theological overtones, then a fallacious association between *Big Bang* and *Creation* inevitably arises.



k is the curvature of space in FLRW models

$$k \leq 0$$

$$k > 0$$

If $k = 1$ (red curve), the universe is closed and space is spherical; after expanding, the universe decelerates and ends in a new singularity;

If $k = 0$ (blue curve), the universe is flat, space is Euclidean; the universe will expand forever, decelerating slightly;

If $k = -1$ (green curve), the universe is open, space is hyperbolic; the universe will expand forever, but with greater speed;

Present observations suggest that the universe is open and accelerating

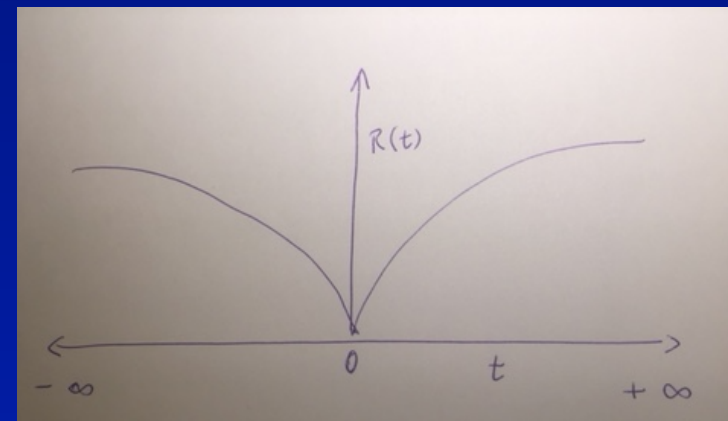
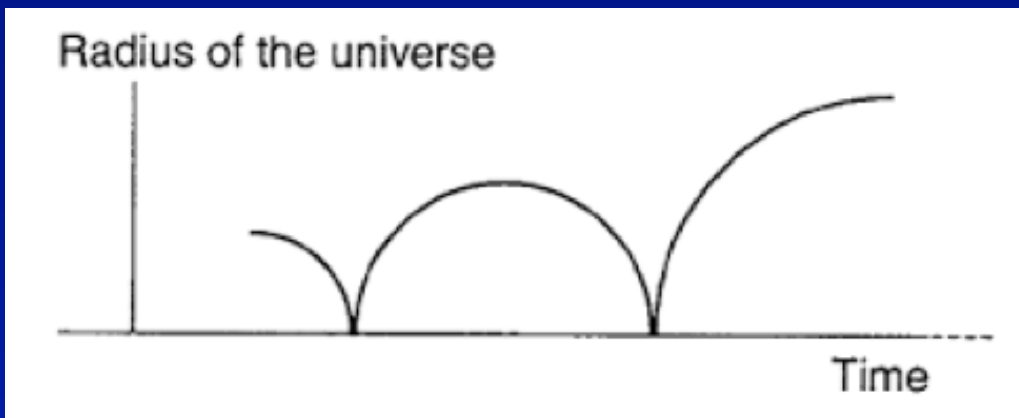
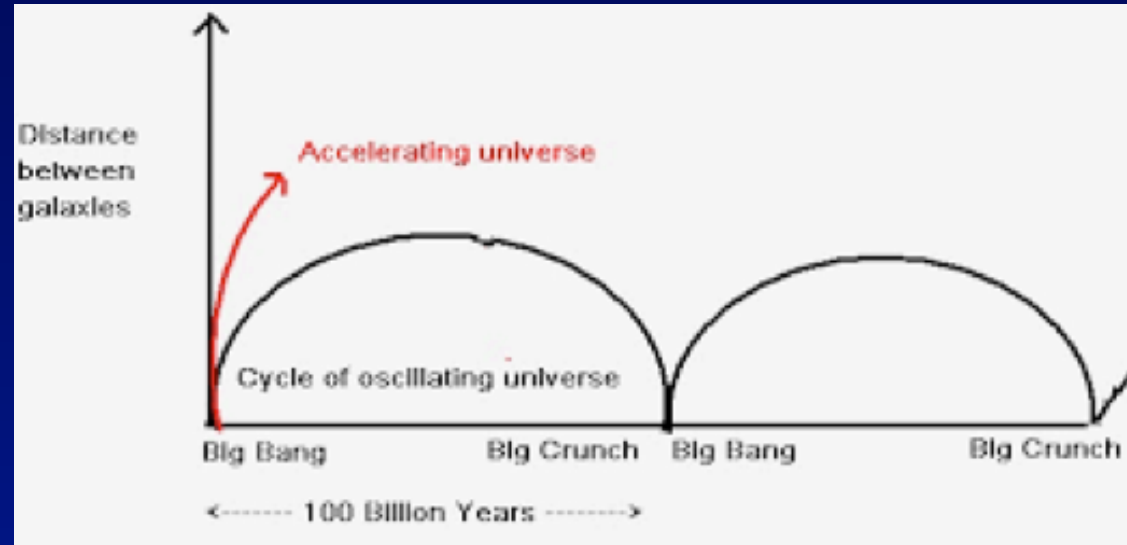
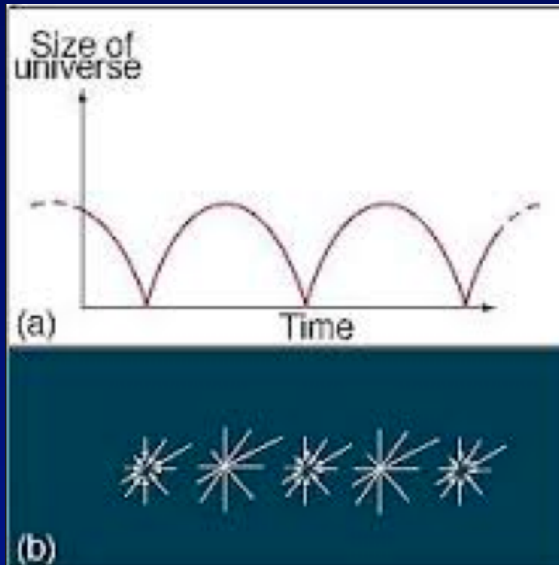
B-1) Steady-state cosmological models without any initial space-time singularity

- ✓ models of the universe without beginning or end, without any gravitational horizon, introduced by Einstein and De Sitter before the discovery of the expansion of the universe (1929)
- ✓ after the discovery of the expansion of the universe, these models were maintained by introducing a local "creation" of mass, such as the cosmic density, homogeneity, and symmetry remain unchanged
- ✓ these models were used by some authors, in the 1960s, in an anti-theological sense, just to remove the initial space-time singularity, erroneously considered to be *too close to* the theological idea of creation.

B-2) Cycloidal or oscillating universe models

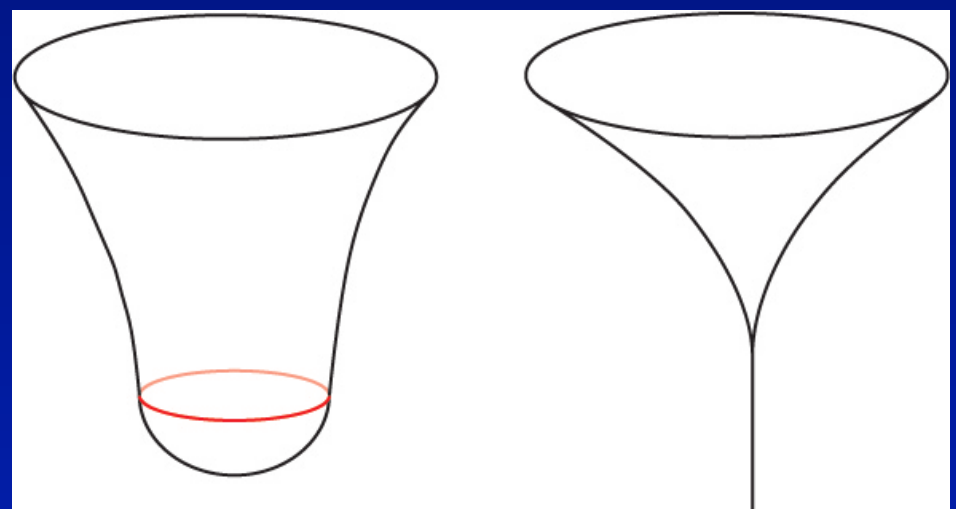
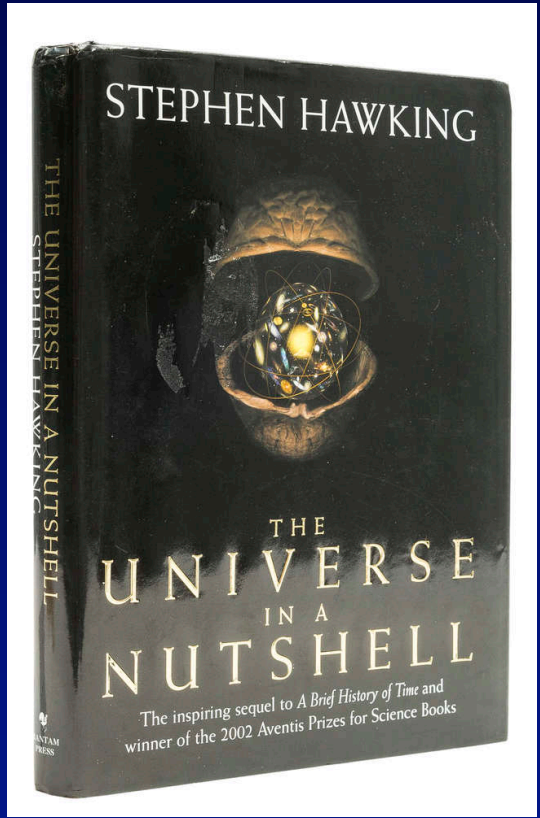
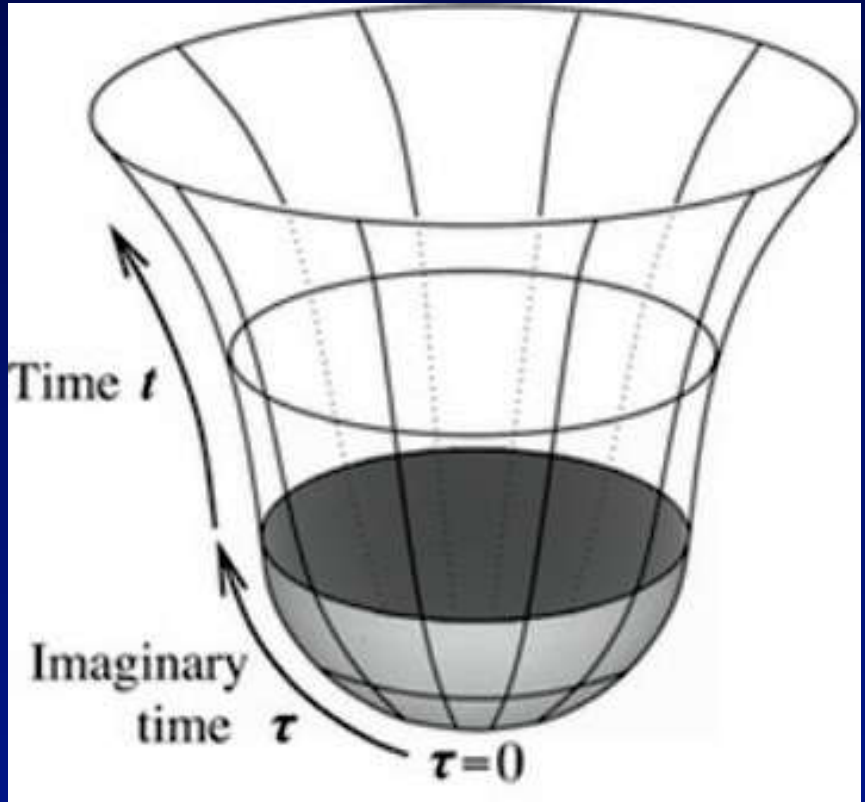
- ✓ These models predict the expansion of a new *Big Bang* after a corresponding *Big Crunch*, and so *ad infinitum*
- ✓ They are possible only in a universe having a curvature parameters $k > 0$ (presently, observations are rather consistent with a open universe, $k \leq 0$)
- ✓ According to some authors, each cycle would not be perfectly symmetrical and reversible; therefore the number of cycles would be finite, not infinite, and the global entropy always increasing
- ✓ From a purely mathematical point of view, an oscillating model exists also for $k \leq 0$. However, it would have one "bounce" only, at $t = 0$, for a $R(t)$ ranging from $t = -\infty$ to $t = +\infty$, then asking for a reversibility of the arrow of time.

B-2) Cycloidal or oscillating universe models



B-3) Models that remove the initial space-time singularity by eliminating the geometrical dimension of time

- ✓ Originally proposed by John Hartle and Stephen Hawking in 1974
- ✓ By means of a geometric transformation, and introducing an imaginary time ($t \rightarrow -it$), a space-time 4-D geometry admits the limit of a 3-D space geometry
- ✓ Once the $t = 0$ initial singularity is removed, then the cosmic model has no boundary conditions: it becomes a "self-contained universe"
- ✓ In reality, this cosmological model does *not start from nothing*: it assumes the geometry of the super-space it uses, and all the maths you need to compute the probability that a 3-D geometry can emerge from a dimensionless point

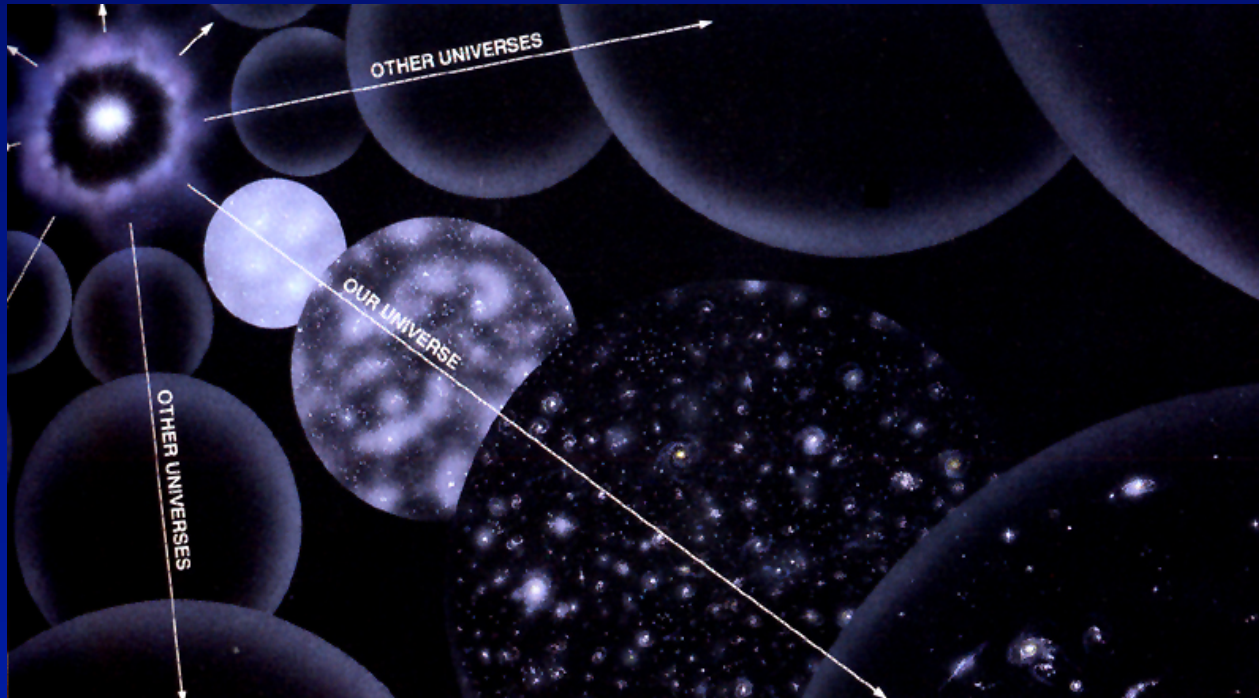
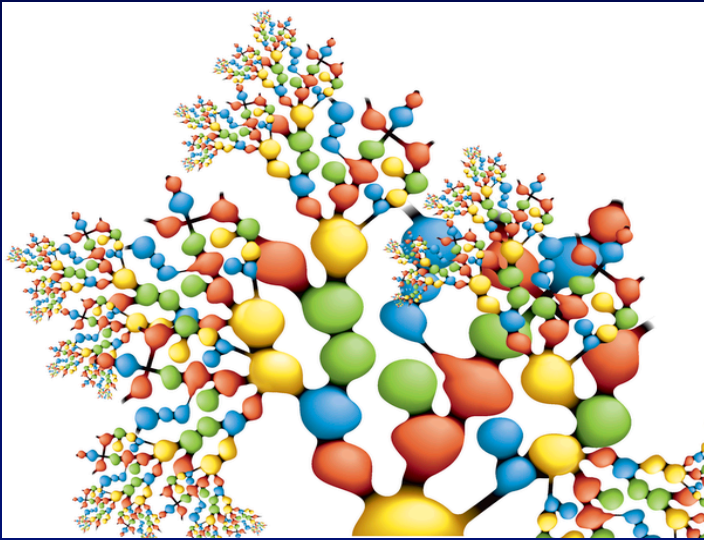


B-4) Cosmological models describing the origin of the universe as a quantum fluctuation

- ✓ Originally proposed in the 1970s by A. Vilenkin, E. Tryon, Y. Zel'dovich, A. Starobinski, L. Krauss
- ✓ Become possible in a theoretical framework which unifies the 4 fundamental forces (quantum gravity): in so doing, the universe becomes, as a whole, a *quantum object*.
- ✓ Operate under the assumption that the sum of gravitational energy (negative) and mass-energy (positive) present in the universe is algebraically *zero*
- ✓ Describing the *appearance of* the universe without any violation of the laws of conservation, they have been (erroneously) invoked to show the plausibility of a (theological) *creation from nothing*, or, instead, to argue that such a creation is unnecessary...

C) Cosmological models of multi-verse: many independent universes originate during the inflation cosmological epoch

- ✓ Originally proposed by Alan Guth, and then by S. Hawking. A. Vilenkin, Q. Smith, these models describe how many causally disconnected (isolated and independent) space-time regions originate during an initial phase of inflation
- ✓ Sophisticated geometries describe the possibility of sequences of *big-bangs* and their ramifications, subordinating child-universes to mother-universes
- ✓ These models are invoked to find an *explanation* for the unusual anthropic conditions given in *our* universe
- ✓ Models of many or even infinite universes, more or less consciously, recall the idea of a universe without beginning or end, the object of a continuous chaotic transformation...



Artist's views of a multiple universes model emerging from inflation

■ Some philosophical and theological clarifications...



- ☞ The dependence of a created world on a Creator is much more (and other) than solving the problem of the **beginning of time**: a universe without a beginning requires an **ontological foundation**, and therefore an **origin**
- ☞ Resorting to an infinity of worlds or to an infinite duration of time, does not escape the need to have a foundation for what is contingent
- ☞ Cosmological models **predicting** or, instead, **avoiding** a space-time gravitational singularity, do not confirm nor contradict the theological concept of creation.



- ☞ Cosmological models describing the appearance of the universe from quantum "nothingness" or from the "void" of space-time, do not involve the concept of metaphysical nothingness: every model must start from assuming some form of being (geometric, algebraic, physical, virtual, etc.)
- ☞ Actually, none of these models presume to start from nothing. They pre-suppose the metrics and laws forming the basis of the space-time geometry, or they presuppose the quantum representation the models use
- ☞ As expected, all these models operate within a mathematical framework that bears no relationship with meta-physical nothingness



“However successful our scientific explanations may be, they always have certain starting assumptions built in. For example, an explanation of some phenomenon in terms of physics presupposes the validity of the laws of physics, which are taken as given. But one can ask where these laws come from in the first place. One could even question the origin of the logic upon which all scientific reasoning is founded. Sooner or later we all have to accept something as given, whether it is God, or logic, or a set of laws, or some other foundation for existence.”

P.C.W. Davies, *The Mind of God. Science and the Search for Ultimate Meaning*, Simon & Schuster, London 1992, p. 15.

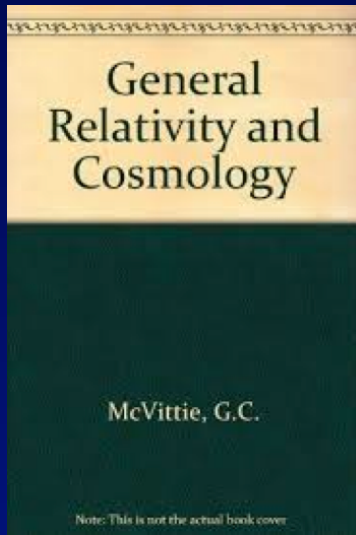
“Although we may be able to find a cause for every event (unlikely in view of quantum effects), still we would be left with the mystery of why the universe has the nature it does, or why there is any universe at all. [...] The universe is the way it is because God has chosen it to be that way. Science, which by definition deals only with the physical universe, might successfully explain one thing in terms of another, and that in terms of another and so on, but the totality of physical things demands an explanation from without.”

Idem. *God and the New Physics*, Penguin, London 2006, pp. 101, 108.



Michael Heller (1936-)

“Actually, contemporary physical cosmology is not only the science of the whole universe, but also a science concerning those assumptions that permit the very possibility of a science of the universe... and choosing among these assumptions, cosmologists unconsciously resort to philosophical a-priori pre-comprehensions and pre-suppositions.”

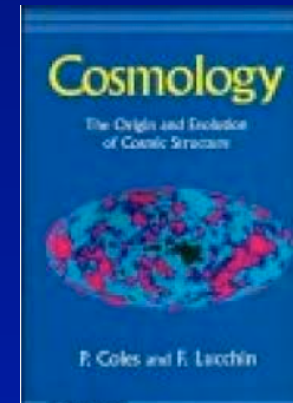


“An individual scientist may perhaps believe that he pursues his work without considering philosophical questions, but this belief is illusory and arises simply because the scientist has unconsciously acquired some particular metaphysical outlook.”

G.C. McVittie, *General Relativity and Cosmology*, Univ. of Illinois Press, Urbana 1963, p. 3

“Subtle influences of personal philosophy, cultural, and in some cases, religious background lead to very different choices of paradigm in many branches of science, but this tendency is particularly noticeable in cosmology...”

P. Coles, F. Lucchin, *Cosmology. The origin and Evolution of Cosmic Structure*, Wiley and Sons, Chichester 1995, xi





3. The notion of creation between philosophy of nature and theology

■ Physical cosmology attempting to conceptualize the entire universe as a unitary intelligible object



- ✓ The “universe” constitutes a typically philosophical object, because “the *whole*” cannot be the object of any possible experience, nor of any direct empirical investigation
- ✓ Speaking of the *whole* is always an ideal construction, which starting from experience moves towards a conceptual generalization
- ✓ A cosmology that wants to be “a science of the whole” should necessarily include meta-empirical assumptions and a priori presuppositions
- ✓ A *physical definition* of the universe, when possible, always remains *philosophically incomplete*

Consider the following "definitions" of the universe:



- “The totality of existing entities insofar as they are referable to a single cause of their being”
(metaphysical notion)
- “Everything that exists, having a direct or indirect connection with observed physical and astronomical objects”
(cosmological-observational description)
- “The connected set of possible space-time events, which includes the present time and place, and the physical objects existing in all such events”
(physical-mathematical notion)

☞ The metaphysical and physical concepts of universe do not necessarily coincide. The first one is independent of the variety of models which describe the material universe. A metaphysical notion of *universe can be compatible with different cosmological models.*

■ Science, i.e. the art of starting from *something*...

- ✓ Empirical analysis necessarily requires the existence (being) and specific properties (nature, essence) of material entities. To be objects of empirical analysis, the “objects of physics” must be and must be something.
- ✓ The possibility of extracting energy from the geometry of space-time (vacuum energy) is not to create anything, but to deduce (physical) quantities from other (geometric, quantum field, etc.) quantities.
- ✓ To “create” matter or energy by means of a quantum fluctuation of the physical vacuum, is to deduce the existence of something (energy or matter) from the existence of something else (a system of laws, physical properties, etc.), which represent the ontological pre-suppositions of scientific analysis, whether real or virtual.
- ✓ Cosmological analysis of the whole of the physical universe copes with the philosophical problem of ontological and logical incompleteness. The empirical sciences, cosmology in particular, come up against the very foundations of being and knowing.

■ Thomas Aquinas seems to have taken into account the philosophical questions raised by contemporary cosmology. Here are the the titles of some *Quaestiones* he presents:



from the *Commentary to P. Lombard's Sentences* (book II, d. 1, q. 1)

"Whether there is a first principle only" (a. 1)

"Whether the act of creating can be made by agents other than God" (a. 3)

"Whether the world is eternal" (a. 5)

from *Summa theologiae* (I pars, qq. 44-47)

"Whether primary matter is created by God, or is an independent coordinate principle with Him" (q. 44, a. 2)

"Whether the universe always existed" (q. 46, a. 1)

"How God is said to have created heaven and earth in the beginning" (q. 46, a. 3)

"The unity of the world: whether there is one world only" (q. 47, a. 3).

Here are some key-points of Aquinas' thought on creation

- Creation should be understood first and foremost as a relationship
- Creation is not a motion or a change
- Creation is a transcendent act, outside of time
- Time cannot be the measure of creation: the beginning of the world cannot be deduced from the world itself
- The world depends *ab aeterno* on a Creator, and therefore a universe of infinite duration would also depend on God, because He is the creator of time
- Creation and preservation in being are a single act of God the Creator



“It is said that things were created at the beginning of time, not because the beginning of time is the measure of the creative act itself: but because the heavens and the earth were created together with time. [...] Now creation is not a motion and not even the end of a motion.”

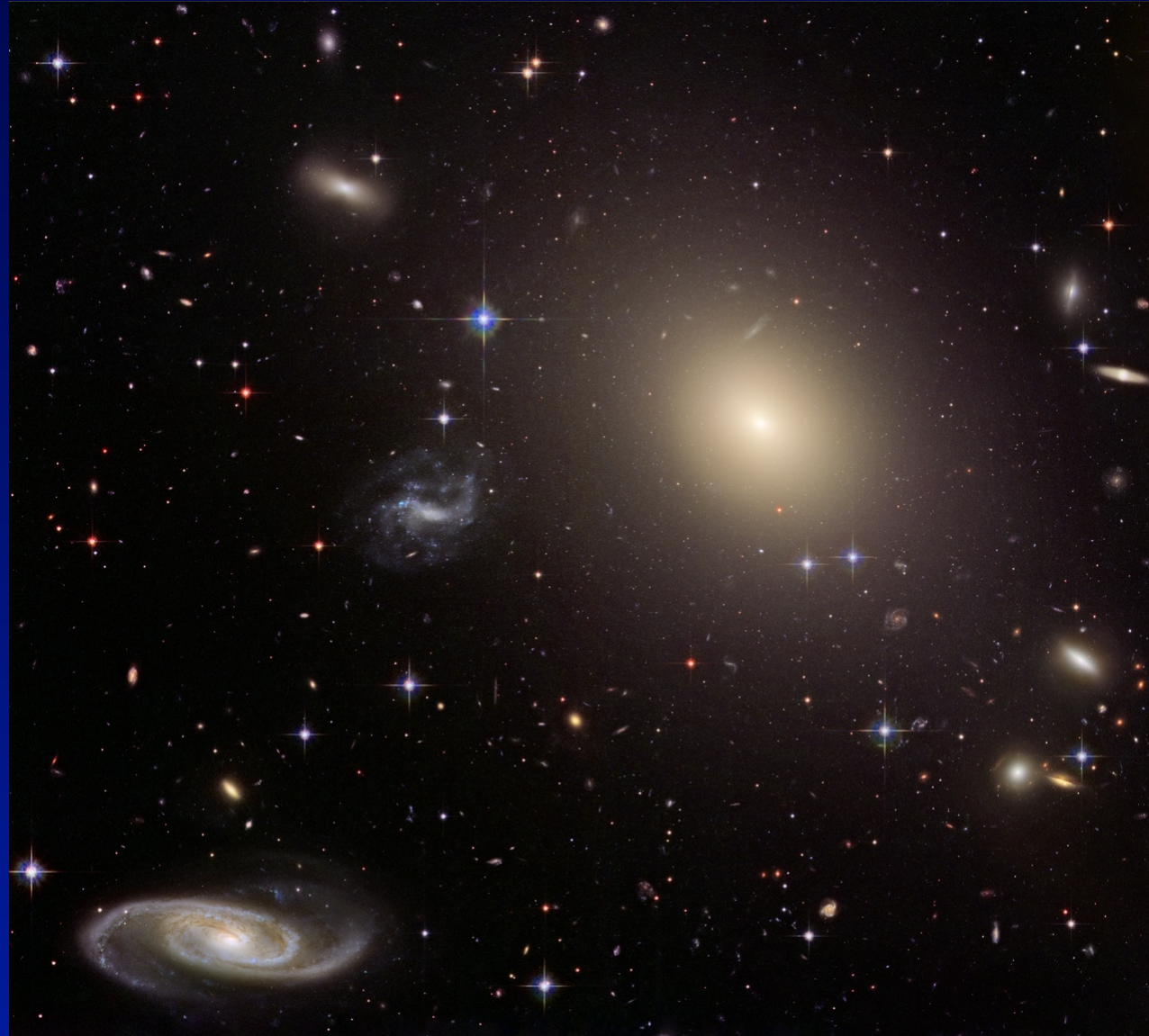
(Summa theologiae, I, q. 46, a. 3)

“Creation places something in the thing created according to relation only; because what is created, is not made by movement, or by change. [...] Hence creation in the creature is only a certain relation to the Creator as to the principle of its being.”

(Summa theologiae, I, q. 45, a. 3)

“This world is said to be one on account of its unity of order, according to which some things are ordered to others; for everything that comes from God is ordered in itself and is ordered towards God; for this reason all things con-
corporate in one world. Various worlds were admitted by those who did not establish an ordering wisdom as the cause of the world, but randomness.”

(Summa theologiae, I, q. 47, a. 3)



Abell S740 cluster of galaxies, 450 million light-years from the sun

4. Conclusions: cosmology, theology and the human wondering on ultimate questions



- Contemporary cosmology has today the theoretical, and in part the observational tools, to conceptualize the physical universe as a single intelligible object.
- This is a quite new situation, which allows cosmology to address ultimate philosophical questions, usually the object of philosophy of nature and metaphysics (origin of the cosmos, purpose and meaning of cosmic evolution, etc.).
- In encountering these questions, cosmology perceives the problem of foundations and the problems of incompleteness, logical and ontological, recognizing the need for a meta-language and a meta-physics, able to work with a broader level of abstraction.



- These ultimate questions have no complete nor consistent answer within the scientific empirical method, but they are bound to arise because it is the scientist, a knowing *personal subject*, who is theoretically and existentially prompted to address them.
- Theologians should not see with suspicion this new conceptual frame displayed by physical cosmology; they should appreciate that ultimate questions are kept alive by science and help scientists to distinguish the different levels of abstraction there involved.
- At the same time, theologians should note and explain that the search for understanding and the search for ultimate meanings is driven by a *personal subject*, whose insights and thoughts on reality necessarily and spontaneously transcend the empirical knowledge.



■ Theologians, again, cannot limit themselves to providing epistemological clarifications and pointing out misunderstandings, when discussing on theology and science: they must also make the most of the fact that these questions arise among men and women of science.

■ It is inevitable that they arise, because the physical universe is the effect of a personal Word (Logos), which appeals and attracts.

■ Questions about the origin, the whole, the meaning and the purpose of all, which cosmology raises, must be placed in dialogue with the reflections of the philosophy of nature and a realist metaphysics.

■ In so doing, the scientific method becomes aware of its very foundations and protect itself from idealistic drifts.



■ As an effect of this dialogue, scientists can realize that the being and the properties of the physical universe **are given**, and theologians unfold **the face of the Giver, the Word-Logos**.

■ Actually, the very meaning of **data** (*datum*) is “givenness,” theologians indicate as the Creator’s loving decision to give.

■ Having this in mind, the *epistemological* “**experience of the foundations of reality**” may become the *religious* “**experience of the encountering with the Giver,**” acknowledging the world and the being as a personal gift.

■ Such a view is consistent with scientific activity, because **the truly ultimate why**, why the world is the way it is and not otherwise, cannot be derived through empirical investigation: **we can receive it only as a gift**.



■ From a general view-point, theologians should not look with suspicion that contemporary science (cosmology, physics, biology, anthropology) is able to trace back the steps of our cosmic and biological history, up to questions about “the *origins*”.

■ Theologians, instead, can remind that such a long history, and the chain of the many scientific causes lying therein, have no access to the ultimate (and the most important) question, namely, *why am I, myself, here?*

☞ In the dialogue between scientists and theologians, the point at stake is not to deny what science says, but to add what science is silent about.

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